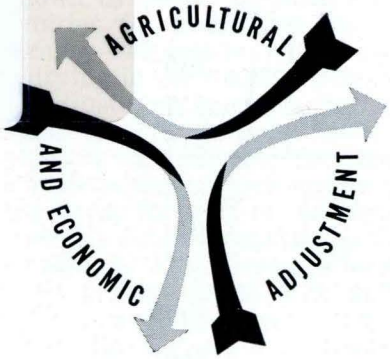

An Analysis of Income Possibilities From Farm Adjustments In Southern Iowa; Including Production of Grade B Milk

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SUMMARY

This study was initiated because of the interest shown by people of Adams County in the opportunities for increasing income on farms in the locality—especially with respect to the role of dairying in the county. It is one of several studies of adjustment opportunities open to farm families being made in southern Iowa. The purpose of the study is to determine the income consequences of certain actions which might be taken by individual farm families on soil types similar to those found in Adams County—not to pass judgment on whether these actions are beneficial or harmful to other persons or the community structure.

This study has been made for Adams County where Sharpsburg and Shelby soils make up most of the cropland. Owner-operation of a 240-acre farm with 152 cultivated acres is used as a basis for the analysis. Analysis is made of returns from different plans, when farms are operated under either average or superior management. Special attention is given to the role of and returns from a grade B dairy enterprise under the two levels of management. For comparative purposes, situations were studied which excluded grade B dairy under average management and which excluded both butterfat cows and grade B dairy under superior management.

Specified resource situations are used for the analysis made by linear programming techniques. These are: sufficient building space to provide for all crops raised; 895 square feet of floor space for fattening hogs, plus sufficient farrowing space in portable farrowing houses; farm space for 20 dairy cows; and poultry housing for 200 hens, with brooder space for the necessary baby chicks. The labor supply is that furnished by the operator and his family, except in the pasture renovation situation where extra labor can be hired. Housewife labor is assumed for care of the poultry flock. Different levels of capital are considered in the analysis.

In all plans computed, use of Shelby cropland is determined by the livestock system. A CCOM rotation is used throughout on Sharpsburg soils, but the rate of fertilizer changes with capital levels, moving to the highest rates only when capital is nonlimiting and dairy cows are not included in the plan. For the farm under average management, operating without the opportunity of a grade B dairy enterprise, 11 cows producing butterfat are in the optimum plan at both the $5,000 and $10,000 capital levels. Hogs represent the next most profitable livestock investment at low capital levels and expand to the limit allowed by building space when capital is sufficiently great. As capital is increased above $10,000, commercial heifers and deferred steers replace the butterfat enterprise.

When grade B dairy cows are allowed, they outcompete other livestock for funds at the $5,000 capital level. At the $10,000 capital level, the dairy herd size increases, but hogs also enter the plan. Plans including the grade B dairy enterprise have higher returns than those excluding this enterprise at these two capital levels. At the nonlimiting capital level, however, hog numbers are increased, and cattle feeding, represented by commercial heifers, is included. A laying flock is included only in plans where capital is not limited.

Under superior management, hogs return more to capital than do other livestock enterprises when milk cows and grade B dairy cows are not allowed in the plan. Capital returns increase, and enterprises enter the plan in this order: hogs, followed by deferred-fed steers, medium steers and hens. With a 12-cow minimum for grade B dairy, this enterprise enters the optimum plan only at the $12,146 capital level. At higher or lower capital levels optimum plans include fewer than 12 grade B cows under superior management—an enterprise size which would not meet the market specification for whole milk sales and equipment financing.

As part of the analysis, dairy and beef cows and fall utilization of native pasture were forced into the plan to attain a farm organization with greater income stability and less risk. Previous studies have shown that these enterprises have less income variance than hogs or feeder cattle. In this step, 12 dairy cows producing grade B milk and 9 beef cows were forced into the plan. The question to be answered was: How much income must be sacrificed for a plan of this type?

Under superior management, net returns are reduced to a level approximately 20 percent below the competitive plans which exclude all dairy enterprises. Under average management, forcing dairy and beef cows into the plan hardly reduces income and might be preferred by some operators for this reason. The study indicates, especially for average managers, that there are several plans which give about the same return. Hence, selection of a plan might be based on personal preference, ability to stand risks, capital position or efficiency in predicting future markets.

Pasture renovation, since it returns less to capital than other enterprises, enters the optimum plan only at a capital level of $27,211. Even then, it comes into the plan only when land purchase is not considered as an alternative. Returns to capital from pasture renovation generally cannot compete with investments in livestock or land buying.

When the land-buying activity is included as an alternative, pasture renovation is eliminated from the plan. Optimum farm size, based on the criterion of profit maximization, increases from 240 to 483 acres in the plan with nonlimiting capital. A family farm of this size in Adams County would include 306 acres of cropland, 151 acres of permanent pasture and 26 acres of building site, roads and waste. The optimum plan, including land buying, gives a return of more than 6 percent on the last increments of capital.

A farm of this size operated under ownership, however, requires a large capital outlay. The total capital involved is over $85,000—even though only

40 percent of the added acreage is assumed to require operator's equity. Assuming a 40-percent equity in all capital, the operator would need $43,864 of equity funds for the 483 acres, plus that represented by the livestock, equipment and supplies in the optimum plan. But as census data show, a significant shift toward farms of this size is taking place in southern Iowa and Adams County. Between 1949 and 1954, an 18-percent increase took place in the size of farms in the 260 to 480 acreage interval. During the same period, the number of farms in every census group below 260 acres decreased.

This study indicates that average managers can make some improvement in income by an optimum selection of enterprises and use of somewhat more capital. For the plans studied for farms under average management, net income ranged from $2,036 for a plan using $5,000 in operating capital (excluding that invested in machinery and real estate and including hogs and dairy cows producing butterfat) to $4,207 of net income for a plan using $17,140 of operating capital and including hogs, cattle feeding and poultry. The greatest income opportunity for the average operator, however, is in improving management while using more capital. Results for a superior manager ranged from a net income of $2,288 for a plan using $5,000 of working capital to $8,038 of net income for a plan using $27,211 of working capital without land buying, or to $10,367 of net income for a farm of 483 acres under land buying.

An Analysis of Income Possibilities From Farm Adjustments In Southern Iowa; Including Production of Grade B Milk[1]

BY HAROLD C. LOVE AND EARL O. HEADY

This study was initiated to investigate the competitive position and income opportunity of several livestock and crop enterprises under the soil, climatic, price and market conditions of farms in Adams County, Iowa, and the adjacent area. Farmers and others in Adams County expressed a desire that this study be made to determine income opportunities from improved organization of farms in the area.

With the advent of a local dairy plant and market, they also wished to know whether a dairy enterprise producing grade B milk could have a profitable place in the farm organization. Finally, they expressed a desire to know more about the optimal size and organization of farms operated by family labor. This study has been conducted accordingly and is one of several being conducted to determine income possibilities of on-farm adjustments open to Iowa farmers.

According to state census reports, the beef-cow herd is the most common cattle enterprise in the southern pasture region of Iowa. The development of new markets, new highways and new methods of transportation, however, may improve the competitive position of other cattle enterprises. Recent innovations indicate greater improvements in product output per hour of labor input for milk production than for other livestock enterprises. Hence, it appears that while dairying has had only a minor role in farming of the area, its position might well change. Since improved technology also has taken place in other enterprises, however, the possibility of improving income by greater specialization in dairy products can be determined only through an analysis of the complete organization of farms on the particular soil association.

This study of owner-operator "benchmark" situations in Adams County is one of a series made using linear programming to furnish reference points to be used by the Agricultural and Home Economics Extension Service in the Farm and Home Planning Program. These studies also will serve as general guides in adjusting Iowa farming to meet changes in markets, technology and farm programs. The study has been applied only to owner-operator situations because the majority of farms in the area are managed under this form of tenure.

OBJECTIVES

In general, the objective of this study is to determine, using linear programming, the optimum organization of farms, represented by specific soil and management situations in Adams County. To keep the study manageable, however, the analysis applies largely to farmers of average managerial ability, operating a farm of average size with labor of the farm family. While one purpose of the study is to determine the role of the dairy enterprise in farm organizations, given a new market outlet in the locality, the more general objective is to determine the most profitable over-all organization of farms with these typical resource situations. Over-all organization is stressed since the problem of successful farm management is not that of determining which enterprises are profitable, but of determining which enterprises are **most** profitable. While the main objective is to study farm organization and profit for farms of typical size, an auxiliary objective is to estimate how large family farms in the area might be if capital were available and the only restraining resources were typical family labor and the buildings available.

The more specific objectives of the study are to (1) determine profit-maximizing farm plans for certain basic situations for farms operated under average management, (2) compare competitive position and profitability of a grade B dairy enterprise with all other crop and livestock activities in over-all farm organization when capital is at various levels, (3) investigate the profitability of pasture renovation, as compared with other investment alternatives, (4) estimate the farm size, capital requirements and enterprise composition which maximize profits when family labor and building space, rather than capital, are limiting resources, (5) estimate the cost of using low risk enterprise combinations in farming the area and (6) compare the amount of instability and risk in

[1] Project 1328, Iowa Agricultural and Home Economics Experiment Station. The authors are indebted to Laurel Loftsgard, H. B. Howell, Ronald Krenz, Jim Davies, Glen E. Gillett, Bruce R. Taylor, Fred Foreman, W. R. Duncan, W. H. Shrader, John Pesek and others who contributed to this study.

two general farm plans, using variance, standard deviation and the coefficient of variation as measures of this instability.

LOCATION AND DESCRIPTION OF FARMING IN THE AREA

Adams County is the western county in an Iowa type-of-farming area frequently designated as the southern pasture region. As shown in table 1, the land values of this area are lower than in other parts of the state. These lower land values are a simple reflection of the fact that this land is less productive than that in other areas of the state and that a greater proportion of it is permanent pasture.

The number of farms in Adams County declined from 1,456 in 1949 to 1,370 in 1954—a 6-percent drop in 5 years. Conversely, the average size of all farms increased from 187 to 198 acres, or 5.8 percent. According to the 1954 census, 598 farms, or 44.1 percent of all commercial farms, contained 180 acres or more. The model farm size was 240 acres in 1954. The proportion of tenancy was only 33.1 percent.

In agreement with the trend toward larger farm size, this study considers farms of 240 acres. The county land use distribution, on a percentage basis, is given in the first column of table 2. The percentage distribution used for the farm situation studied is shown in the second column of table 2. Yields for corn and oats averaged 44.8 and 29.0 bushels, respectively, in Adams County over the period 1945-54.

Soil Types

Sharpsburg and Shelby soils make up most of the cropland area in Adams County. Although a complete soil survey has not been made in Adams County, the Agronomy Department of Iowa State University estimates that the cropland in the area consists of 60 percent or more Sharpsburg and 40 percent or less Shelby. Shelby soils have a slope ranging from 9 to 13 percent. They are considered less responsive to heavy fertilizer applications than are the gently rolling, more fertile Sharpsburg soils. Shelby occurs on the sides of the hills, while Sharpsburg and closely related soil types are found on the hilltops and the level valley areas. Erosion control measures—such as more frequent use of grasses, legumes and closely drilled crops, terraces and diversion ditches—are important for Shelby and associated soils.

TABLE 1. IOWA FARM LAND VALUES, NOV. 1, 1955[a].

Type-of-farming area	Price per acre	Comparison in percent
Southern pasture	$140	51.8
Northeast dairy	190	70.3
Western livestock	231	85.5
Eastern livestock	242	89.6
North-central grain	270	100.0

[a] Murray ,W. G. Farm land values increase in 1955. Iowa Farm Science. 11:292. July, 1956.

TABLE 2. DISTRIBUTION OF LAND USE FOR ADAMS COUNTY AND FOR THE FARM SITUATION STUDIED.

Use of land	Adams County	Farm situation studied
	(percent)	(acres)
Cropland	63.3	152
Native pasture	31.4	75
Buildings, roads and waste	5.3	13
Total	100.0	240

Livestock Numbers and Relative Importance of the Major Livestock Enterprises

Livestock numbers and sales provide an indication of the organization employed by farmers in a particular period. In Adams County beef cows outnumbered dairy cows by more than two to one, with numbers of 12,069 and 4,873, respectively, in 1955. A total of 1,106 farms reported milk cows, but only 876 reported cream sales and only 42 sold whole milk. In the spring of 1956, 10,003 sows farrowed, while 1955 fall farrowings were reported to be 6,869. In 1954, 1,036 farms in the county sold eggs. The average number of hens and pullets of laying age was 119 per farm. The relative contribution to income of various livestock enterprises is given in table 3. As these data indicate, dairy products have contributed only a minor proportion of income in the past.

During the 6-year period, 1949-54, the number of calves born on farms in Adams County increased from 11,803 to 16,658. Hens and pullets of laying age declined from 186,477 to 163,398 in the same period. No definite trends occurred in hog and sheep numbers in Adams County. The trend in cattle numbers parallels state and national changes in the cattle population. The decline in poultry numbers also follows trends for Iowa and other Midwestern states.

FARM SITUATION USED FOR STUDY

A typical farm situation in Adams County was selected as a reference point for this study. The selection was made by county and state extension personnel in conference with the farm planner of the Adams County Soil Conservation District. The selection committee considered the following characteristics to be important in defining the farm situation: (a) a rolling topography typical of Adams County, (b) a 240-acre owner-operated

TABLE 3. LIVESTOCK AND LIVESTOCK PRODUCTS SOLD IN 1954 FROM 1,291 COMMERCIAL FARMS—ADAMS COUNTY, IOWA[a].

Item	Sale value	No. farms reporting	Income rank relative to hogs (percent)
Hogs	$3,976,882	1,291	100.0
Cattle	2,854,131	1,207	71.0
Milk and cream	460,592	918	11.5
Poultry and eggs	425,162	1,036	10.6
Sheep	104,982	191	2.6

[a] Computed from the annual Iowa farm census, 1954. Iowa Dept. Agr., Des Moines. Numbers of farms differ from those given elsewhere, since those in the table refer only to commercial farms.

farm[2] (the trend farm size in the county is approaching), (c) cropland of the two major soil types made up of about 60 percent Sharpsburg and 40 percent Shelby, (d) management levels representative of the area and (e) buildings in quantities and sizes found on typical farms throughout the county.

