Profit-Maximizing Plans for Soil-Conserving Farming in the Spring Valley Creek Watershed in Southwest Iowa

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SUMMARY

The purpose of this study is to determine whether farmers in the Spring Valley Creek Watershed in Mills County, Iowa, can profitably conserve their soil to an increased extent. These farmers presently fall far short of conservation goals of public agencies. Although the conservation goals are stated in terms of preventing loss of topsoil, closely related problems of gullying, flooding and channel siltation are important. Solution of these interrelated problems is stressed by the activities of various governmental agencies. The need for control of the headwaters and tributary streams was recognized in Public Law 566—the Small Watershed Act. The limited funds made available under this act are used in building structures and in encouraging local participation in projects for controlling soil and water erosion.

This study is part of an investigation of alternative water-control measures in a particular watershed. In the watershed studied, no concerted action has been taken by the group of farmers to organize under Public Law 566. Hence, the research is expected to be useful in directing actions of farmers in this watershed, and similar watersheds, for deciding whether or not to participate in the Small Watershed Program. The questions toward which this research is directed are: Can farmers in the Spring Valley Creek Watershed in southwest Iowa, where soil is easily eroded, profitably adjust their farming operations to conserve their soil at recommended levels? Or, does a lack of possibility to improve farm income under conservation farming methods require participation in, and subsidy from, public watershed programs?

The present farming organization of 28 farmers of Spring Valley Creek Watershed is compared with plans devised by linear programming for maximum income obtainable from the resources of the farms subject to rigid soil-erosion restrictions. Various methods of meeting the soil-conservation goal are possible. These range from extensive use of forage crops to the most intensive row cropping which, when used with terracing and contour-listing, meet the watershed-conservation goal. Livestock enterprises are included because of the interaction between the crops and livestock in determining optimum use of farm resources.

The comparisons between the present and optimum soil-conserving plans provide the following generalizations:

1. Net profit could be increased by an estimated $1,744 per farm by changing from present farming systems to economically planned soil-conserving systems of farming.

2. Increased use of capital would give high returns on most farms. It is estimated that added capital would return up to 50 percent on investments on some farms in the study. To obtain this level of return, capital must be invested in the proper enterprises, and farmers must be able to obtain average levels of efficiency in use of resources.

3. Row cropping can be increased on farms of the watershed, and the Soil Conservation Service goals for diminishing soil loss can still be attained. Row crops are presently grown on 48 percent of the cropland, but the optimum soil-conserving plans allow 71 percent of the cropland to be in row crops. Optimally, forage should be grown mainly on steeper slopes or areas otherwise unsuited for cultivation. Grain production should be increased by nearly 40 percent to meet the changing livestock needs and to provide cash-grain sales. The additional row crops are permissible because of the profitability of complete terracing and contouring to arrest erosion while allowing more intensive cropping. Grain production in the optimum plans would be increased by use of improved cultural practices and by increased acreage of grain on the better land.

4. Fertilizer is estimated to be used at only about 15 percent of the optimum level. However, successive years of drouth just before initiation of the study probably cut fertilizer use to less than it would otherwise have been. Optimum plans include a higher rate of fertilizer application than currently used on all of the farms programmed.

5. Livestock production should be more specialized than at present. Fewer forage-consuming and more grain-consuming types of livestock were in the optimum plans of most farms.

This study shows that a soil-conserving farming system could be profitably adopted on all farms of the Spring Valley Creek Watershed. Also, treatment for soil erosion has beneficial effects on other conditions. Since soil erosion, flooding and gully development are all caused by excessive water movement, treatment for one of these conditions has concurrent advantageous effects on the others. By reducing soil erosion on individual farms, at least partial achievement of watershed objectives for control of gullies and flooding would be attained. It is estimated that control of soil erosion in Spring Valley Creek Watershed by the methods given in this study would be effective in attaining watershed goals. Hence, it appears that additional public subsidies would not be required if farmers would adopt conservation plans that are more profitable than present farming systems. The profitability of individual farm conservation plans makes evident the needs to use education for bringing about private action for control of soil and water. A program to teach farmers the advantages of over-all economic farm plan-

ning for conservation seems particularly appropriate because of the complementarity of public and private goals.

Many farmers do not now believe that conservation practices can be integrated into a profitable farm organization. Wider acceptance of conservation farming can be gained by showing farmers the advantages of farm plans that consider the unique set of problems of each farm. Capital, type and amount of land, buildings, labor, farmer ability and preferences must all be integrated into ideal conservation plans. Better attainment of conservation goals on individual farms would then free the limited public funds allocated to conservation activities to be used in critical areas where private action is not feasible.

Profit-Maximizing Plans for Soil-Conserving Farming in the Spring Valley Creek Watershed in Southwest Iowa[1]

by Jay C. Andersen, Earl O. Heady and W. D. Shrader[2]

One of the major problems in agricultural production is to achieve the proper or desired allocation of resources over time. This also is the core of the conservation problem both for the individual producer and for society. Many of the resources needed for production are of a stock nature; what is not used is conserved, and vice versa. When the decision is made to use some of this type resource, the decision is also made not to conserve that same amount for future use. Other resources provide a flow of services over time in such a way that the flow can be maintained without competition for resource use among time periods. Soil resources have characteristics of both these resource types. By proper management, soil resources can be used to give off a desired flow of services at present and still serve the same purpose in the future.

Gullying, flooding and siltation from excessive runoff are closely related to soil conservation. Control of these problems is important in a soils and climatic region such as the Corn Belt. Hence, soil conservation in its usual interpretation has meaning beyond the sense of allocation of resources over time. Water management is closely related. Without adequate control of runoff in the watersheds, gullies develop as water accumulates while seeking its way to streams and rivers. As the excessive runoff develops further, the channels overflow causing damaging floods to farmlands, towns and cities.

Watershed Programs

The need for emphasis on control of erosion and runoff in tributary and major watersheds has been recognized in public legislation. Special funds emphasizing flood control in small watersheds have been provided under Public Law 566. Each project under this law is a local undertaking with federal help. Funds for these purposes are limited, so not all watersheds can be developed at once. There is need for analysis of watersheds in different locations and under different climatic conditions to insure optimal use of public funds. Economic analysis can be used to determine whether the degree of control of erosion and runoff desired by society is profitable to individual farm operators. Government investment in watershed development should be allocated to those situations where most benefits can be obtained from erosion and runoff control. The public, through government action, should have priority where individual farm operators cannot profitably control erosion. If it is found that erosion and runoff control are profitable to individual farm operators, no special public subsidies or controls may be necessary. In watersheds where the level of erosion and water control desired by the public is not profitable to individual farmers, special compensation and regulatory action may be necessary to bring about satisfactory watershed management. Public subsidies become relevant when erosion control and water management prove unprofitable to the individual but are profitable to society.

Damages from soil erosion and water runoff usually extend beyond the boundaries of a given farm. These damages often harm nonfarm individuals and groups, as well as other farms. The small watershed program under Public Law 566 is designed to provide an aggregation of participating farmers and governmental units so that the interfarm and off-farm benefits from multipurpose conservation activities can be realized within the organized group. One of the purposes of the watershed group organization is to encourage participation of farmers who otherwise do not use conservation practices. A high level of participation by individuals is required in activities such as terracing where conservation measures are suitable for individual action. Where individuals cannot adopt soil-conserving plans because of lack of capital, unfavorable tenure arrangements or lowered profits from erosion control, programs and institutions to overcome these obstacles are needed to attain watershed objectives. If all farms can be reorganized profitably, while at the same time attain objectives for the watershed as a whole, then efficient means of attaining watershed goals will involve mainly education and technical assistance.

The study reported here is part of an investigation

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1 Project 1135, Iowa Agricultural and Home Economics Experiment Station.

2 Jay C. Andersen, currently with the Farm Economics Research Service of the USDA, was a research associate at Iowa State University when this study was made.

of water management alternatives in a tributary watershed. It is concerned with the time-usage aspects of conservation and related problems of water control. The problem is to determine whether soil conservation at currently recommended levels is profitable to individual farm operators in the Spring Valley Creek Watershed in Mills County, Iowa. While it is assumed that control of soil erosion will have beneficial effects on water runoff, a hydrologic analysis is not included in this part of the study. An investigation of the runoff and gully development associated with various levels of soil conservation in Spring Valley Creek Watershed was reported by Landgren.[3] For the study as a whole, the question asked is whether farms making up a watershed should or must be organized into a legal, civil government unit to control soil erosion and water runoff at publicly desired levels. Linear programming methods were used in this part of the study to derive profit-maximizing farm plans under the restraint of erosion control. This study indicates the extent to which the goal of erosion control is consistent with increased profits on the farms that make up the watershed.

Objectives of the Study

The general objective of this study is to compare the profitability of present farming systems and practices in the Spring Valley Creek Watershed with plans that control erosion. The specified level of erosion control is: The rate of soil loss must not exceed the maximum allowable annual soil-loss rate currently used in planning by the Soil Conservation Service.

Specifically, the objectives of the study are as follows:

1. To compare the income attainable and the resources required for the current cropping and farm organization with those in an optimum soil-conserving cropping system on farms in the Spring Valley Creek Watershed of Mills County, Iowa.

2. To determine the farm organization changes necessary to attain soil-conserving optimum farm plans.

3. To provide profit-maximizing conservation plans for the farmers who operate within Spring Valley Creek Watershed.

4. To compare the conflict or consistency of public goals in soil conservation in a particular watershed against income attainable on individual farms.

5. To investigate the adequacy of linear programming for specifying optimum plans for conservation farming.

[3] Norman E. Landgren. Income and hydrologic effect of alternative farm plans in a watershed. Unpublished Ph.D. thesis. Iowa State University Library. 1962.

Description of Area and Soils

The Spring Valley Creek Watershed is located in the southern part of Mills County, Iowa. It lies 10 to 15 miles east of the Missouri River and is approximately 25 miles north of the southern boundary of Iowa. The Spring Valley Creek originates in Section 10 of Rawles Township and flows southeasterly for about 7 miles, emptying into the West Nishnabotna River. This watershed, containing 5,234 acres, lies in the Marshall-Monona transition soils zone on the western edge of the Marshall soil association. Broad, gently sloping ridge tops of Marshall soil divide the drainage systems in the Marshall-Monona transition area and thus form the boundary for Spring Valley Creek Watershed as well as for other watersheds and subwatersheds. The most prevalent soil series in the watershed is the Monona series. Others found are Marshall and small amounts of Ida silt loam, Dow silt loam, and several waterway, valley bottom and floodplain soils.

A detailed soils map and description of soils was prepared by the Soil Conservation Service and the Department of Agronomy, Iowa State University. For farm planning, each farm was segmented into from 3 to 10 soil categories according to soil series, slopes, state of antecedent erosion and previous installation of terraces. A total of 17 soil classificaions was used in the farm planning work. Yield estimates, cropping capabilities in compliance with the erosion restriction, optimal fertilizer rates and estimates of the annual soil loss rates for the various crop and land treatment alternatives were prepared for each of the soil classifications.

