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CT OF AN *Erosion Control* PROGRAM ON LABOR & POWER REQUIREMENTS

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The data presented in this report were obtained from a detailed accounting study of dairy farms in Winona County, Minnesota. The data relating to changes in size and shape of fields and slope of operations and the relationship of labor and power expenditures to size and shape of fields and slope of operations were prepared by A. W. Anderson and presented in a master's thesis entitled "A Study of the Effect of Shape and Size of Field on the Labor and Power Expenditures for Crop Production." This thesis is on file at the library of the University of Minnesota.

Cover picture by courtesy of the Soil Conservation Service

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Effect of an Erosion Control Program on Labor and Power Requirements

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Interest in erosion control in Minnesota has been growing steadily in recent years. Farmers recognize the serious effect of continued erosion upon the productive value of their farms. Many farmers are now following programs that materially reduce losses from erosion, but fear of increased labor and power requirements deters many others from adopting effective erosion control programs. Since the value of labor and power constitutes from one fourth to one half of the cost of producing crops, economy in their use is an important factor affecting earnings.

The purpose of this study is to analyze the effect of the adoption of an erosion control program upon the labor and power needed for crop work. Emphasis will be placed upon the effect of changes in the sizes and shapes of fields.

The analysis deals specifically with areas subject to water erosion. The conclusions, particularly those concerning the effect of size and shape of fields, will also apply to areas subject to wind erosion. The information on effect of size and shape of fields will be valuable to anyone interested in field arrangement.

Source of Data

This analysis is based upon records kept by a group of Winona County farmers. Almost one third of the land in the county is moderately eroded and one seventh is severely eroded. The problems of erosion and erosion control are typical of those in Fillmore, Houston, Wabasha, Goodhue, and Olmsted counties (see figure 1). They resemble the problems of other areas sufficiently closely to give widespread usefulness to the information.

Records were obtained from 20 to 25 farmers each year from 1935 to 1940. Each farmer reported the hours of labor and power used, operations performed and acreages covered, pro-

[1] The authors acknowledge their indebtedness to the farmers who cooperated in this study, to R. H. Loreaux and F. E. Wetherill, who served as fieldmen, and to G. A. Sallee, who supervised the gathering and tabulation of the data during the first years of the project. They especially wish to thank G. A. Pond for generous advice and help in preparing the data and manuscript.

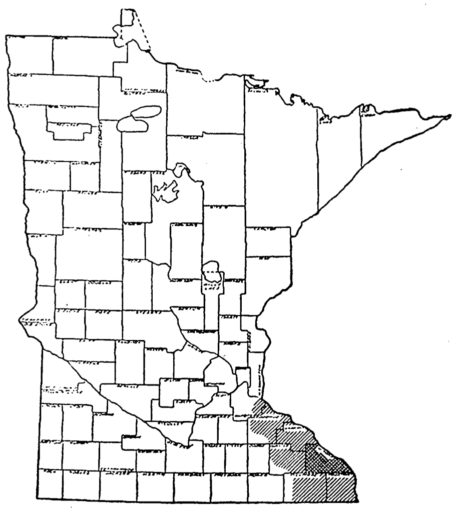

Fig. 1. Location of Area Studied.
The data were obtained in Winona County—the darker-shaded area. The results are also applicable to the lighter-shaded area.

duction of each field, inventories, expenses, receipts, farm produce used in the house, and other pertinent data. Each farm was measured and mapped. A fieldman visited each farm two or three times a month to collect the records, check them for completeness and accuracy, and obtain supplementary information.

These farms were larger than the average of the county—288 acres compared with 178. The crops grown and the livestock kept were typical.

Most of the farms were hilly, with moderate to severe erosion problems. A few were only gently rolling with minor erosion problems. No farmer used any special erosion control program in 1935. In the fall of 1935, fifteen farmers signed an agreement with the Soil Conservation Service, U. S. Department of Agriculture, to carry out a water-erosion control program. Other farmers signed agreements in later years. These programs were begun in 1936 and in full operation in two or three years. With present planning techniques, these programs might be somewhat different.

The analysis of the change that is made in the farm organization and methods of operation when an erosion control program is put into effect is based upon the records of 10 farmers from whom continuous data were obtained from the year before the program was started until the changes were nearly complete. Data relating to labor used on different crops and for different sizes and shapes of fields were obtained from all records gathered.