The farm selected is located in Prescott Township. The owner has a 37.5-percent equity position in the land and is currently using approximately $3,000 of borrowed operating capital at a 7-percent interest rate. This capital position is typical of many young owner-operators in the county.

The land use on this farm closely approximates the county averages given in table 2. Public utilities serving the property include a well-graded and graveled highway, electricity and telephone. The water supply on this farm is dependable, but an adequate water supply from wells is not always available in this part of the state. Frequently the water supply must be supplemented with well-developed farm ponds and filter systems, or by placing water, hauled from municipal supplies, in storage cisterns or tanks. Whenever modern dairy or other livestock enterprises are among the alternatives under study, an adequate water supply is necessary and is assumed for this study.

Levels of Management

Both average and superior management alternatively are assumed for crop production. Management level is reflected through the levels of fertilizer application and crop yields per acre. The appropriate yields and practices were provided by members of the Agronomy Department of Iowa State. Several cropping plans or rotations are considered in the study, each fertilized at zero, low and medium levels with yields at corresponding levels. The same rotations are included for superior management, with fertilization at medium and high levels and yields adjusted accordingly.

Practices in livestock also have been selected to represent situations of both average and superior management. These differences in management are reflected through the magnitude of input-output coefficients used and the prices or grade realized at marketing. Superior management supposes more selective buying in replacement cattle programs and a higher grade and sale price for finished beef. Differences between average and superior management in livestock production were based on information from both resident and extension personnel of the Animal Husbandry Department of Iowa State University. The differences between average and superior management are expressed in the input-output data in tables of the text and appendix.

[2] Two-thirds of all farms in Adams County are at least partly owner-operated. Furthermore, the capital expenditures necessary to meet requirements for a locally developing grade B milk market would be more feasible on an owner-operated farm.

TABLE 4. HOURS OF AVAILABLE LABOR PER MONTH AND IN MONTHLY GROUPS FOR THIS STUDY.

Month	Total available man-hours	Total available man-hours for group of month
December	275	825
January	275	
February	275	
March	335	685
April	350	
May	350	700
June	350	
July	350	700
August	350	
September	300	875
October	300	
November	275	
Total	3,785	

Labor Supply

The labor supply used for this study represents that typical for an operator and his family. All enterprises except poultry compete for the labor supply given in table 4. The housewife's labor was assumed to be sufficient to care for a poultry enterprise of up to 200 hens. The annual labor supply is divided into periods of 2 or 3 months each, depending on labor requirements for particular farm operations and the number of working days available.

Capital Resources

The term "capital level" refers to the initial investment in the basic livestock and livestock equipment for a particular plan, plus the annual variable costs for the livestock and crop enterprises. Initial investment funds for the purchase of land, service buildings, crop machinery and the annual fixed costs presented in appendix table A-1 are excluded from the "capital levels" mentioned later.

It is assumed that the owner-operator has adequate machinery for crop production. In this study, the list of crop machinery used in computing fixed costs is in agreement with the engineering optimum for farms of 240 acres under varying weather uncertainty.[3] Hence, wherever capital figures are shown in the text, one amount can be added to these figures to represent machinery investment and another to represent real estate investment if it is desired to compute total capital requirements. Machinery investment approximates $10,505, while the real estate investment for 240 acres approximates $31,558—a total of $42,063. This amount should be added to the capital levels shown in the tables to obtain the total amount of capital required for the particular owner-operator plan being considered.

Similarly, the returns for farm plans in the subsequent sections are computed without deducting fixed costs. Net profit, in the absence of borrowed capital, can be computed by subtracting

[3] Heady, E. O., McKee, Dean E. and Haver, C. B. Farm size adjustments in Iowa and cost economies in crop production for farms of different sizes. Iowa Agr. Exp. Sta. Res. Bul. 428. 1955.

fixed costs of $2,005—the approximate amount of fixed costs on a 240-acre farm owned without debt. Farms with borrowed capital would have higher fixed costs, depending on the amount of funds borrowed and the interest rate paid. Net return or farm profit, then, is the return figure shown, less fixed costs. Hence, the profitability of all plans may be compared directly from the figures in the tables, since, for any one farm situation, fixed costs are the same.[4]

Farmers differ in the amount of capital they control. Therefore, plans are computed to indicate how crop rotations and livestock enterprises should vary depending upon the amount of capital available. For these purposes, capital is permitted to vary from $5,000 upward to a level where it does not limit the kind or size of enterprises. All other resources are freely available within the limits explained elsewhere, except in two situations. In one situation family labor can be supplemented with seasonal labor hired for $1 per hour. This alternative is offered to study the income opportunities in pasture renovation. These plans will include hired labor only if it returns more than $1 per hour.

In a second situation, acreage restrictions are relaxed to study the profitability of buying land in comparison with investments in more crop or livestock activities on a given land area. Also, as mentioned earlier, this phase of the analysis allows examination of farm sizes which are most profitable for families using only their own labor and with the typical supply of buildings and machinery.

Most earlier linear programming studies have dealt with plans for discrete levels of capital. In this study, however, variable capital programming is used.[5] Capital is considered to be a continuous variable while all other resources are held constant. This method indicates the enterprise which gives the highest returns to capital as well as the optimum plan for each level of capital. As capital is increased, enterprises returning less on capital are brought into the plan. A capital optimum for unlimited capital thus provides a plan where the net returns to additional capital would be zero.

Building Resources

Land and labor supplies have been explained earlier (tables 2 and 4). Buildings also are assumed to be fixed in quantity, to provide possible limits to the number of hog, dairy and poultry units produced, and to be sufficient for any number of beef cattle. Building resources include 1,680 square feet of dairy space, 895 square feet of hog space and 824 square feet of poultry space. This quantity of building space for dairy is assumed to allow a maximum of 20 milk cows of any type. Similarly, the quantity of poultry space allows keeping 200 hens either under average or superior management. Building requirements for the various hog enterprises vary with system of production and the type of management. These requirements are given in tables A-3 and A-4 of the appendix.

Prices and Markets

The prices used in computing the maximum profit plans are given in table 5. Historical price relationships between commodities bought and sold by farmers are the basis for the projected prices used in this study. The level of prices used in computing input-output data is based on a corn price of $1.20 per bushel (the net farm price after deduction of hauling and marketing costs), with other product prices adjusted according to the long-run relationship between corn and other commodity prices. The long-run periods used are: (1) for market hogs, 1947 through 1955, and 1950 through 1955 for sows and gilts, (2) for beef cattle, 1935 through 1955 and (3) 1951 through 1955 for seed and poultry products. Prices used for supplement feeds, butterfat and grade B dairy products are those currently quoted in southern Iowa. For this study, hog prices are based on the Des Moines market; the Omaha market is used for cattle prices.

To determine the average adjusted price for a product, the average price of the product during its price period was divided by the average price of corn during the same period. The resulting ratio then was multiplied by $1.20—the net selling price of corn after deducting transportation and handling charges. This method retains the historical average price ratios between all products. The peak of a livestock population cycle for cattle or hogs roughly corresponds to the low in the price cycle and vice versa. The length of price and livestock population cycle periods used in determining ratios for the various commodities is not uniform. For market hogs the period used (1947 through 1955) contains approximately two cycles. For packing sows and breeding gilts a one-cycle period (1950 through 1955) was used. The cattle price period used in this study is 21 years, 1935 through 1955. This period includes two cattle number cycles measured from peak to peak—1935 to 1945 and 1945 to 1955.

If the general price level fluctuates from the level used in this study, the optimum profit plans will retain the same enterprise composition as long as the price ratios between the various commodities remain the same; but the net farm income will increase or decrease from the levels shown in this study. On the other hand, if cattle prices rise while corn or hog prices remain constant or decrease, the optimum plan might well differ from those presented.

Expansion of the market for whole milk is

[4] Capital is often the most limiting resource and, therefore, the controlling resource in many plans. Beginning farmers usually have more productive uses for their capital than a complete line of new machinery. Perhaps on most farms the machinery depreciation schedule is an accumulation over several years and frequently includes some second-hand equipment.

[5] Heady, Earl O. and Candler, Wilfred V. Linear programming methods. Iowa State University Press, Ames, Iowa. 1958. Ch. 6.

TABLE 5. AVERAGE ADJUSTED PRODUCT PRICES USED FOR THIS STUDY[a].

Item	Unit	Purchase price (dollars)	Selling prices (dollars)	
			Average management	Superior management
Seed and fertilizer:				
Corn	bu.	11.50	—	—
Oats	bu.	0.88	—	—
Legume and grass mixture, 14 lbs.	acre	4.79	—	—
Nitrogen (N)	lb.	0.13	—	—
Phosphate (P_2O_5)	lb.	0.10	—	—
Feed and grain:				
Corn	bu.	1.30	1.20	1.20
Oats	bu.	0.62	0.62	0.62
Hay (baled)	ton	17.40	—	—
Cattle supplement	cwt.	4.42	—	—
Hog supplement	cwt.	5.30	—	—
Livestock and livestock products:				
Oct. good-to-choice steer and heifers	cwt.	19.84	19.84	21.34
Beef cow	——	144.27	—	—
Milk cow	——	144.00	—	—
Medium dairy cow	——	192.00	—	—
Superior dairy cow	——	228.00	—	—
Cull cow	cwt.	—	12.47	12.47
Veal calf	cwt.	—	18.00	18.00
Heifer 2-year old, milk	head	—	144.00	144.00
Heifer 2-year old, medium dairy	head	—	192.00	192.00
Heifer 2-year old, superior dairy	head	—	228.00	228.00
Nov. medium yearling, 700 lbs. (feeders)	cwt.	15.01	—	—
May 900-1,100 lb. steer grading "good"	cwt.	—	18.15	19.29
Nov. 900-1,100 lb. steer grading "choice"	cwt.	—	21.83	22.08
May commercial-to-good heifers, 780 lbs.	cwt.	—	17.55	18.55
April culled brood sow	——	—	15.18	15.18
Sept. breeding gilt or sow	cwt.	16.09	—	—
Oct. breeding gilt or sow	cwt.	—	15.46	15.46
Feb. market hogs, 225 lbs.	cwt.	—	16.65	16.65
March market hogs	cwt.	—	16.93	16.93
April market hogs	cwt.	—	16.57	16.57
July market hogs	cwt.	—	18.43	18.43
Aug. market hogs	cwt.	—	18.80	18.80
Sept. market hogs	cwt.	—	18.04	18.04
Oct. market hogs	cwt.	—	16.45	16.45
Nov. market hogs	cwt.	—	15.81	15.81
Sexed chicks (laying breed)	each	0.30	—	—
Cull hen	lb.	—	0.14	0.14
Cockerel	lb.	—	0.22	0.22
Eggs	doz.	—	0.28	0.28
Butterfat	lb.	—	0.59	0.59
Grade B milk, net after hauling	cwt.	—	2.92	2.92

[a] Based on past price relationships and adjusted to a judgment estimate of $1.20 per bushel for corn.

anticipated for Adams County, given the addition of a dairy product plant. Therefore, special consideration had to be given to dairy product prices. A new grade B whole-milk market, plus the purchase of other dairy products on a pick-up route, represents a specialized market not previously available to farmers in Adams and adjoining counties.

Pasture Prices

In Adams County, as in other parts of the southern pasture region of Iowa, opportunities exist each year for renting out native pasture. The annual rental rates on pasture are estimated at $4 per acre for the pasture season. In this study, livestock can obtain their required roughage from (1) grazing on the meadow in the crop rotation, (2) hay produced on the rotation meadow or (3) grazing from the native pasture. The first method has no specified charge, the second method calls for a charge of $5.69 per ton to cover harvest and storage costs, while the third method incurs a charge of $4 per acre.

LINEAR PROGRAMMING TECHNIQUE

Linear programming is a mathematical method for specifying the kinds and the sizes of the enterprises and practices which will produce a maximum revenue (before deduction of fixed costs). This selection is made subject to the conditions of limitations imposed by the fixed quantities of resources. The logic and procedure of the application of linear programming are available from several sources.[6] In essence, the linear programming procedure is a form of budgeting. The linear programming technique compares all the feasible plans (a feasible plan is one which utilizes no more of each resource than is available),

[6] Dorfman, Robert. Application of linear programming to the theory of the firm. University of California Press, Berkeley and Los Angeles. 1952. pp. 24-44, 79-94.

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however, and selects the plan with the maximum return. In budgeting, the same input-output information on resources is needed, but budgeting gives no assurance that a particular plan will maximize return. If budgeting were used to determine the optimum, all possible plans would have to be computed, and the one with the highest returns then would be selected by observation. Thus, while the same results can be obtained by both procedures, linear programming specifies the optimum plan much more efficiently.

ENTERPRISES CONSIDERED

Enterprises considered in this study are those felt to be relevant in Adams County. An explanation of each follows.

Crop Rotations

The same crop rotations are included for both levels of management studied. The panel of farmers from Adams County and members of the Department of Agronomy at Iowa State decided that the following rotations should be included: (1) Shelby soils, corn-oats-meadow (COM) and c o r n - oats - meadow - meadow (COMM); (2) Sharpsburg soils, corn-oats-meadow (COM) and corn-corn-oats-meadow (CCOM).

Fertilization levels included are zero, low and medium for average management, and medium and heavy for superior management. All further reference to rotations will include a subscript denoting the level of fertilization. For example, COM_0 is a corn-oats-meadow rotation with no fertilizer, while COM_1, COM_2 and COM_3 represent this same rotation at low, medium and heavy rates of fertilization, respectively. The yield and fertilizer response estimates were prepared by the Agronomy Department of Iowa State from county yield data, soil testing records and fertilizer experiments in Adams and adjoining counties. The estimated yield per acre for each crop grown under the various combinations of management level, soil type and rate of fertilization is given in table 6. The basic input-output data for the various rotations are presented in table 7.