The soils of the 28 farms that were analyzed are described in table 1. The first column of table 1 is an aggregation of the soil types into four cropping intensity classes, depending on their susceptibility to erosion. The "Very critical upland soils" average about 15 percent slope and will meet the conservation objective with about 25 percent frequency of row crops if terracing and contouring are practiced. Similarly the types called "Critical upland soils" average 11 percent slope and will support about 50 percent frequency of row crops if terracing and contouring are used. "Good upland soils" are soils where slopes average 3 or 7 percent on which continous row cropping may be practiced if terracing and contouring are used to meet the soil-loss restriction. "Waterway, valley bottom and floodplain" soils have no restrictions as to crops or practices as far as erosion is concerned. The second column lists the commonly used mapping symbol which gives the same information as columns 3, 4 and 5. The series name, slope and erosion factor found in columns 3, 4 and 5 are those used in soil mapping; they are explained in the table footnotes. The erosion factor represents the degree to which erosion has already taken place. Column 6 indicates whether the land, as classified by the previous characteristics, is now

Table 1. Arable soils of 28 farms wholly or partly within the Spring Valley Creek Watershed.[a]

Group	Mapping symbol	Soil series	Average percent slope[b]	Erosion factor[c]	Presently terraced	Total acres	Percent of total area
Very critical upland soils	10-15-3	Monona	15	3	No	94	1.9
	10-15-3T	Monona	15	3	Yes	8	0.2
Subtotal						102	2.1
Critical upland soils	10-11-2	Monona	11	2	No	1,415	28.8
	10-11-2T	Monona	11	2	Yes	359	7.3
	10-11-3	Monona	11	3	No	125	2.5
	10-11-3T	Monona	11	3	Yes	60	1.2
	1-11-2	Ida	11	2	No	28	0.6
	1-11-2T	Ida	11	2	Yes	15	0.3
Subtotal						2,002	40.7
Good upland soils	9- 3-1	Marshall	3	1	No	434	8.8
	9- 3-1T	Marshall	3	1	Yes	718	14.6
	10- 7-2	Monona	7	2	No	414	8.4
	10- 7-2T	Monona	7	2	Yes	222	4.5
Subtotal						1,788	36.3
Waterway, valley bottom and flood-plain soils	11- 3-0	Napier	3	0	No	505	10.2
	212- 1-+	Kennebec	1	+	No	227	4.6
	87- 1-+	Colo	1	+	No	131	2.7
	134- 1-+	Zook	1	+	No	90	1.8
	220- 1-0	Nodaway	1	0	No	78	1.6
Subtotal						1,031	20.9
Total						4,923[d]	100.0

[a] These 17 classifications are an aggregation from 56 original soil mapping units. The 17 classifications are named for the most prevalent unit in each classification.

[b] Slope groups:

Average percent slope	*Range (%)*
1	0- 1.9
3	2.0- 4.9
7	5.0- 8.9
11	9.0-13.9
15	14.0-17.9

[c] Erosion factor:

Class	*Degree of erosion*
+	12 inches or more of recent overwash
0	None
1	Slight
2	Moderate
3	Severe
4	Very severe, dissected, nonarable

[d] These 28 farms also contained 609 acres of nonarable land, making a total of 5,532 acres in the 28 farms. This acreage is greater than the total acreage of the watershed, since many of these farms were located partly outside of the watershed. Some land in the watershed is not included in the 28 farms, since data required for planning phases of this study could not be obtained from all farm operators who have land in the watershed. About three-fourths of the land in the watershed is included in the 28 farms for which this table was made.

terraced. Acreages of each of the soil classifications and the percentages they represent of the total are found in columns 7 and 8.

Crops presently grown in the Spring Valley area are corn, oats, hay, pasture, soybeans and wheat plus some minor acreages of other crops. Milo and sorghum crops have gained in importance during recent years. Rawles Township, in which most of the watershed lies, was planted to about 40 percent corn and 10 percent oats in the period 1940-56. Corn is considered to be the most profitable crop in the area. The extent of row cropping permissible on the steeper slopes is limited under farm plans designed to restrict soil loss. Because of steep slopes and some areas of permanent pasture on hilly land, forage supplies generally are plentiful. Hence, small dairy herds and beef cattle are kept on most farms to use the forage. Hogs and chickens are also raised on most farms, with hogs being the most important source of livestock income.

METHOD OF ANALYSIS

It was expected that profit-maximizing farm plans would be computed using linear programming methods for each farm in the watershed. However, a few farm operators could not be interviewed to obtain the information necessary to plan their farms. Two sets of farm plans were computed for each of the 28 farms where sufficient information was available. The two sets of plans were: (a) those where the optimum livestock system was computed to complement cropping practices and land treatment measures presently being used; and (b) those where both crop and livestock enterprises were allowed to change in any manner that would meet the soil-conservation restriction in prescribing the most profitable plan for the limited resources on each farm.

This procedure was used to obtain a comparison of present cropping practices with optimum cropping practices in soil-conserving farm plans. This method gave optimum livestock systems with each of the cropping systems. In the optimum plans where crops were allowed to vary, activities were limited by the quantities of land of the 17 classifications, the labor available in five parts of the year, capital obtainable and existing building facilities on each farm. In addition, erosion control was enforced. The erosion-control restraint was the goal used by the Soil Conservation Service for this area; i.e., annual soil loss must be no more than 5 tons per acre per year on any soil type. Within the limitations of these restraints, the profit-maximizing plans were computed on the basis of average historical price relationships among the items purchased and sold by farmers in this area. Input-output coefficients were charactertistic of farming practices currently used on farms in the watershed.

The farm survey, which included an inventory of resources, conservation practices and crop and livestock systems, was completed before planning work. From this survey, the current cropping plans and farm organization were obtained. These resource availabilities and farm practices data also provide the basic data for determining farm organization, resource requirements and farm income for the optimum plans computed by linear programming methods.

There are four main elements in linear programming models used for deriving profit-maximizing farm plans. There are: (1) alternative farm enterprises, such as cropping and livestock enterprises; (2) prices of outputs sold and resources bought for determining net revenue for each activity; (3) input-output coefficients which show the amount of each resource used and the quantity of output produced per unit of activity; and (4) restrictions on quantities of available resources. The general nature of the linear programming procedure is to derive the combination of activities or enterprises that maximizes farm net revenue subject to the resource limitations.

Prices, Planning Alternatives and Resource Availability

The basic data of prices, input-output relationships for crop and livestock enterprises and resource restrictions used in this study are described in the following sections.

Prices Used

Prices used in computing optimum programs for individual farms were adjusted to a corn price of $1.20 per bushel. Other prices were adjusted to the same relationship to corn price as has prevailed in past years. This adjustment was done by using the formula:

$$\text{commodity adjusted price} = \frac{\text{commodity average price}}{\text{corn average price}} \times \$1.20.$$

Three different time periods were used for determining average historical prices. The period 1953-57 was used for crop, milk, egg and lamb prices. Longer periods were used for hog prices (1947-57) and for cattle prices (1935-57) to include cyclical price movements.

Although price level is important in a farm planning study, a proportional change in all prices of the study would not change the plans. Only income would change. Thus, if all prices were adjusted to a corn price of $1 or $0.80 or any other level, the farm incomes, but not the farm enterprises, would have been different from those that were obtained. The set of prices used in this analysis is shown in table 2. Buying prices of some items which could be either bought or sold are higher than selling prices to account for handling costs.

Table 2. Price data for study of farms of Spring Valley Creek Watershed.

Item	Unit	Selling price	Buying price
Crops:			
Corn	bushel	$ 1.20	$ 1.30
Oats	bushel	0.64	----
Milo	cwt.	1.85	----
Soybeans	bushel	2.26	----
Wheat	bushel	1.84	----
Hay	ton	11.00	16.50
Livestock and livestock products:			
Butterfat	pound	0.60	----
Grade A milk	cwt.	3.40	----
Lambs	pound	17.97	----
Eggs	dozen	0.30	----
Hogs			
220-240 pounds (Sept.)	cwt.	17.61	----
220-240 pounds (March)	cwt.	16.50	----
300-pound sows (June)	cwt.	15.37	----
400-pound sows (Dec.)	cwt.	13.34	----
Cattle			
450-pound choice calves (Oct.)	cwt.	----	20.10
650-pound choice yearlings (Nov.)	cwt.	----	19.58
650-pound medium yearlings (Nov.)	cwt.	----	15.13
1,000-pound choice steers (Dec.)	cwt.	23.77	----
950-pound choice steers (Nov.)	cwt.	23.98	----
1,120-pound choice steers (Nov.)	cwt.	24.06	----
1,070-pound choice steers (Sept.)	cwt.	23.47	----
937-pound good steers (May)	cwt.	19.59	----
Fertilizer:			
Nitrogen	pound	----	0.13
Phosphorus	pound	----	0.09

Description of Enterprises and Input-Output Data

Crop and livestock enterprises used in this analysis are those commonly found in the watershed area. Radically different types of crops or livestock operations would not likely be readily adopted. Cropping systems, fertilizer levels, conservation practices and livestock enterprises used as alternatives in farm planning are those described.

As a basis for soil-conserving cropping plans, choice among five rotations was allowed. These rotations were: continuous corn; corn, soybeans; corn, corn, oats with a catch crop of sweetclover; corn, corn, oats, meadow; and corn, oats, meadow, meadow.

Two conservation alternatives were paired with each cropping sequence. These two alternatives were a system with conservation practices, including level terraces and contouring, and a system with no mechanical conservation practices. The use of conservation practices brought many of the cropping sequences within the allowable rate of soil loss so that more cropping activities were made feasible. The conservation requirement could be met either by heavy use of non-row crops where slopes were not too steep or by terracing and contouring. Two levels of fertilizer treatment were used in combination with each of the allowable rotations. Therefore, there were initially five cropping, two fertilizer and two conservation alternatives, making a total of 20 possible activities for each type of soil.

Many of the most intensive rotations were excluded from use on lower cropping capability soil types. In other cases, rotations were allowed only in connection with mechanical conservation practices. Thus, many activities were eliminated for particular soils because they would result in loss of more than 5 tons of topsoil per year. On some of the steep slopes where non-row crops are necessary in addition to terracing to meet the conservation restriction, it may be necessary to place some terrace backslopes in permanent meadow because of difficulties in operation of machinery on these steep slopes. The rotations allowed on these steep slopes all have sufficient meadow for covering backslopes, but any possible differences in costs or income from permanent seeding were not considered.

Cropping sequences having less than 50 percent corn were eliminated from level, bottomland soils where it was supposed that farmers would insist on a high intensity of corn. Activities that included terracing were not used on the bottomland soils. Physical input-output data for all crop activities that were used in the programming models for each of the 17 soil types are found in the Appendix. Labor and operating capital requirements for each crop are given in table 3. While these production data do not reflect most differences among farms, differences do arise because of the different mix of soil types, and hence yields differ on the different farms.

Twelve separate livestock enterprises were allowed to compete for the resources of the farms for which plans were made. These included: two hog-raising enterprises, three dairy systems, two calf-feeding enterprises, two yearling-feeding enterprises, a poultry (hen) enterprise, a farm flock of sheep and a beef-breeding herd. A brief description of each livestock enterprise follows.

Spring hog litters. Pigs are farrowed in April. An average of 6.8 pigs is weaned. A total quantity of 1,524 pounds of pork is marketed including the sow. One gilt is kept for replacement.

Spring-fall hog litters. In this system, two litters of hogs are marketed a year from a sow. Spring litters are farrowed in April, and fall litters are farrowed in September. One gilt from the fall litter is kept for replacement. A total of 3,052 pounds of pork, including the sow, is marketed annually.

