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The Relationship between Soil Maintenance and Profitable Farming

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FOREWORD

This study was a joint project with the Soil Conservation Service, the Bureau of Agricultural Economics, and the Agricultural Adjustment Administration of the United States Department of Agriculture. The authors were responsible for the compiling and writing of this report.

THE RELATIONSHIP BETWEEN SOIL MAINTENANCE AND PROFITABLE FARMING

F. L. MORISON AND J. I. FALCONER

PURPOSE OF STUDY

In 1935 a project was undertaken by a committee appointed by the Director of the Ohio Agricultural Experiment Station to determine what adjustments would be necessary in the Ohio cropping system to bring about a farming program that would maintain the productivity of Ohio soils on a long-time basis.[1] It was felt that a crop acreage distribution that would conserve the soil would be a better basis for an agricultural adjustment program than the historical base. The study indicated a desirable reduction of 16 per cent in the corn acreage of Ohio, a 13 per cent reduction in the small grain acreage, and an increase of 16 per cent in the acreage of hay and rotation pasture.

These conclusions were arrived at by making use of the "soil productivity balance" concept. During the past several years workers at the Ohio Agricultural Experiment Station and The Ohio State University have developed a method of calculating the annual rate at which soil improvement or deterioration takes place as a result of cropping. Corn has been found to deplete the productive capacity of the soil at the rate of about 2 per cent for each crop; wheat is one-half as destructive as corn. Timothy has a neutral effect; a crop of clover hay just offsets the effect of a crop of corn; and a crop of alfalfa hay the first year after seeding builds up the productive capacity by 2.5 per cent. Other crops are assigned their respective values as soil productivity builders or destroyers. Additional restorative effects are calculated for the use of manure and commercial fertilizer. The soil productivity effect assigned to a given crop is an approximate measure of the balance between the favorable and unfavorable effects of that crop upon the capacity of the soil to produce. "Soil productivity balance" is the term which has been used to express the net effect of the cropping practice for the year upon soil productivity. In brief it may be said that "soil productivity balance" varies according to the relative amounts of cropland in soil-depleting and restorative crops; the quality of the hay crops, or the relative amounts of legumes and timothy; the amount and quality of manure and fertilizer used; and the extent to which erosion is held in check.[2]

It seemed appropriate to secure information as to what percentage of Ohio farmers were now carrying on farming practices that would maintain the productivity of their soil as computed according to the "soil productivity balance" indexes. It was also deemed desirable to determine the relationship between these practices and the resulting income for the year. Accordingly, in the summer of 1936 the Department of Rural Economics, Ohio Agricultural Experiment Station, in cooperation with the Soil Conservation Service, the Bureau of Agricultural Economics, and the Agricultural Adjustment Administration of the United States Department of Agriculture, carried on the present study in four areas in the State.

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[1]A Basis for Regional Agricultural Adjustments in Ohio. Rural Economics Mimeograph Bulletin No. 83, The Ohio State University. September 1935.

[2]For additional detail regarding method of computing "soil productivity balance" see R. M. Salter, R. D. Lewis, and J. A. Slipher: "Our Heritage—the Soil", Agricultural Extension Service Bulletin 175, The Ohio State University. April 1936. Further refinements in evaluating the effects of various crops and practices are being made at the time of writing this publication, July 1937.

METHOD OF STUDY

The four areas were selected as being more or less typical of a larger section in their respective parts of the State. A solid block of farms totaling 10,000 acres or thereabouts was studied in each area. Thus there was no bias in selecting the farms; any preconceived ideas which the enumerator may have had as to what constituted a representative farm did not enter into the selection of farms studied. It is believed, however, that 15 or 18 square-mile sections scattered throughout a type of farming area would have been more representative of that area than any one solid block such as was studied.

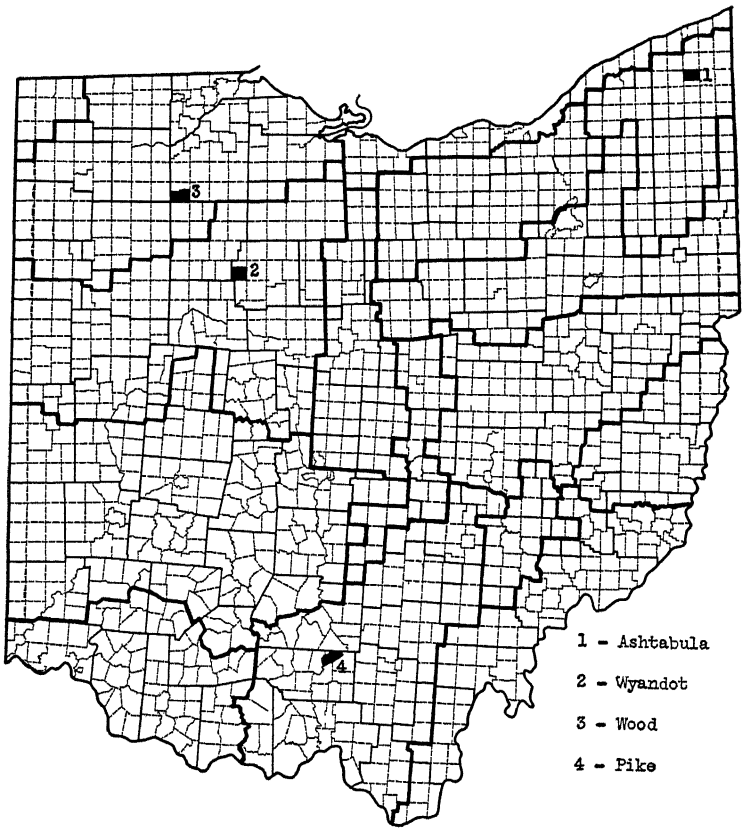

Fig. 1.—An agricultural-area map of Ohio, showing location of four blocks of farms studied

A detailed farm management record covering the year July 1, 1935, to June 30, 1936, was secured for each farm in these four blocks. Considerable supplementary data were secured relating to the cropping history of each separate field for the preceding 4 or 5 years, including the crop grown, yield, and the use of lime, fertilizer, manure, and green manure crops. The Soil Conservation Service prepared maps of each of the areas showing farm and

field boundaries, erosion, cover, slope, and soil type. A few tracts, some too small to be considered as farms and others that were parts of larger farming units located outside the area, were not included in the tables presented herewith.

DESCRIPTION OF THE FOUR AREAS

ASHTABULA COUNTY

This area includes the northern two-thirds of Lenox Township, in the central part of the county. It is an old dairy section of level to gently rolling topography. The poor state of repair of many of the unpainted barns and silos, and the numerous "Farm for Sale" signs indicate even to the casual observer the agricultural distress of the area as a whole. Scattered throughout the area, however, are farms in an excellent state of fertility, with soils originally no better than those on neighboring farms that are approaching the submarginal.

Mahoning silty clay loam predominates, comprising 71 per cent of the area surveyed and 84 per cent of the total rotated area; Trumbull silty clay loam is next in importance, comprising 15 per cent of the total farm area and 11 per cent of the rotated area. These soils are very acid in their reaction, and natural drainage is very poor. Fifty-eight per cent of the area had less than a 3 per cent slope, 24 per cent had slopes of 3 to 6 per cent, and the remainder was mapped with slopes ranging up to more than 12 per cent. Three per cent of the land was mapped as having no erosion, 70 per cent with less than 25 per cent of the surface soil removed, 14 per cent with from 25 to 50 per cent of the surface removed, and 13 per cent with more than 50 per cent removed.

The average size of farm in the Ashtabula area was 95 acres. Thirty of the eighty-six farms in the area were 60 acres or smaller in size; 36 ranged from 61 to 120 acres; 13 had 121 to 180 acres; and 7 had more than 180 acres each. Fifty per cent of the land in farms was cropland. The rotation most commonly followed was one of corn, oats, and 2 years of hay. There was practically no rotation pasture; about the only fences were those around the permanent pasture fields. Permanent pastures were generally of poor quality. Considerable areas of swampy land were included in this so-called pasture, and much of the pasture was grown up to brush and briers. Practically none of the woods was fenced against livestock.

Dairy cattle were the leading class of livestock, providing 62 per cent of the gross receipts in 1935. Poultry was second in importance, furnishing 16 per cent of the receipts. Pigs were fed for home butchering on one-half of the farms, and sales of small numbers of weanling pigs or fat hogs were made by 17 of the farms. Because of the poorly drained pastures, sheep were kept on only three farms.

Thirty of the farms had tractors, most of them old-style tractors purchased 10 or 15 years ago. In addition to these there was an average of 2.0 horses per farm. Eight of the farmers owned neither source of power, hiring their machine work done by neighbors. Small size of business, lack of essential buildings and equipment, and shortage of funds for making capital improvements, such as tile drainage and liming, were serious handicaps to many of the farmers.

WYANDOT COUNTY

This area covers the southern three-fifths of Richland Township in the western part of the county. It is a general farming section of level to very gently rolling topography on the eastern edge of the corn belt. Farm buildings on the whole are adequate and in good repair, and the general appearance of the community is one of thrift.

Crosby, Brookston, and Miami silty clay loams were the important soils, comprising 44, 24, and 14 per cent, respectively, of the total area surveyed. Ninety-five per cent of the area was mapped as having a slope of less than 3 per cent. Four per cent of the area had no apparent erosion, 95 per cent was mapped as having less than 25 per cent of the surface soil removed, and only 1 per cent had lost more than 25 per cent of the surface soil.