If the total supply of feed grain produced by the rotations is used by the livestock enterprises, additional grain may be purchased for 10 cents per bushel above the selling price. The additional charge covers handling, hauling and other costs. When livestock can utilize grain profitably at the 10-cent premium, the grain buying activity comes into the plan to supply the amounts necessary above that produced on the farm. Livestock production is not permitted to exceed that possible from the forage produced by the native pasture and the crop rotation on the farm. Forage in the form of hay is not sold when produced in surplus, but pastures may be rented out when not used.

Livestock Enterprises

Two levels of management—average and superior—are considered for hogs, beef and grade B dairy enterprises. A milk cow enterprise selling cream on a butterfat basis is included only for average management. A summary of the input-output coefficients for livestock enterprises is presented in table 8. The basic data for each livestock enterprise are given in the appendix tables A-3 to A-12. The nature of each enterprise is presented in the following paragraphs. Conditions for average management are explained in detail, while under superior management only the differences from average management are presented. Hog production systems are placed on a unit basis. One unit may consist of one, two or three litters. In the notation (1:0 ratio), the first numeral denotes the number of spring litters, and the second numeral denotes the number of fall litters.

TABLE 6. FERTILIZER TREATMENTS AND CROP YIELD FOR ROTATIONS BY SOIL TYPE.

Rotation	Average management									Superior management					
	No fertilizer[a]			Low fertilizer			Medium fertilizer			Medium fertilizer			High fertilizer		
	N	P	Yield[b]	N	P	Yield	N	P	Yield	N	P	Yield	N	P	Yield
Sharpsburg soil															
Corn	0	0	56	0	0	59	0	20	62	30	20	70	40	40	72
Oats	0	0	28	0	20	30	20	30	36	10	30	39	10	30	40
Meadow	0	0	1.5	0	0	1.8	0	0	2.0	0	0	2.2	0	0	2.3
Corn	0	0	56	0	0	59	0	20	62	30	20	70	40	40	72
Corn	0	0	49	30	0	56	40	20	59	60	20	65	70	40	68
Oats	0	0	28	0	20	30	10	30	36	10	30	39	0	30	40
Meadow	0	0	1.5	0	0	1.8	0	0	2.0	0	0	2.2	0	0	2.3
Shelby soil															
Corn	0	0	30	0	15	35	0	40	38	—	—	—	—	—	—
Oats	0	0	30	0	20	31	0	20	32	—	—	—	—	—	—
Meadow	0	0	0.8	0	0	1.1	0	0	1.4	—	—	—	—	—	—
Corn	0	0	30	0	15	35	0	40	38	30	50	43	40	50	45
Oats	0	0	30	0	30	31	0	30	32	20	30	36	10	40	36
Meadow	0	0	0.8	0	0	1.1	0	0	1.4	0	0	1.8	0	0	1.8
Meadow	0	0	0.6	0	0	0.9	0	0	1.0	0	0	1.4	0	0	1.6

[a] Fertilizer amounts are shown in pounds per acre of available nutrients added.
[b] Yields are shown in bushels per acre for grain and tons per acre for meadow.

TABLE 7. INPUT-OUTPUT DATA AND RESOURCE REQUIREMENTS FOR VARIOUS CROP ROTATIONS.

Shelby soils rotations (per acre unit)[a]

	Unit	Average management						Superior management			
		COM_0	COM_1	COM_2	$COMM_0$	$COMM_1$	$COMM_2$	COM_2	COM_3	$COMM_2$	$COMM_3$
Inputs:											
Seed	dollars	3.14	3.14	3.14	2.36	2.36	2.36	3.14	3.14	2.36	2.36
Fuel and repairs	dollars	7.02	7.02	7.02	5.39	5.26	5.27	7.02	7.02	5.26	5.26
Fertilizer	dollars	0.00	1.17	2.00	0.00	1.12	1.75	4.50	4.50	3.63	3.87
Harvest costs	dollars	2.05	2.29	2.45	1.53	1.72	1.83	2.76	2.85	2.07	2.14
Total variable costs	dollars	12.21	13.62	14.61	9.28	10.46	11.21	17.42	17.51	13.32	13.63
Outputs:											
Gross value	dollars	18.20	20.41	21.81	13.65	15.30	16.36	24.64	25.44	18.48	19.08
Returns before fixed costs	dollars	5.99	6.79	7.20	4.37	4.84	5.15	7.22	7.93	5.16	5.45
Corn equivalent	bushels	15.00	17.17	18.00	11.25	12.87	13.50	20.33	21.00	15.25	15.75
Hay	tons	0.27	0.37	0.47	0.35	0.50	0.60	0.60	0.60	0.80	0.85
Labor input:											
Dec.-Jan.-Feb.	hours	0.12	0.12	0.12	0.09	0.09	0.09	0.12	0.12	0.09	0.09
March-April	hours	0.69	0.79	0.79	0.51	0.59	0.59	0.79	0.79	0.59	0.59
May-June	hours	0.87	0.90	0.90	0.65	0.68	0.68	0.90	0.90	0.68	0.68
July-Aug.	hours	1.50	1.50	1.50	1.12	1.12	1.12	1.50	1.50	1.12	1.12
Sept.-Oct.-Nov.	hours	0.99	0.99	0.99	0.65	0.65	0.65	0.99	0.99	0.65	0.65

Sharpsburg soils rotations (per acre unit)[a]

	Unit	Average management						Superior management			
		COM_0	COM_1	COM_2	$CCOM_0$	$CCOM_1$	$CCOM_2$	COM_2	COM_3	$CCOM_2$	$CCOM_3$
Inputs:											
Seed	dollars	3.14	3.14	3.14	2.86	2.86	2.86	3.14	3.14	2.86	2.86
Fuel and repairs	dollars	7.02	7.02	7.02	8.35	8.35	8.35	7.02	7.02	8.35	8.35
Fertilizer	dollars	0.00	0.67	2.53	0.00	1.47	3.37	3.40	4.50	5.00	6.32
Harvest costs	dollars	3.13	3.31	3.58	3.94	4.30	4.61	4.01	4.12	5.10	5.30
Total variable costs	dollars	13.29	14.14	16.28	15.15	16.98	19.19	17.57	18.78	21.31	22.83
Outputs:											
Gross value	dollars	28.19	29.80	32.24	35.84	39.15	41.88	36.06	37.06	46.54	48.20
Returns before fixed costs	dollars	14.90	15.66	15.96	20.69	22.17	22.69	18.49	18.28	25.23	25.37
Corn equivalent	bushels	23.33	24.66	26.66	29.75	32.50	34.75	29.83	30.66	38.62	40.00
Hay	tons	0.50	0.60	0.66	0.35	0.45	0.50	0.73	0.77	0.55	0.575
Labor input:											
Dec.-Jan.-Feb.	hours	0.12	0.12	0.12	0.18	0.18	0.18	0.12	0.12	0.18	0.18
March-April	hours	0.69	0.79	0.79	0.73	0.80	0.80	0.79	0.79	0.80	0.80
May-June	hours	0.87	0.90	0.90	1.30	1.35	1.35	0.90	0.90	1.35	1.35
July-Aug.	hours	1.50	1.50	1.50	1.31	1.31	1.31	1.50	1.50	1.31	1.31
Sept.-Oct.-Nov.	hours	0.99	0.99	0.99	1.30	1.30	1.30	0.99	0.99	1.30	1.30

[a] Subscripts on each rotation indicate rate of fertilization.

Two-litter hog system under average management (1:1 ratio). Each sow farrows two litters of pigs; the spring litter is farrowed in March and marketed in September, while the fall litter is farrowed in September and sold in March. The sow, sold in May, is replaced by a gilt saved from the fall litter. A total of 13 pigs are weaned, and 2,902 pounds of pork are marketed annually from each sow. Death losses after weaning of 0.44 pig per litter are used for all systems under average management. For all hog systems used in this study, a market weight of 225 pounds is used. Building and equipment requirements per hog are less for the two-litter system than under the one-litter system. The input-output data for all hog systems are included in appendix tables A-3 to A-6.

Two-litter hog system under superior management (1:1 ratio). Each sow farrows in February and August, while barrows and gilts are sold in August and February, respectively. Each sow weans 14.6 pigs annually, with 3,361 pounds marketed. Death losses after weaning of 0.22 pig per litter are used for all systems under superior management. More protein and less grain are required per hundredweight of pork produced under superior management.

Three-litter hog system under average management (2:1 ratio). Two litters are farrowed in the spring and one in the fall. A replacement gilt is saved from the fall litter, bred the following spring for fall farrowing and again for spring farrowing. This sow is sold in May after weaning her spring litter. The second replacement gilt is saved from the spring litter, bred in the fall to farrow the following spring and sold in May after weaning her first litter. The spring litters are farrowed in March and sold in September. The fall litter is farrowed in September and marketed the following March. A total of 19.5 pigs are weaned from the three litters. Of the 4,365 pounds of pork marketed, 2,502 pounds of market hogs are sold in September and 1,138 pounds in March.

Three-litter system under superior management (2:1 ratio). As compared with average management, protein consumption per hundredweight of pork produced is increased, while corn consumption is lowered.

Spring-litter system under average management (1:0 ratio). Each sow farrows only one litter, averaging 6.5 pigs weaned annually. March is the month for farrowing, and September the month for sale of market hogs. A total of 1,463 pounds of pork is produced. The sow is sold in May after weaning her first litter, and one replacement gilt is saved from each litter.

Spring-litter system under superior management (1:0 ratio). An average of 7.3 pigs is weaned per litter. Farrowing and sale dates for the market hogs are February and August, respec-

TABLE 8. BASIC INPUT-OUTPUT DATA FOR LIVESTOCK ENTERPRISES USED IN THIS STUDY[a].

Item	Units	Average management									
		Milk cow	Grade B dairy cow	1:0 hogs	1:1 hogs	2:1 hogs	De-ferred steers	Commer-cial heifers	Medium steers	Beef cows	Poultry per hen
Inputs[b]											
Basic stock	dollars	144.00	192.00	47.52	47.52	95.04	84.32	52.12	105.21	163.75	0.36
Equipment	dollars	10.00	100.00	22.60	27.53	55.05	13.50	13.50	13.50	13.13	1.15
Misc. variable cost	dollars	60.30	79.01	75.37	149.45	224.80	35.86	28.91	27.60	25.73	2.52
Corn equivalent	bu.	31.37	43.30	107.15	212.47	319.58	40.00	24.00	15.00	4.77	1.63
Hay equivalent	tons	6.35	6.56	0.29	0.58	0.87	2.00	1.00	1.25	5.47	.....
Commercial feed	lbs.	192.00	312.00	731.75	1,451.00	2,182.50	350.00	250.00	150.00	64.00	42.00
Labor											
Dec.-Jan.-Feb.	hours	39.06	40.63	6.34	15.30	20.12	3.31	3.00	2.75	5.61	0.441
March-April	hours	25.42	26.45	3.17	13.32	21.82	2.27	3.00	3.00	3.79	0.378
May-June	hours	24.15	26.09	8.50	5.31	7.28	0.45	1.25	1.25	3.61	0.537
July-Aug.	hours	21.81	23.52	1.98	8.68	12.00	1.97			3.30	0.332
Sept.-Oct.-Nov.	hours	32.61	34.62	6.01	17.43	23.78	9.72	2.75	1.00	4.03	0.412
Total	hours	143.05	151.31	26.00	60.04	85.00	17.72	10.00	8.00	20.34	2.10
Outputs											
Meat	dollars	50.69	57.54	249.04	487.51	736.55	214.39	138.23	179.94	76.95	0.72
Milk	dollars	138.22	230.39	.....	.....	.....	.....	.....	.....	.....	.....
Eggs	dollars	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.18
Total		188.91	287.93	249.04	487.51	736.55	214.39	138.23	179.94	76.95	4.90
Return[c]		90.96	156.96	45.09	83.10	128.25	46.21	28.40	29.27	45.50	0.43
		Superior management									
Inputs[b]											
Basic stock	dollars		228.00	47.52	47.52	95.04	84.32	52.12	105.21	163.75	0.36
Equipment	dollars		100.00	30.48	31.23	62.46	13.50	13.50	13.50	13.13	1.15
Misc. variable cost	dollars		90.43	96.67	191.91	288.58	35.86	28.91	27.60	30.90	1.05
Corn equivalent	bu.		59.59	96.14	190.86	287.00	40.00	24.00	15.00	5.51	1.66
Hay equivalent	tons		6.97	0.27	0.54	0.81	2.00	1.00	1.25	5.69	.....
Commercial feed	lbs.		391.00	1,100.00	2,184.65	3,285.10	350.00	250.00	150.00	73.90	46.00
Labor											
Dec.-Jan.-Feb.	hours		40.64	4.86	13.96	18.61	3.31	3.00	2.75	5.61	0.44
March-April	hours		26.44	2.96	12.10	20.11	2.27	3.00	3.00	3.79	0.38
May-June	hours		26.09	8.01	6.41	9.56	0.45	1.25	1.25	3.61	0.54
July-Aug.	hours		23.52	3.15	8.21	12.05	1.97	.....	.....	3.30	0.33
Sept.-Oct.-Nov.	hours		34.62	7.02	18.32	24.67	9.72	2.75	1.00	4.03	0.41
Total	hours		151.31	26.00	59.00	85.00	17.72	10.00	8.00	20.34	2.10
Outputs											
Meat	dollars		71.38	299.80	573.97	873.78	226.57	146.03	191.34	92.54	0.72
Milk	dollars		273.87	.....	.....	.....	.....	.....	.....	.....	.....
Eggs	dollars		.....	.....	.....	.....	.....	.....	.....	.....	5.35
Total			345.25	299.80	573.97	873.78	226.57	146.03	191.34	92.54	6.07
Return[c]			183.31	87.76	150.03	240.80	58.39	36.20	40.67	55.03	1.39

[a] Sources of these data are given in appendix tables A-3 through A-12.

[b] Total inputs include capital investment in basic stock and equipment.