Dairy cows for butterfat production. Production from this enterprise includes 216 pounds of butterfat and 417 pounds of meat from calves and cull cows per one-cow unit per year. The productive life of each cow is 5 years. Replacement stock are included for a one-cow unit.

Dairy cows producing Grade A milk. Production per cow includes 7,650 pounds of fluid milk and 437 pounds of meat from calves and cull cows. Productive life is 5 years, and the cow units include replacement stock.

Dairy cows producing Grade A milk—feed purchased. This activity is the same as the preceeding one, except that feed is bought on a monthly basis as returns from milk are forthcoming.

Choice steer calves deferred-fed. Choice calves weighing 450 pounds are purchased in October. They are wintered over, grazed about 90 days on pasture then full-fed until sold at 1,000 pounds in December.

Table 3. Capital expenses and labor requirements for various crops.[a]

				First-year meadow[b]		Second-year meadow	
	Corn	Oats	Soybeans	Pasture	Baled	Pasture	Baled
Capital costs:							
"Constant" cost (dollars per acre)[c]	17.08	13.11	17.06	7.66	18.70	5.15	16.19
"Variable" cost (dollars per bushel or ton)[d]	0.08[e]	0.05[e]	0.05[e]	----	2.75[f]	----	2.75[f]
Labor (hours per acre):[g]							
Dec.-Jan.-Feb.	0.52	----	----	----	----	----	----
March-April	1.18	1.26	0.59	----	----	----	----
May-June	3.51	----	2.33	----	6.22	----	6.22
July-Aug.	1.07	3.76	0.67	----	5.30	----	5.30
Sept.-Oct.-Nov.	3.72	----	2.41	----	4.48	----	4.48

[a] These are figures for owner-operators. Appropriate adjustments were made for various tenancy arrangements. Source: Gerald W. Dean, et al. Economic optima in soil conservation farming and fertilizer use for farms in the Ida-Monona soil area of western Iowa. Iowa Agr. and Home Econ. Exp. Sta. Res. Bul. 455. 1958.

[b] Costs and labor for planting meadow are included in oats nurse crop.

[c] "Constant" costs refer to operating costs that are independent of yield, such as seed cost.

[d] "Variable" costs include operating costs, such as hauling and elevating, that vary with yields.

[e] Per bushel.

[f] Per ton.

[g] For fertilization with commercial fertilizer add this labor: Corn = 0.2 hour per acre in May-June; Oats = 0.3 hour per acre in March-April; Soybeans = 0.2 hour per acre in May-June.

Choice steer calves drylot-fed. Choice calves weighing 450 pounds are purchased in October. After wintering over, they are placed in drylot and full-fed until sold at 950 pounds in October.

Choice yearling steers deferred-fed. Choice, 650-pound yearling steers are purchased in November. These steers, too, are wintered then grazed on pasture for 90 days. After a period of full feeding, they are sold in November at 1,120 pounds.

Medium yearling steers drylot-fed. Medium-grade feeders are purchased at 650 pounds in November. They are put in drylot until sold at 937 pounds in April.

Beef cows—sell calves. A beef breeding herd is maintained. The 90-percent calf crop is sold as choice feeder calves at 450 pounds in October.

Ewe and lamb. Ewes save a 125-percent lamb crop. Lambing is done in late winter so that the 90-pound lambs may be sold on the early summer market.

Hens. The laying flock averages 15 dozen eggs per hen per year. It is assumed that the hens do not compete for regular farm labor but use only the labor of the wife or other family members.

The expense, income and labor coefficients for livestock activities are shown in table 4. Prices used for this table are shown in table 2. These livestock alternatives were used in computing profit-maximizing farming systems for both (a) cropping programs held fixed as they were found on the farms and (b) cropping systems revised to meet erosion-control restraints.

Transaction activities were used to allow realistic business operations in the farm programs. These activities included buying and selling of grain and hay. Selling of feed was allowed only where livestock did not provide a better market. The watershed is fairly near the Omaha stockyards, so a hay market is well established. The programming model allowed feed to be purchased only if livestock enterprises allowed a profitable transformation. A capital-selling activity was also incorporated into the programming models. Without a capital-selling activity, farm enterprises would have been introduced until the marginal productivity of capital was driven to zero since variable capital programming was used in this study.[4] It was believed that the farm operators would prefer an investment that offers more certainty than farming enterprises if expected returns from capital in their farm business was less than 5 percent. Therefore, the capital-selling activity was introduced to use all capital that would not return more than 5 percent in the farm business.

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4 For a more complete description of variable resource programming, see: E. O. Heady and W. V. Candler, Linear programming methods. Iowa State University Press, Ames, Iowa. 1958. Ch. 7. The programming solutions were obtained by using an electronic computer. The details of the method used can be found in: D. D. Grosvenor and H. O. Hartley. IBM 650 program for linear programming. Statistical Laboratory, Iowa State University, Ames, Iowa. 1960. (Mimeo.)

Table 4. Basic input-output data for livestock enterprises (per-head basis).[a]

Item	Unit	Hog litters: Spring (per litter)	Hog litters: Spring and fall (per 2 litters)	Dairy cow (butter fat) (per cow)	Dairy cow (Grade A) (per cow)	Dairy cow (Grade A) buy feed (per cow)	Choice steer calves deferred fed (per head)	Choice steer calves drylot fed (per head)	Choice yearling steers deferred fed (per head)	Medium yearling steers drylot (per head)	Beef cows sell calves (per cow)	Ewe and lamb (per ewe)	Poultry (per hen)
Inputs:													
Capital	$	128.92	219.88	222.89	372.30	386.31	133.68	146.92	168.64	146.18	202.61	27.80	3.67
Corn equivalent	bu.	118.90	250.00	31.50	43.00	---	54.00	63.00	50.00	33.00	8.00	2.03	1.60
Hay equivalent	ton	0.70	0.70	6.50	6.80	---	2.00	1.00	2.77	0.75	5.47	0.90	---
Housing	sq. ft.	38.60	63.50	84.00	84.00	84.00	---	---	---	---	---	10.00	4.12
Labor:													
Dec.-Jan.-Feb.	hr.	4.64	13.44	39.06	39.34	39.34	3.85	1.78	1.83	2.62	5.61	2.20	---
Mar.-April	hr.	9.50	17.23	25.42	25.89	25.89	0.92	0.85	1.22	5.20	3.80	0.90	---
May-June	hr.	4.65	6.90	16.74	18.65	18.65	0.68	4.28	0.98	1.25	3.61	0.65	---
July-August	hr.	4.89	6.60	15.50	17.33	17.33	2.18	5.18	3.50	---	3.31	0.50	---
Sept.-Oct.-Nov.	hr.	8.33	14.81	27.28	29.79	29.79	7.27	6.91	8.25	1.05	4.04	0.85	---
Outputs:													
Meat or feeder	lbs.	1,524	3,052	417	437	437	1,000	950	1,120	937	500	148	4.87
Milk (B.F. or milk)	lbs.	---	---	216	7,650	7,650	---	---	---	---	---	---	---
Eggs (doz.)	doz.	---	---	---	---	---	---	---	---	---	---	---	15.0
Wool (lbs.)	lbs.	---	---	---	---	---	---	---	---	---	---	9.0	---
Value of output	$	261.66	504.53	180.06	317.78	317.78	237.70	227.81	269.47	193.56	87.54	23.32	5.18
Net return	$	58.66	76.69	37.02	139.23	70.16	40.73	14.94	29.62	12.45	26.41	7.93	0.40

[a] These coefficients are for the owner-operator case. Adjustments were made to conform to tenure arrangements where necessary. Sources of the data were: Research Bulletins 456, 455, 451, 449, 440 and 437 of the Iowa Agricultural and Home Economics Experiment Station; FM-1185 and FM-1186 (2nd Rev.), Department of Economics and Sociology, Iowa State University Cooperative Extension Service.

Resource Restrictions

Resources available on any given farm are limited in the short run. One of the most limiting production resources on farms is capital. Results of this and previous studies indicate that additional capital on some farms could return as much as 50 percent per year if properly used.

All farms are also limited in the amount and type of land available in a relatively short planning period. The acreage of each soil type found on each farm was used as a restriction in the programs. From the total of 17 soil types in the watershed, an average of six different soil types was found on each farm and was used as a programming restriction. A different set of input-output coefficients was used for each soil type as explained in connection with the discussion on cropping activities. This procedure allowed differentiation of productivity of soils within, as well as between, farms. The use of each of the soil types was restricted to cropping and conservation combinations that would limit soil loss to less than 5 tons per acre per year. Thus, the type of use as well as the quantity of land was restricted.

The quantity of labor presently available on the farms was used as the restriction on optimum plans for most of the farms. For five of the larger farms, where substantial labor-hiring had been practiced, the programming models allowed labor-hiring to the extent that it was profitable. Labor restrictions were specified for five seasons which cover the whole year. Thus, labor could be limiting in some seasons and not in others, depending on the seasonal labor availability and the combination of enterprises in the plan.

Livestock enterprises are limited by special feed and building restrictions in addition to the general labor and capital restrictions. All feeds were placed into categories of either hay equivalents or corn equivalents. Livestock enterprises were allowed to enter optimum plans only if sufficient feed was available, but both hay and grain could be furnished either by the cropping rotations or by purchase. Feed produced on the farms and not fed to livestock was automatically sold in the planning models. Buildings for livestock were limited to the space presently available on the farms. From a farm management viewpoint, a more useful long-run plan might have been to allow building construction for additional livestock space. However, since the focus of this study was conservation planning, building space availability was held constant to better measure the effects of soil-conserving cropping plans on farm profits.

Planning Framework

The two important problems of farmers or other producers are: (1) what quantities of each product should be produced; and (2) how much can be paid for additional resources. Linear programming answers both of these questions. The production quantities are given by the level of the various activities in the programming solution. Marginal valuations or marginal value products of resources are given by the Z_j-C_j values of the resource-disposal activities. A Z_j-C_j value on a disposal activity is the amount by which profit would be reduced by disposing of one unit of a resource presently available. Since it is a marginal valuation, this value can also be interpreted as the amount by which profit would be increased by acquiring an additional unit of the resource. But, since these are marginal values, they are strictly valid only at one particular set of resource availabilities and at one production plan. However, some inferences can be drawn about the profitability of acquiring additional resources.

The variable resource method of linear programming was used in generating optimum farm plans. As mentioned previously, capital was the resource varied in this study. The method of variable capital programming has interesting economic implications. Activities are brought into the farm plan in sequence according to their marginal returns with respect to capital. Those activities having highest marginal productivity are introduced first. Activities that are successively less profitable with respect to capital are introduced only as the capital restriction is relaxed. A change in activities (the farm plan) results at each level of capital where the marginal productivity of capital changes. Since the linear programming procedure assumes constant returns to scale and perfect divisibility of resources and activities, exact farm plans can be obtained for quantities of capital between those points where capital productivity changes. Thus, the variable capital procedure gives optimum farm plans at all levels of capital. Although plans were computed for the entire range of possible capital levels, two particular levels were selected for special examination. These were: (1) the average amount of capital that had been used in the farm business in the years 1953 to 1957 and (2) the amount of capital that drove marginal returns to capital to 5 percent.