The average size of farm in this area was 133 acres. Thirteen of the 80 farms were 60 acres or smaller in size; 30 of them ranged from 61 to 120 acres; 22 had 121 to 180 acres; and 15 were larger than 180 acres. Seventy-nine per cent of the land in farms was rotated. The rotations most commonly followed were corn-wheat-clover, and corn-wheat-clover-timothy. Owing to numerous failures of clover seedings, nearly one-half of the hay acreage during the years 1932-1936 was in timothy. Many of the fields were fenced. In 1935 approximately 35 per cent of the acreage in meadow was used for rotation pasture, and about 11 per cent was cut for timothy or alsike clover seed.

Seventy-one per cent of the gross cash receipts of these farms was from livestock. Hogs ranked first, providing a little more than 30 per cent of the total receipts. All but 6 of the 80 farms kept hogs. Cattle, sheep, and poultry were of next importance, in the order named. Sheep were kept on 68 of the farms, an average of 35 ewes per farm. Thirty-six of the farms had tractors. In addition there was an average of 3.0 work horses per farm.

WOOD COUNTY

This area covers the southern half of Jackson Township, in the southwestern corner of the county. It is a cash crop area of level to flat topography, a part of what was once called the "Great Black Swamp." Farm buildings, though not large, are adequate for the type of farming followed and are in a fair state of repair. The general appearance of the area is one of high productivity.

Brookston clay and clay loam are the predominating soil types, comprising 93 per cent of the rotated area. These soils are rated among the most productive soils in the State. Natural drainage is poor because of the excessively flat topography; good surface drainage has been obtained through the construction of deep surface ditches and the extensive use of tile drains. Ninety-five per cent of the area was mapped as having a slope of less than 3 per cent; much of this is even less than a 1 per cent slope. In consequence of this flat topography and the relative newness of the area agriculturally, there is little evidence of erosion; 98 per cent of the area was mapped as having lost less than 5 per cent of the surface soil.

The average size of farm in the Wood County area was 128 acres. Eight of the seventy-six farms had 60 acres or less, 41 ranged from 61 to 120 acres in size, 12 had 121 to 180 acres, and 15 were larger than 180 acres. Eighty-eight per cent of the total farm area was rotated cropland. Only 3 per cent of the area was in tillable permanent pasture and 4 per cent in woodland, most of which was pastured.

It can hardly be said that there was any general practice as to crop rotation. Perhaps the most common rotation was corn-oats-hay; corn may follow corn, sometimes 3 years in succession, and wheat may be substituted for oats, or follow after oats. A 2-year rotation of corn-oats was encountered frequently, with the oats ground seeded to a legume to be plowed under for a green manure catch crop, although seedings were not always successful. Meadows were largely of alfalfa, alsike, or mammoth clover. Those of alfalfa were generally harvested 2 years. Only 20 per cent of the acreage in meadow was used for rotation pasture; 28 per cent was cut for clover seed. The second cutting of a considerable acreage of alfalfa was also used for seed production. Large quantities of alfalfa hay were sold, and sugar beets and cannery tomatoes were also grown as cash crops. Sixty-two per cent of the corn, 67 per cent of the oats, and 87 per cent of the wheat raised in 1935 were sold.

Hence, only 42 per cent of the gross cash receipts of these farms was from livestock. Cattle, hogs, poultry, and sheep were of importance in the order listed. Fifty of the seventy-six farms had tractors. In addition, there was an average of 2.9 work horses per farm.

PIKE COUNTY

This area comprises parts of Jackson and Pee Pee townships in the northeastern part of the county. The area was selected for the purpose of getting more information on farms in the Scioto River valley.

A wide variety of soil conditions is found, even on individual farms. The farms are long and narrow, some extending back to the hills as far as 3 miles away from the Scioto River. The wide flood plains of the river valley are necessarily used for cropland; buildings and pasture are located on the terraces or rolling uplands. Genesee loam and silt loam are the prevailing soil types on the flood plains, whereas on the terraces or second bottoms Fox fine sandy loam is found extensively. These are highly productive, well-drained soils. Ninety-three per cent of the Genesee loam and 79 per cent of the Fox fine sandy loam are in cropland.

The 33 farms in the river valley had an average of 278 acres per farm. Two-thirds of the area was operated by crop-share tenant farmers. Six of the farms had 120 acres or less; 11 ranged from 121 to 240 acres; 8 had from 241 to 360 acres; and 8 ranged from 361 to 800 acres. Cropland comprised 66 per cent of the total area in farms.

Corn is grown year after year on some of the land subject to overflow, with a "rest" at infrequent intervals during which the land is allowed to grow up in weeds, or more recently it may be seeded to sweet clover. On river bottom land less likely to be flooded, corn is still the important crop, usually in a 2-year rotation followed by wheat which is seeded to sweet clover or mammoth clover for a green manure catch crop; or alfalfa may be seeded in the wheat or oats and cut for hay 2 years. The flood-plain portions of these farms are not fenced and receive little manure or commercial fertilizer. The upland portions provide the necessary permanent pasture. In some cases part of the sweet clover sown in the wheat for green manure is cut for hay and fed on the farm.

This is a cash grain area; 74 per cent of the corn grown in 1935 was sold. Only 33 per cent of the gross cash receipts was from livestock. Hogs ranked first among the livestock, providing 19 per cent of the total cash receipts; cattle second with 11 per cent. Most of the farmers kept from 3 to 6 cows of mixed

dairy breeding; six of them kept herds of beef cows ranging from 15 to 40 in number, and total sales of beef cattle exceeded the income from cream and dairy stock. Seventeen of the farms were equipped with tractors. In addition there was an average of 5.5 work horses per farm.

ANALYSIS OF FINDINGS

Tables 1, 2, 3, and 4 represent a partial summary of the findings which will be discussed in more detail in the following pages. The farms in each area have been grouped with reference to their soil-building practices as measured by "soil productivity balance." If during the year the sum total effect of soil-building practices on a farm equaled the total effect of soil-depleting practices, then the "soil productivity balance" for the year would be zero. If the soil-building practices exceeded the soil-depleting practices, then the balance would be a plus amount. The greater the excess of soil-depleting over soil-building

TABLE 1.—86 farms, Ashtabula County, Ohio, grouped according to annual soil productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5	All farms
Productivity balance interval, per cent...	+0.50 to + .26	+0.25 to 0	−0.01 to − .25	−0.26 to − .50	−0.51 to − .75	+0.50 to − .75
Number of farms	9	19	26	20	12	86
Annual productivity balance, 1933-1936...	+.42	+.09	−.13	−.34	−.62	−.14
Crop yield index	131	107	101	91	74	100
Per cent of farms with index 100 or more..	100	68	50	40	17	52
Per cent of rotated area, 1933-1936—						
In corn	24.2	21.1	21.9	20.0	24.1	21.7
In other row crops	1.1	.8	1.7	1.1	3.2	1.4
In wheat	4.8	4.7	4.0	3.9	4.4	4.3
In oats	23.7	20.5	20.2	16.6	18.2	19.7
In buckwheat	1.0	2.8	2.2	2.2	5.9	2.5
In soybean hay	.8	1.3	1.8	3.8	7.9	2.7
In total depleting crops	55.6	51.2	51.8	47.6	63.7	52 3
In hay and rotation pasture	44.4	46.4	44.6	44.0	22.8	42.7
In idle cropland	0	2.4	3.6	8.4	13.5	5.0
Per cent of hay acreage, excluding soybean—						
Clover	60	26	15	8	4	21
Mixed clover and timothy	13	16	14	11	13	14
Timothy	27	58	71	81	83	65
Restorative factor for hay	1.9	1.1	.7	.4	.3	.8
Manure equivalent, tons per rotated acre.	4.2	2.8	2.7	1.9	1.3	2.5
Fertilizer, tons per 100 rotated acres	5.0	3.6	3.5	2.6	2.3	3.4
Lime, tons per 100 rotated acres	10.9	5.3	3.6	2.5	2.4	4.5
Soil productivity factor, unimproved*	3.44	3.52	3.44	3.49	3.40	3.46
Land operated by owner or related tenant, per cent	90	79	74	76	73	78
Average size of farm, acres	127	93	95	99	64	94.5
Rotated acres per farm	58	50	46	48	33	47.0
Yields per acre, 1935						
Corn, bushels	46	34	34	32	24	34
Oats, bushels	38	31	31	28	24	31
Wheat, bushels	30	22	18	18	15	19
Hay, tons	1.6	1.2	1.2	1.1	.9	1.2
Animal units per farm	28	14	15	12	7	14
Animal units per 100 rotated acres	48	28	32	24	22	30
Hay-consuming animal units per 100 rotated acres	42	25	29	21	16	27
Labor income per farm, 1935, dollars	070	718	545	393	216	557
Labor income per rotated acre, dollars	18.34	14.50	11.74	8.12	6.48	11.85

*Computed from productivity indexes, Special Circular 44, Ohio Experiment Station.