[c] Return does not include capital investment for equipment for all enterprises and basic stock for dairy, hog and beef cow enterprises or any deduction for hay or pasture other than harvest cost for hay equivalent fed.

tively. A total of 1,693 pounds of pork per litter is produced annually.

Butterfat dairy under average management. Cows are considered average in ability, producing 189 pounds of butterfat, after provision for 110 pounds of whole milk for starting the calf. The 4,443 pounds of skim milk is valued on a substitution basis for corn and protein replaced in the hog ration. The productive life of each cow is 5 years. Net returns and feed costs for milk cows are computed on the basis of butterfat and livestock sales per cow, plus an allowance for skim milk. Feed requirements and costs include those for a cow of 1,250 pounds and replacement stock. Sales of 2-year-old heifers not needed for replacement are at the price of $144. Production and resource requirements for all dairy enterprises are included in appendix table A-1.

Grade B dairy under average management. Annual production per cow averages 8,000 pounds of milk, with 110 pounds fed to the calf and 7,890 pounds sold as whole milk. Mature cows weigh 1,300 pounds. Sales of 2-year-old heifers not needed for replacement are at the price of $192.

Grade B dairy under superior management. Annual milk production per cow is 9,500 pounds, with 9,379 pounds sold as whole milk and 121 pounds used for the calf. Mature cows weigh 1,350 pounds. Sales of 2-year-old heifers not needed for replacement are at the price of $228. As indicated in table 8, the difference between management levels or production techniques for dairy enterprises under two management levels are reflected in the milk production and feed requirements per cow.

Deferred-fed steer calves under average management. Good to choice 425-pound steer calves are purchased in November. They are wintered in drylot on a daily ration of 1 pound of protein supplement, 4 to 5 pounds of grain plus all the silage or mixed hay they will consume. Winter gains average 200 pounds. The steers are put on pasture without grain from May 1 to Aug. 1, then are moved to drylot for a finishing period of approximately 100 days. The total gain is 550 pounds, and November sale weight at the market is 975 pounds. Death loss is computed at 3 percent. Input-output data for this enterprise are given in appendix table A-8.

Deferred-fed steer calves under superior management. The purchase date, price, feed require-

ments, total gain and sale date are identical with those under average management. The difference between average and superior management is the $1.25 per hundred increase in sale price received by the superior manager. As a result of more careful grading at the time of purchase the superior manager has fewer "throw outs" to sell at a lower price.

Commercial heifers wintered and short-fed under average management. Very plain 400-pound heifers grading commercial are purchased in October and wintered in drylot on a daily ration of 1 pound of protein supplement, 4 to 5 pounds of grain plus all the roughage they will consume. About Feb. 1 the daily grain ration is increased. The heifers are placed on a full feed of grain from March 1 until their sale in the last half of May. Sale weight is 780 pounds, and the average gain per head is 380 pounds. Additional data are given in the appendix table A-9.

Commercial heifers wintered and short-fed under superior management. This enterprise is the same as under average management, except that more selective buying is exercised. Consequently, a premium of $1 per hundred in selling price is realized.

Medium steers wintered and short-fed under average management. Common to medium yearling steers weighing 700 pounds are purchased in November and wintered until Feb. 15. The daily ration includes 1 pound of protein supplement plus all the roughage they will consume. The short, full feeding period (Feb. 15 to approximately May 15) requires only 15 bushels of corn per steer. Weight at the market is 1,000 pounds, and the average total gain is 300 pounds per head. The initial weight of the yearlings causes this enterprise to have the highest capital outlay of all the replacement cattle programs considered in this study. Managerial skill in buying cattle of this class is of paramount importance, but skill needed in feeding and handling is lower than for other replacement programs. Input-output data for this enterprise are given in appendix table A-10.

Medium steers wintered and short-fed under superior management. Buying and selling dates, feed requirements and total gain are the same as under average management. A selling price advantage of $1.14 per hundredweight over average management is assumed for this enterprise as a result of superior buying skill.

Beef cows producing feeder calves under average management. Cows have a productive life of 6.25 years and an annual culling and replacement rate of 16 percent. Calves average 390 pounds at weaning. After replacement, heifers are selected from the 85-percent calf crop; 278.5 pounds of good and choice calf is sold per cow. The average weight of cull cows is 1,000 pounds. The enterprise begins with the purchase of young 900-pound cows with calves at side at a cost of $164. The beef cow enterprise uses approximately 41 pounds of hay equivalent for each pound of corn fed. Of the 5.47 tons of hay equivalent required for each cow and replacements annually, only 1.15 tons are consumed as hay; the rest is obtained from pasture and stalk fields. Other data are given in appendix table A-11.

Beef cows producing feeder calves under superior management. Annual feed requirements for corn, protein and roughage are slightly higher per cow and replacement unit than under average management. Variable costs include a higher breeding cost. Calves average 425 pounds at weaning. After replacement, heifers are selected from a 90-percent calf crop, and 321.3 pounds of good and choice calf per cow are marketed at a price of $20.59. This price premium is due to quality and uniformity in the calf crop resulting from breeding and feeding practices which are better than for average management. Cull cows weigh 1,100 pounds.

Poultry under average management. Laying hens are replaced with pullets each year. Sexed chicks are purchased each spring. Cull hens are estimated at 11 percent of the total. Hence, an average of 1.25 chicks must be purchased for each potential layer. Mortality rates are 10 percent for chicks and 15 percent for hens. Annual egg production per hen is 180. The enterprise is considered supplementary to other enterprises with respect to labor but does compete for capital. Resource requirements for average and superior management levels are given in appendix table A-12.

Poultry under superior management. Annual egg production per hen is 230 eggs. The higher egg production per hen results from the use of more high-protein commercial feed per hen, greater attention to the details of care and regularity in culling and feeding and use of replacement pullets from high-producing flocks.

Labor Requirements

The labor coefficients used in each livestock activity are those for an enterprise of sufficient size to use labor efficiently per unit of output. Labor requirements for crops and livestock are given in table 9. Because labor per unit of livestock does vary with the size of the enterprise, a "mean" labor coefficient tends to underestimate labor on small enterprises, but to overestimate that for large enterprises. The amount of this error is considered unimportant for the range of enterprise sizes expected in this study.

ANALYSIS OF PLANS

The results of the analysis are presented in this section. Optimum plans or farm organizations, computed by linear programming techniques, are presented for both average and superior management. Three possible organizations to conform with the resource situations discussed

TABLE 9. LABOR REQUIREMENTS FOR CROPS AND LIVESTOCK.

Rotation or enterprise and management level	Unit	Total man hrs./yr.	Distribution by month (haying labor not included)				
			Dec. Jan. Feb.	March April	May June	July Aug.	Sept. Oct. Nov.
Corn-oats-meadow[a]	rotated acre	4.3053	0.121	0.792	0.903	1.500	0.989
Corn-oats-meadow-meadow[a]	rotated acre	3.1382	0.091	0.594	0.678	1.125	0.651
Corn-corn-oats-meadow[a]	rotated acre	4.9516	0.182	0.801	1.355	1.312	1.302
Pasture renovation[b]	acre	4.3086	0	2.475	0.417	1.417	0
Corn[c]	acre	7.2	0.364	0.826	2.657	0.749	2.604
Oats[c]	acre	5.3	------	1.550	------	3.750	------
Meadow[d]	acre	11.62	------	------	4.520	3.850	3.250
Deferred-fed calves[a] (average and superior)	per head	17.731	3.312	2.274	0.450	1.971	9.724
Milk cow[a] (average)	per head and replacements	143.057	39.060	25.420	24.153	21.814	32.610
Dairy cow[a] (superior)	per head and replacements	151.310	40.635	26.445	26.093	23.517	34.620
Beef cow[a] (average and superior)	per head and replacements	20.345	5.610	3.795	3.609	3.301	4.030
Commercial heifers wintered and short fed[e] (average and superior)	per head	10.000	3.000	3.000	1.250	——	2.750
Medium yearling steers wintered and short fed[e] (average and superior)	per head	8.000	2.750	3.000	1.250		1.000
Hogs, 1:1 ratio[a] (average)	per sow[f]	60.038	15.297	13.320	5.309	8.682	17.430
Hogs, 1:1 ratio[a] (superior)	per sow[f]	59	13.960	12.100	6.413	8.205	18.323
Hogs, 2:0 ratio[a] (average)	per 2 sows[f]	85	20.119	21.822	7.285	11.998	23.776
Hogs, 2:1 ratio[a] (superior)	per 2 sows[f]	85	18.614	20.108	9.559	12.052	24.667
Hogs, 1:0 ratio[a] (average)	per sow[d]	26	6.344	3.172	8.502	1.976	6.006
Hogs, 1:0 ratio[a] (superior)	per sow[d]	26	4.862	2.964	8.008	3.146	7.020

[a] Adapted from Heady, Earl O., Loftsgard, Laurel D., Paulsen, Arnold and Duncan, E. R. Optimum farm plans for beginning farmers on Tama-Muscatine soils. Iowa Agr. Exp. Sta. Res. Bul. 440. 1956.

[b] Adapted from Hunt, Donnell. Farm power and machinery manual, hourly requirements for field operations. Iowa State University Press, Ames, Iowa. 1956.

[c] Ross Baumann. Agr. Res. Serv., U. S. Dept. Agr. (Unpublished research.) 1955.

[d] Meadow for livestock (2.5 tons per acre assumed) all harvested.

[e] Love, H. C., Coolidge, J. H. and McKinney, R. D. More money from your farm. Kansas State College. Manhattan Agr. Ext. Serv. Circular 244. 1956.

[f] 1:1 ratio refers to one spring litter and one fall litter; 2:1 ratio refers to two spring litters and one fall litter.

earlier are outlined for average management. Similarly, five possible organizations are outlined for superior management. These plans show the organization for benchmark farms which will maximize profits under the price and technology situations explained earlier. Hence, they indicate the kinds of cropping plans and the quantities of hogs, poultry, dairy cattle and beef cattle which farmers might best employ where their goal is maximum profit for the farm as a whole.

All optimum plans are restricted to the forage produced on the farm, but additional feed grain may be purchased. In addition to other restrictions mentioned, plans which include a grade B dairy enterprise are not considered feasible below a 12-cow minimum. The cooperative creamery in Adams County established this minimum in connection with the financing of equipment and development of the grade B market. This minimum applies to all optimum plans which include grade B dairy under average and superior management.

Annual fixed costs, excluding interest paid on borrowed funds, for farm plans which include the grade B dairy enterprise are $329 higher than for plans not containing this enterprise. If funds were borrowed for the dairy facilities, fixed costs would increase accordingly. The additional capital required for buildings and equipment accounts for this difference; this capital expenditure is itemized in appendix table A-2.

Mechanical innovations such as the milking parlor, the bulk cooling tank and the pipeline milker are of the labor-decreasing but total-cost-increasing type. Such additions favor expanding the scale of the dairy enterprise to spread the higher fixed costs over more units. While these innovations have been included in the input-output data for the grade B dairy enterprise, various limiting factors assumed for the study did not permit expansion of the enterprise to use such equipment at full capacity. Hence, the grade B dairy enterprise may be slightly more competitive than this study indicates. A market price improvement for milk would make this enterprise highly competitive with other livestock enterprises in southwestern Iowa.

The farm plans presented in this study are computed for average price relationships and, therefore, reflect optimum plans over time rather than the optimum for a particular year. These plans furnish reliable guidance and foundations for farm organization if future agricultural price relationships remain similar to the last 5 or 10 years. The farm situations studied represent a few of the important organization problems faced by owner-operators.

Average Management

The optimum plans for average management are presented in the following paragraphs. The plans presented for superior management, in the following section, indicate more nearly the profit potential which exists for farms in the area.

Optimum farm plans for owner-operation; 152 cultivated acres (no grade B dairy enterprise)

This situation permits dairy cows kept for butterfat production to compete with all other livestock and poultry enterprises in the use of avail-

able capital. The crop rotations (COM, COMM) for Shelby soil type and those for Sharpsburg soil type (COM, CCOM) can be produced with zero, low and medium levels of commercial fertilizer application.

Optimum plans are given in table 10 for capital levels of $5,000, $10,000 and unlimited capital. At the $5,000 capital level all cropland is utilized and fertilized at the highest rate available to the average operator. The 11 butterfat cows obtain their hay equivalent from the meadow in the crop rotation, and the 75 acres of native pasture are rented out. Five hog litters under the (1:1 ratio) spring and fall farrowing system complete the organization at this capital level.

Both types of cropland, capital and forage are limiting factors. The number of dairy cows producing butterfat is limited to the forage produced by the crop rotations. The limited supply of capital also prevents the purchase of additional roughage-consuming livestock. Dairy production, rather than beef cattle production, is encouraged, because capital limits production so greatly that surplus labor and forage is allowed for the butterfat enterprise. The dairy and hog enterprises are small, since most of the limited capital is used most profitably for crops. At this capital level the crop rotations containing the largest amounts of grain have priority over livestock in the use of limited capital. Hence surplus corn is sold. Deductions of approximately $2,005 in fixed costs from the return leave a small remainder to be divided between family living and purchase of new equipment. In this situation capital accumulation would be slow.

This outcome corresponds to results from research for other soil areas of Iowa; namely, that the highest return to capital generally comes from planting cropland, with the maximum amount of corn allowed, and applying fertilizer. While returns from fertilizer are as high as for any other investment opportunity open, the opportunity to realize this high return does not exist until investment has been made in planting the crops.

When the operating capital is increased to $10,000, the cropping system and milk cow numbers remain unchanged from the $5,000 level. Hog numbers, however, increase to 30 litters of 2:1 ratio (20 spring and 10 fall litters)—the limit of building space. September, October and November labor and capital limit beef cattle enterprises to seven deferred-fed calves and nine commercial heifers. All except 19 acres of the native pasture are utilized by the livestock. All forage produced by rotations is utilized by the livestock, but because of capital and labor limitations on livestock, additional forage would have little value. The plan shows 199 bushels of corn sold.

Capital becomes unlimiting at a level of $17,140. The plan corresponding to this capital level is shown at the bottom of table 10. With the addition of capital, the Sharpsburg soil retains the $CCOM_2$ rotation, but demands of livestock for forage now change the crop rotation on the Shelby soil from COM_2 to $COMM_2$.