Changes in Farm Organization and Operation

Changes in Land Use

Some changes in the farm organization and methods of operation were necessary in order to reduce erosion on these farms. On the ten farms for which data were obtained both before the adoption of the program and after it was nearly complete, a little less than ten per cent of all cropland was retired from crops and seeded down to permanent pasture or isolated for gully control (see table 1). Most of

Table 1. Land Use Before and After Adoption of an Erosion Control Program, 10 Winona County Farms

Land use	Acres		Per cent of land	
	Before	After	Before	After
Cropland	175.5	158.8	61	55
Permanent pasture, woods	103.7	122.1	36	42
Farmstead, roads, waste	10.8	9.1	3	3
Total land per farm	290.0	290.0	100	100

Table 2. Cropping System Before and After Adoption of an Erosion Control Program, 10 Winona County Farms

Crops	Acres		Per cent of cropland	
	Before	After	Before	After
Corn	25.1	22.4	14	14
Soybeans	1.6	5.5	1	4
Other intertilled	1.6	2.0	1	1
Total intertilled	28.3	29.9	16	19
Small grains	95.3	81.5	54	52
Hay	40.1	41.8	23	26
Rotation pasture	8.6	5.2	5	3
Fallow, seedings, etc.	3.2	.4	2	.....
Total cropland	175.5	158.8	100	100

this was badly eroded land on the steeper slopes. Some woodland was fenced to prevent damage by grazing livestock. These changes in land use are similar to those that occurred in other nearby erosion control demonstration areas.[2]

Changes in Cropping System

The acreage of intertilled crops increased slightly (see table 2). The acreage of corn was reduced, but the acreage of soybeans was increased. The increased acreage of soybeans resulted partially from need for hay on some farms and partially from the regulations of the agricultural adjustment program. The other intertilled crops, principally potatoes, remained practically unchanged.

The small grain acreage was reduced by fourteen acres, representing almost the full reduction in cropland. This concentration of the adjustment upon the small grains represented a move to maximize feed production. According to the records gathered from these farms, feed production per acre was considerably smaller from small grains than from either corn or hay.

The acreage of hay was increased slightly. This increase was smaller than was originally planned. Seeding failures on many farms and a surplus of roughage on a few farms limited the increase. The acreage of cropland used for pasture was reduced. More permanent pasture was available and it was inconvenient to graze the contour strips.

Fallowing land and seeding legumes without nurse crops were practically eliminated. These practices before adoption of the erosion control program resulted from the regulations of the agricultural adjustment programs.

Changes in Number and Sizes of Fields

A major recommendation of the Soil Conservation Service was to cultivate the cropland in long, narrow strips following the contour of the land instead of in the conventional square or rectangular fields. A typical farm layout before and after the adoption of the program is shown in figure 2.

The average number of fields on the ten farms for which records were obtained both before and after the

[2] "A Preliminary Study of Farming and of the Soil Conservation Program in the Deer-Bear Creek Demonstration Area," Hjalmer O. Anderson and C. Herman Welch, Jr. Special mimeographed report of the U. S. Department of Agriculture, Soil Conservation Service and Bureau of Agricultural Economics, and the Minnesota Agricultural Experiment Station, June, 1939.

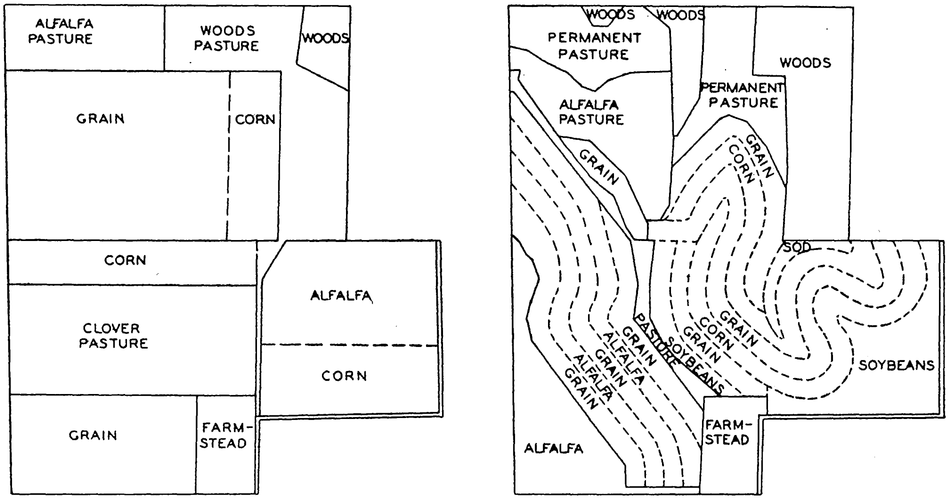

Fig. 2. Farm Layout Before and After Completion of a Soil Erosion Control Program. Solid lines represent fences. Broken lines represent unfenced field divisions.