TABLE 2.—80 farms, Wyandot County, Ohio, grouped according to annual soil productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5	All farms
Productivity balance interval, per cent	+0.20 to 0	−0.01 to −.15	−0.16 to −.30	−0.31 to −.45	−0.46 to −.60	+0.20 to −.60
Number of farms	12	12	24	15	17	80
Annual productivity balance, 1932-1936	+.04	−.10	−.23	−.38	−.53	−.26
Crop yield index	111	106	95	95	94	100
Per cent of farms with index 100 or more	83	67	38	33	35	48
Per cent of rotated area, 1932-1936—						
In corn	26.0	26.0	27.2	28.4	31.9	27.8
In wheat	23.5	19.0	24.0	27.9	25.1	24.0
In oats	6.3	5.3	4.6	4.5	7.2	5.4
In total depleting crops	56.8	53.0	58.0	62.2	65.4	59.0
In hay and rotation pasture	43.1	46.3	41.9	37.5	34.4	40.8
Per cent of hay acreage, excluding soybean—						
Alfalfa	10	4	4	1	0	4
Clover	19	13	14	7	15	13
Clover-timothy mixtures	37	33	33	45	32	36
Timothy	34	50	49	47	53	47
Restorative factor for hay	1.4	1.1	1.0	.9	.7	1.0
Manure equivalent, tons per rotated acre	2.3	1.9	1.7	1.4	1.2	1.65
Per cent of rotated area Crosby soil	45.7	54.9	46.5	41.1	45.3	46.6
Soil productivity factor, unimproved*	4.93	4.99	4.99	4.96	4.98	4.97
Land operated by owner or related tenant, per cent	99	84	83	86	70	84
Average size of farm, acres	141	162	131	144	101	133.3
Rotated acres per farm	104	128	105	115	82	105.5
Yields per acre, 1935						
Corn, bushels	61	61	54	53	53	56
Wheat, bushels	29	26	27	25	26	26
Oats, bushels	45	42	34	29	36	36
Animal units per farm	35	34	28	24	14	26
Animal units per 100 rotated acres	34	27	27	21	17	25
Hogs produced per 100 rotated acres, hundredweight	118	84	108	71	49	88
Hay-consuming units per 100 rotated acres	21	18	16	14	10	16
Hay fed per hay-consuming animal unit, tons	1.2	1.6	1.0	.9	.8	1.2
Per cent of receipts from livestock	85	79	77	57	48	71
Per cent of corn sold, 1935	1	6	5	21	50	15
Labor income per farm, 1935, dollars	1,604	1,455	1,400	1,166	875	1,283
Labor income per rotated acre, dollars	15.42	11.36	13.31	10.09	10.63	12.16

*Computed from productivity indexes, Special Circular 44, Ohio Experiment Station.

factors, the greater the deficit balance, or in other words, the higher the annual rate of soil deterioration. In Ashtabula County, for example, the first two groups of farms were building up their soil productivity, whereas the last three groups were destroying their soil productivity. In the fifth group the productivity of the soil was being decreased at the rate of 0.51 to 0.75 of 1 per cent each year.[3]

DISTRIBUTION OF CROPS

In the Ashtabula area it is of significance to note that other factors were more closely associated with the maintenance of soil productivity than was percentage distribution of crop acreage into depleting and restorative crops. The

[3]The farms in three of the areas were divided into five groups. In the Pike County area, however, where only 33 of the farms studied could be classed as river valley farms, it was necessary to limit the sorting to three groups. Hence, the Pike County data were not included in many of the smaller tables, although reference to table 4 will show that about the same trends were in evidence there as in the other areas.

percentage of the rotated acreage in depleting crops was lower in this area than in the other areas studied. In table 1 it will be noted that in Group 1, farms with the best balance, the percentage of the rotated area in depleting crops was greater than the average of all farms and was exceeded only by those in Group 5. The latter group not only had the smallest percentage in hay but also had the largest amount of idle cropland.

The Wyandot County area (table 2) showed only a gradual increase in percentages of intertilled crops and of all depleting crops combined, and a corresponding decrease in the percentage in "grass" as the rate of soil depletion increased. The best balanced farms had 87 per cent as much depleting cropland as the most poorly balanced. These first two areas are perhaps typical of the situation in areas where there is considerable difference in kind of hay grown on individual farms.

In Wood County, the Group 1, or the best balanced farms, had only 68 per cent as much land in row crops as did Group 5, and 77 per cent as much in total depleting crops (see table 3). Farmers in Group 1 had three and one-half

TABLE 3.—76 farms, Wood County, Ohio, grouped according to annual soil productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5	All farms
Productivity balance interval, per cent...	+0.35 to 0	−0.01 to −.25	−0.26 to −.50	−0.51 to −.75	−0.76 to −1.25	+0.35 to −1.25
Number of farms	12	22	18	16	8	76
Annual productivity balance, 1933-1936...	+.12	−.16	−.37	−.63	−.97	−.31
Crop yield index, 3-year average	102	106	101	94	86	100
Per cent of farms with index 100 or more	67	68	50	38	0	50
Per cent of rotated area, 1933-1936—						
In corn	30.0	32.9	35.5	37.0	40.4	34.3
In other row crops	1.7	4.2	3.4	3.5	6.0	3.5
In wheat	7.8	8.1	8.1	8.2	5.7	7.9
In oats	27.2	27.2	31.0	33.8	35.9	30.1
In soybeans (grain)	1.8	1.7	.6	1.0	1.1	1.3
In total depleting crops	68.5	74.1	78.6	83.5	89.1	77.1
In hay and rotation pasture	31.5	24.6	21.0	16.3	9.1	22.3
In legume green manure crop	10.8	9.0	9.3	6.9	2.3	8.5
Restorative factor for hay, per cent	1.9	1.9	1.7	1.6	1.5	1.7
Per cent of rotated area Brookston soil	95.3	95.1	92.5	94.0	82.4	93.5
Soil productivity factor, unimproved*	7.35	7.32	7.28	7.33	7.10	7.31
Manure equivalent, tons per rotated acre.	1.9	1.7	1.4	1.2	1.1	1.5
Farms with adequate tile, per cent	58.3	63.6	61.1	12.5	0	44.7
Land operated by owner or related tenant, per cent	64	64	65	46	37	59
Average size of farms, acres	145	140	131	122	79	128.4
Rotated acres per farm	125	121	116	111	67	112.8
Yields per acre, 1935						
Corn, bushels	57	61	61	54	46	58
Oats, bushels	49	51	47	45	48	48
Animal units per farm	23	16	15	10	7	15
Animal units per 100 rotated acres	18	13	13	9	11	13
Hay-consuming animal units per 100 rotated acres	10	9	8	6	7	8
Hay fed per hay-consuming animal unit, tons	2.0	1.6	1.8	1.7	1.3	1.7
Hogs produced per 100 rotated acres, hundredweight	69.7	25.0	28.7	12.7	11.6	30.4
Per cent of receipts from livestock	69	38	36	22	15	42
Per cent of corn sold, 1935	36	61	66	71	81	62
Per cent of oats sold	57	72	63	77	80	67
Labor income per farm, 1935, dollars	1,754	1,550	1,471	1,061	454	1,345
Labor income per rotated acre, dollars	14.02	12.76	12.68	9.54	6.79	11.92

*Computed from productivity indexes, Special Circular 44, Ohio Experiment Station.

times as much of their cropland in meadow (including hay, rotation pasture, and clover seed) as did those in Group 5. In this area there is little difference in the quality of hay raised by the different groups. In other words, balance must be effected largely by shift in acreage if there is not so much room for improvement in quality of hay. It will be noted that besides having more hay, the Group 1 farmers also made much greater use of legumes as green manure crops.

The evidence would indicate that percentage distribution of the rotated area into soil-depleting and soil-conserving acreage is not in itself an adequate basis for comparing the rate of soil improvement or depletion on individual farms. In addition it is necessary to know not only the proportion of the depleting crop acreage in corn and other intertilled crops but also the kind or quality of restorative crops grown.

TABLE 4.—33 river valley farms, Pike County, Ohio, grouped according to annual soil productivity balance

	Group 1	Group 2	Group 3	All farms
Productivity balance interval, per cent	+0.10 to −.30	−0.31 to −.60	−0.61 to −1.20	+0.10 to −1.20
Number of farms	10†	14	9	33
Annual productivity balance, 1933–1936	−.11	−.42	−.94	−.47
Per cent of rotated area, 1933–1936—				
In corn	40.3	50.4	65.0	49.3
In wheat	27.2	23.8	12.3	22.9
In soybean hay	6.0	1.8	1.6	3.4
In oats	3.6	5.0	.7	3.6
In total depleting crops	77.1	81.0	79.9	79.3
In hay and rotation pasture	13.1	5.7	6.9	8.8
In legume green manure crop	30.6	32.3	3.5	26.3
In idle cropland	1.5	1.9	11.1	3.5
Per cent of hay timothy	25.8	46.3	60.9	36.7
Manure equivalent, tons per rotated acre	1.5	1.0	.8	1.1
Average soil productivity factor, unimproved*	4.90	5.71	5.90	5.67
Land operated by owner or related tenant, per cent	54	18	15	34
Average size of farm, acres	360	253	224	278
Rotated acres per farm	232	185	128	184
Yields per acre, 1935				
Corn, bushels	58	58	49	56
Wheat, bushels	15	15	12	15
Animal units per farm	45	28	12	29
Animal units per 100 rotated acres	20	15	9	16
Per cent of receipts from livestock	50	25	12	33
Per cent of corn sold, 1935	58	77	90	74
Labor income per farm, 1935, dollars	2,298	2,083	990	1,850

*Computed from productivity indexes, Special Circular 44, Ohio Experiment Station.
†Two of these farms in balance.

QUALITY OF HAY

A restorative factor for hay, indicating the annual rate at which these crops build up the productive capacity of the soil, was calculated for each farm. The size of the factor depends first on the relative amounts of legumes and timothy in the total hay area and second on the rate of manure application.

The greatest variation in quality of hay was found on farms in the Ashtabula County area; 60 per cent of the area in hay on farms in Group 1 was clover, as contrasted with only 4 per cent of this kind of hay in Group 5. It will be recalled that in the scale for estimating the effects of various crops on soil pro-

ductivity, timothy has a neutral effect; any restorative effect of a cropping system, other than the effects of green manure crops, comes about because of the legumes within that system. In connection with the Ashtabula County data it is of particular interest to note that farmers in Group 1 applied more than four and one-half times as much lime to a given area as did those in Group 5.