Dairy cows are not included in this plan. The labor previously used in butterfat production is now partly transferred to beef feeding enterprises. The commercial heifers and the deferred-fed steers combine in this operation to provide income from cattle sales each May and November. The cattle numbers now are limited by forage from both the pasture and the rotation. Purchase of grain is indicated by the negative sign beside the 1,813 bushel grain deficit.

The poultry enterprise, the last to enter the farm organization, is limited by building space. Hogs are limited to 30 litters by building space, since the possibility of increasing hog space was not investigated in this study. In the unlimited capital situation, labor is no longer fully utilized in any month. When capital is available in sufficient quantities and grain can be purchased, greater returns are realized from the limited forage supply when it is used for cattle feeding, rather than for dairy cows from which butterfat is marketed.

From both the theoretical and practical view-

TABLE 10. OPTIMUM FARM PLANS, FOR OWNER-OPERATION UNDER AVERAGE MANAGEMENT; 152 CULTIVATED ACRES (NO GRADE B DAIRY ENTERPRISE).

Plan No.	Capital	Return	Enterprises in the farm plan	Limiting resources	Corn deficit or surplus
1	$ 5,000	$4,041[a]	91 acres Sharpsburg ($CCOM_2$)	Sharpsburg land	+3,387 bu.
	Less fixed costs	2,005	61 acres Shelby ($COMM_2$)	Shelby land	
	Net return	2,036	11 milk cows (butterfat)	Capital	
			10 hog litters (1:1 ratio)[b]	Forage	
			75 acres pasture (rented out)		
2	$10,000	$5,473	91 acres Sharpsburg ($CCOM_2$)	Sharpsburg land	+199 bu.
	Less fixed costs	2,005	61 acres Shelby ($COMM_2$)	Shelby land	
	Net return	3,468	11 milk cows (butterfat)	Capital	
			30 hog litters (2:1 ratio)[b]	Sept.-Oct.-Nov. labor	
			7 deferred-fed steers	Hog bldg. space	
			9 commercial heifers	Forage	
			19 acres pasture (rented out)		
3	Unlimiting ($17,140)	$6,212	91 acres Sharpsburg ($CCOM_2$)	Land	—1,813 bu.
			61 acres Shelby ($COMM_2$)	Hog bldg. space	
			30 hog litters (2:1 ratio)[b]	Poultry bldg. space	
	Less fixed costs	2,005	37 deferred-fed steers	Forage	
	Net return	4,207	200 hens		
			32 commercial heifers		

[a] All gross return figures include returns from pasture rented out at $4/acre when this practice is called for in the plan.

[b] In all tables of results, the number of litters refers to total in a year.
Example: 10 hog litters (1:1 ratio) means 5 spring and 5 fall litters;
30 hog litters (2:1 ratio) means 20 spring and 10 fall litters.

points, the owner's equity position assumes increasing importance as the plans move from the optimum for $10,000 to that of unlimiting capital. The interest earned on all capital up to the $10,000 level is at least 21 percent; whereas the last increment of capital necessary to reach the $17,140 level earns only 4.7 percent. The encumbered owner-operator may wish to operate at capital levels which provide a higher rate of return—at least high enough to pay interest costs. Up to $15,500 can be invested in the farm, under these assumptions, before returns to capital are driven below 7 percent. These figures would suggest, however, that the farmer who operates with funds limited to about $12,000 might prefer a plan including the dairy enterprise because of the greater stability of income, as well as the level of return on funds.

FARM PLANS FOR OWNER-OPERATION; 152 CULTIVATED ACRES, INCLUDING A GRADE B DAIRY ENTERPRISE

This situation is analyzed to provide a guide for farmers concerned with the profitability of a grade B dairy enterprise as compared with a butterfat and other livestock enterprises. The question posed is: When allowed to compete for the use of capital, will a grade B dairy enterprise be included in the optimum plan? The results of the empirical analysis are given in table 11. The 12-cow minimum imposed on the grade B dairy enterprise does not allow dairying to be included in an optimum plan where capital is restricted to $5,000. At the capital level of $5,760, however, the 12-cow minimum is fulfilled, and the dairy enterprise dominates the livestock program. Adequate grain and roughage is obtained by using $CCOM_1$ on Sharpsburg soil and $COMM_2$ on the Shelby soil. Both capital and forage combine to limit the size of the dairy herd, although the forage limitation is not sufficient to use the last alternative in this respect; namely, grazing the native grass pasture. Hence, the 75 acres of permanent pasture are rented out. This is in agreement with the optimum plan for $5,000 capital in table 10. This pasture could be utilized if funds were diverted from investment in fertilizer and if the cropping plan were changed to use fewer funds. Making this shift simply to cause full utilization of native pasture at a low capital level, however, would cause a decrease in profit. The use of limited capital for producing and selling grain provides a larger return than any livestock combination which requires the use of native pasture to supply forage.

A comparison of income from this plan with the optimum plan for $5,000 capital in table 10 shows a gain of $118 in net returns for an additional capital investment of $760. Hence, at the low capital level, there is no great difference in returns between the plan with a butterfat enterprise and one with grade B milk. A main reason that the difference is small is that the 12 cows in the plan with grade B milk do not provide a large enough enterprise for efficient utilization of the added equipment investment. With a small enterprise, the fixed cost per unit of output remains relatively high.

At the $10,000 capital level, the dairy enterprise expands to 17 cows, and 19 litters of pigs are included in the optimum plan. (See plan 2 in table 11). All cropland is now fertilized at the highest rate to provide grain and roughage. The dairy herd is of a size to use all forage from native and rotation pasture, and forage limits the size of the dairy herd. December, January and February labor and September, October and November labor limit hog production and cause the use of both the 1:1 ratio and the 1:0 ratio, thus placing emphasis on the production of spring pigs.

This plan returns $151 more than the plan at the same capital level in table 10 but which includes feeder cattle and more hogs. This similarity in income emphasizes the fact that there are numerous farm plans which may return about the same income. Hence, final decision on the one to select may depend on personal preference, desire for security, expectation of future markets and similar considerations.

The optimum plan, in which capital is no longer a limiting factor, is obtained with $12,674, producing a net return of $4,054. This plan (plan 3 in table 11) includes a grade B dairy enterprise. It is reached with $4,466 less capital and pro-

TABLE 11. OPTIMUM FARM PLANS FOR OWNER-OPERATION UNDER AVERAGE MANAGEMENT: 152 CULTIVATED ACRES (INCLUDING GRADE B DAIRY).

Plan No.	Capital	Return (includes pasture rent)	Enterprises in the farm plan	Limiting resources	Grain deficit or surplus
1	$ 5,760 (Lowest level with 12 cows)	$4,488	91 acres Sharpsburg ($CCOM_1$) 61 acres Shelby ($COMM_2$) 12 dairy cows (grade B) 75 acres pasture (rented out)	Sharpsburg land Shelby land Forage Capital	+3,269 bu.
	Less fixed cost	2,334			
	Net return	2,154			
2	$10,000	$5,953	91 acres Sharpsburg($CCOM_2$) 28 acres Shelby ($COMM_2$) 33 acres Shelby (COM_2) 17 dairy cows (grade B) 12 hog litters (1:1 ratio) 7 hog litters (1:0 ratio)	Land Capital Dec.-Jan.-Feb. labor Sept.-Oct.-Nov. labor	+1,477 bu.
	Less fixed cost	2,334			
	Net return	3,619			
3	Unlimiting ($12,674)	$6,388	91 acres Sharpsburg($CCOM_2$) 61 acres Shelby ($COMM_2$) 15 dairy cows (grade B) 15 hog litters (2:1 ratio) 10 hog litters (1:0 ratio) 17 commercial heifers 200 hens	Land Mar.-Apr. labor Sept.-Oct.-Nov. labor Poultry bldg. space Hog bldg. space Forage	—83 bu.
	Less fixed cost	2,334			
	Net return	4,054			

duces $153 less net return than the parallel situation given in table 10.

This organization for unlimiting capital shows a reduction of two cows in the dairy herd, as compared with the $10,000 optimum plan in table 11. Hog and poultry production are limited by building space. March-April labor, September, October and November labor and forage limit the size of the dairy and commercial heifer enterprise.

The last increment of funds needed to reach the $10,000 capital level in table 11 earns a return of 23 percent. The last increment needed to reach the $12,674 level in table 11, however, earns less than 5 percent. Returns to capital decline rapidly above the $11,000 level. From the viewpoint of the operator, the use of credit at the $10,000 capital level, and possibly at the $11,000 level, would be profitable. Lenders, as well as operators, might view the unlimiting capital optimum in this situation as having less risk than a parallel capital level when grade B dairying is excluded. As compared with the last plan of table 10, net income is $153 less. Capital requirements also are $4,500 less, however, and 37 percent of the gross receipts are from the more stable dairy enterprise. Other research comparing the income and risk from various livestock enterprise combinations would support such an opinion.

FARM PLANS FOR OWNER-OPERATION; 152 CULTIVATED ACRES AND 16 GRADE B DAIRY COWS "FORCED" INTO THE PLAN[7]

This situation was analyzed to provide guidance to farmers who desire the income stability of a dairy enterprise and also wish to utilize all pasture and cropland with a minimum of operating capital. Hence, the questions to be answered by the programming techniques are: How will requirements of 16 dairy cows alter the investment in other enterprises? How much capital will be required to meet the conditions of this number of cows and full use of pasture? What will be the consequent income? The procedure of "forcing" 16 cows into the plan requires use of the native pasture and the necessary amounts of other limited resources for this number of cows. After these requirements have been met for dairying, other livestock and crop enterprises then are allowed to compete for the remaining resources.

The results in table 12 indicate that $7,137 of capital is required for a "minimum plan" which utilizes all the native pasture for grade B dairy cows and has all cropland in rotation. By adding the land and machinery investment of $42,063 to this, a total investment of $49,200 is required. When fixed costs of $2,334 are subtracted from the $4,943 returns, the resulting net farm income is $2,609. Thus, for a year's labor and the management of assets valued at $49,000, the operator has a net income of less than $3,000. The dairy enterprise has the least variable income (i.e., the lowest coefficient of variation) of any major livestock enterprise in Iowa.[8] From the standpoint of income stability alone, this plan might be the one with most appeal for a manager of average ability. Income is derived from two sources: the sale of cash grain and receipts from the dairy herd. Funds are insufficient for a hog enterprise if pasture and cropland are to be fully utilized and a 16-cow dairy herd is to be maintained. At the capital level indicated, the crop rotations receive only the lowest rates of commercial fertilizer ($CCOM_1$ and COM_1 for Sharpsburg and Shelby soils, respectively). Capital, all cropland and forage are limiting factors.

At the $10,000 capital level, the plan is practically identical with the $10,000 capital optimum described in the previous situation when grade B dairy cows were freely competing for the use of resources with all other enterprises. Hence, a different plan is not presented in table 12.

Capital becomes unlimiting at the $12,111 level when the 16 grade B cows are "forced" into the plan. (See plan 3 in table 12.) In most respects this plan differs little from, and is not superior to, the unlimiting capital optimum of plan 3 in table 11. Requiring 16 dairy cows, instead of the

[7] Number of cows required to utilize all forage when no pasture is rented out.

[8] Brown, William G. and Heady, E. O. Economic instability and choices involving income and risk in livestock and poultry production. Iowa Agr. Exp. Sta. Res. Bul. 431. 1955.

TABLE 12. FARM PLANS FOR OWNER-OPERATION UNDER AVERAGE MANAGEMENT; 152 CULTIVATED ACRES (16 GRADE B DAIRY COWS "FORCED IN")[a].

Plan No.	Capital	Return	Enterprises in the farm plan	Limiting resources	Grain deficit or surplus
1	$ 7,137	$4,943	91 acres Sharpsburg ($CCOM_1$)	Capital	+3,316 bu.
Less fixed cost		2,334	61 acres Shelby (COM_1)	Land	
Net return		2,609	16 dairy cows (grade B)	Forage	
2	$10,000	$5,953	91 acres Sharpsburg ($CCOM_2$)	Capital	+1,477 bu.
Less fixed cost		2,334	28 acres Shelby ($COMM_2$)	Land	
Net return		3,619	33 acres Shelby (COM_2)	Dec.-Jan.-Feb. labor	
			17 dairy cows (grade B)	Sept.-Oct.-Nov. labor	
			12 hog litters (1:1 ratio)	Forage	
			7 hog litters (1:0 ratio)		
3	Unlimiting ($12,111)	$6,306	91 acres Sharpsburg ($CCOM_2$)	Land	+328 bu.
			61 acres Shelby ($COMM_2$)	Forage	
Less fixed cost		2,334	16 dairy cows (grade B)	Hog bldg. space	
Net return		3,972	14 hog litters (1:0 ratio)	Poultry bldg. space	
			9 hog litters (2:1 ratio)	Dec.-Jan.-Feb. labor	
			8 commercial heifers	Sept.-Oct.-Nov.- labor	
			2 deferred-fed steers		
			200 hens		

[a] Number of cows required to fully utilize all forage when no acres are rented out.

15 cows which come into the plan when all enterprises are allowed to compete freely for resources, causes some decrease in all hog and beef enterprises. It also results in a decrease in net returns of $82. While income is decreased only slightly, the addition of one cow will not appreciably increase the stability of income.

Superior Management

Plans are now presented for five situations representing superior management. The levels of management differ in the manner outlined earlier.

Optimum Farm Plans for Owner-Operation; 152 Cultivated Acres (All Activities Except Milk Cows and Grade B Dairy)

In the previous sections the farm plans discussed were under average management. In this section these same resources are used to develop optimum plans under superior management. The differences between average and superior management for crop production are given in table 6 and table 7. The basic input-output data for livestock enterprises under superior management are given in table 8 and in appendix tables A-3 through A-12.