completion of the erosion control program increased from 17 to 32. The number of fields was almost doubled.

The number of small fields was increased greatly (see table 3). The number of fields smaller than 8 acres in size was increased more than threefold. Prior to the adoption of the erosion control program only 18 per cent of the cropland was in fields smaller than 8 acres in size. After completion of the program 56 per cent of the cropland was in fields of this size.

The average size of fields was reduced from 10.3 acres to 5.0 acres. This is a reduction to less than half of the previous size. The reduction in average size was proportionately greater than the increase in number because of the reduction in total cropland.

Changes in Shapes of Fields

Prior to the adoption of the program, 78 per cent of the fields on these farms were regular in shape, that is, the sides were parallel. Most of these were the conventional rectangular fields. After completion of the program, only 42 per cent were regular. Many of

Table 3. Change in Number of Fields per Farm and Proportion of Cropland by Size Groups Before and After Adoption of an Erosion Control Program, 10 Winona County Farms

Size of field	Before			After		
	Number of fields	Per cent of fields	Per cent of cropland	Number of fields	Per cent of fields	Per cent of cropland
Less than 4.0 acres	4.6	27	5	15.8	49	21
4.0- 7.9 acres	3.6	21	13	10.6	33	35
8.0-11.9 acres	3.5	21	21	4.4	13	27
12.0-15.9 acres	2.1	12	15	1.1	3	10
16.0-19.9 acres	1.4	8	14	.3	1	3
20.0 acres and over	1.9	11	32	.2	1	4
Total fields	17.1	100	100	32.4	100	100

these were narrow strips of uniform width following the contour of the hillsides. The remaining 58 per cent were irregular in width, thus necessitating many short rows for intertilled crops.

The increase in number of irregular fields resulted largely from the practice of laying out each strip with the upper and lower lines on the contour. Since the slope frequently varied from one end of the field to the other, the width of the strip was not constant.

Before the adoption of the erosion control program, 59 per cent of the fields were less than twice as long as wide, that is, nearly square. Only 12 per cent were six or more times as long as wide, that is, long and narrow. After completion of the program, only 18 per cent were approximately square. More than half of these were small fields of less than 4.0 acres. These were hog lots and other odd patches. Nearly half (47 per cent) were more than 6 times as long as they were wide.

Changes in Slope of Operations

One of the important recommendations of the Soil Conservation Service was to perform field operations on the contour rather than up and down the slopes in order to prevent rapid run-off and gullying. Prior to the initiation of the erosion control program, only one third of the fields was operated on the contour. Many of these were sufficiently level to present no erosion hazard regardless of the method of operation. After completion of the erosion control program, 90 per cent of the cropland was cultivated on the contour. Much of this was in narrow strips following the contour of the slopes.

Other Changes

Limited areas of land were terraced on a few farms. Most of these were constructed as experiments and demonstrations rather than as a major part of the erosion control program.

Nearly all of the drains or drainage ways were seeded to grass, if not already in sod, in order to prevent gullying.

A few masonry dams were constructed to stop the growth of gullies too large to be filled and controlled by sodding.

A large amount of new fences was constructed. Part of this was used along new boundaries between crop and permanent pasture land. Part was used to isolate woods or areas for gully control.

Changes in Labor and Power Used

Effect of Changes in Land Use

The retirement of land from crops to permanent pasture tended to reduce field labor by a nearly proportional amount. In the past, little labor has been used for permanent pasture except for fence maintenance. Some labor was used on these farms to seed in the retired areas and establish a sod. Under the practices recommended by the Soil Conservation Service, some labor would be expended on these retired areas for periodic renovation of the pasture stands and for cutting of weeds.

Since nearly 10 per cent of the cropland on these farms was retired from cultivation, the total hours of labor and power needed for field work would be reduced by a nearly equal percentage unless offset by other changes.