In the Wyandot County area, farms in Group 1 had considerably better hay than those in Group 5. In the former, 10 per cent of the area in hay and rotation pasture was in alfalfa as contrasted with only 0.2 per cent of this legume in Group 5. Timothy comprised 34 per cent and 53 per cent of the hay and rotation pasture acreage in the two respective groups; clovers and clover-timothy mixtures comprised the rest of the meadowland and were of less importance than normal because of numerous clover failures in recent years.

It was previously pointed out that there was no great difference in the quality of hay or meadow crops in the five Wood County groups of farms. Brookston soil is not acid and when drained is rated as an excellent alfalfa soil. This legume predominated; all but four of the farms grew alfalfa. Alsike and mammoth red clover ranked next in importance. Sweet clover was relatively unimportant, except as a green manure catch crop in a 2-year rotation of corn and oats; that which was allowed to stand longer was used almost exclusively for seed production.

TABLE 5.—Percentage composition of hay, rotation pasture, and seed crops, Wood County area, by soil productivity balance groups*

Crop	Group 1	Group 2	Group 3	Group 4	Group 5
Alfalfa	47.6	44.3	47.7	44.8	64.0
Clover	24.7	41.0	36.5	33.4	17.7
Sweet clover	15.7	7.0	3.0	6.6	5.6
Timothy	12.0	7.7	12.8	15.2	12.7
Total	100.0	100.0	100.0	100.0	100.0

*In this and following tables Group 1 represents farms having a plus or zero annual soil productivity balance rating, whereas Group 5 represents farms having the greatest negative balance.

In areas where there is already a relatively large acreage of hay of low quality, improvement should be along the lines of higher-quality hay. But in areas where hay is of high quality, maintenance or further improvement of the soil through the hay crop must result largely from an increased acreage of legumes and a reduction in the acreage of depleting crops.

AMOUNT OF MANURE AND FERTILIZER

In computing "soil productivity balance", the effect of different crops was varied according to the amount of manure and fertilizer used. Manure and fertilizer result in larger crops and hence larger plant residues. Thus, the larger the application of manure, the greater the restorative effect of a crop of clover and the smaller the negative effect of a depleting crop, such as corn. Two hundred pounds of commercial fertilizer of the kinds ordinarily used were figured as being equivalent to a ton of farm manure. "Manure equivalent" is the term used to include tons of manure plus its equivalent in the form of fertilizer.

TABLE 6.—Manure equivalent, in tons per rotated acre

Farms grouped according to soil productivity balance

Area	Group 1	Group 2	Group 3	Group 4	Group 5	Average
Ashtabula	4.2	2.8	2.7	1.9	1.3	2.5
Wyandot	2.3	1.9	1.7	1.4	1.2	1.6
Wood	1.9	1.7	1.4	1.2	1.1	1.5

Farms which showed the best balance had two to three times as much manure per acre of rotated cropland as farms which were farthest out of balance. The larger amounts of manure in the Ashtabula area resulted from a greater amount of livestock per unit of area, a greater relative importance of dairy cattle, and a heavier feeding of hay and silage.

CHANGES NECESSARY TO BRING FARMS INTO BALANCE

It may be of interest to point out the changes necessary to bring about a balanced productivity on all farms that were out of balance, using the various methods that may be employed, (1) a shift in acres of depleting and restorative crops, (2) shifting acreage and applying manure at the rate used on all farms in balance, (3) shifting acreage and increasing quality of hay equal to that grown on farms in balance, and (4) shifting acreage, increasing manure application, and increasing the quality of hay equal to that on all farms in balance.

TABLE 7.—Percentage of rotated area in various crops on farms in and out of balance, and changes necessary to bring the latter into balance, Ashtabula County area

	All farms in balance* 1933–1936	All farms not in balance				
		1933–1936 average	After bringing into balance by following method			
			Shifting acreage only	Shifting acreage and increasing manure†	Shifting acreage and increasing hay quality‡	Shifting acreage, increasing manure† and hay quality‡
Per cent of rotated area—						
Corn	22.2	21.5	13.2	17.2	22.3	25.6
Other row crops	.9	1.7	1.7	1.7	1.7	1.7
Wheat	4.7	4.0	4.0	4.0	4.0	4.0
Oats	21.6	18.5	13.2	17.2	22.3	25.6
Buckwheat	2.0	2.9	2.9	2.9	2.9	2.9
Soybean hay	1.3	3.5	3.5	3.5	3.5	3.5
Total depleting crops	52.7	52.1	38.5	46.5	56.7	63.3
Other hay	45.7	41.0	61.5	53.5	43.3	36.7
Idle cropland	1.6	6.9	.....	.....	.....	.....
Total	100.0	100.0	100.0	100.0	100.0	100.0
Productivity balance	+ .21	− .28	.00	.00	.00	.00

*All farms with a zero or plus soil productivity balance.

†Increasing amount of manure so that rate of application equals that on all farms in balance.

‡Increasing quality of hay equal to that found on all farms in balance.

To bring about a balance on the 58 farms in the Ashtabula County area that were out of balance, a wide range of conditions would prevail, depending on the method used. If the amount of manure and quality of hay were left at

their 1933-1936 level and balance were achieved only by shifting acreage, it would be necessary to reduce the corn acreage from 21.5 to 13.2 acres per 100 acres in crops, a reduction of 39 per cent; decrease the acreage in oats 29 per cent; and increase the acreage in hay 50 per cent. If quality of hay and amount of manure were both increased to the level of conditions on all farms in balance, the acreage of corn and oats on farms out of balance might actually have been increased and the farms would have been in balance. The data in table 7 illustrate the effectiveness of high-quality hay in bringing about a balanced soil productivity.

TABLE 8.—Percentage of rotated area in various crops on farms in and out of balance and changes necessary to bring the latter into balance, Wyandot County area

	All farms in balance* 1932–1936	All farms not in balance				
		1932–1936 average	After bringing into balance by following method			
			Shifting acreage only	Shifting acreage and increasing manure†	Shifting acreage and increasing hay quality‡	Shifting acreage, increasing manure† and hay quality‡
Per cent of rotated area—						
Corn	26.0	28.1	20.0	24.8	25.3	26.4
Other row crops	0	.3	.3	.3	.3	.3
Wheat	23.5	24.1	17.5	20.3	21.5	24.1
Oats	6.3	5.2	5.2	5.2	5.2	5.2
Soybeans	1.0	1.7	1.7	1.7	1.7	1.7
Total depleting crops	56.8	59.4	44.7	52.3	54.0	57.7
Hay and rotation pasture	43.1	40.4	55.3	47.7	46.0	42.3
Idle cropland	.1	.2	0	0	0	0
Total	100.0	100.0	100.0	100.0	100.0	100.0
Annual productivity balance	+ .04	− .32	.00	.00	.00	.00

*All farms with a zero or plus soil productivity balance.
†Increasing amount of manure so that rate of application equals that on all farms in balance.
‡Increasing quality of hay equal to that found on all farms in balance.

In the Wyandot County area, use of the combination method of shift in acreage and increase in manure application and hay quality to the level of farms in balance would have made necessary a reduction from 28.1 acres of corn to 26.4 acres per 100 acres in rotated cropland, a decrease of about 6 per cent, and an increase of less than 5 per cent in the acreage of hay. This is a decidedly less radical change than would be necessary were the balance to be achieved by a shift in acreage only.

SIZE OF FARM

There was some correlation between productivity balance and size of farm. Those with the best balance tended to be larger than average, and those farthest out of balance were smaller than average in size.

This tendency may be expected, since the better farms in the long run make the larger incomes and have more funds available for the purchase of additional land. In order to provide a sufficient income, the owners of small farms tend to put a larger proportion of their land into corn and other depleting crops.

It is not to be inferred, however, that small farms must necessarily follow soil-depleting practices. This is brought out in a grouping of the Wyandot County area according to size of farm. In that area 15 per cent of the farms were in balance. Two out of fifteen large farms with 181 acres or more were in balance. There were 13 small farms of 60 acres or less, and 2 of these were maintaining their productivity. About the same proportion was found in each of the other size groupings.

TABLE 9.—Average size of farms, in acres

Farms grouped according to soil productivity balance

Area	Group 1	Group 2	Group 3	Group 4	Group 5	Average
Ashtabula	127	93	95	99	64	94.5
Wyandot	141	162	131	144	101	133.3
Wood	145	140	131	122	79	128.4

In the Wood County area, however, 27 per cent of the large farms of 181 acres or more were in balance, but none of the small farms of 60 acres or less achieved this rating. The small farms in the latter area followed about the same type of farming as the large farms, planting a larger proportion of their land to corn and selling as large a percentage of it. One of the principal differences was that for a given acreage only about 30 per cent as much green manure was plowed under on the small farms.

TENANCY

The tenant who expects to remain only a short time on a farm, or who is uncertain whether he will derive benefit from the use of fertilizer and manure or the sowing or plowing under of soil-building crops, has little incentive to maintain the productivity of the soil. This is a situation for which tenant farmers have received more than their share of the blame. In this study numerous cases were found where the landlord took little or no interest in the purchase of clover seed or the use of fertilizer or lime. The fact that two families, owner and tenant, must derive their income from a single farm often leads to the planting of larger acreages of corn than are advisable, with little regard for future yields.

Table 10 shows the percentage of the area in farms that were operated by owners and tenants related to owners; the latter, because of more certain tenure and the possibilities of future ownership, have been observed to take equally as good care of the soil as owners.