No attempt was made to find the most profitable level of conservation for each farm. However, one farm was used to determine the rate of soil loss at which profit was maximized. For this particular farm, with its unique set of resources and operator planning horizon, it was found that an average of 6 tons per acre per year soil loss was associated with maximum farm profit at present level of capital use. Some of the soil types had higher soil loss rates. They ranged up to nearly 10 tons per acre per year. In this study, however, the concern was mainly the comparison of present cropping systems with an optimum set of practices that would meet the public goal, not the private optimum rate of conservation.

ANALYSIS OF RESULTS AND PROFIT-MAXIMIZING PLANS

This section contains comparisons of present farming systems with characteristics of the optimum plans for farms of the watershed. The various income, production and resource relationships are tabulated by farm types rather than by individual-farm operating units. This procedure is used because of the large amount of data needed for presentation had results for each farm been tabulated separately. Each farmer included in the study and the county extension director were given a summary of plans prepared for the individual farms. General conclusions of the study remain unchanged, and the results are more easily understood when the material is presented by farm-size and tenure groups.

Five situations were studied and tabulated, where appropriate, for each farm type: (a) present crop and livestock enterprises; (b) present crops with optimum livestock where operating capital is limited to current use; (c) present crops and optimum livestock with sufficient operating capital to reduce marginal returns to 5 percent; (d) optimum cropping and livestock plan with soil loss restricted where operating capital is limited to current use; and (e) optimum cropping and livestock plan where soil loss is restricted, but with sufficient operating capital to drive marginal returns to 5 percent. Characteristics of the plans having present cropping systems and optimum livestock provide the benchmark for determining the feasibility of plans which include optimum soil-conserving cropping systems. The characteristics of the present farm organization, as well as those of the benchmark plans, are based on the same prices and input-output coefficients as used in the derivation of optimum soil-conserving farm plans. Producer estimates of crop yields, feed fed and livestock output were used only to classify each crop or livestock enterprise into categories which could be evaluated in terms of the data used in deriving optimum plans. This procedure was used to enable comparisons of the various plans.

Comparison of Income and Capital Use

Income varied widely among farms for each planning situation. Small farms (those with fewer than 175 acres of cropland) had much lower net revenue than large farms for every situation programmed. (Fixed costs must be deducted from net revenue, in table 5, to obtain net income.) Even though fixed costs for small farms are lower, net incomes are still, in general, much less for small farms. Fixed costs were not estimated for all farms in this study, since these costs have no bearing on the optimum combination of enterprises. Capital use is much higher on large farms than on small farms in this watershed and could be profitably increased on most farms.

Table 5. Average net revenue and capital use by type of farm.

Type of farm	Type of plan	Net revenue	Operating capital used or required
Owner-operated farms			
Small farms	Benchmark-Present capital[a]	$ 4,449	$10,723
	Benchmark-High capital[b]	5,406	16,771
	Optimum-Present capital[c]	5,724	10,723
	Optimum-High capital[d]	6,453	14,219
Large farms	Benchmark-Present capital	7,715	32,988
	Benchmark-High capital	9,080	43,550
	Optimum-Present capital	11,002	32,988
	Optimum-High capital	12,368	37,864
Crop-share leased farms			
Small farms	Benchmark-Present capital	1,719	6,296
	Benchmark-High capital	2,793	13,962
	Optimum-Present capital	2,746	6,296
	Optimum-High capital	3,937	14,700
Large farms	Benchmark-Present capital	3,752	14,057
	Benchmark-High capital	4,548	25,249
	Optimum-Present capital	5,300	14,057
	Optimum-High capital	5,971	23,389
Livestock-share leased farms			
	Benchmark-Present capital	1,743	7,281
	Benchmark-High capital	1,907	8,453
	Optimum-Present capital	2,480	7,281
	Optimum-High capital	2,757	9,492
All types of farms (average)			
	Benchmark-Present capital	4,254	15,730
	Benchmark-High capital	5,260	23,707
	Optimum-Present capital	5,998	15,730
	Optimum-High capital	6,978	21,619

[a] Present crops are fixed and optimum livestock enterprises are planned at present operating-capital levels. Present crops are defined as those used in the period 1953-57.

[b] Present crops are fixed and optimum livestock enterprises are planned with operating-capital availability increased to the extent that marginal return to operating capital is driven to 5 percent.

[c] Optimum crop and livestock enterprises are planned simultaneously, subject to the conservation restriction. Operating capital is fixed at the present level of use.

[d] Optimum crop and livestock enterprises are planned simultaneously, subject to the conservation restriction; operating-capital availability is increased to the extent that marginal return to operating capital is driven to 5 percent.

Profitability of Soil-Conserving Farm Plans

A reorganization of cropping practices could increase farm income by a large amount. Owner-operators could gain most by changing to optimum cropping patterns. However, tenant farmers could also gain substantially by using the cropping practices recommended in this study. Proposed changes in the cropping system involve nearly complete terracing, heavier row cropping as allowed by the conservation restriction and application of commercial fertilizer to nearly all crops. These changes will be discussed in detail later.

Table 5 gives average net revenue and operating capital needs for each planning situation for the five types of farms. These five farm types are used rather than individual farms for convenience in presenting data and to show effects of size of farm and tenure arrangements. Where a farmer both owned and rented part of his farm, his farm was placed into the category of the dominant tenure arrangement. Landlords' shares of net revenue and operating capital are not included in this analysis.

Several comparisons can be made from table 5. The difference between net revenue from (a) plans with present crops and optimum livestock and (b) plans with optimum crops and livestock is the estimated increase in profit possible from shifting to an optimum soil-conserving cropping plan. This increase varies among the farm types and according to capital availability. These increases for each type of farm at present level of capital availability are shown in table 6. These increases in revenue are the gains attributed to the cropping system that controls erosion as compared with the present cropping pattern. Fertilizer use and other improved cropping practices are included in the optimum cropping system so that part of the increased net revenue is not attributable to conservation practices alone. It is claimed only that whole-farm planning that includes a soil-conservation restriction would be more profitable than present farming systems.

Table 6. Estimated net revenue increase which could be attained by changing to the optimum soil-conserving cropping plan by type of farm.

Type of farm	Estimated net revenue increase for changing to optimum cropping system
Small owner-operated farms	$1,275
Large owner-operated farms	3,620
Small crop-share leased farms	1,027
Large crop-share leased farms	1,548
Livestock-share leased farms	737
Average for all farms	$1,744

Use of present livestock enterprises in the comparison, rather than use of the optimum livestock organization for present crops, would make the whole-farm planning approach appear even more profitable by comparison. A more direct comparison of the revenue from crops alone might be desirable, but optimum farm plans cannot be derived in terms of crops alone. To be meaningful, optimum farm plans must consider all the relevant resource restrictions and production alternatives. Use of the optimum livestock systems with each cropping plan appears to be a satisfactory method for comparing the two alternatives.

Capital Utilization

Capital shortage is frequently cited as a deterrent to conservation. Terracing and other mechanical practices or livestock to make use of forage both require considerable operating capital. Shortage of capital causes farm operators to make short-run investments which they believe more profitable than conservation activities. The data of tables 5 and 6 show that by proper farm planning, it is possible to obtain higher profit when scarce capital is invested in conservation measures than when present erosion-producing farming methods are used. Any loss of profit resulting from use of capital in terraces and other erosion-control measures can easily be offset by good farm organization.

Rationing of operating capital greatly reduces farm incomes in plans for farms in the Spring Valley Creek Watershed. Many of the farm operators had only small amounts of capital in use. A few were cropping their farms with as little expense as possible, while keeping almost no livestock. However, some farms, especially large-sized, owner-operated farms, typically had beef-feeding enterprises with large requirements for operating capital. The amounts of operating capital in present use and the amount necessary to drive marginal returns to 5 percent are shown for each type of plan by type of farm in table 5. On the average, $7,977 more operating capital than presently used would be required on each farm to drive marginal returns to 5 percent where crops are held fixed. But, only $5,889 would be required if both crops and livestock were optimally planned. With plans of the latter type, average return to additional capital is nearly 17 percent in the range from present amount of capital used up to the amount that would drive marginal return to 5 percent. As an average, the farmers in Spring Valley Creek Watershed could use approximately 50 percent more operating capital before marginal returns would be driven to 5 percent. Small crop-share leased farms could use over twice as much as is used at present. Considering uncertainty and dislike for using borrowed funds, many of the farmers would likely restrict capital use even if the optimum plans were adopted.

The method of linear programming used in this study provides marginal value products or shadow prices as Z_j-C_j values for each of the resources.[5] These latter values may be interpreted as the marginal return of an additional unit of resource. Remember that the Z_j-C_j values are marginal values and caution must be used not to extrapolate beyond their valid range. Nevertheless, these marginal values indicate the feasibility of acquiring additional resources. Optimum farm organization would provide a return as high as 45 percent on added capital for many farms. On farms which are not optimally organized, investments could earn somewhat greater than 45 percent if the best alternative was chosen. This very high return would be possible because non-optimal farm organizations often do not utilize some of the most profitable investment alternatives. A farmer presently using very small amounts of capital may not be able to realize as much as 45 percent return on an increment of added investment because of poorer than average managerial ability. However, if management help was given, very substantial returns are attainable for farmers who could and would increase capital use from very low levels.

The averages of the marginal returns to capital at present levels of use for farms in each of the five types in the two planning situations are given in table 7. Added investments in the plans where

[5] See: Earl O. Heady and Wilford V. Candler, Linear programming methods. Iowa State University Press, Ames, Iowa. 1958. Ch. 3.

Table 7. Average value of an additional dollar of operating capital by type of plan and type of farm at the present level of capital use.

Type of farm	Type of plan	Marginal value product for operating capital
Owner-operated farms		
Small farms	Benchmark-Present capital	$0.23
	Optimum-Present capital	0.27
Large farms	Benchmark-Present capital	0.11
	Optimum-Present capital	0.15
Crop-share leased farms		
Small farms	Benchmark-Present capital	0.17
	Optimum-Present capital	0.22
Large farms	Benchmark-Present capital	0.12
	Optimum-Present capital	0.12
Livestock-share leased farms		
	Benchmark-Present capital	0.11
	Optimum-Present capital	0.13
All farms (average)		
	Benchmark-Present capital	0.16
	Optimum-Present capital	0.19

cropping practices are fixed do not yield returns as high as where crops and practices are variable. Some of the most profitable capital uses are for fertilizing and other improved practices, as well as for more intensive cropping. Marginal returns to capital would be about the same for owner-operators as for tenants, even though owner-operators use more capital. However, operators of smaller farms could realize higher returns on additional investment than operators of large farms. Operators of these small farms could profitably invest in fertilizer, more intensive rotations where conservation restrictions would allow and livestock enterprises. Since marginal returns to capital are higher than interest rates at present levels of capital use, capital should be borrowed from a strictly profit-maximizing point of view, if not from the standpoint of societal interest in conservation.

Present and Optimum Use of Land

Present cropping and land-treatment systems are quite different from the cropping and mechanical practices associated with the optimum soil-conserving plans. Crops grown, terracing practices and fertilizer use were studied to determine whether changes from current practices would be profitable.