Effect of Changes in Cropping System

The change in the proportion of cropland used for different crops increased the average hours required per acre of cropland. The use of cropland is shown in table 2. According to the labor records obtained from these farmers, the average number of man hours used per acre was 23 for intertilled crops, 9 for small grain, and 7 for hay, fallow, and legume seedings.

On the basis of these requirements 10.3 hours were used per acre of cropland before the adoption of an erosion control program. The changes in the cropping system increased hours required per acre to 10.9 or an increase of 6 per cent.

Effect of Changes in Size of Fields

The time required per acre for field work increased as the result of the reduction in average size of fields. The time required per acre was higher on small fields than on large fields for all operations. With small fields more time was lost with frequent turns, in opening and finishing fields, and in moving from one field to another.

The operations performed on these farms can be divided into three groups according to the relationship of time used per acre to the size of field. This relationship for each of the three groups is presented graphically in figure 3.[3] The time used per acre is shown as a percentage of the average hours for all sizes of fields. The average time required per acre for these operations was .31 hours for group I, .72 hours for group II, and 1.43 hours for group III.

Group I operations included (1) harrowing with three horses; (2) harrowing with four horses; and (3) harrowing with two-plow tractors. These are relatively fast operations, usually covering from 3 to 5 acres per hour. The implements are wide and can be operated at a fairly high speed.

The labor expenditure per acre is high for small fields, and drops very rapidly as the size increases. It continues to fall as field size is increased, but at a decreasing rate. Large savings in labor can be made by enlarging the small fields. Additional, but smaller, savings can be made by enlarging the large fields.

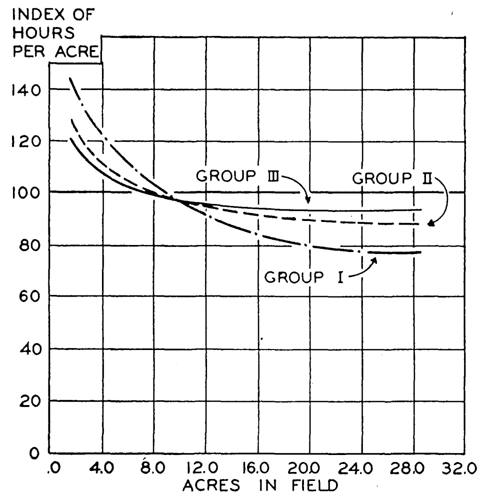

Fig. 3. Relationship of Time Expended per Acre to Size of Field for Three Groups of Operations.

This generalization can be illustrated by the following example. If 100 acres was divided into fields of less than 4 acres each, about 44 hours would be needed for harrowing. Only 35 hours would be needed with fields between 4 and 8 acres in size, 30 hours with fields between 8 and 12 acres, 27 hours with fields between 12 and 16 acres, 25 hours with fields between 16 and 20 acres, and 24 hours with fields of 20 acres and larger. Increasing the size of fields from less than 4 acres each to 4 to 8 acres would save nine hours, or about one day. This represents a saving of about one-fifth in the time required for harrowing. Increasing the fields to 8 to 12 acres would save an additional five hours, or about half a day. Savings made by increasing the size of fields to more than 16 acres would be so small that considerations other than the saving of labor and power might be more important.

[3] The data from which this graph was prepared are presented in table 4.

Table 4. Average Hours Expended per Acre and Number of Cases, by Size Groups and by Operations, Winona County, 1935-1940