TABLE 10.—Percentage of land operated by owners or related tenants

Farms grouped according to soil productivity balance

Area	Group 1	Group 2	Group 3	Group 4	Group 5	Average
Ashtabula	90	79	74	76	73	78
Wyandot	99	84	83	86	70	84
Wood	64	64	65	46	37	59
Pike	.....	.....	54	18	15	34

Farms in balance were operated largely by owners or related tenants, whereas tenants unrelated to the owner were found largely on farms farthest out of balance. Some of these tenants, because of length or security of their tenure, were following practices which maintained soil productivity; on the other hand, owner-operators who were heavily in debt tended to follow practices which depleted the soil.

Table 11 is a tabulation of these four areas, together with a group of farms in Miami County; owners renting additional land were excluded. A larger percentage of owner-operators had farms which were in balance, whereas a higher percentage of farms operated by unrelated tenants was badly out of balance.

TABLE 11.—Tenancy as related to soil productivity balance, five Ohio areas

Tenure	Total number of farms	Farms in balance		Farms with balance of −0.50 per cent or more		Productivity balance, all farms, per cent
		Number	Per cent of total	Number	Per cent	
Owner	169	39	23.1	29	17.2	−0.24
Tenant, related	40	8	20.0	8	20.0	− .26
Tenant, not related	68	5	7.4	21	30.9	− .39

CROP YIELDS AND PRODUCTIVITY BALANCE

It will be recalled that productivity balance, as calculated by the method described herein, is a measure of the rate of change in the productive capacity of the soil. It is not an index of the capacity of the soil to produce. However, there should be a high degree of correlation between balance and yield on farms of a given soil type where the same practices have been followed for a considerable number of years.

A weighted crop yield index was computed for individual farms, taking the average yields of all farms in a given area as 100.

TABLE 12.—Crop yield index and percentage of farms with yields average or better, by productivity balance groups

	Group 1	Group 2	Group 3	Group 4	Group 5	Average
Crop yield indexes:						
Ashtabula	131	107	101	91	74	100
Wyandot	111	106	95	95	94	100
Wood	102	106	101	94	86	100
Per cent of farms with yields average or better:						
Ashtabula	100	68	50	40	17	52
Wyandot	83	67	38	33	35	48
Wood	67	68	50	38	0	50

In each of these three areas there was little or no difference in soil type in the five groups of farms. Crop yield index was not computed for farms in the Pike County area because of the wide range of soil types found there.

There was a very close correlation between productivity balance and crop yield in the Ashtabula County area; farms with the best balance had an average crop yield index of 131, whereas farms with the highest rate of soil deterioration had crop yields 74 per cent of the average for the entire area. In the other areas, and particularly in Wood County, the correlation between maintenance of soil productivity during the past 4 or 5 years and crop yields was not as close. The Wood County area is a relatively new farming section of very productive soil, with some virgin land being brought into cultivation each year. Some farms had good yields in spite of poor farming practices. In other cases, operators of badly run-down farms were taking steps to improve their soil, although yields were still at a low level, reflecting practices of former tenants rather than present methods. It is of interest to note that none of the Wood County farms farthest out of balance had a crop yield index of 100 or more.

RELATION OF PRODUCTIVITY BALANCE TO FEED PRODUCTION

In suggesting changes in the cropping system for a farm that would be necessary to bring about a balanced soil productivity, two questions commonly raised by farmers are: "How can I get along on any less corn than I am now raising?" and "How can I dispose of any increased acreage of hay?"

Total production of feed in the Ashtabula, Wyandot, and Wood County areas throws some light on the relative importance of these two questions concerning corn and hay. In this computation all feed produced was reduced to a common denominator, a feed unit, regardless of the method of disposing of it. One bushel of corn was considered as 1 feed unit, 1 bushel of oats as 0.5 unit, 1 bushel of wheat as 1.1 units, 1 ton of alfalfa hay as 25 units, 1 ton of clover hay as 22 units, 1 ton of timothy hay 15 units, 1 ton of corn silage 6 units, with rotation pasture varying according to its equivalent yield of hay.

In each of these three areas the feeding problem that would arise from making shifts in cropping systems seems to be one of devising ways and means of disposing of more hay and rotation pasture and not one of getting along with less corn. In making this statement it is assumed that after several years larger yields per acre will follow the shift from a cropping system which depletes the productivity of the soil to one which brings about a balance.

TABLE 13.—Total feed units produced per 100 rotated acres, Ashtabula County farms, grouped according to productivity balance

Crop	Group 1	Group 2	Group 3	Group 4	Group 5
Corn, grain	708	597	558	562	526
Corn, silage	584	210	324	120	108
Small grains	620	470	434	338	407
Total grain and silage	1,912	1,277	1,316	1,020	1,041
Corn stover	212	179	167	169	158
Soybean hay	34	41	60	96	209
Other hay	1,517	1,004	849	738	306
Total feed units	3,675	2,501	2,392	2,023	1,714

Largely because of better yields per acre and higher quality of hay, the Ashtabula County farms in Group 1, those with the best productivity balance, produced more than twice as many feed units per 100 rotated acres as did farms

in Group 5. This was about the same ratio as existed between the amounts of livestock carried by the two groups. For each 100 acres in rotation in Group 1, corn and silage together yielded about twice as many feed units as were produced in this form in Group 5. There were, however, three times as many units in hay, including soybean hay, on farms in Group 1. Farmers in this group disposed of the relatively larger amount of hay by feeding 50 per cent more per hay-consuming animal unit, even though they were also feeding more than twice as much silage per animal unit of dairy cattle.

TABLE 14.—Total feed units produced per 100 rotated acres, Wyandot County farms, grouped according to productivity balance

Crop	Group 1	Group 2	Group 3	Group 4	Group 5
Corn	1,573	1,596	1,463	1,517	1,697
Small grains	903	659	839	902	861
Corn stover	472	479	439	455	509
Hay and rotation pasture	1,380	1,497	1,195	934	777
Total feed units	4,328	4,231	3,936	3,808	3,844

In the Wyandot County area it will be noted that in Group 5 there were only 8 per cent more feed units of corn per 100 acres of rotated land than in Group 1, even though farms in the group farthest out of balance had 23 per cent more of their rotated area in this crop. Here again the principal difference in the feed supply of the various groups was in the amount of feed in the form of hay and rotation pasture. Only about one-fourth of the feed units in the form of small grain, mostly wheat, and about two-thirds of the corn stover were fed. Farmers in Group 1 sold practically no corn; those in Group 5 sold one-half of theirs. It can be seen how this would leave about the same ratio between corn and hay on the two groups of farms.

TABLE 15.—Total feed units produced per 100 rotated acres, Wood County farms, grouped according to productivity balance

Crop	Group 1	Group 2	Group 3	Group 4	Group 5
Corn	1,716	2,004	2,155	1,980	1,862
Small grains	924	964	951	981	1,051
Corn stover	515	601	646	594	559
Hay	842	646	455	311	276
Rotation pasture	173	211	205	154	103
Total feed units	4,170	4,426	4,412	4,020	3,851

The Group 1 farms in the Wood County area produced only 8 per cent less corn per 100 acres of rotated cropland than did Group 5, with 26 per cent less land in corn. Group 1, however, had two and two-thirds times as many feed units as Group 5 in the form of hay and rotation pasture. Here the problem would definitely be one of disposing of relatively larger amounts of hay on farms that were in balance. This group of farms had more livestock, sold less corn, and fed 50 per cent more hay per hay-consuming animal unit. One-third of their 1935 hay crop was sold, whereas Group 5 farmers sold only 9 per cent of theirs. A question might be raised as to how many farmers can find a cash market for one-third of their hay, year after year.

It might be of further interest to note that the Wood County farms which were in balance not only had 2.7 times as much of their rotated area in hay and rotation pasture, but also used nearly 10 times as much land for clover seed production (alsike, mammoth, and sweet clover) as did Group 5.

TABLE 16.—Percentage of rotated area in hay, rotation pasture, and clover seed, Wood County area

Farms grouped according to productivity balance

Crop	Group 1	Group 2	Group 3	Group 4	Group 5
Hay	17.8	13.7	9.9	7.0	6.1
Rotation pasture	4.1	4.5	4.7	4.6	2.0
Clover seed	9.6	6.4	6.4	4.7	1.0
Total	31.5	24.6	21.0	16.3	9.1

Thus an increased amount of hay and rotation pasture need not necessarily result in a corresponding increase in the number of cattle and other roughage-consuming livestock. Increased feeding of high-quality hay to dairy cattle with a reduction in the feeding of grain, increased use of legume rotation pasture for hog production, increased production of clover and alfalfa seed, and the increased use of forage crops for soil improvement will go a long way toward utilizing the apparent surplus of forage crops resulting from shifts that would conserve the soil.

AMOUNT OF LIVESTOCK

It was previously pointed out that one of the factors in the calculation of productivity balance is amount and quality of manure. It was also shown that on farms in balance two or three times as much manure per acre was applied as on farms farthest out of balance. That is to say that livestock farmers in general do a better job of maintaining soil productivity than do cash grain farmers.

It was just pointed out how the total amount of feed produced per 100 rotated acres was greater on farms in balance, the result of larger yields per acre. The amount of livestock kept in the different groups might be expected to be proportional to the feed supply.