Optimum plans for one situation of superior management which exclude a butterfat and grade B dairy enterprise are presented for the following reasons: (a) Enterprises involving greater uncertainty and a wider range of net returns frequently are associated with superior management skills and a strong capital position. (b) According to the 1954 U. S. Census, nearly 20 percent of the Adams County farms reported no milk cows, and only 42 farms sold whole milk. (c) Beef cow population in Adams County is more than double that of milk cows. The results of the analysis of this situation are presented in table 13.

At the $5,000 capital level, the most profitable use of capital is use of the CCOM rotation at the second level of fertilization ($CCOM_2$). At this very low capital level, it is more profitable to invest the second increment of capital in efficiently produced livestock than in cropping of Shelby soils. (In practice, a superior manager with this small amount of capital might best rent out the unused Shelby soil.) Hence, hogs produced in a 1:1 litter system use the remaining capital, because they provide a more profitable use of limited funds, than cropping of Shelby soils or the investment in cattle to utilize the native pasture. The only limiting resources for this plan are Sharpsburg soil and capital.

Since not all land is cropped by the operator in plan 1, a second plan was devised which required the use of the Shelby land. This alternate plan, also at $5,000 of capital, is plan 2 in table 13. The Sharpsburg land would be used as in plan 1. The most profitable use of Shelby soil is COM_3, but use of capital for this purpose reduces the hog enterprise from 22 to 14 litters of 1:1 ratio and reduces income by $156. Obviously, then, the returns on capital used for cropping Shelby land or for more hogs are not greatly different. If we allow Shelby land to be rented out at $8 per acre, however, the alternate plan 2 returns $644 less than plan 1.

Even though it isn't forced in, all cropland, including Shelby soil, is included in the optimum plan when capital reaches the $8,546 level. In this plan, the hog enterprise reaches the maximum level allowed by buildings before any beef cattle enterprises enter the plan. Native pasture is still rented out at this capital level. The limiting resources now are hog building space, capital and cropland.

TABLE 13. OPTIMUM FARM PLANS FOR OWNER-OPERATION UNDER SUPERIOR MANAGEMENT; 152 CULTIVATED ACRES (ALL ACTIVITIES EXCEPT MILK COWS AND GRADE B DAIRY).

Plan No.	Capital	Return	Enterprises in the farm plan	Limiting resources	Grain deficit or surplus
1	$ 5,000	$4,293	91 acres Sharpsburg ($CCOM_2$)	Sharpsburg land	+1,356 bu.
	Less fixed costs	2,005	61 acres Shelby (not cropped)		
	Net return	2,288	22 hog litters (1:1 ratio)	Capital	
			75 acres pasture (rented out)		
2	$ 5,000 (alternate plan)	$4,137	91 acres Sharpsburg ($CCOM_2$)	Land	+3,459 bu.
			61 acres Shelby (COM_2)	Capital	
	Less fixed costs	2,005	14 hog litters (1:0 ratio)		
	Net return	2,132	75 acres pasture (rented out)		
3	$ 8,546	$6,070	91 acres Sharpsburg ($CCOM_2$)	Cropland	+1,232 bu.
	Less fixed costs	2,005	61 acres Shelby (COM_3)	Capital	
	Net return	4,065	36 hog litters (2:1 ratio)	Hog bldg. space	
			75 acres pasture (rented out)		
4	$10,000	$6,617	91 acres Sharpsburg ($CCOM_2$)	Cropland	+797 bu.
	Less fixed costs	2,005	61 acres Shelby (COM_3)	Capital	
	Net return	4,612	36 hog litters (2:1 ratio)	Hog bldg. space	
			11 deferred-fed steers		
			53 acres pasture (rented out)		
5	$12,134	$7,418	91 acres Sharpsburg ($CCOM_2$)	Cropland	+160 bu.
	Less fixed costs	2,005	61 acres Shelby (COM_3)	Capital	
	Net return	5,413	36 hog litters (2:1 ratio)	Hog bldg. space	
			27 deferred-fed steers		
			21 acres pasture (rented out)		
6	Unlimiting ($22,167)	$9,692	91 acres Sharpsburg ($CCOM_3$)	All land	—1,445 bu.
			61 acres Shelby ($COMM_3$)	Poultry bldg.	
	Less fixed costs	2,005	38 deferred-fed steers	Sept.-Oct.-Nov. labor	
	Net return	7,687	36 hog litters (2:1 ratio)	Forage	
			42 medium yearling steers	Hog bldg. space	
			200 hens		

TABLE 14. OPTIMUM FARM PLAN FOR OWNER-OPERATION UNDER SUPERIOR MANAGEMENT; 152 CULTIVATED ACRES (INCLUDING GRADE B DAIRY AND ALL ACTIVITIES EXCEPT THE BUTTERFAT DAIRY ENTERPRISE).

Plan No.	Capital	Return	Enterprises in the farm plan	Limiting resources	Grain deficit or surplus
1	$12,134[a] (including 12 cows)	$7,931	91 acres Sharpsburg ($CCOM_2$) 36 acres Shelby (COM_3) 12 dairy cows 36 hog litters (2:1 ratio) 25 acres Shelby (not cropped) 15 acres pasture (rented out)	Sharpsburg land Capital Hog bldg. space Sept.-Oct.-Nov. labor Feed grain	0
Less fixed costs		2,334			
Net return		5,597			

[a] As capital is increased, a poultry enterprise comes into the plan. Since September-October-November labor and feed grain are both limiting in the above plan, however, adding a poultry enterprise calls for an increase of COM acres (for feed grain), which in turn must get September-October-November labor by decreasing the number of dairy cows.

At the $10,000 capital level, 11 deferred-fed steers enter the optimum plan. These steers use 22 acres of native pasture and leave 53 acres to be rented out. Land use and the limiting resources are the same as in the previous plan. Grain sales decline to 797 bushels.

The deferred-fed steer enterprise increases to 27 head, or more than double the number in the previous plan, for the optimum plan at the $12,134 capital level. Hogs remain at the maximum of 36 litters, 24 spring and 12 fall, and surplus pasture is rented out. The only limiting resources are capital, cropland and hog building space. The return of $7,418 represents a net income of $5,413 after the deduction of $2,005 in fixed costs. The total investment managed is $54,197 ($42,063 in land and machinery plus $12,134 operating capital). This plan is included for comparison with plan 1 in table 14 to be presented in the next situation.

When limitations are not placed on funds, capital increases to a level of $22,167 before a final optimum plan is attained. The resulting plan (plan 6 in table 13) has a return of $9,692, or a net, after deducting fixed costs, of $7,687. The Sharpsburg soils now are fertilized at the highest rates ($CCOM_3$). The rotation on Shelby is changed to $COMM_3$ to meet the forage requirements of a much larger beef cattle program.

The beef cattle enterprise is almost evenly divided between deferred-fed steers and medium yearling steers. In conformity with all other situations in this study, the poultry enterprise is the last to enter the plan, indicating a low return to capital. It is limited to 200 hens by the size of the poultry building. Other limiting resources include all land, hog buildings, fall labor and forage. This plan provides cattle sales in May—the seasonal high for medium steers—and in November—the seasonal high for good to choice 900-1,100-pound steers. The last increment of capital needed to reach the level of this plan returns more than 12 percent interest. Under superior management the more speculative replacement cattle enterprise has a premium place in farm organization, as compared with the situations under average management.

OPTIMUM FARM PLANS FOR OWNER-OPERATION; 152 CULTIVATED ACRES (INCLUDING GRADE B DAIRY AND ALL OTHER ACTIVITIES EXCEPT BUTTERFAT DAIRY)

This study indicates that under the conditions of superior management the grade B enterprise enters the optimum plans only over a very narrow range of capital. Plans with small amounts of capital do not meet the 12-cow minimum required for the grade B dairy herd and, hence, were discarded. At capital levels of about $13,000, other enterprises become sufficiently profitable and competitive to reduce the number of cows in the grade B dairy herd below the 12-cow minimum. Only one plan, that with $12,134, included a grade B enterprise with as many as 12 cows. In practice, however, a feasible optimum plan might include 11 to 13 dairy cows, and the capital required might vary by $1,000 depending upon market conditions. In general, firmly established owner-operators with superior management skills and operating capital on either side of this range are not likely to switch to grade B dairy unless its competitive position improves. Young owner-operators, with this amount of capital and heavy debt loads, however, might plan in this direction to attain greater stability of income, even though they sacrifice some profit.

In this optimum plan, $CCOM_2$ is the crop rotation for all Sharpsburg soil, and COM_3 is used on 36 acres of Shelby. Hogs (2:1 ratio) and dairy cows use capital more efficiently than does cropping the remaining Shelby. (It would be rented out if profits were maximized under the conditions specified.) The dairy cows use 60 acres of native pasture; the remaining 15 acres can be rented out. In actual practice, of course, the Shelby cropland and the pasture probably would not be rented out. Income would be reduced slightly, but not enough to cause an owner-operator to rent out, rather than to crop or pasture, this small amount of land.

Comparison of the optimum plans at the $12,134 capital level, with (table 14) and without (table 13) dairy cows, now can be made. The two plans are identical with respect to the use of crop rotations and fertilizer levels on Sharpsburg soil and have identical hog enterprises. Both call for renting out small acreages of native pasture. Differences between the two plans are as follows: (a) Under the dairy plan, 25 acres of Shelby soil are left idle but are fully utilized with the hog and deferred-fed steer combination in table 13. (b) The hog enterprise accounts for 58 percent of the livestock investment when the dairy enterprise is included, but 64 percent when 27 deferred-fed steers are included in place of dairy. At the same capital level of $12,134, net returns are $184 higher for the plan with dairy cows.

Variance in livestock income also would be somewhat less for the plan which includes dairying. To measure this possibility, variance in livestock income per $100 of costs was computed by applying prices which existed over the past 25 years. The results are given in table 15.

Again the choice between the two plans probably would be based on capital position, risk aversion, personal preference and other such items rather than on difference in income as expressed by the prices and input-output coefficients used in this study. Since dairy cows are included only at this single capital level, however, the analysis which follows does not include further consideration of dairying as a competitive enterprise under superior management.

OPTIMUM FARM PLANS FOR OWNER-OPERATION UNDER SUPERIOR MANAGEMENT; 152 CULTIVATED ACRES (12 GRADE B DAIRY COWS AND 9 BEEF COWS FORCED IN TO UTILIZE ALL ROUGHAGE)

Neither of the two plans just discussed, with capital limited, utilize all of the pasture forage. In the next plan, 12 dairy cows and 9 beef cows are "forced into" the plan to utilize all forage under superior management. The cow enterprises are not competitive in the sense that they will be included if they are the most profitable enterprise or excluded if they are not. Other enterprises are still considered to be competitive, however, and enter the plan, within the restrictions of using 12 dairy cows and 9 beef cows, as they represent the most profitable use of scarce resources.

Beef cows producing feeder calves were included as possible alternatives in all situations studied. They do not enter optimum farm plans at any capital level, however, because they return less on investments than other enterprises studied. Yet the coefficient of variation for returns per $100 of all cost is lower for beef cow herds than for any other beef cattle enterprise.[9] Since this variation is also low for the dairy enterprise, a plan combining these two enterprises to use roughage has low risk and may be preferred by some operators. Hence, this type of plan was computed to determine the cost, in terms of income lost, of using a cattle program combining low risk and "full forage utilization" characteristics under superior management. The resource restrictions are identical with those used in other situations. The minimum of 12 grade B dairy cows to meet market firm requirements leaves enough native pasture for 9 beef cows and replacements.[10]

A capital level of $8,903 is required to establish this low-risk organization and a full cropping program. The net return is $3,141 (plan 1 in table 16). Capital, all cropland and forage are the limiting resources. Comparing this plan with that for the $8,546 capital level (plan 3 in table 13) indicates that the cost is $924 in returns sacrificed, but $357 less operating capital is needed. Avoiding risk in this instance reduces net income by 23 percent.

At the $10,000 capital level, however, the optimum plan (plan 2 in table 16) gives a return of $3,729, or $883 less than the plan (plan 4 in table 13) for $10,000 capital where feeder cattle are allowed. At this capital level, avoidance of risk and utilization of all forage would reduce net income by 19 percent. In plan 2 of table 16, five brood sows producing 10 litters in 1:1 ratio are included. The crop rotation on Shelby soil changes, as compared with the first plan of this table, from COM_3 to $COMM_3$.

Only capital and all land are limiting resources. When capital is not a limiting resource (plan 3 in table 16), net return is $6,109. This return is $1,578 below that of plan 6 in table 13 where dairy and beef cows are not forced into the plan. These two plans are not entirely comparable because the plan of table 13 uses $22,167 of operating capital, as compared with $15,126 for the plan of table 16. The return on the added $7,041, however, is better than 20 percent. Between these two situations, the operator would need to decide: Should he use more capital and gain approximately $1,600 in income, or should he invest less capital and take less risk? The existence of many small beef cow herds and some small butterfat herds in the area suggests that some farmers probably consider the income sacrifice to be offset by a greater certainty of income. It is also possible, however, that they are not aware of the amount of income sacrificed to gain greater income stability.

OPTIMUM PLAN FOR OWNER-OPERATION; 152 CULTIVATED ACRES (INCLUDING ALL ACTIVITIES PLUS PASTURE RENOVATION)

The types of plans previously presented are only a few of the many that could be developed to lessen risk. The analysis now turns to the possibility of pasture renovation as an investment alternative. A comparison then will be made of returns from pasture renovation and returns from purchase of more land when management is at the superior level.

[9] Brown and Heady, **op. cit.**, p. 552.

TABLE 15. A COMPARISON OF THE LIVESTOCK ENTERPRISE COMBINATIONS FROM TWO OPTIMUM PLANS AT THE $12,146 CAPITAL LEVEL, WITH VARIATION IN INCOME MEASURED BY RETURNS PER $100 ALL COSTS USING VARIANCE, STANDARD DEVIATION AND COEFFICIENT OF VARIATION[a].

Composition of the livestock plan	Variance	Std. Dev.[b]	C.V.[c]
36 litters (2:1 ratio) hogs and 12 grade B dairy cows	381.5	18.6	19.5
36 litters (2:1 ratio) hogs 27 deferred-fed steers	792	28.1	25.5

[a] Adapted from Brown, William G. and Heady, E. O. Economic instability and choices involving income and risk in livestock and poultry production. Iowa Agr. Exp. Sta. Res. Bul. 431. 1955. p. 555.