Operation	Acres in field						
	Less than 4.0	4.0 to 7.9	8.0 to 11.9	12.0 to 15.9	16.0 to 19.9	20.0 and over	All sizes
Group I	Average hours per acre						
Harrowing with 3 horses	.44	.40	.35	.30	.32	.31	.38
Harrowing with 4 horses	.45	.35	.32	.31	.24	.26	.33
Harrowing with 2-plow tractor	.32	.23	.17	.20	.14	.15	.22
Group II							
Springtoothing with 2-plow tractor	.60	.46	.43	.43	.39	.40	.48
Springtoothing with 3-plow tractor	.55	.48	.43	.48	.47	.42	.48
Drilling grain with 3 horses	.92	.75	.76	.76	.64	.71	.81
Drilling grain with 4 horses	.79	.67	.58	.62	.57	.57	.64
Cultivating corn, 2 rows with 3 horses	1.13	.86	.90	.90	.86	.62	.97
Cutting grain with 4 horses	1.10	.92	.86	.82	.75	.75	.91
Cutting grain with 2-plow tractor	.78	.68	.63	.52	.61	.57	.65
Cutting grain with 3-plow tractor	.76	.62	.65	.58	.55	.50	.59
Drilling corn with 2 horses	1.08	.86	.80	.81	.76	.80	.93
Group III							
Plowing with 2-plow tractor	1.55	1.31	1.21	1.30	1.23	1.16	1.35
Plowing with 3-plow tractor	1.65	1.17	1.12	1.27	1.08	1.16	1.29
Cultivating corn, 1 row with 2 horses	1.73	1.47	1.60	1.44	1.42	1.45	1.59
Cutting corn with 3 horses	1.79	1.76	1.68	1.60	1.56	1.70	1.72
Mowing alfalfa with 2 horses	1.46	1.29	1.10	.97	1.12	1.09	1.30
Mowing clover and timothy with 2 horses	1.46	1.33	1.10	1.17	1.24	1.10	1.31
Group I	Number of cases						
Harrowing with 3 horses	60	42	41	17	21	15	196
Harrowing with 4 horses	75	97	76	43	34	60	385
Harrowing with 2-plow tractor	55	73	66	25	15	21	255
Group II							
Springtoothing with 2-plow tractor	122	105	91	45	22	23	408
Springtoothing with 3-plow tractor	72	79	44	29	23	42	289
Drilling grain with 3 horses	77	55	33	18	10	11	204
Drilling grain with 4 horses	86	136	105	57	49	82	515
Cultivating corn, 2 rows with 3 horses	41	28	20	1	7	3	100
Cutting corn with 4 horses	66	62	38	31	17	32	246
Cutting grain with 2-plow tractor	39	56	46	29	17	21	208
Cutting grain with 3-plow tractor	8	24	29	22	24	31	138
Drilling corn with 2 horses	106	86	49	15	10	10	276
Group III							
Plowing with 2-plow tractor	85	84	55	23	17	16	280
Plowing with 3-plow tractor	47	50	34	16	15	18	180
Cultivating corn, 1 row with 2 horses	89	68	48	13	12	8	238
Cutting corn with 3 horses	54	48	37	17	14	17	187
Mowing alfalfa with 2 horses	86	66	28	15	10	6	211
Mowing clover and timothy with 2 horses	57	39	21	15	11	10	153

Group II operations include (1) springtooothing with two-plow and (2) with three-plow tractors; (3) drilling grain with three horses and (4) with four horses; (5) cultivating corn with two-row cultivator and three horses; (6) cutting grain with four horses, (7) with two-plow tractor, and (8) with three-plow tractor; and (9) planting drilled corn with two horses. These are operations with which 1 to 2 acres can be covered per hour. The implements are narrower in width than those included in group I.

As with group I operations, there is at first a rapid drop in labor expenditures per acre as the size of the field is increased. But the rate of gain decreases more rapidly with further increases in size for group II operations. Only a small amount of labor can be saved by increasing the size of field above 12 acres.

Group III operations include (1) plowing with two-plow tractors and (2) with three-plow tractors; (3) cultivating corn with one-row cultivator and two horses; (4) cutting corn with three horses; (5) mowing alfalfa, first cutting, with two horses; and (6) mowing clover and timothy, first cutting, with two horses. These are slow operations, covering only from ½ to 1 acre per hour. The working width of the implements is narrow and the draft per foot of working width is frequently heavy.

As with the preceding groups, the labor expenditures per acre at first drop very rapidly with increasing size. But the savings from additional increases soon become small. To cover 100 acres with these operations would require about 171 hours with fields of 4 acres or less, 146 hours with fields from 4 to 8 acres, 138 hours with fields from 8 to 12 acres, and 135 hours with fields of 12 acres or more. Three working days could be saved by increasing the field size from less than 4 acres to fields between 4 and 8 acres. Only moderate savings could be made by enlarging the fields beyond 8 acres, and very little by enlarging them beyond 12 acres.

For operations covering more than 5 acres per hour the advantages of large fields would be greater than is shown here. Operations of this type may be used in the more nearly level areas where larger equipment can be used, and may be found more frequently as tractor and machines are improved. In areas or with types of farming where a large proportion of the operations are very rapid, the most efficient size of field will be larger than for the farms included in this study.