TABLE 17.—Animal units per 100 rotated acres, three areas grouped according to productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5	Average
Hay-consuming animal units:						
Ashtabula	42	25	29	21	16	27
Wyandot	21	18	16	14	10	16
Wood	10	9	8	6	7	8
Total animal units:						
Ashtabula	48	28	32	24	22	30
Wyandot	34	27	27	21	17	25
Wood	18	13	13	9	11	13

In the Ashtabula area the amount of livestock in the different groups was nearly proportional to the feed units produced, excluding permanent pasture. In the other two areas the amount of livestock on farms out of balance was not

in proportion to the feed units produced. Thus, in Wyandot County 7.9 animal units were kept per 1,000 feed units produced on rotated cropland in Group 1; the number decreased to 4.4 animal units in Group 5.

It may be of interest to note the 1935 production of livestock in two of the western Ohio areas.

TABLE 18.—Pounds of livestock produced per 100 rotated acres, two areas grouped according to productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5
Wyandot County:					
Hogs	11,779	8,423	10,762	7,084	4,949
Cattle and calves	3,175	1,809	2,075	1,638	1,519
Sheep and lambs	3,685	2,139	2,204	1,216	763
Total	18,639	12,371	15,041	9,938	7,231
Wood County:					
Hogs	6,974	2,500	2,874	1,273	1,163
Cattle and calves	3,815	1,619	793	469	670
Sheep and lambs	1,089	719	0	73	0
Total	11,878	4,838	3,667	1,815	1,833

Farmers who have the largest corn acreage are ordinarily thought of as the ones who produce the most livestock, especially hogs. This corn-hog concept does not hold in these two areas. Here farms farthest out of balance produced the least pork, although they had the largest percentage of their rotated area in corn. On the other hand, farms in balance had the least number of acres of corn, yet produced the most pork per 100 acres of rotated cropland. This seemingly contradictory situation came about partly as a result of difference in yield per acre but largely because the farms that were out of balance sold larger amounts of their corn.

TABLE 19.—Percentage of corn sold, 1935

Area	Group 1	Group 2	Group 3	Group 4	Group 5
Wyandot	1	6	5	21	50
Wood	36	61	66	71	81

INCOME

Those concerned with any program of soil conservation are interested in the probable effect of that program on farm income. To be of interest to farmers, the mere conserving of soil for posterity is not enough.

Labor income schedules were secured for all farms. Data on labor income throw some light on the ultimate effect of a program which conserves the soil. Because of differences in size of farm, labor income is also shown in dollars per 100 rotated acres, which, for purposes of this study may be better than total income as a basis for comparison within a given are

It is interesting to observe that the groups of farmers who were doing the best job of maintaining their soil were also making the best incomes on the average. Practices which maintain the soil result in increased yields and improved quality of hay. Hence it becomes possible to keep more livestock and

to secure better returns from them with a smaller expenditure for feed. It will be recalled that these farmers, besides securing better yields, had larger farms and fed a larger proportion of their available feed supply. It can hardly be said, therefore, that the better labor incomes of farmers in Group 1 were the result of better soil-management practices alone; they were the result of other good farm management practices as well. The data show that good farm incomes need not be secured at the expense of the soil, the farmer's principal asset. The groups of farmers not maintaining their soil productivity would show to even greater disadvantage were a justifiable charge made for soil depletion, the same as depreciation of buildings and fences is included as an operating cost.[4] Furthermore, in calculating income of farms where soils were being improved there might well have been included an additional credit for some increase in value of real estate.

TABLE 20.—Labor income, 1935, three areas grouped according to productivity balance*

	Group 1	Group 2	Group 3	Group 4	Group 5
Dollars per farm:					
Ashtabula	1,070	718	545	393	216
Wyandot	1,604	1,455	1,400	1,166	875
Wood	1,754	1,550	1,471	1,061	454
Dollars per 100 rotated acres:					
Ashtabula	1,834	1,450	1,174	812	648
Wyandot	1,542	1,136	1,331	1,009	1,063
Wood	1,402	1,276	1,268	954	679

*In order to make the labor income figures comparable, each farm, regardless of tenure, was considered in the calculation as if owned by the operator.

It is not to be inferred that better incomes would result immediately upon shifting from a cropping system with large acreages of corn and other soil-depleting crops to one having less corn and more acres of high-quality hay and rotation pasture. The immediate effect of crop adjustment toward less corn would be a sacrifice in farm income. Sufficient time would have to elapse to bring about better yields and to make the other necessary adjustments before incomes as large or larger would be secured.

A STUDY IN SIX OTHER COUNTIES

In the spring of 1936 a study similar to the one just reported was made by the Department of Rural Economics in six Ohio counties—Hancock, Miami, Portage, Licking, Brown, and Belmont. Some of the data from that study are presented in tables 21 to 26 inclusive.

The two studies differed in a number of respects, and the data, therefore, are not strictly comparable. Because of the inclusion of all farms in a solid block comprising one-half to two-thirds of a township, the farms in an area in the four-county study were more or less similar as to soil and topography. In the six-county study a representative number of farmers located on each of the more important soil types of that county were interviewed, and in some counties a wide range of conditions was covered.

[4]For instance, cropland valued at $80 per acre and having a productivity balance of —0.75 in 1935 could be said to have suffered a soil loss of 60 cents per acre that year.

Fig. 2.—Location of six counties studied

The method of computing productivity balance differed, although the final results were essentially the same. Thus in the four-county study the restorative effect of a crop of clover was calculated as being greater with increased use of manure, whereas in tables 21 through 26 the restorative factor for hay is uniform for hay of a given kind, regardless of the amount of manure and fertilizer that may have been used. In other words, separate effects were calculated for crops, manure, and fertilizer. It will be seen that erosion is shown as a separate item. The farms were grouped according to productivity balance including erosion.

In the Licking County data it will be noted that the increase in annual erosion from Group 1 to Group 5 was not proportional to the acreage of depleting crops. This is so because there was a difference in soil type and slope in the various groups. Cardington, Bennington, and Marengo types of soil prevailed in Group 1; Muskingum, Fallsbury, and Hanover in Groups 4 and 5.

In the Brown County data a difference in soil type and erosion accounted in part for the range in erosion conditions. In the groups with the greatest erosion and the highest annual rate of soil deterioration were found more farms with Fairmount, Eden, and Heitt soils occupying steep slopes. More tobacco was grown in Groups 4 and 5 and more of the land was allowed to lie idle.

TABLE 21.—66 farms, Hancock County, Ohio, 1936

Grouped according to annual soil productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5
Productivity balance interval, per cent	+0.30 to 0	−0.01 to −.20	−0.21 to −.40	−0.41 to −.60	−0.61 to −1.00
Number of farms	8	13	20	17	8
Productivity balance, including erosion	+.09	−.18	−.32	−.49	−.75
Erosion, per cent	.04	.05	.06	.05	.03
Productivity balance, excluding erosion	+.13	−.13	−.26	−.44	−.72
Per cent of rotated area—					
In corn	29.1	29.7	29.0	31.5	39.9
In other row crops	.....	.9	2.5	1.5	4.9
In wheat	19.3	20.0	23.0	25.1	15.1
In oats	10.5	14.5	17.4	12.3	18.3
In soybeans for seed	1.9	.3	.9	.....	.....
In soybean hay	.5	.6	1.6	.....	.6
In other hay and rotation pasture	38.7	34.0	25.6	29.6	21.2
Per cent of hay acreage, excluding soybeans—					
Alfalfa	27.0	15.4	16.4	14.7	34.8
Clovers	25.2	18.3	9.8	2.3	22.6
Mixed legumes and timothy	41.7	62.6	68.1	58.6	27.4
Timothy	6.1	3.7	5.7	24.4	15.2
Restorative factor, hay and rotation pasture	1.4	1.3	1.1	.8	1.0
Manure, tons per rotated acre	2.7	2.0	2.0	1.8	1.1
Average size of farm, acres	97	123	148	105	122
Rotated acres per farm	74	98	113	85	97
Normal yields per acre					
Corn, bushels	45.6	43.3	43.7	39.8	40.6
Wheat, bushels	25.6	23.2	22.0	21.5	19.2
Oats, bushels	47.0	44.5	42.5	37.0	39.0
Hay, tons	1.8	1.6	1.5	1.4	1.6
Animal units per farm	28.1	26.6	30.8	23.1	18.8
Animal units per 100 rotated acres	37.9	27.0	26.6	27.0	19.3
Hay-consuming animal units per 100 rotated acres	21.9	15.8	14.9	16.3	11.1
Hay fed per hay-consuming animal unit, tons	1.5	1.3	1.4	1.1	1.1
Silage fed per hay-consuming animal unit, tons	.5	1.3	1.2	.....	.....
Stover fed per hay-consuming animal unit, acres	1.2	1.1	1.3	1.5	1.5
Hogs produced per 100 rotated acres, hundredweight	146	117	121	95	83
Per cent of corn sold	5.7	10.4	12.7	24.4	50.9