Cropping Sequences

Conservation of soils subject to erosion may be achieved by using cropping sequences that include extensive forage crops or mechanical erosion-control practices, such as terracing and contouring, or a combination of these. These alternative methods were used competitively in this study for finding the most profitable means of reducing erosion losses. However, only continuous meadow would reduce annual soil losses below 5 tons per acre per year on land with average slopes of 11 percent or more if terraces and contouring are not used. Hence, for the 43 percent of the tillable land area in the planned farms which has slopes of 11 percent or more, it was necessary to include terracing and contouring on all cropping sequences used. Program solutions left some of this type of land idle and unterraced. As a practical matter, some kind of cover crop would be used to meet the conservation requirements and also, in many cases, to provide useful pasture.

A summary of present and optimum crop acreages is shown in table 8. Total acreages are given for each major crop for each type of farm and for all farms. The percentages of the cropland in row crops are shown in table 9. The progamming solutions specify a substantial increase in row crops. Hay and pasture acreages are decreased. Conservation objectives are nevertheless met in the optimum farm plans by careful placement of heavy row-crop concentrations on soils that are not subject to severe erosion losses. Terracing slopes also allows heavier row cropping. The increase in idle cropland acres brought about by planning is due to relative enterprise profits which cause scarce resources to be used for activities other than cropping steep and low-producing soils.

At present, far too little distinction is made between the steep upland soils and the more level upland soils or the bottomland and waterway soils. By comparison with the optimum cropping system, farmers of Spring Valley Creek Watershed plant too many row crops on the steep land and too few row crops on the level areas.

It was found that crop-sharing tenants have nearly 20 percent more of their cropland in row crops than do owner-operators. According to the optimum farm plans, however, row-crop intensity should be lower on leased land than on owner-operated land. The reason for this relationship is as follows: A larger proportion of the steep land was programmed to remain idle (in actual practice to be placed in permanent pasture) on leased land, than on owner-operated land. It is more profitable for tenants to use their limited resources on some livestock enterprises than to apply these resources to cropping their poorer land where they must pay the landlord a share of the crop.

It was also found that row-crop intensity is greater for small farms than for large farms in both crop-sharing and owner-operating situations. The plans show that there should be little difference in row-cropping intensity between large and small farms operated by owners. Small crop-share leased farms should have more intensive row cropping than large crop-share leased farms if profits are to be maximized. Large farms of the type studied have a shortage of nonland resources which caused the programs to specify a rather large amount of idle land as permanent pasture for the poorer soils.

No large differences in optimum row-cropping intensity can apparently be ascribed to availability of capital, except in the case of small crop-share

Table 8. Crops grown, by type of farm, at present and for optimum conservation plans (total acres for each group of farms).

Type of farm	Type of plan	Corn	Oats[a]	Meadow[b]	Soybeans	Sorghum[c]	Soil bank	Idled[d]	Total cropland
Owner-operated farms									
Small farms	Present organization	456	145	489	7	34	29	0	1,160
	Optimum-Present capital	594	152	156	221	0	0	37	1,160
	Optimum-High capital	640	161	164	161	0	0	34	1,160
Large farms	Present organization	459	132	605	25	51	43	0	1,315
	Optimum-Present capital	727	131	146	262	0	0	49	1,315
	Optimum-High capital	901	142	167	92	0	0	13	1,315
Crop-share leased farms									
Small farms	Present organization	594	77	277	21	18	21	1	1,009
	Optimum-Present capital	566	60	60	222	0	0	101	1,009
	Optimum-High capital	531	109	170	111	0	0	88	1,009
Large farms	Present organization	557	192	260	15	16	2	2	1,044
	Optimum-Present capital	575	115	105	109	0	0	140	1,044
	Optimum-High capital	577	113	108	128	0	0	118	1,044
Livestock-share leased farms	Present organization	151	59	98	0	57	30	0	395
	Optimum-Present capital	126	27	48	78	0	0	116	395
	Optimum-High capital	160	46	45	45	0	0	99	395
Total of all types of farms	Present organization	2,217	605	1,729	68	176	125	3	4,923
	Optimum-Present capital	2,588	485	515	892	0	0	443	4,923
	Optimum-High capital	2,809	571	654	537	0	0	352	4,923

[a] Includes a small amount of wheat in present crops.
[b] Hay and pasture, only tillable land is included.
[c] Milo for grain or sorghum crops for silage.
[d] Idle land in optimum plans would be in permanent pasture.

Table 9. Average percentages of four types of cropland in row crops by type of farm.

Type of farm	Type of plan	Proportion of very critical upland soils in row crops[a]	Proportion of critical upland soils in row crops[b]	Proportion of good upland soils in row crops[c]	Proportion of valley bottom and floodplain soils in row crops[d]	Proportion of all cropland in row crops
Owner-operated farms						
Small farms	Present	18	37	43	53	41
	Optimum-Present capital	0	49	100	100	73
	Optimum-High capital	20	47	100	96	69
Large farms	Present	e	32	42	34	37
	Optimum-Present capital	e	50	100	100	79
	Optimum-High capital	e	50	100	100	79
Crop-share leased farms						
Small farms	Present	8	42	62	76	64
	Optimum-Present capital	0	33	100	94	80
	Optimum-High capital	0	28	64	96	63
Large farms	Present	33	46	62	50	52
	Optimum-Present capital	0	24	100	78	55
	Optimum-High capital	0	26	97	81	62
Livestock-share leased farms	Present	e	47	54	42	49
	Optimum-Present capital	e	10	100	100	54
	Optimum-High capital	e	20	85	100	54
All types of farms (average)	Present	32	40	52	61	48
	Optimum-Present capital	0	37	100	94	71
	Optimum-High capital	7	39	91	91	66

[a] Average slope 15 percent.
[b] Average slope 11 percent.
[c] Average slopes are 3 and 7 percent.
[d] No eroding hazard.
[e] None of this type soil.

leased farms. In this case, the relaxation of the capital restriction allows livestock activities to drive some of the least profitable crop activities out of the farm plans.

Terracing Practices

Terracing and contouring have great advantage in optimum organizations of farms for conservation farming. As shown in table 10, a large gap exists between the present extent of terracing on the farms studied and the amount of terracing specified in the optimum plans. Here again, there is a large difference between farm types. All but 4 of the 28 farms had some terraces. Owner-operators again show a higher perference for conservation farming by having greater proportions of their farms put into terraces.

Presently, the flat, upland soils are terraced to a greater extent than the steeper hillsides. Physical and economic factors make this advisable. First, it is likely that the present value of the net returns expected from terracing is greater on the gently sloping upland soils than it is on the steeper soils. The possible productivity loss from erosion may not be very great on the already eroded steep soils, whereas terraces protect the good level soils so that very intensive cropping practices can be used. Second, the steep soils make it difficult to farm backslopes on terraces. Farmers object to sodding down back-

Table 10. Average percentages of four types of cropland terraced by types of farms in the base situation and for optimum cropping practices.

Type of farm	Type of plan	Percentage of very critical upland soils terraced	Percentage of critical upland soils terraced	Percentage of good upland soils terraced	Percentage of all cropland terraced
Owner-operated land[a]					
Small farms	Present organization	0.0	38.6	68.7	49.6
	Optimum-Present capital	0.0	100.0	100.0	97.7
	Optimum-High capital	80.0	95.9	100.0	96.6
Large farms	Present organization	b	36.3	71.2	55.7
	Optimum-Present capital	b	100.0	100.0	100.0
	Optimum-High capital	b	100.0	100.0	100.0
Crop-share leased land					
Small farms	Present organization	0.0	10.3	19.9	16.3
	Optimum-Present capital	0.0	83.2	100.0	91.8
	Optimum-High capital	0.0	89.3	100.0	91.3
Large farms	Present organization	37.2	18.4	58.0	35.1
	Optimum-Present capital	0.0	63.4	100.0	75.0
	Optimum-High capital	0.0	76.9	97.9	82.1
Livestock-share leased land	Present organization	b	18.6	62.6	36.7
	Optimum-Present capital	b	31.7	100.0	59.6
	Optimum-High capital	b	43.4	100.0	66.5
Average of land from all farm types	Present organization	27.4	26.6	55.6	40.8
	Optimum-Present capital	0.0	81.7	100.0	98.2
	Optimum-High capital	29.7	87.9	99.6	91.7

[a] In this table a parcel of soil was placed in the tenure category under which it was actually operated. For instance, if an owner-operator rents an extra 10 acres, the 10 acres would appear in the rented category.
[b] No land of this type.

slopes, since there is inconvenience with some crops and crop yields are less. Third, it is not advisable to leave the flat, broad, ridge tops unterraced, and then to proceed to terrace farther down on the slopes. Terraces would tend to wash out—a serious problem for the level terraces used in the area. Also, wet areas may develop below level terraces on lower slopes. Side hills must be done last, if only part of the terracing is done at one time.

In the programming of farms, it was estimated that all cropland should be scheduled for terracing, except cropland that is most profitably left idle or a permanent pasture. On tenant-operated farms, the cost of terraces was depreciated over 4 years as contrasted to the 20-year depreciation period for owner-operators. Even with the increased annual costs of terracing for tenants, because of the shorter tenure expectancy, it would be more profitable to use terracing and intensive crops than to depend on high-forage rotations to achieve conservation. This relation held true even for gently sloping Marshall soils where erosion losses could be adequately curbed by moderate use of forage crops.

Fertilizer Use

Investment in fertilizer is an efficient method for increasing farm profits. The farm programming done in connection with this study showed that fertilizer application was one of the most profitable uses of resources.

Table 11 compares present fertilizer use with optimum rates of use. An extremely wide difference, particularly in the case of crop-sharing tenants, exists between the present practices and those which are recommended. The present fertilizer use was difficult to estimate. Although the measure is not precise, indication is given of the relative position of each type of farm. The over-all average level of fertilizer use is about 15 percent of the recommended level of use.

Soils are seldom scheduled to be cropped without fertilizer in the programming phases of this study. The difference between the optimum fertilizer use indexes and 100, the recommended use rate, arises where some land should be left idle because of more

Table 11. Average fertilizer use index in two plans and in the base situation.

Type of farm	Type of plan	Fertilizer use index Recommended rate = 100[b] (percent)
Owner-operated land[a]		
Small farms	Present organization	14.1
	Optimum-Present capital	100.0
	Optimum-High capital	97.1
Large farms	Present organization	25.7
	Optimum-Present capital	99.5
	Optimum-High capital	99.5
Crop-share leased land[a]		
Small farms	Present organization	6.9
	Optimum-Present capital	90.5
	Optimum-High capital	90.9
Large farms	Present organization	5.5
	Optimum-Present capital	80.6
	Optimum-High capital	88.6
Livestock-share leased land[a]	Present organization	16.5
	Optimum-Present capital	49.8
	Optimum-High capital	53.0
Average of land from all farm types	Present organization	13.6
	Optimum-Present capital	89.8
	Optimum-High capital	89.2

[a] In this table a parcel of soil was placed in the tenure category under which it was actually operated. For instance, if an owner-operator rents an extra 10 acres, the 10 acres would appear in the rented category in this table.
[b] Recommended rate is a composite of the recommended levels of fertilizer application which were given for each cropping sequence on each soil type.

profitable alternatives than cropping and fertilizing of poorer soils on farms with limited resources.

Limited capital is usually given as the reason for limited use of fertilizer. Table 11 shows that, on the average, fertilizer should be used to the same extent in the limited capital situations as in the high capital situations. A general rule can be made: Crops and fertilizer should be a part of the farm plan even at very low capital levels because they give highest return on limited capital. Then, for higher amounts of capital, livestock enterprises become profitable. Balanced fertilizer programs that maintain fertility at a high level are profitable on all farms studied.