The farmers included in this study spent about 10 per cent of their field work time on operations of group I type, 40 per cent on group II type, and 50 per cent on group III type. Decisions regarding field size, therefore, must be based primarily upon group II and group III operations. In the erosion problem areas of southeastern Minnesota, only a small saving in field labor can be made by increasing the size of fields beyond 12 acres. The size can be reduced to 8 or 10 acres without encountering a large increase in time expenditures. The soil conservation benefits to be obtained by reducing the size of fields to less than 4 acres in size must be quite large to offset the higher labor requirements in very small fields.

The change in labor and power requirements resulting from the change in sizes of fields can be calculated by multiplying the labor requirements for each size group, as shown in figure 2, against the percentage of the cropland in fields of that size. The labor and power requirements for group I operations increased by 20 per cent, group II operations by 10 per cent, and group III operations by 6 per cent. The time required per acre for all field operations combined was increased by 9 per cent.

Effect of Changes in Shape of Fields

More time is required to perform an operation on an irregular than on a regular field of the same size. For group I operations (covering 2 to 5 acres per hour), 9 per cent more time was required per acre on irregular than on regular fields. The difference was 2 per cent for group II operations and 4 per cent for group III.[4] In making this analysis irregular fields were compared with all regular fields of the same size, ratio of length to width, and slope of operations.

There are several factors causing more time to be needed on irregular than on regular fields. First, there are more short rounds with time wasted in turning at the ends. Second, there is more overlapping or partial use of machine capacity when completing a field. Third, on irregular field strips with several bulges or wide parts, considerable time is wasted in traveling to another bulge after completing one. Fourth, on irregular fields that have oblique ends, much time is spent in traveling empty along the ends. This applies particularly to operations customarily performed in "lands" such as plowing and cutting corn.

Only 10 per cent of the field work is performed on operations in group I, 90 per cent on operations in groups II and III. For all operations combined, the time requirements on irregular fields are less than 4 per cent higher than on regular fields. That is an increase of less than one-half hour in a 10-hour day of work.

The introduction of an erosion control program increased the proportion of irregular fields from 22 to 58 per cent of all fields. According to the previous comparisons, this change would result in an increase of slightly more than one per cent in the time required to perform the field work, or

[4] The average number of hours per acre and differences between irregular and regular fields for each operation are presented in table 5. They are significant beyond the 5 per cent point.

Table 5. Effect of Regularity of Field Shape on Hours Expended per Acre, Winona County, 1935-1940

Operation	Number of paired observations	Hours per acre on regular fields	Labor on irregular compared with regular fields
Group I			Per cent
Harrowing with 3 horses	25	.39	+11
Harrowing with 4 horses	108	.35	+ 1
Harrowing with 2-plow tractor	63	.21	+14
Group II			
Springtoothing with 2-plow tractor	120	.49	+ 4
Springtoothing with 3-plow tractor	87	.46	+11
Drilling grain with 3 horses	40	.79	+ 1
Drilling grain with 4 horses	170	.64	+ 6
Cultivating corn, 2 rows with 3 horses	26	1.02	−11
Cutting grain with 4 horses	69	.90	+ 2
Cutting grain with 2-plow tractor	50	.65	+ 6
Cutting grain with 3-plow tractor	36	.60	− 5
Drilling corn with 2 horses	74	.90	+ 4
Group III			
Plowing with 2-plow tractor	67	1.35	+ 1
Plowing with 3-plow tractor	53	1.23	+17
Cultivating corn, 1 row with 2 horses	57	1.62	− 3
Cutting corn with 3 horses	47	1.74	0
Mowing alfalfa with 2 horses	67	1.41	− 7
Mowing clover and timothy with 2 horses	44	1.23	+14

less than 10 minutes in a 10-hour day. This is not a serious increase; it can easily be offset by the benefits derived from the erosion control program.

Many of the farmers have objected strenuously to the irregular strips on their reorganized farms. Apparently this is not wholly due to increased time required for the operation. It is probably in part due to irritation caused by the need of turning on stub rows and damage to crops caused on such turns.