TABLE 22.—57 farms, Miami County, Ohio, 1936

Grouped according to annual soil productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5
Productivity balance interval, per cent	+0.20 to 0	−0.01 to −.20	−0.21 to −.40	−0.41 to −.60	−0.61 to −.80
Number of farms	8	9	15	13	12
Productivity balance, including erosion	+.04	−.15	−.30	−.47	−.72
Erosion, per cent	.09	.10	.12	.13	.14
Productivity balance, excluding erosion	+.13	−.05	−.18	−.34	−.58
Per cent of rotated area—					
In corn	29.0	33.4	31.3	33.8	37.3
In other row crops	.4	1.2	1.0	1.1	.7
In wheat	26.6	27.5	24.1	25.2	23.8
In oats	6.1	9.2	10.4	10.5	11.5
In soybean hay	.....	.....	1.2	.....	.....
In other hay and rotation pasture	37.9	28.7	32.0	29.4	26.7
In legume green manure crop	1.4	7.4	.8	1.3	.....
Per cent of hay acreage—					
In alfalfa and clovers	37.2	43.1	28.1	18.4	15.0
In mixed legumes and timothy	62.8	56.9	71.9	81.6	68.1
In timothy	.....	.....	.....	.....	16.9
Restorative factor, hay and rotation pasture	1.4	1.5	1.2	1.0	1.0
Manure, tons per rotated acre	2.7	2.1	2.1	1.7	1.4
Average size of farm, acres	76	109	108	127	118
Rotated acres per farm	66	95	91	110	94
Normal yields per acre					
Corn, bushels	55.9	55.5	47.5	46.8	43.3
Wheat, bushels	28.9	26.4	25.1	24.1	24.0
Hay, tons	2.2	1.9	1.6	1.6	1.4
Animal units per farm	25.7	28.8	26.7	28.7	19.3
Animal units per 100 rotated acres	39.0	30.2	29.4	26.0	20.5
Hay-consuming animal units per 100 rotated acres	30.0	18.4	19.0	16.1	15.0
Hogs produced per 100 rotated acres, hundredweight	84	134	121	113	58
Per cent of corn sold	12.0	28.7	29.1	31.7	50.8
Land operated by owner or related tenant, per cent	86.1	83.7	65.4	60.3	57.9

TABLE 23.—81 farms, Portage County, Ohio, 1936

Grouped according to annual soil productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5
Productivity balance interval, per cent	+0.40 to 0	−0.01 to −.20	−0.21 to −.40	−0.41 to −.60	−0.61 and over
Number of farms	14	26	17	11	13
Productivity balance, including erosion	+.17	−.12	−.33	−.46	−.77
Erosion, per cent	.10	.15	.13	.15	.18
Productivity balance, excluding erosion	+.27	+.03	−.20	−.31	−.59
Per cent of rotated area—					
In corn	25.0	22.7	24.4	24.7	30.7
In other row crops	1.2	5.3	7.7	4.1	5.5
In wheat	13.5	15.2	15.0	16.4	17.1
In oats	22.5	23.2	23.0	25.0	23.4
In soybean hay	.6	.7	2.3	.8	2.3
In other hay and rotation pasture	37.2	32.9	27.6	29.0	21.0
Per cent of hay acreage, excluding soybean—					
Clover and alfalfa	47.2	27.6	19.1	17.5	15.4
Mixed clover and timothy	39.2	45.3	53.6	44.0	52.4
Timothy	13.6	27.1	27.3	38.5	32.2
Restorative factor, hay and rotation pasture	1.2	1.0	.9	.7	.7
Manure, tons per rotated acre	3.7	3.1	2.9	2.3	2.1
Average size of farm, acres	107	133	119	118	105
Rotated acres per farm	46	68	59	58	50
Normal yields per acre					
Corn, bushels	43.9	42.7	42.2	39.0	38.3
Wheat, bushels	22.6	22.4	20.5	20.7	17.5
Oats, bushels	45.2	45.2	39.1	38.2	35.4
Hay, tons	1.6	1.5	1.4	1.4	1.3
Animal units per farm	17.7	22.8	18.1	16.4	13.6
Animal units per 100 acres in farms	16.6	17.1	15.1	13.9	13.0
Animal units per 100 rotated acres	38.5	33.8	30.5	28.2	27.1
Hay-consuming animal units per 100 rotated acres	34.7	31.1	26.8	23.4	21.5
Hay fed per hay-consuming animal unit, tons	1.7	1.6	1.6	1.5	1.3
Silage fed per hay-consuming animal unit, tons	2.9	3.2	2.3	2.0	1.6
Stover fed per hay-consuming animal unit, acres	.4	.3	.6	.6	1.0

TABLE 24.—75 farms, Licking County, Ohio, 1936

Grouped according to annual soil productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5
Productivity balance interval, per cent	+0.40 to 0	−0.01 to −.40	−0.41 to −.80	−0.81 to −1.20	−1.21 and over
Number of farms	10	25	19	13	8
Productivity balance, including erosion	+.11	−.24	−.53	−1.06	−1.58
Erosion, per cent	.11	.17	.24	.71	1.05
Productivity balance, excluding erosion	+.22	−.07	−.29	−.35	−.53
Per cent of rotated area—					
In corn and row crops	27.4	29.5	34.5	31.6	33.3
In wheat	22.0	24.9	24.3	26.9	28.4
In oats	5.1	4.3	3.8	1.6	4.8
In soybean hay	1.2	3.1	1.8	.5	.....
In other hay and rotation pasture	44.3	38.2	35.6	39.4	31.1
In idle cropland	.....	.....	.....	.....	2.4
Per cent of hay acreage, excluding soybean—					
Alfalfa	13.4	5.8	3.9	2.9	.....
Clover	19.2	7.5	7.5	2.9	7.8
Mixed clover and timothy	50.5	61.6	57.1	44.8	27.9
Timothy	16.9	25.1	31.5	49.4	64.3
Restorative factor, hay and rotation pasture	1.0	.7	.7	.5	.4
Manure, tons per rotated acre	3.2	2.9	2.5	2.2	2.1
Lime per 100 rotated acres, tons	9.6	2.8	3.0	.5	0
Average size of farm, acres	137	132	130	161	158
Rotated acres per farm	67	70	69	68	52
Normal yields per acre					
Corn, bushels	47.8	46.3	44.4	38.4	33.3
Wheat, bushels	21.1	20.8	19.8	18.0	14.2
Hay, tons	1.6	1.5	1.4	1.0	.9
Animal units per farm	31.0	29.5	25.2	23.4	17.6
Animal units per 100 acres in farms	22.6	22.4	19.5	14.5	11.1
Animal units per 100 acres rotated	46.2	41.9	36.6	34.5	33.9
Hay-consuming animal units per 100 acres rotated	36.9	31.1	24.4	28.6	30.2
Hay fed per hay-consuming animal unit, tons	1.6	1.4	1.3	1.1	.9
Silage fed per hay-consuming animal unit, tons	1.3	.9	.6	.2	.4
Stover fed per hay-consuming animal unit, acres	.6	.8	1.0	1.0	.9

TABLE 25.—80 farms, Brown County, Ohio, 1936

Grouped according to annual soil productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5
Productivity balance interval, per cent	−0.10 to −.35	−0.36 to −.60	−0.61 to −.85	−0.86 to −1.10	−1.11 and over
Number of farms	6	24	24	11	15
Productivity balance, including erosion	−.21	−.50	−.69	−.96	−1.52
Erosion, per cent	.14	.12	.28	.60	.85
Productivity balance, excluding erosion	−.07	−.38	−.41	−.36	−.67
Per cent of rotated area—					
In corn	21.8	24.1	26.1	23.6	25.5
In other row crops	3.0	1.5	3.4	6.2	9.7
In wheat and rye	7.9	15.2	15.9	10.6	17.8
In soybean hay	2.9	2.7	1.8	.....	.3
In other hay and rotation pasture	64.4	54.6	44.0	45.7	32.4
In idle cropland	.....	1.9	8.8	13.9	14.3
Per cent of hay acreage excluding soybean—					
Alfalfa and clover	4.1	.3	3.7	8.1	12.2
Mixed clover and timothy	36.9	10.0	32.9	11.3	24.4
Timothy	59.0	89.7	63.4	80.6	63.4
Restorative factor, hay and rotation pasture	.4	.1	.4	.3	.4
Manure, tons per rotated acre	1.2	1.0	.9	.8	.7
Average size of farm, acres	112	111	126	129	96
Rotated acres per farm	96	87	93	72	55
Normal yields per acre					
Corn, bushels	34.2	34.0	30.9	29.7	29.7
Hay, tons	1.2	1.2	1.2	1.0	1.4
Animal units per farm	18.5	19.3	20.3	17.6	14.4
Animal units per 100 acres in farms	16.5	17.5	16.2	13.6	14.9
Animal units per 100 rotated acres	19.3	22.3	21.7	24.2	26.1
Hay-consuming animal units per 100 rotated acres	10.6	13.2	12.7	17.7	18.4
Hay fed per hay-consuming animal unit, tons	1.1	1.1	.9	.7	.8
Stover fed per hay-consuming animal unit, acres	1.8	1.5	1.4	1.1	1.0

TABLE 26.—62 farms, Belmont County, Ohio, 1936
Grouped according to annual soil productivity balance

	Group 1	Group 2	Group 3	Group 4	Group 5
Productivity balance interval, per cent	+0.50 to 0	−0.01 to −.25	−0.26 to −.50	−0.50 to −.75	−0.75 and over
Number of farms	12	10	17	11	12
Productivity balance, including erosion	+.21	−.13	−.36	−.60	−1.03
Erosion, per cent	.29	.52	.51	.54	.84
Productivity balance, excluding erosion	+.50	+.39	+.15	−.06	−.19
Per cent of rotated area—					
In corn	16.6	17.8	21.5	21.6	24.2
In other row crops	.....	.3	2.1	.5	2.8
In wheat	7.6	8.5	11.3	12.9	8.9
In oats	8.3	13.8	12.9	12.9	16.8
In soybean hay	1.0	.....	1.7	.5	.5
In other hay and rotation pasture	66.5	59.6	50.5	51.6	43.5
In idle cropland	.....	.....	.....	.....	3.3
Per cent of hay acreage, excluding soybean—					
Alfalfa	37.0	39.3	27.9	30.4	9.2
Clover	3.5	2.9	2.9	2.3	1.1
Mixed clover and timothy	34.7	33.8	31.3	12.4	17.4
Timothy	24.8	24.0	37.9	54.9	72.3
Restorative factor for hay	.7	.7	.6	.4	.3
Manure, tons per rotated acre	3.2	3.1	3.0	2.6	2.4
Lime, tons per 100 rotated acres	18.0	15.3	13.3	10.1	6.7
Average size of farm, acres	112	150	120	102	80
Rotated acres per farm	50	59	51	53	35
Normal yields per acre					
Corn, bushels	51.5	48.0	47.6	43.4	34.7
Wheat, bushels	23.1	22.3	20.5	20.0	19.5
Hay, tons	1.8	1.8	1.7	1.5	1.2
Animal units per farm	23.2	26.8	23.4	21.4	14.0
Animal units per 100 rotated acres	46.2	45.6	45.3	40.6	37.3
Hay-consuming animal units per 100 rotated acres	39.5	38.9	39.2	35.9	31.7
Hay fed per hay-consuming animal unit, tons	2.0	1.9	1.6	1.6	1.7
Silage per hay-consuming animal unit, tons	.6	.8	1.2	1.2	1.7

In the Belmont County data a difference will likewise be noted in erosion losses in Groups 1 and 5, indicating a difference in slope. Westmoreland soils were found to a somewhat greater extent in Group 1, Muskingum soils in Group 5.