Forage Production and Use

Acreage of hay and meadow is much lower in the optimum plans than in currently used plans (table 12). This drop in forage acreage, while still allowing attainment of the soil conservation objective, results from use of mechanical practices and a careful placement of crops with regard to soil slopes. The reduced forage production is also attributable to a decrease in needs for forage. The decrease in high forage-consuming enterprises, such as dairy cows, beef cows and ewes, makes less hay necessary. For the optimum programs with present level of capital use, forage consumption would be about 500 tons greater than production for the farms as a group. It would be possible to offset this forage deficit by placing the poorer soils, which should be left idle according to the optimum plans, into long-term meadows.

When larger amounts of capital are used in the plans, the forage deficit becomes large. However, this deficit could be met by additional use of corn silage, or, in most years, by purchases of hay from some of the nearby hilly soil areas. In summary, the aggregative problems of forage supplies and needs for the programmed plans seem to be rather easily solved.

Grain Production and Use

It would be profitable to increase grain production substantially on farms of Spring Valley Creek Watershed. It was estimated that there is less grain grown at present than is needed for the livestock produced. Table 13 shows present and planned production and livestock feed-grain needs, as well as the surplus or deficit of grains. Under present organization, it was estimated that grain use presently exceeds total grain production (including landlord's share) by 12,500 bushels for the group of 28 farms studied. If these farms adopted the optimum farm plans, there would be a surplus of about 58,000 bushels of grain. In this case, there would be more grain produced, but less would be fed. Even at high capital levels, where more livestock are included in plans, the production approximately equals the use of grain.

Two aspects of the optimum plans contribute to higher grain production: Acreage of grain is greater in total, even though row cropping on steep land is limited. Use of fertilizer and other yield-increasing practices also contributes to greater grain production.

Production of grain on crop-share leased farms appears less per farm than on owner-operated farms since only the tenant's share of production is shown. Deficits in grain availability are more prevalent on tenant farms than on owner-operated farms. Livestock-share leased farms presently have some grain surplus, but in the optimum plans, production and use would be about equal.

Table 12. Average quantity (tons) of hay and pasture produced and used by type of farm.

Type of farm	Type of plan	Hay grown	Hay fed	Surplus or deficit[a]
Owner-operated farms				
Small farms	Present organization	120	117	3
	Benchmark-Present capital	120	83	37
	Benchmark-High capital	120	140	-20
	Optimum-Present capital	49	64	-15
	Optimum-High capital	44	107	-63
Large farms	Present organization	263	283	-20
	Benchmark-Present capital	263	223	40
	Benchmark-High capital	263	346	-83
	Optimum-Present capital	105	164	-59
	Optimum-High capital	114	338	-224
Crop-share leased farms				
Small farms	Present organization	78	55	23
	Benchmark-Present capital	78	48	-30
	Benchmark-High capital	78	99	-21
	Optimum-Present capital	29	27	2
	Optimum-High capital	79	101	-22
Large farms	Present organization	97	98	-1
	Benchmark-Present capital	97	103	-6
	Benchmark-High capital	97	155	-58
	Optimum-Present capital	98	93	5
	Optimum-High capital	102	178	-76
Livestock-share leased farms	Present organization	48	46	2
	Benchmark-Present capital	48	64	-16
	Benchmark-High capital	48	65	-17
	Optimum-Present capital	62	62	0
	Optimum-High capital	73	94	-21
All farms (average)	Present organization	138	136	2
	Benchmark-Present capital	138	112	26
	Benchmark-High capital	138	180	-42
	Optimum-Present capital	67	85	-18
	Optimum-High capital	83	177	-94
All farms (total)	Present organization	3,858	3,817	41
	Benchmark-Present capital	3,858	3,143	715
	Benchmark-High capital	3,858	5,044	1,186
	Optimum-Present capital	1,878	2,384	-506[b]
	Optimum-High capital	2,329	4,956	-2,627[c]

[a] Surplus is positive, deficit negative.

[b] 433.1 acres of land programmed to remain idle is available for permanent meadow. If this were used as improved pasture, it could yield about 1.7 tons per acre. This would give 736 tons of hay, more than enough to make up the deficit.

[c] 342.4 acres of land programmed to remain idle could produce 582 tons of hay equivalent at 1.7 tons per acre to make up part of the deficit.

Value of Additional Land

The shadow prices generated in the programming solutions provide indications of the value (per year) of additional land for each farm. Table 14 shows these values for the four land-use intensity classes by type of farm. As might be expected, an additional amount of the better land is estimated to be

Table 13. Grain produced and used (bushels) by type of farm.

Type of farm	Type of plan	Grain grown	Grain fed	Surplus or deficit	Total bushels purchasable from crop-share landlords
Owner-operated farms					
Small farms	Present organization	3,103	3,870	-767	----
	Benchmark-Present capital	3,103	3,998	-895	----
	Benchmark-High capital	3,103	5,561	-2,458	----
	Optimum-Present capital	4,680	3,252	1,428	----
	Optimum-High capital	4,878	4,948	-70	----
Large farms	Present organization	3,912	7,255	-3,343	----
	Benchmark-Present capital	3,912	6,169	-2,257	----
	Benchmark-High capital	3,912	9,972	-6,060	----
	Optimum-Present capital	7,610	6,088	1,522	----
	Optimum-High capital	9,381	10,921	-1,540	----
Crop-share leased farms					
Small farms	Present organization	1,973	2,521	-548	----
	Benchmark-Present capital	1,973	1,928	45	----
	Benchmark-High capital	1,973	4,333	-2,360	----
	Optimum-Present capital	2,643	2,257	386	----
	Optimum-High capital	2,653	4,617	-1,964	----
Large farms	Present organization	3,529	5,292	-1,763	----
	Benchmark-Present capital	3,529	4,612	-1,083	----
	Benchmark-High capital	3,529	6,977	-3,448	----
	Optimum-Present capital	4,929	4,945	-16	----
	Optimum-High capital	5,023	6,867	-1,844	----
Livestock-share leased farms	Present organization	2,289	1,359	930	----
	Benchmark-Present capital	2,289	1,710	579	----
	Benchmark-High capital	2,289	2,235	54	----
	Optimum-Present capital	2,102	2,018	84	----
	Optimum-High capital	2,652	2,652	0	----
All farms (average)	Present organization	3,000	4,390	-1,390	----
	Benchmark-Present capital	3,000	3,901	-901	----
	Benchmark-High capital	3,000	6,320	-3,320	----
	Optimum-Present capital	4,723	3,876	847	----
	Optimum-High capital	5,317	6,540	-1,223	----
All farms (total)	Present organization	83,990	122,939	-38,949	26,450
	Benchmark-Present capital	83,990	109,235	-25,245	26,450
	Benchmark-High capital	83,990	176,967	-92,977	26,450
	Optimum-Present capital	132,245	108,535	23,710	34,355
	Optimum-High capital	148,885	183,127	-34,242	34,648

Table 14. Average marginal value (per year) of an additional acre of land by type of land and type of farm (dollars per acre).

Type of farm	Type of plan	Very critical upland soils	Critical upland soils	Good upland soils	Bottom-land drainage-way soils
Owner-operated land					
Small farms	Optimum-Present capital	a	9.32	28.82	32.63
	Optimum-High capital	8.98	12.43	27.90	33.97
Large farms	Optimum-Present capital	a	13.65	30.21	37.49
	Optimum-High capital	a	17.29	33.00	44.94
Crop-share leased land					
Small farms	Optimum-Present capital	0	0.60	8.34	12.90
	Optimum-High capital	0	2.15	7.28	12.45
Large farms	Optimum-Present capital	0	0.42	6.98	10.62
	Optimum-High capital	0	0.79	5.93	7.40
Livestock-share leased land	Optimum-Present capital	a	0	9.03	10.18
	Optimum-High capital	a	0	7.68	8.97
All land (average)	Optimum-Present capital	0	7.10	18.12	20.58
	Optimum-High capital	3.99	9.61	18.69	21.99

a No observations.

worth far more than additional acreage of poor, steep land. At the present level of capital use, an additional acre of steep eroded cropland actually would be worthless to any farm. At high capital levels, added amounts of this type of cropland would have some value. It has a fairly high forage-producing ability in supplying the livestock which accompany the programs for higher capital use.

Marginal value of a unit of land for small farms was about the same as the marginal value of the same type of land for larger farms. Since the large farms were much more profitable, it seemed that smaller farms could more profitably use additional land. However, the value of an additional amount of land depends on the entire bundle of resources available on the farm. Therefore, capital and hog farrowing space, which are limiting on most small farms, and other resource restrictions, which are limiting in the program solutions, cause additional land to be no more valuable to small farms than to large farms when both are optimally organized.

As would be expected, an additional unit of owner-operated land would have much higher value than does a unit of leased land. It cannot be concluded directly, however, that it would always pay a tenant to buy land or an owner-operator to buy more land rather than to rent if he wishes to expand. Nor do these values indicate that it would be profitable for farmers to acquire more land by either renting or buying. The fixed costs of land ownership must be considered, along with the allocation of capital over the whole farm organization. However, some estimates of the possible gain can be made from these marginal coefficients with respect to the advisability of acquiring additional land. If acquisition costs, depreciated to a yearly basis, plus other fixed costs of land ownership, are less than the marginal values (shadow prices) given in table 14, purchase of additional land would be profitable if sufficient capital is available. Again, caution should be exercised. These quantities refer only to part of the range of the data. Also these marginal values are based on optimum farm organizations, whereas actual land acquisition would need to be based on expected performance for each individual.

Comparison of Livestock Systems

At present, the farmers in Spring Valley Creek Watershed have far more diversified livestock systems than this study shows to be profitable. Farmers have tended to have a few of several kinds of livestock. The plans computed for this study suggest more specialized livestock enterprises, except when plans are limited by particular resource restrictions. Farmers should develop the most profitable livestock enterprise until housing, labor or other restrictions cut off further production; then move to the next most profitable type of livestock that fits in with the over-all plan.

Some advanced types of livestock production, such as multiple-farrowing hog enterprises do not appear in this study. The farms were all planned on the assumption of an average level of management. It was believed that average managers would not be able to adequately manage the multiple-farrowing systems. For the same reason, heavy, short-fed, beef-feeding operations were not included. Some operators seem to be capable of higher level management than reflected in this study, but differences in managerial ability are very difficult to evaluate objectively. Hence, management at an average level was used for all operators in this study. Assumption of above-average management would have caused farm reorganizations to comply with plans including conservation to be even more relatively profitable.

Present and Optimum Livestock Enterprises

A summary of livestock enterprises in the present organization and for the optimum plans is presented in table 15. Dairying enterprises are not in the optimum plans. However, grade A milk production could be profitable where facilities are available and new investment would not be required. Grade A milk production was not profitable at production levels being attained among dairy herds of the area. To test the level of production required to make dairying profitable, a programming model using the previously discussed set of prices, which varied the level of milk yield per cow, was computed for one of the farms with grade A milk production facilities. The model indicated that, even with efficient labor use for conventional stanchion barns on hand, a level of approximately 9,000 pounds of milk per cow was necessary for dairying to be a profitable alternative in comparison with the other farm activities competing for the available resources. Of course, a sufficient rise in the milk price would make dairying more profitable at current levels of production per cow.