[b] Standard deviation.

[c] Coefficient of variation.

[10] In this situation the necessary resources are reserved to meet the requirements of the dairy and beef cows; thereafter, all other activities compete for remaining resources.

TABLE 16. OPTIMUM FARM PLAN FOR OWNER-OPERATION UNDER SUPERIOR MANAGEMENT; 152 CULTIVATED ACRES (12 GRADE B DAIRY COWS AND 9 BEEF COWS "FORCED IN" TO UTILIZE ALL FORAGE).

Plan No.	Capital	Return	Enterprises in the farm plan	Limiting resources	Grain deficit or surplus
1	$ 8,903	$5,475	91 acres Sharpsburg ($CCOM_2$)	Capital	+4,031 bu.
	Less fixed cost	2,334	61 acres Shelby (COM_3)	All land	
	Net return	3,141	12 dairy cows		
			9 beef cows		
2	$10,000	$6,063	91 acres Sharpsburg ($CCOM_2$)	Capital	+2,770 bu.
	Less fixed cost	2,334	61 acres Shelby ($COMM_3$)	All land	
	Net return	3,729	12 dairy cows		
			9 beef cows		
			10 hog litters (1:1 ratio)		
3	$15,126 (Unlimiting)	$8,443	91 acres Sharpsburg ($CCOM_2$)	All land	+206 bu.
			61 acres Shelby ($COMM_3$)	Hog bldg. space	
	Less fixed cost	2,334	12 dairy cows	Poultry bldg. space	
	Net return	6,109	9 beef cows	Sept.-Oct.-Nov. labor	
			5 hog litters (1:0 ratio)	Forage	
			27 hog litters (2:1 ratio)		
			5 medium steers		
			200 hens		

Pasture renovation enters the optimum plan only at high capital levels, when labor restrictions are lifted and family labor can be supplemented by hired labor in the fall and early spring months. The hired labor is necessary for expansion of livestock to utilize more forage from pasture improvement. The first plan, and the only one computed where pasture renovation enters the organization, is given in table 17. (The input-output data for the pasture renovation activity are included in appendix table A-13.)

Labor restrictions are lifted by permitting labor to be hired at $1 per hour. Hiring of labor permits an increase in the deferred-fed steer enterprise. Both Sharpsburg and Shelby soils are planted to rotations using the highest rate of fertilizer. Pasture renovation represents a satisfactory use of capital only when large quantities are available and other investment opportunities are lacking, since investment returns from renovation are low. The results of this study are in agreement with other research on pasture renovation.[11]

The entire 75 acres of permanent pasture are not renovated because of forage limitation from the crop rotations. Among those considered in this study, the rotations producing a maximum of forage are used, and all forage from them is utilized for hay. The scale of the resulting livestock enterprise, limited as it is by forage, requires approximately 72 renovated acres and 3 unrenovated acres. (In practice, the farmer probably would renovate all acres.) The returns to the very last increment of capital in this optimum plan do not exceed 3 percent—less than the interest rate on borrowed capital. Earlier studies considered the life of renovated pasture to be 15 or 20 years, or even longer with proper maintenance. Since drouths in recent years have caused some complete failures in renovated pasture, however, the life of renovated pasture in this study is considered to be 10 years. Seeding and establishment of the stand require 11 years of elapsed time to obtain 10 years of grazing. Seeding failures are expected one time in six. These factors, plus high costs of establishment and annual maintenance, place renovation of pasture in a poor competitive position with respect to other uses for limited capital on farms in southern Iowa.[12] (Even if a life of 20 years is assumed, the return on the last increments of capital invested on renovation is only 6 percent.)

[11] Heady, Earl O., Olson, Russell O. and Scholl, J. M. Economic efficiency in pasture production and improvement in southern Iowa. Iowa Agr. Exp. Sta. Res. Bul. 419. 1954. McKee, Dean E., Heady, Earl O. and Scholl, J.M. Optimum allocation between pasture improvement and other opportunities on southern Iowa farms. Iowa Agr. Exp. Sta. Res. Bul. 435. 1956.

[12] The 6-year average yields (1949-54) at the pasture improvement farm in Albia, Iowa, are 93 pounds of beef per acre on the unimproved check and 248 pounds for renovation from a trefoil-bluegrass mixture. The latter has been adjusted to 221 pounds in this study, to account for seeding failures and establishment each 10 years. (Scholl, J. M., Hughes, H. D. and McWilliams, Richard. Renovation can double pasture production. Iowa Farm Science. 9:7-8. 1955.)

OPTIMUM FARM PLAN FOR OWNER-OPERATION (INCLUDING PASTURE RENOVATION, GRADE B DAIRY, ALL OTHER ACTIVITIES AND LAND BUYING)

A final analysis made for superior management is that of land buying. This alternative was added to determine the farm size which might be optimum for a farm operated entirely with family labor. Interest also is in the magnitude of income generated by a farm of this size. Finally, this activity was added to determine whether a farmer might better expand the base of his operation and his volume of business through pasture renovation or through adding to acreage of his farm.

When pasture renovation and land buying op-

TABLE 17. OPTIMUM PLAN FOR OWNER-OPERATION UNDER SUPERIOR MANAGEMENT; 152 CULTIVATED ACRES (ALL ACTIVITIES INCLUDING PASTURE RENOVATION).

Plan No.	Capital	Return	Enterprises in the farm plan	Limiting resources	Grain surplus or deficit	Hours of labor hired
1	$27,211 (Unlimiting)	$10,043	91 acres Sharpsburg ($CCOM_3$)	All land	—2,735 bu.	56 hrs. in March-April
			61 acres Shelby ($COMM_3$)	Hog bldg. space		
	Less fixed cost 2,005		86 deferred-fed steers	Poultry bldg. space		425 hrs. in Sept.-Oct.-Nov.
	Net return 8,038		36 hog litters (2:1 ratio)	Forage		
			200 hens			
			72 acres renovated pasture			

portunities were considered together, priority and use of capital always went to land buying. This selection occurred under land buying assumptions requiring a 40-percent down payment on land priced at $131.49 per acre, with interest paid on the remainder. The buying activity included land of the same type and soil combination as the basic farm. Thus, each 10 acres purchased would include 3.8 acres of Sharpsburg cropland, 2.5 acres of Shelby cropland and 3.1 acres of native pasture. The remaining 0.6 acre consists of roads and waste.

In this situation, designed to determine the optimum farm size within the restrictions of family labor, all other restrictions are the same as in the situations discussed earlier, except that land is now placed in the same category as feed grains (i.e., land may be purchased as long as farm returns are increased). As a user of capital, however, the land buying activity must compete with all other enterprises open to the farm. (See earlier discussion of activities considered.) The buying operation starts from the base of 152 acres of cultivated land. The basic input data for the land buying activity are given in appendix table A-14.

Within the assumptions outlined, the farm size increases to 483 acres, in terms of profit optimum, when capital is not limiting. A farm of this size would require a purchase of 243 acres, starting from the original size of 240 acres in cropland and native pasture. In this plan the down payment of $52.60 per acre purchased is included in the capital figure given in table 18. Thus, the down payment on newly purchased land requires $12,782, and other activities require $30,643, to make up the capital of $43,425—an amount which does not include the original $42,063 invested in the first 240 acres, plus the machinery and equipment for field operation. As mentioned in the previous section, land buying is a better competitor for the use of capital than pasture renovation. No pasture is renovated in this plan. The crop rotations provide ample forage at the highest rate of fertilization. Hence, the permanent pasture is rented out. In common with other nonlimited capital plans which do not include dairy cows, the highest level of fertilization is used on the Sharpsburg soils. This plan shows a return of more than 6 percent on the last increment of capital used.

Thus a farmer with a full equity in a 240-acre farm may well consider expanding to twice this acreage under the conditions assumed in this study if his goal is profit maximization and if he is not concerned with relinquishment of farm operation by other persons. But to expand to the scale just mentioned, he would need about $85,000 in capital, less that which he might borrow for livestock and equipment. (The $85,000 assumes full equity in the first 240 acres and 40 percent equity in the added acreage. If all 483 acres and all capital and equipment were owned with 40 percent equity, he would need only $43,864 of his own capital.)

It also should be pointed out that the plan just described emerges under the assumption of labor supply and hog building space held fixed at the magnitude used in other situations. If these restrictions were lifted, the hog enterprise would be expanded somewhat before all of the additional capital indicated is invested in more land. With the addition of hired labor and more machinery, however, the optimum acreage would not be restricted to 483 acres.

SOME GENERAL IMPLICATIONS

This study has indicated that there are some possibilities for increasing and stabilizing income by adding a dairy enterprise for farms in the Shelby-Sharpsburg soil complex. This opportunity is open especially to farmers of average managerial ability. The study also shows that, with limited capital, there are several farm plans, involving different types of cattle programs which return about the same income. Hence, final selection of a plan may well rest on personal preferences, risk aversion, capital limitations or special market opportunities open to the farm family.

The study also indicates that over some range of combinations, the level of management is more important in lifting incomes to a considerably higher level than are the specific enterprises included in the farm plan. It also indicates that considerable improvement can be made in income through expansion of farm size. This alternative requires availability of fairly large amounts of capital, however, particularly if operation is under ownership. Farmers with limited assets might well focus attention on improving managerial ability as a means of producing given levels of income with a lower cost collection of inputs or

TABLE 18. OPTIMUM FARM PLAN FOR OWNER-OPERATION UNDER SUPERIOR MANAGEMENT (INCLUDING PASTURE RENOVATION, GRADE B DAIRY, ALL OTHER ACTIVITIES AND LAND BUYING).

Plan No.	Capital	Return	Enterprises in the farm plan	Limiting resources	Grain deficit or surplus
1	Unlimiting	$12,851	183 acres Sharpsburg ($CCOM_3$)	Land	+4,181 bu.
	$43,425		123 acres Shelby ($COMM_3$)		
	(above 6% return)		33 deferred-fed steers	Poultry bldg. space	
Less fixed cost[a]		2,484	18 hog litters (1:0 ratio)	March, April labor	
Net return		10,367	113 medium steers	Sept.-Oct.-Nov. labor	
			200 hens		
			243 acres land purchased		
			151 acres permanent pasture rented out		
			No pasture renovated		

[a] Fixed cost includes $2,005 as explained previously, plus 1.5 percent of the value of the 243 acres purchased, as an allowance for real estate tax.

resources or of producing more income from given resources and capital. But, at the prices used in this study, a grade B dairy enterprise does not compete as favorably as other cattle enterprises under superior management. Even then, some farmers of superior management ability and limited funds might wish to sacrifice some income for the greater certainty and stability of income provided by a dairy enterprise. Also, improvement in markets, dairy product prices and dairy production technology beyond the levels used in this study could cause the dairy enterprise to have a more important place in farm organization for the superior manager.

APPENDIX

TABLE A-1. ESTIMATED INVESTMENT AND FIXED COSTS FOR OWNER-OPERATOR FARM.

Farm machinery description	Price[a]	Estimated salvage value	Estimated[b] life (years)	Annual depreciation
Tractor (3-plow, new)	$ 2,575.00	$232	10	$219
Plow (3-bottom 14", used)	230.00	34	11	18
Tandem disk (10' wheel mounted, new)	555.00	83	12	39
Cultivator (2-row, used)	140.00	21	9	13
Power mower (7', new)	340.12	51	12	24
Corn planter (4-row, used)	410.00	61	10	35
Drag harrow (24', used)	100.00	15	11	8
Rotary hoe (2-row, new)	205.00	31	12	14
2 flare box wagons on 4-wheel rubber tire trailers (used)	400.00	60	13	26
Fertilizer spreader (10', new)	241.00	36	8	26
Grass seeder tractor (mounted new)	91.60	14	12	6
Corn picker (2-row, used)	740.00	111	8	79
Elevator (32', used)	300.00	45	12	21
Side delivery rake (new)	275.00	41	12	19
Roto baler (used)	700.00	105	8	74
Combine (6', used)	885.00	133	8	94
Manure loader (used)	168.00	25	10	14
Manure spreader (used)	250.00	37	7	30
Auto (farm share 50%)	1,900.00	285	6	135
Total	10,505.72	1,574	---	894

Summary of annual fixed costs

Item	Amount
Total machinery depreciation	$ 894.00
Depreciation on fences, tiling and service buildings[c]	360.00
Real estate taxes[d]	473.36
Personal property taxes on machinery and insurance on service buildings[d]	142.21
Electricity (farm share)	35.00
Miscellaneous expense	100.00
Total fixed costs	2,004.57
Investment summary, nonliquid assets	
Real estate investment, 240 acres at $131.49[e]	31,557.60
Machinery investment (original cost, new or used)	10,505.72
Total nonliquid assets	42,063.32

[a] Based on used machinery prices prevailing at farm auction sales in southern Iowa during 1955-56, where used prices are shown.
[b] Estimated life based on Internal Revenue Service Bulletin "F," Adjusted.
[c] As reported by the owner of an Adams County farm.
[d] Estimated to be 1.5 percent of current value.
[e] Value of farmland in Adams County, 1954 Census of Agriculture.

TABLE A-2. FIXED COST INCREASE ASSOCIATED WITH GRADE B DAIRY.

Item	Price	Estimated salvage value	Estimated life, years	Annual depreciation
Milk house	$1,000	---	25	$ 40
Cooling tank (250 gal.)	2,500	$250	15	150
Milking machine	600	60	10	54
Other equipment	200	---	10	20
Total	4,300	---	---	264
Additional property tax[a]				65
Other fixed costs from table A-1				2,005
Total estimated fixed costs with grade B dairy enterprise				$2,334

[a] Estimated to be 1.5 percent of current value.

TABLE A-3. BASIC INPUT-OUTPUT DATA FOR HOG SYSTEMS USED IN THIS STUDY.