Labor income data were not obtained in the six-county study. Some indication of the volume of business may be had from the data on acres and yields per acre of the various crops and amount of livestock per 100 rotated acres. It is of interest to note that more than half of the corn was sold on Miami and Hancock County farms that were farthest from balance. Although they had more acres of corn, these farms produced less pork than farms which were in balance.

CAN MORE HAY BE USED?

Some additional information was secured in five of these counties on methods of feeding and quantities of feed consumed by different classes of livestock. Farmers were asked to give their opinions as to whether they could feed more hay without increasing their present numbers of roughage-consuming livestock. A more liberal feeding of hay on farms in balance was noted in these counties, just as in the four-area study.

TABLE 27.—Farmers' opinions regarding the feeding of more hay

County	Number of farms	Per cent of farmers who believed they could use more hay and pasture with present numbers of livestock	Tons of hay fed per dairy cattle unit—		Per cent difference	Per cent increase in total amount of hay that might be fed
			By farmers who could use more hay	By farmers who could not		
Hancock	67	49	0.90	1.38	53	26
Portage	81	60	1.14	1.56	37	22
Licking	75	49	1.05	1.38	31	15
Brown	80	45	.53	.89	65	29
Belmont	62	65	1.32	1.82	38	25
Total	365	53	1.06	1.48	40	21

Approximately 53 per cent of the farmers were of the opinion that they could make greater use of hay and rotation pasture with no increase in their livestock, particularly if the hay were of better quality than that which they had been feeding. The remaining 47 per cent of the farmers, who were using hay as liberally as they thought possible or advisable, were feeding about 40 per cent more hay per dairy cattle unit. If the sample is adequate, it might then be assumed that Ohio farmers could make use of 21 per cent more hay with no change in numbers of roughage-consuming livestock.

POSSIBLE SHIFTS IN LIVESTOCK

The farmers were asked about the changes they might make in their livestock program, should an increased acreage of hay and pasture result in more roughage than could be fed to their present number of cattle, horses, and sheep.

TABLE 28.—Possible shifts in livestock, five Ohio counties

County	Per cent of farmers who might make following changes after shifting to more hay and pasture than could be consumed by livestock on farms in 1936					
	Sell less corn	Feed fewer hogs	Keep more dairy cattle	Keep more beef cattle	Keep more sheep	No change in livestock numbers
Hancock	24	54	49	43	57	0
Portage	2	5	85	6	11	4
Licking	.....	11	43	24	73	5
Brown	1	20	50	48	35	4
Belmont	1	1	74	16	32	7
Average	5	18	60	27	41	4

As might be expected, such a shift in cropping plans would result in less corn, so that in western Ohio the opinion was expressed by about one-fourth of the farmers that less corn would be sold, and about one-half of them said that fewer hogs would be produced. The probability that farmers would expand along the type of farming now followed is indicated, in that most of the Portage and Belmont County farmers stated that they might increase the number of dairy cattle. The diversity of Hancock County livestock is indicated by the answers to the question in that county. It should be understood that on some farms an increase in dairy cattle for instance might mean an increase of only

one or two cows. Thus the figures are indicative of the trend but not of the percentage change in livestock numbers that might result from an increase of more than 20 per cent in hay acreage.

FACTORS PREVENTING A SHIFT IN CROPS AND LIVESTOCK

Shifts in farming practices come slowly, as farmers generally have some reason, valid or otherwise, for continuing along the same line year after year. Farmers in these five counties were asked what prevented them from shifting to more hay and pasture and making the necessary resultant changes in their livestock enterprises. A summary of their answers to this question is given in table 29; about one-fourth of the farmers mentioned more than one unfavorable factor.

TABLE 29.—Percentage of farmers who stated following factors stood in way of making shifts in crops and livestock

County	Lower income would result	Small size of farm and shortage of grain	Change in crops would mean change in farm layout	Lack of capital for lime and tile, needed for legumes	Barns inadequate for more hay-consuming livestock	Lack of labor to handle additional livestock	Age, health, or personal preferences	No interference
Hancock...	12	18	22	8	31	13	6	15
Portage...	2	10	9	33	28	12	20	1
Licking....	4	19	12	8	32	15	20	15
Brown.....	5	6	18	24	36	12	21	6
Belmont...	6	23	16	15	44	11	13	8
Average.	5	15	15	18	34	13	16	9

With more time for consideration of the question a different set of answers might have been secured. These are the answers that were given on the spur of the moment, with no suggestions on the part of the enumerator. It is of interest to note that only 5 per cent of the farmers expressed the possibility of lower income, although this is probably included indirectly in the next factor, small size of farm. Several of the answers as classified in table 29 might be combined in a general heading of small size of farm business.

Inadequacy of barns meant in some cases that haymows were now generally filled to capacity. In other cases the stables would need to be rearranged to accommodate more dairy cows, or possibly a part of the first floor now given over to machinery storage would need minor repairs to put it in shape for beef cattle or sheep. That a considerable number of interviews were made at the barn may account for a seemingly high number of answers giving the barn as a limiting factor.

Some of the problems involved were related to tenancy. No separate tabulation was made of the number of times this factor was mentioned as an obstacle. Problems mentioned, however, were the fact that farm income had to be shared between two parties, landlord and tenant; failure of the landlord to provide lime and tile; and the personal desires of the landlord regarding how the farm ought to be handled. Perhaps a more important obstacle, but not mentioned by the tenant for obvious reasons, was an attitude of indifference regarding the soil, fostered by insecurity of tenure.

SUMMARY

The farms in this study were sorted on the basis of "annual soil productivity balance", a term used to designate the estimated rate at which productivity of the soil is being built up or depleted.

Farms with a zero or plus soil productivity balance, i. e., those on which soils are being maintained or improved, have been spoken of in this bulletin as being in balance. Fifteen per cent of the 696 farms studied in the 10 areas included in the two projects reported here were in balance.

The farms which were in balance showed certain essential characteristics when contrasted with those which were farthest out of balance:

The percentage of rotated cropland in depleting crops (corn, other intertilled crops, small grains, and soybeans) was less, and the proportion in legumes and grasses, or conserving crops, was greater, on farms in balance in all 10 of the areas. This is to be expected, since distribution of crops is one of the factors determining balance. This factor is of especial significance in areas where the quality of hay is very similar on all farms.

The quality of hay, or relative amount of alfalfa and clovers as compared with timothy, was higher on farms in balance in all 10 areas. The difference in quality between groups was not great in Wood County, where alfalfa and clovers were grown on nearly all farms, nor in Brown County, where timothy predominated in all five groups.

More manure was produced per unit of rotated area on farms in balance in all areas. In most cases the rate of application was one and one-half to two and one-half times as heavy as on farms farthest out of balance.

A calculation showing the various ways in which farms that are out of balance may be brought into balance emphasized particularly the importance of high-quality hay.

There was a tendency for larger-than-average farms to have a better balance than small farms. In other words, owners of small farms generally find it necessary to have a high proportion of their land in soil-depleting crops

Owners and tenants related to owners were doing a better job of maintaining their soil, on the average, than were nonrelated tenants.

Crop yields were better in all 10 areas on farms showing the best balance as compared with farms farthest out of balance. The relationship between balance and yield was more marked in an old agricultural area like Ashtabula County than in a new section of fertile soil, such as was found in Wood County.

More livestock were kept on farms in balance in all areas studied. Those out of balance sold larger proportions of their corn and other feed grains.

Farmers whose soils were being maintained had less of their land in corn but, because of better yield, produced nearly as much corn as those with the highest annual rate of soil deterioration.

The feeding problem that would arise as a result of shifting to a greater acreage of soil-conserving crops seems to be one of devising ways and means of disposing of the increased amount of forage.

In all areas where the data were secured, more hay was fed per roughage-consuming animal unit on farms that were in balance.

Increasing the amount of hay and rotation pasture need not necessarily result in a corresponding increase in the numbers of roughage-consuming livestock.

More than half of the farmers interviewed in five scattered counties believed they could use more hay with no increase in livestock numbers, particularly if the hay were of better quality.

A number of obstacles stand in the way of desirable shifts in farming systems. Inadequate buildings, small size of business, lack of capital, tenancy problems, and age of the farm operator all must be taken into account.

Farmers who were doing the best job of maintaining their soil were making the best incomes. Not all of the additional income can be credited to better soil management practices; these farmers were better operators all along the line. The data show that good farm incomes need not be secured at the expense of the soil.