The Z_j-C_j values, the net returns over fixed costs, from the general programming models (the shadow prices) show that cows producing only butterfat were extremely unprofitable for all farms in the study. It was estimated that the marginal loss from introducing one butterfat-producing cow into the plans approached $100, as compared with other uses of resources in devising a profit-maximizing farm organization.

The cattle-feeding program specified by the linear programming results revolved mainly around a specialized deferred-fed calf program. The optimum plans for the current level of capital showed that the number of cattle currently fed on farms usually is the most profitable number. The plans showed some farmers decreasing numbers of cattle and others increasing, however. Beef-cow herds are generally much less profitable than beef-feeding. However, some of the larger farms had extended cattle feeding to a point where marginal return on investment was small. Under these circumstances, small beef-cow herds were profitable as a supplementary enterprise.

In general, spring hog litters are the most profitable livestock enterprise included in the programs. Next in order of profit from all scarce resources are deferred-fed calves. For a few farms, ewe flocks, laying hens and beef cows in limited quantities proved to be profitable in the order mentioned.

Farm Building Costs and Marginal Value Products

With the exception of hog-farrowing facilities, farm buildings seldom limited the plans. Most livestock facilities are adequate in quantity for the amount of capital and labor on the farms of the watershed. While some farmers of the Spring Valley Creek Watershed could profitably invest in hog facilities, because building space limits profits, this investment would not be profitable for the majority.

Marginal value productivities of the annual services of various types of livestock buildings are shown in table 16. These values, in general and as an average for all farm situations, are about equal to the annual costs per unit of adding to building facilities for hogs. The zero marginal value productivities arise in table 16 where buildings are already in excess of needs.

Labor Use

Labor use would decrease on all the farms studied, if all farms were optimally organized under present resource availabilities. Labor requirements would decrease by about 10 percent in the heavy cropping season from May to November and would decrease by about 40 percent in the winter months. Labor would be in surplus relative to requirements for

Table 15. Average number of livestock by type of farm.

Type of farm	Type of plan	Spring hog litters	Fall hog litters	Cream producing milk cows	Grade A dairy cows	Choice feeder calves	Yearling feeders	Ewes	Hens	Beef cows	Purchased feeder hogs
Owner-operated farms											
Small farms	Present organization	10	6	1	--	22	5	21	43	3	--
	Benchmark-Present capital	17	--	--	--	32	--	6	--	--	--
	Benchmark-High capital	20	--	--	--	59	--	3	--	--	--
	Optimum-Present capital	16	--	--	--	24	--	--	18	--	--
	Optimum-High capital	19	--	--	--	45	--	--	64	--	--
Large farms	Present organization	7	4	2	9	5	105	16	98	19	27
	Benchmark-Present capital	19	--	--	5	67	--	16	--	5	--
	Benchmark-High capital	20	--	--	--	172	--	--	--	5	--
	Optimum-Present capital	18	--	--	1	73	--	--	25	--	--
	Optimum-High capital	18	--	--	--	163	--	--	35	--	--
Crop-share leased farms											
Small farms	Present organization	16	3	3	--	--	--	--	34	5	--
	Benchmark-Present capital	6	--	--	--	22	--	--	--	--	--
	Benchmark-High capital	17	--	--	--	42	--	--	--	--	--
	Optimum-Present capital	16	--	--	--	8	--	--	--	--	--
	Optimum-High capital	22	--	--	--	41	--	--	--	--	--
Large farms	Present organization	23	12	--	--	17	13	1	94	10	--
	Benchmark-Present capital	17	--	--	--	46	--	--	--	--	--
	Benchmark-High capital	24	--	--	--	80	--	--	--	6	--
	Optimum-Present capital	24	--	--	--	38	--	--	--	--	--
	Optimum-High capital	24	--	--	--	81	--	--	--	--	--
Livestock-share farms	Present organization	8	4	--	--	--	35	--	--	1	--
	Benchmark-Present capital	1	--	--	--	64	--	--	--	--	--
	Benchmark-High capital	13	--	--	--	54	--	--	--	2	--
	Optimum-Present capital	13	--	--	--	45	--	--	--	--	--
	Optimum-High capital	13	--	--	--	68	--	--	--	--	--
All farms (average)	Present organization	13	6	2	2	10	32	9	62	11	7
	Benchmark-Present capital	13	--	--	1	44	--	6	--	1	--
	Benchmark-High capital	19	--	--	--	88	--	1	--	3	--
	Optimum-Present capital	17	--	--	--	30	--	--	9	--	--
	Optimum-High capital	20	--	--	--	76	--	--	27	--	--
All farms (total)	Present organization	361	155	47	52	270	910	265	1,745	310	189
	Benchmark-Present capital	369	--	--	32	1,235	--	163	--	39	--
	Benchmark-High capital	532	--	--	--	2,457	--	36	--	73	--
	Optimum-Present capital	488	--	--	6	831	--	--	242	--	--
	Optimum-High capital	553	--	--	--	2,126	--	--	744	--	--

Table 16. Annual value of an additional unit of specified farm buildings by type of farm.

Type of farm	Type of plan	Grade A dairy barn ($/cow)	Cow barn ($/cow)	Hen house ($/hen)	Hog farrowing ($/litter spring pigs)	Lambing shed ($/ewe)
Owner-operated farms						
Small farms	Benchmark-Present capital	--	0	0	6.18	--
	Benchmark-High capital	--	0	0	5.02	--
	Optimum-Present capital	--	0	0	15.83	--
	Optimum-High capital	--	0	0.56	12.74	--
Large farms	Benchmark-Present capital	0	0	0	9.26	0
	Benchmark-High capital	0	0	0	8.88	0
	Optimum-Present capital	0	0	0.04	11.58	0
	Optimum-High capital	0	0	0.04	7.33	0
Crop-share leased farms						
Small farms	Benchmark-Present capital	--	0	0	11.58	--
	Benchmark-High capital	--	0	0	12.35	--
	Optimum-Present capital	--	0	0	10.81	--
	Optimum-High capital	--	0	0	9.65	--
Large farms	Benchmark-Present capital	--	0	0	6.56	--
	Benchmark-High capital	--	0	0	9.26	--
	Optimum-Present capital	--	0	0	3.47	--
	Optimum-High capital	--	0	0	6.18	--
Livestock-share leased farms	Benchmark-Present capital	--	--	--	0	--
	Benchmark-High capital	--	--	--	1.16	--
	Optimum-Present capital	--	--	--	11.58	--
	Optimum-High capital	--	--	--	7.33	--
All farms (average)	Benchmark-Present capital	0	0	0	7.72	0
	Benchmark-High capital	0	0	0	8.11	0
	Optimum-Present capital	0	0	0.04	11.58	0
	Optimum-High capital	0	0	0.24	9.65	0

every class of farm during the winter season. The decline in winter labor requirements would be due primarily to a decrease in dairy herds, ewe flocks and fall-farrowed hogs. All farms, except large owner-operated units, would profitably use less than one man's labor in the winter months.

A summary of labor use for each farm group and each planning situation is included in table 17. The changes in labor requirements for the different planning situations are very similar for all of the types of farms. In general, smaller farms would use slightly less than one man's labor in the optimum plans while the larger farms need somewhat more than one man's labor in the summer months.

Table 17. Average monthly labor use for summer and winter months by type of farm (hours).

Type of farm	Type of plan	May to Nov. ave. monthly labor use	Dec. to Apr. ave. monthly labor use
Owner-operated farms			
Small farms	Present organization	250	145
	Benchmark-Present capital	231	111
	Benchmark-High capital	281	141
	Optimum-Present capital	225	100
	Optimum-High capital	265	132
Large farms	Present organization	461	334
	Benchmark-Present capital	443	198
	Benchmark-High capital	543	263
	Optimum-Present capital	416	150
	Optimum-High capital	559	272
Crop-share leased farms			
Small farms	Present organization	248	140
	Benchmark-Present capital	213	77
	Benchmark-High capital	273	128
	Optimum-Present capital	196	84
	Optimum-High capital	273	127
Large farms	Present organization	351	214
	Benchmark-Present capital	341	152
	Benchmark-High capital	411	210
	Optimum-Present capital	371	158
	Optimum-High capital	431	189
Livestock-share leased farms	Present organization	281	133
	Benchmark-Present capital	277	105
	Benchmark-High capital	300	136
	Optimum-Present capital	270	112
	Optimum-High capital	320	139
All farms (average)	Present organization	323	203
	Benchmark-Present capital	303	130
	Benchmark-High capital	370	180
	Optimum-Present capital	293	118
	Optimum-High capital	375	177

Programming results indicated, as expected, that the marginal value of an additional unit of labor was higher for large farms than for small farms. Programming alternatives for some large farms included labor purchase. Accordingly, the marginal value of labor was lower than if the labor supply had been limited to that supplied by the operator and family (the procedure used for small farms). Marginal value products for labor are shown in table 18 for each type of farm. The marginal value productivity of labor increases with increased capital availability to the farms. Abundance of labor relative to availability causes small farms to have zero marginal value productivities of labor in the December-April period.

Implications in Policy

In this study, a group of farms located in the Spring Valley Creek Watershed in Mills County, Iowa, were examined to determine the profitability of conservation to individual farm operators. No attempt was made to determine the exact level of conservation that would be most profitable for each farm. The present farm organization was compared with a system that would control erosion. The primary objective was to determine whether individual farmers, without government help beyond the present cost-sharing on terraces and other mechanical practices, could reorganize their farms to meet conservation goals specified by the Soil Conserva-

Table 18. Average value of an additional hour of labor by type of farm (dollars per hour).

Type of farm	Type of plan	Dec.-Jan.-Feb. labor	Mar.-Apr. labor	May-June labor	July-Aug. labor	Sept.-Oct. Nov. labor
Owner-operated farms						
Small farms	Benchmark-Present capital	0.00	0.00	0.00	0.57	0.00
	Benchmark-High capital	0.00	0.00	0.36	0.96	2.33
	Optimum-Present capital	0.00	0.00	0.29	0.00	0.52
	Optimum-High capital	0.00	0.00	1.24	0.00	2.43
Large farms	Benchmark-Present capital	0.09	0.21	0.41	0.39	1.02
	Benchmark-High capital	0.21	0.15	0.25	0.75	1.58
	Optimum-Present capital	0.02	0.10	0.80	0.19	0.84
	Optimum-High capital	0.23	0.24	0.75	0.56	1.53
Crop-share leased farms						
Small farms	Benchmark-Present capital	0.00	0.00	0.00	0.00	0.00
	Benchmark-High capital	0.00	0.00	0.20	0.00	2.05
	Optimum-Present capital	0.00	0.00	0.17	0.00	0.00
	Optimum-High capital	0.00	0.00	0.40	0.00	1.77
Large farms	Benchmark-Present capital	0.00	0.00	0.00	0.00	0.66
	Benchmark-High capital	0.00	0.00	0.00	0.00	2.56
	Optimum-Present capital	0.00	0.00	1.23	0.00	0.69
	Optimum-High capital	0.18	0.00	1.38	0.00	1.74
Livestock-share leased farms	Benchmark-Present capital	0.00	0.00	0.66	0.50	0.51
	Benchmark-High capital	0.00	0.00	0.66	0.50	1.38
	Optimum-Present capital	0.00	0.00	0.23	0.00	0.55
	Optimum-High capital	0.00	0.00	0.66	0.07	1.19
All farms (average)	Benchmark-Present capital	0.03	0.07	0.19	0.32	0.43
	Benchmark-High capital	0.06	0.05	0.34	0.55	1.97
	Optimum-Present capital	0.01	0.03	0.52	0.08	0.52
	Optimum-High capital	0.08	0.06	0.90	0.15	1.88

tion Service and still maintain or increase farm profits.