Less time is required to perform an operation on a field that is long and narrow than on one of the same size that is short and comparatively square. For group I and II operations, the time expended per acre on fields that were 3 to 5 times as long as wide was 7 per cent less than on fields of equal size that were nearly square. On fields 6 or more times as long as they were wide, the time expended per acre was 11 per cent less. For group III operations the differences found were only slight. For all operations in field work, weighted by their relative importance, the differences were 4 and 6 per cent respectively.[5]

Since most operations are performed lengthwise of the fields, fewer turns, and therefore less wasted time, are required for the long, narrow fields than for short, broad fields of the same acreage.

Under the erosion control program the proportion of long, narrow fields was much larger than under the pre-

[5] The average number of hours per acre and differences between the three groups of fields by ratio of length to width are presented in table 6. They are significant beyond the 5 per cent point.

Table 6. Effect of Ratio of Field Length to Width on Hours Expended per Acre, Winona County, 1935-1940

Operation	Hours per acre on ratio 1-2 fields	Labor on ratio 3-4-5 fields compared with ratio 1-2 fields		Labor on ratio 6 and over fields compared with ratio 1-2 fields	
		No. of paired observations	Per cent lower or higher	No. of paired observations	Per cent lower or higher
Group I					
Harrowing with 3 horses	.37	50	−1	30	−1
Harrowing with 4 horses	.32	91	−7	47	−8
Harrowing with 2-plow tractor	.22	47	−20	26	−13
Group II					
Springtoothing with 2-plow tractor	.48	80	−7	49	−15
Springtoothing with 3-plow tractor	.46	50	−5	22	0
Drilling grain with 3 horses	.79	35	+2	32	−5
Drilling grain with 4 horses	.65	99	−11	54	−8
Cultivating corn, 2 rows with 3 horses	.95	14	−7	13	−17
Cutting grain with 4 horses	.95	40	−14	25	−23
Cutting grain witb 2-plow tractor	.66	33	−17	21	−17
Cutting grain with 3-plow tractor	.57	27	+15	14	−11
Drilling corn with 2 horses	.97	54	−9	44	−16
Group III					
Plowing with 2-plow tractor	1.33	52	−2	42	−5
Plowing with 3-plow tractor	1.15	28	+5	18	+32
Cultivating corn, 1 row with 2 horses	1.56	56	−3	47	+4
Cutting corn with 3 horses	1.78	41	−7	25	−8
Mowing alfalfa with 2 horses	1.38	43	−12	29	−7
Mowing clover and timothy with 2 horses	1.23	27	+16	19	−15

vious field layout (see page 6). This change alone, with field sizes remaining about the same, would reduce labor expenditures about 3 per cent.

Effect of Changes in Slope of Field Operations

The time expended per acre was about the same when the operations were performed on the contour or level as when they were performed up and down the hills. The comparisons were made for fields of equal size and similar shapes and lengths. There was some indication that working on the contour saved some time for operations of heavy draft, as plowing and springtoothing, although the data were not conclusive.[6] Working on the contour may save fuel compared with working up and down hill, but data on fuel consumption were not obtained.

[6] The average number of hours per acre and the differences between working on the contour and up and down hill for each operation are presented in table 7.

Effect of Other Changes

The records obtained from these farmers do not provide an adequate basis for estimating the effect of other changes upon labor requirements. It seems probable, however, that some time would be needed to maintain the additional sodded drains, dams, and extra fences. Many of the new fences were laid out on the contour, with numerous corners, and consequently would probably require more time for maintenance than the old fences.

There is no evidence from these records that the erosion control program caused any major change in cropping practices or in types of machinery used. Even though most of the corn on the farms with erosion control programs was drilled when it was formerly checked, the number of times it was cultivated was not changed. On some farms, the spring-tooth field cultivator with power lift was substituted

Table 7. Effect of Slope of Operation on Hours Expended per Acre, Winona County, 1935-1940

Operation	No. of paired observations	Hours per acre on contour-operated fields	Labor on noncontour compared with contour-operated fields
Group I			Per cent
Harrowing with 3 horses	38	.36	− 3
Harrowing with 4 horses	83	.32	− 5
Harrowing with 2-plow tractor	38	.19	0
Group II			
Springtoothing with 2-plow tractor	66	.47	− 7
Springtoothing with 3-plow tractor	49	.46	− 3
Drilling grain with 3 horses	33	.75	+ 4
Drilling grain with 4 horses	110	.63	+ 1
Cultivating corn, 2 rows with 3 horses	9	.91	− 7
Cutting grain with 4 horses	42	.96	− 6
Cutting grain with 2-plow tractor	39	.67	− 7
Cutting grain with 3-plow tractor	25	.59	− 4
Drilling corn with 2 horses	27	.87	+ 2
Group IIII			
Plowing with 2-plow tractor	33	1.26	+ 4
Plowing with 3-plow tractor	27	1.08	+16
Cultivating corn, 1 row with 2 horses	28	1.50	+ 6
Cutting corn with 3 horses	32	1.74	− 3
Mowing alfalfa with 2 horses	46	1.30	+ 4
Mowing clover and timothy with 2 horses	33	1.32	− 3

for the skid-type spring-tooth. This reduced the damage to sodded drains, but did not affect labor requirements materially.

Net Effect of All Changes

The effect upon labor and power requirements of the different changes caused by the introduction of the erosion control programs on these ten farms has been presented in the preceding pages. The effects of each of these changes were:

The reduced acres of cropland reduced labor 10 per cent.

The change in the cropping system increased labor 6 per cent.

The increased proportion of small fields increased labor 9 per cent.

The increased proportion of irregular fields increased labor 1 per cent.

The increased proportion of long, narrow fields reduced labor 3 per cent.

The increased proportion of fields operated on the contour caused no change in labor.

The net effect of any or all of these changes can be calculated by multiplying together the corresponding percentage changes. The change in labor and power requirements that would result from the changes in field sizes, field shapes, and slope of operations on the farms, with no change in acres of cropland or cropping system, would be 1.09 x 1.01 x .97 x 1.00 = 1.07, or an increase of seven per cent. If the change in the cropping system were included, the labor and power requirements would be 13 per cent (1.07 x 1.06 = 1.13) greater than before introduction of the erosion control program. With all changes, including the reduction in the acreage of cropland, the labor and power requirements would be 2 per cent (1.13 x .90 = 1.02) greater than before the introduction of the erosion control program. On these farms the effects of the different changes practically offset each other, leaving only a small net increase in labor and power required.

The amount of power actually used on these farms, as determined from their labor records, increased from the equivalent of 4,939 hours of horse work before the program to 4,974 hours after its completion.[7] The amount of power used on a group of farms not introducing an erosion control program increased 8 per cent during the same period.[8] Since the number of these records was small and many factors other than the erosion control program affected the power expenditures, this corresponds reasonably closely with the previous conclusion that the erosion control program increased labor and power requirements by 2 per cent. The hours of man labor used on crops on these farms is of limited significance for this comparison, because it is very difficult to determine how much of the change in hours is due to the rapid shift from horse to tractor power that occurred during this period.

In the analysis presented in the main part of this bulletin, the effect of each part of the erosion control program on the use of labor has been analyzed. Each of those effects can be definitely attributed to the erosion control program. The over-all change in hours of labor and power actually

[7] According to the records obtained on these farms 2 horsepower tractor hours were equal to 1 horse hour.

[8] "Effects of an Erosion Control Program on the Organization and Operation of a Group of Winona County Farms," C. Raymond Hoglund. Master's thesis on file at library of University of Minnesota.

expended before and after the program can be used as a check upon the reasonableness of the previous analysis, but they are influenced by so many factors other than the erosion control program that, studied by themselves, they do not provide convincing evidence of the effect of the program.

The effect of the introduction of an erosion control program might be different on other farms. The changes in land use, cropping systems, field sizes and shapes, and slopes of operations might have been different if present planning techniques had been used. But the effect of the changes planned on any farm or group of farms can be calculated from the preceding information in the same manner as has been done for these farms.

SUMMARY

The introduction of erosion control programs on the farms studied resulted in (1) changes of some cropland to permanent pasture or woodland, (2) increases in hay and decreases in small grain acreages, (3) increases in the number of fields and decreases in the average size of fields, (4) increases in the proportions of fields of irregular shape, and (5) increase in the proportions of long, narrow fields. The labor and power used in field operations were increased by the changes in the cropping systems, by the reductions in field sizes, and by the greater irregularity of fields. They were decreased by the retirement of cropland and by the change to long, narrow fields. The net effect of all changes was an increase of two per cent. These farmers spent only slightly more time in the fields with programs designed to control erosion than they did with their previous farm program.