It was found that the farms in this study could profitably adopt farm plans that would provide for conservation of topsoil. These profitable adjustments required substantial reorganization of the farms. However, with the set of resources presently used, these reorganizations could be made profitably on all farms studied. The procedure of planning farms with respect to physical considerations alone is inadequate. For example, some farms with limited land, livestock facilities and operating capital could not provide adequate family living levels if too high a percentage of cropland is devoted to forage production as the means of attaining erosion control. Whole-farm planning, using resource limitations, relevant production alternatives and alternative methods of attaining conservation goals is desirable for deriving profitable farm plans that achieve conservation. Some of the farmers presently following conservation plans most closely could increase profit most by using the farm plans developed in this study. Other farmers have not adopted single conservation practices because of increased costs and decreased income associated with them. However, these same farmers could profitably adopt over-all farm plans that include attainment of minimum levels of conservation. Thus, linear programming is an appropriate tool for specifying optimum soil-conserving farm plans, since resource limitations and production possibilities of many kinds can be considered.

Adoption of the profitable soil-conserving farm plans derived in this study would require substantial farm organization changes. However, once these changes were made, all farms studied would have greater profit and would attain a level of conservation that would result in better water control for the watershed as a whole. In the case of our study, profits could be improved with current amounts of capital and existing conditions of ownership and tenancy.

For the particular watershed, there appears to be no conflict between (a) public goals for control of soil erosion and water runoff and (b) profits of individual farmers. Greater amounts of both can be attained if farms are reorganized to increase income while meeting the restraints in erosion. Because of the apparent complementarity between public and private goals, an important role of public agencies is to carry education to farmers. The role of the government would be to facilitate reorganization of farms to attain conservation. Public funds for practice subsidies then can be allocated to watersheds where the level of conservation required for meeting society's interest in erosion and runoff control is not profitable to individual farmers.

APPENDIX

Table A-1. Crop yields by soil types, crop sequences, conservation practices and fertility levels used in programming, Spring Valley Creek Watershed[a].

		Fertilizer level					Average yearly per acre soil loss in tons	
		F_0[b]		F_1[b]				
Rotation	Crop	Yield[c] without conservation practices	Yield with conservation practices	Fertilizer rate N-P-K[d]	Yield[c] without conservation practices	Yield with conservation practices	Without conservation practices	With conservation practices
Marshall silt loam, 2 to 5 percent slope, erosion factor of 1 or 2.								
COMM	corn	65	68	10-25-0	67	70	--	--
	oats	35	35	10-65-0	40	40	2	0.4
	meadow$_1$	2.0	2.0	0	2.8	2.8	--	--
	meadow$_2$	1.8	1.8	0	3.0	3.0	--	--
CCOM	corn$_1$	--[e]	68	20-25-0	--[e]	70	--	--
	corn$_2$	--	58	60-25-0	--	68	6	1
	oats	--	35	30-45-0	--	40	--	--
	meadow	--	2.0	0	--	2.8	--	--
CCO$_{sc}$	corn$_1$	--	58	50-25-0	--	65	--	--
	corn$_2$	--	53	80-25-0	--	63	10	2
	oats	--	30	30-25-0	--	40	--	--
CSB	corn	--	51	80-25-0	--	65	14	3
	soybeans	--	21	0-10-0	--	26	--	--
C	corn	--	25	80-25-0	--	64	14	3
Monona and Marshall silt loam, 5 to 9 percent slope, erosion factor of 1, 2, or 3.								
COMM	corn	--	56	10-25-0	--	65	--	--
	oats	--	38	20-65-0	--	40	6	1
	meadow$_1$	--	2.2	0	--	2.8	--	--
	meadow$_2$	--	2.2	0	--	2.8	--	--
CCOM	corn$_1$	--	55	20-25-0	--	65	--	--
	corn$_2$	--	45	60-25-0	--	60	15	2
	oats	--	38	30-45-0	--	40	--	--
	meadow	--	2.2	0	--	2.8	--	--
CCO$_{sc}$	corn$_1$	--	50	50-25-0	--	62	--	--
	corn$_2$	--	40	80-25-0	--	57	26	4
	oats	--	30	30-25-0	--	40	--	--
CSB	corn	--	35	80-25-0	--	60	39	5
	soybeans	--	20	0-10-0	--	25	--	--
C	corn	--	30	80-25-0	--	58	39	5
COMM	corn	--	50	10-25-0	--	58	--	--
	oats	--	25	20-65-0	--	36	15	2
	meadow$_1$	--	2.2	0	--	2.8	--	--
	meadow$_2$	--	2.2	0	--	2.8	--	--
CCOM	corn$_1$	--	48	20-25-0	--	58	--	--
	corn$_2$	--	37	60-25-0	--	55	37	5
	oats	--	25	30-45-0	--	36	--	--
	meadow	--	2.2	0	--	2.8	--	--
Monona silt loam, 9 to 14 percent slope, erosion factor of 3.								
COMM	corn	--	45	15-30-0	--	55	--	--
	oats	--	20	20-90-0	--	35	22	2
	meadow$_1$	--	2.2	0	--	2.8	--	--
	meadow$_2$	--	2.2	0	--	2.8	--	--
CCOM	corn$_1$	--	45	25-30-0	--	55	--	--
	corn$_2$	--	35	70-30-0	--	50	53	5
	oats	--	20	30-60-0	--	35	--	--
	meadow	--	2.2	0	--	2.8	--	--
Monona silt loam, 14 to 18 percent slope, erosion factor of 3.								
COMM	corn	--	40	30-30-0	--	50	--	--
	oats	--	20	20-90-0	--	35	37	5
	meadow$_1$	--	2.2	0	--	2.8	--	--
	meadow$_2$	--	2.2	0	--	2.8	--	--
Ida and Dow silt loam, 9 to 14 percent slope, erosion factor of 2 or 3.								
COMM	corn	--	20	20-30-0	--	50	--	--
	oats	--	15	20-90-0	--	32	23	2
	meadow$_1$	--	0.5	0	--	2.4	--	--
	meadow$_2$	--	0.5	0	--	2.4	--	--
CCOM	corn$_1$	--	20	30-30-0	--	50	--	--
	corn$_2$	--	15	80-30-0	--	48	57	5
	oats	--	15	20-60-0	--	32	--	--
	meadow	--	0.5	0	--	2.4	--	--
Judson silt loam and upland drainage complex, 1 to 3 percent slope, erosion factor of +, 0, or 1.								
COMM	corn	70	--	0-20-0	72	--	--	--
	oats	40	--	5-40-0	45	--	0	0
	meadow$_1$	2.5	--	0	2.8	--	--	--
	meadow$_2$	2.5	--	0	2.8	--	--	--
CCOM	corn$_1$	65	--	10-20-0	70	--	--	--
	corn$_2$	55	--	40-20-0	67	--	0	0
	oats	38	--	5-30-0	45	--	--	--
	meadow	2.5	--	0	2.8	--	--	--
CCO$_{sc}$	corn$_1$	60	--	30-20-0	70	--	--	--
	corn$_2$	50	--	60-20-0	67	--	0	0
	oats	30	--	5-20-0	45	--	--	--
CSB	corn	45	--	80-20-0	67	--	0	0
	soybeans	23	--	0-10-0	26	--	--	--
C	corn	40	--	80-20-0	67	--	0	0
Kennebec silt loam, 0 to 2 percent slope, erosion factor of + or 1.								
CCOM	corn$_1$	68	--	5-20-0	75	--	--	--
	corn$_2$	60	--	30-20-0	70	--	0	0
	oats	32	--	10-25-0	50	--	--	--
	meadow	2.5	--	0	3.0	--	--	--
CCO$_{sc}$	corn$_1$	62	--	20-20-0	73	--	--	--
	corn$_2$	57	--	40-20-0	68	--	0	0
	oats	32	--	10-15-0	50	--	--	--
CSB	corn	55	--	60-20-0	73	--	0	0
	soybeans	24	--	0-0-0	28	--	--	--
C	corn	45	--	60-20-0	70	--	0	0

Table A-1 (continued)

Rotation	Crop	Fertilizer: F_0[b] Yield[c] without conservation practices	F_0[b] Yield with conservation practices	F_1[b] Fertilizer rate N-P-K[d]	F_1[b] Yield[c] without conservation practices	F_1[b] Yield with conservation practices	Average yearly per acre soil loss in tons: Without conservation practices	With conservation practices
Colo silty clay loam, 0 to 2 percent slope, erosion factor of +.								
CCOM	corn$_1$	68	--	5-20-0	70	--	--	--
	corn$_2$	60	--	30-20-0	67	--	0	0
	oats	42	--	10-25-0	52	--	--	--
	meadow	2.8	--	0	3.0	--	--	--
CCO	corn$_1$	63	--	20-20-0	68	--	--	--
	corn$_2$	60	--	40-20-0	65	--	0	0
	oats	40	--	10-15-0	50	--	--	--
CSB	corn	55	--	60-20-0	68	--	0	0
	soybeans	26	--	0-0-0	29	--	--	--
C	corn	45	--	60-20-0	66	--	0	0
Zook silty clay loam, 0 to 2 percent slope, erosion factor of +.								
CCOM	corn$_1$	45	--	10-20-0	48	--	--	--
	corn$_2$	40	--	40-20-0	45	--	0	0
	oats	27	--	10-25-0	35	--	--	--
	meadow	2.2	--	0	2.4	--	--	--
CCO$_{sc}$	corn$_1$	45	--	30-20-0	47	--	--	--
	corn$_2$	40	--	60-20-0	45	--	0	0
	oats	27	--	10-15-0	35	--	--	--
CSB	corn	38	--	70-20-0	47	--	0	0
	soybeans	22	--	0-0-0	24	--	--	--
C	corn	36	--	70-20-0	46	--	0	0
Nodaway silt loam, 0 to 2 percent slope, erosion factor of + or 0.								
CCOM	corn$_1$	68	--	10-20-0	75	--	--	--
	corn$_2$	60	--	40-20-0	70	--	0	0
	oats	42	--	10-25-0	55	--	--	--
	meadow	2.6	--	0	3.2	--	--	--
CCO$_{sc}$	corn$_1$	62	--	30-20-0	73	--	--	-- --
	corn$_2$	57	--	60-20-0	68	--	0	0
	oats	42	--	10-15-0	55	--	--	--
CSB	corn	50	--	80-20-0	73	--	0	0
	soybeans	27	--	0-0-0	30	--	--	--
C	corn	40	--	80-20-0	70	--	0	0

a Crop yield estimates and fertilizer recommendations were based on information contained in: W. D. Shrader, et al. Estimated crop yields on Iowa soils. Iowa Agr. and Home Econ. Exp. Sta. and Coop. Ext. Serv. Spec. Report 25. 1960.

b F_0 assumes application of little or no commercial fertilizer. F_1 represents recommended fertilizing rates.

c Corn and oats yield in bushels per acre; hay yield in tons per acre.

d Fertilizer rate in pounds of available nutrients per acre.

e No yields were estimated where soil loss was above allowable rate.