	Average management	Superior management
1. Number of pigs weaned per litter	6.50	7.30
2. Death loss after weaning	0.44	0.22
3. Replacement gilts	1.00	1.00
4. Number of pigs sold (at 225 lbs.)	5.06	6.08
5. Total cwt. of pork produced (line 3 + line 4) x 225 pounds)	13.63	15.93
6. Total lbs. feed inputs per cwt.	500.00	415.00
7. Protein level (%)	10.20	12.06
8. Corn equivalent per cwt. pork[a] (lbs.)	410.00	318.00
9. Protein supplement per cwt. pork[a] (lbs.)	50.00	65.00
10. Hay equivalent per cwt. pork[a] (lbs.)	40.00	32.00
11. Labor per litter[b] (hours)	33.00	26.00
Capital investment per cwt. pork ($)		
12. Sow	3.12	2.84
13. Equipment	1.49	1.89
14. Total	4.61	4.73
Annual cash expense per cwt. pork ($)		
15. Protein	2.65	3.44
16. Power[b]	0.71	0.55
17. Use of equipment[b]	0.67	0.67
18. Miscellaneous[b]	0.99	0.96
19. Boar service[b]	0.13	0.09
20. Total annual expense per cwt. pork	5.15	5.71
21. Sows and boars sold per litter system at both average and superior management 1:0 (325 lbs.), 1:1 (400 lbs.), 2:1 (725 lbs.)		
22. Building space, (sq. ft. per hog)	10	8

[a] Jensen, A. H., Acker, D. C., Ashton, G. C., Homeyer, P. G., Heady, E. O. and Catron, D V. Different protein levels with and without antibiotics for growing-finishing swine: Effect on growth rate and feed efficiency. Jour. Anim. Sci. 14:69-81. 1955.
[b] Hardin, L. S., Weigle, R. N. and Wann, H. S. Hogs—one- and two-litter systems compared. Purdue Univ. Agr. Exp. Sta. Bul. 565. 1951.

TABLE A-4. FEED REQUIREMENTS AND NUMBER OF PIGS, SOWS AND STAGS SOLD PER LITTER SYSTEM.[a]

	1:1		2:1		1:0	
Management level	Average	Superior	Average	Superior	Average	Superior
1. Pigs weaned (No.)	13.00	14.60	19.50	21.90	6.50	7.30
2. Death loss after weaning (No.)	0.88	0.44	1.32	0.66	0.44	0.22
3. Replacement gilts (No.)	1.00	1.00	2.00	2.00	1.00	1.00
4. Pigs sold (No.)	11.12	13.16	16.18	19.24	5.06	6.08
5. Cwt. of replacement of market hogs (line 3 + line 4) x 225)	27.27	31.86	40.90	47.79	13.63	15.93
6. Cwt. market hogs sold (line 4 x 225)	25.02	29.61	36.40	43.29	11.38	13.68
7. Cwt. sows sold	4.00	4.00	7.25	7.25	3.25	3.25
8. Total cwt. pork sold	29.02	33.61	43.65	50.54	14.63	16.93
Feed requirements basis (line 8)						
9. Corn equivalent (lbs.)	11,898.20	10,687.98	17,896.50	16,071.72	6,000.35	5,383.74
10. Corn equivalent (bu.)	212.47	190.86	319.58	287.00	107.15	96.14
11. Protein supplement (lbs.)	1,451.00	2,184.65	2,182.50	3,285.10	731.75	1,100.45
12. Hay (tons)	0.58	0.54	0.87	0.81	0.29	0.27
13. Annual cash expense ($)	149.45	191.91	224.80	288.58	75.37	96.67
14. Capital investment by litter system ($)						
Sow	47.52	47.52	95.04	95.04	47.52	47.52
Equipment	27.53	31.23	55.05	62.46	22.60	30.48
15. Total capital investment	75.05	78.75	150.09	157.50	70.12	78.00
16. Total capital coefficient	224.50	270.66	374.89	446.08	145.49	174.67
17. Building space (sq. ft.)	73.46	64.08	89.27	72.08	44.62	48.66

[a] Derived from basic input-output data and from price and market assumptions used in this study.

TABLE A-5. HOG SALES BY LITTER SYSTEMS, AVERAGE MANAGEMENT.

1:1—Farrow: March and September—Sell: March and September		
September sale	13.635 cwt. @ $18.04	$245.99
March sale	11.385 cwt. @ $16.93	192.75
May sale of sow	4.000 cwt. @ $15.46	61.84
Total		500.58
Less 45c per cwt. marketing expense (29.02 cwt.)		13.06
GROSS RECEIPTS		$487.52
2:0—Farrow 2 litters in March and 1 in September		
September sale (2 litters less 1 replacement) 25.02 cwt. @ 18.04		$451.36
March sale (1 litter less 1 replacement) 11.385 cwt. @ $16.93		192.75
May sale (2 sows)	7.25 cwt. @ $15.46	112.08
Total		756.19
Less 45c per cwt. marketing expense (43.655 cwt.)		19.64
GROSS RECEIPTS		$736.55
1:0—September sale of pigs farrowed in March		
September sale (1 litter)	11.385 cwt. @ $18.04	$205.39
May sale of sow	3.25 cwt. @ $15.46	50.24
Total		255.63
Less 45c per cwt. marketing expense (14.635 cwt.)		6.59
GROSS RECEIPTS		$249.04

TABLE A-6. HOG SALES BY LITTER SYSTEMS, SUPERIOR MANAGEMENT.

1:1—Farrow: February and August—Sell: August and February		
August sale	15.93 cwt. @ $18.80	$299.48
February sale	13.68 cwt. @ $16.65	227.77
May sale of sow	4.00 cwt. @ $15.46	61.84
Total		589.09
Less 45c per cwt. marketing expense (33.61 cwt.)		15.12
GROSS RECEIPTS		$573.97
2:1—Farrow 2 litters in February and 1 in August		
August sale (2 litters less 1 replacement) 29.61 cwt. @ $18.80		$556.67
February sale (1 litter less 1 replacement) 13.68 cwt. @ $16.65		227.77
May sale (2 sows)	7.25 cwt. @ $15.46	112.08
Total		896.52
Less 45c per cwt. marketing expense (50.54 cwt.)		22.74
GROSS RECEIPTS		$873.78
1:0—August sale of pigs farrowed in February		
August sale (1 litter less replacement) 13.68 cwt. @ $18.80		$257.18
May sale of sow	3.25 cwt. @ $15.46	50.24
Total		307.42
Less 45c per cwt. marketing expense (16.93 cwt.)		7.62
GROSS RECEIPTS		$299.80

TABLE A-7. BASIC INPUT-OUTPUT DATA PER COW INCLUDING REPLACEMENTS.

Production and resource requirements per head	Unit	Average Milk cow B.F. basis	Average Grade B dairy cow	Superior Grade B dairy cow
Feed				
Corn equivalent[a]	bushels	31.37	43.03	59.59
Supplement and calf starter[a]	pounds	192.00	312.00	391.00
Whole milk for calf[a]	pounds	110.00	110.00	121.00
Hay equivalent[a]	pounds	12,694.00	13,114.00	13,946.00
Labor	hours	124.00	129.00	129.00
Building	sq. ft.	84.00	84.00	84.00
Produced and sold[b]				
Milk 3.6% B.F.	pounds	5,362.00	8,000.00	9,500.00
Cull cow[a] 0.20	pounds	250.00	260.00	270.00
2-year-old heifer[a]	dollars	17.57	23.42	.....
2-year-old heifer[a]	dollars	.....	.....	35.70
Veal calf[a] 0.410	pounds	45.10	45.10	.....
Veal calf[a] 0.445	pounds	.....	.....	58.95
Butterfat[a]	pounds	189.00	.....	.....
Skim milk[c]	pounds	4,443.00	.....	.....
Whole milk[a]	pounds	.....	7,890.00	9,379.00
Annual cash expense[d]				
Variable power cost	dollars	3.01	4.50	5.34
Shelter	dollars	4.63	5.23	4.06
Miscellaneous	dollars	15.81	26.14	33.26
Tractor power	dollars	1.70	1.70	1.72
Auto expense	dollars	0.25	0.25	0.25
Truck expense	dollars	1.20	1.20	1.20
Supplement and calf starter	dollars	8.48	13.79	17.28
Hay harvest expense	dollars	21.27	21.98	23.37
Equipment replacement	dollars	2.60	2.60	2.60
Building replacement	dollars	1.35	1.62	1.35
Total	dollars	60.30	79.01	90.43
Capital investment				
Cow	dollars	144.00	192.00	228.00
Equipment	dollars	10.00	100.00	100.00
1/12 of annual cash expense	dollars	5.15	6.58	7.47
Total capital per cow and replacements	dollars	159.15	298.58	335.47

[a] Foreman, Fred, associate professor of dairy husbandry, Iowa State University, Ames, Iowa. Computation of feed requirements, calf production and mortality based on a 4-year record of the Iowa State University dairy herd, 1952-55. (Private communication.) 1956.

[b] Based on mortality rates expressed as percent per cow in the herd.

[c] Morrison, Frank B. Feeds and feeding, feed substitution value of skim milk. Morrison Publishing Co., Ithaca, N. Y. 21st ed. p. 590.

[d] Pond, G. A. and Hasbargen, P. R. Progress report on N. C. 28 project—Minnesota. (Mimeo report.) 1956.

TABLE A-8. BASIC INPUT-OUTPUT DATA FOR DEFERRED-FED STEER CALVES.

Item	Average management	Superior management
Purchase date (Year N)	Nov.	Nov.
Weight at purchase (lbs.)	425	425
Price per cwt.	$ 19.84	$ 19.84
Cost	$ 84.32	$ 84.32
Variable cash costs:		
Protein, $4.42 x 3.50 cwt.[a]	15.47	15.47
Hay equivalent harvest $5.69 x 1.1 ton[a]	6.26	6.26
Power[b]	2.74	2.74
Equipment replacement[b]	2.88	2.88
Miscellaneous[b]	5.01	5.01
Death loss, 3% of other variable costs[b]	3.50	3.50
Total annual cash expense	$120.18	$120.18
Corn (raised), $1.20 x 40 bu.[a]	48.00	48.00
Value of total inputs	$168.18	$168.18
Other inputs:		
Labor (hours)	12.5	12.5
Building space (sq. ft.)	37	37
Equipment per head ($)	$ 13.50	$ 13.50
Outputs:		
Market date (Year N + 1)	Nov.	Nov.
Total gain (lbs.)	550	550
Weight at market (lbs.)	975	975
Sale price per cwt., $1.25 below superior managers because of more "throw outs" or cuts selling at a lower price resulting from poorer grading at time of purchase[c]	$ 21.21	$ 22.46
Market value	$206.80	$218.98
Manure credit, $1.38 x 5.5 cwt. gain[b]	7.59	7.59
Total output	$214.39	$226.57
Less inputs cash value	168.18	168.18
Returns per head before deducting fixed costs	$ 46.21	$ 58.39
Capital coefficients:		
Annual cash expense	$120.18	$120.18
Equipment	13.50	13.50
Total	$133.68	$133.68

[a] Culbertson, Charles C., professor of animal husbandry, Iowa State University, Ames, Iowa. Revision of feed requirements from Love, H. C., Coolidge, J. H. and McKinney, R. D. More money from your farm. Kansas State College (Manhattan) Agr. Ext. Serv. Circular 244. 1956, for Iowa conditions. (Private communication) 1956.

[b] Wilcox, R. H., Mueller, A. G. and Von Lanken, G. D. Detailed cost report for southern Illinois cattle farms. 1954. Dept. of Agr. Econ. Univ. of Illinois. (Mimeo. report) 1956.

[c] Taylor, Bruce R., associate professor of animal husbandry, Iowa State University, Ames, Iowa. Information on cattle market price spreads obtained by average vs. superior managers. (Private communication) 1956.

TABLE A-9. BASIC INPUT-OUTPUT DATA FOR COMMERCIAL HEIFERS.

Item	Average management	Superior management
Purchase date (Year N)	Oct.	Oct.
Weight at purchase (lbs.)	400	400
Price per cwt.	$ 13.03	$ 13.03
Cost	$ 52.12	$ 52.12
Variable cash costs:		
Protein, $4.41 x 2.50 cwt.[a]	11.05	11.05
Hay equivalent harvest $5.69 x 1 ton[a]	5.69	5.69
Power[b]	1.83	1.83
Equipment replacement[b]	2.88	2.88
Miscellaneous[b]	5.01	5.01
Death loss, 3% of other variable costs[b]	2.45	2.45
Total annual cash expense	$ 81.03	$ 81.03
Corn (raised) $1.20 x 24 bu.[a]	28.80	28.80
Value of total inputs	$109.83	$109.83
Other inputs:		
Labor (hours)	10	10
Building space (sq. ft.)	35	35
Equipment per head ($)	$ 13.50	$ 13.50
Outputs:		
Market date (Year N + 1)	May	May
Total gain (lbs.)	380	380
Weight at market (lbs.)	780	780
Sale price per cwt., $1.00 below superior managers because of more "throw outs" or cuts selling at a lower price resulting from poorer grading at time of purchase[c]	$ 17.05	$ 18.05
Market value	$132.99	$140.79
Manure credit, $1.38 x cwt. gain[b]	5.24	5.24
Total output	$138.23	$146.03
Less inputs cash value	109.83	109.83
Returns per head before deducting fixed costs	$ 28.40	$ 36.20
Capital coefficients:		
Annual cash expense	$ 81.03	$ 81.03
Equipment	13.50	13.50
Total	$ 94.53	$ 94.53

[a] See footnote a, table A-8.

[b] See footnote b, table A-8.

[c] See footnote c, table A-8.

TABLE A-10. BASIC INPUT-OUTPUT DATA FOR COMMON OR MEDIUM STEERS WINTERED AND SHORT FED.

Item	Average management	Superior management
Purchase date	Nov.	Nov.
Weight at purchase (lbs.)	700	700
Price per cwt.	$ 15.01	$ 15.01
Cost	$105.07	$105.07
Variable cash costs:		
Protein, $4.42 x 1.50 cwt.[a]	$ 6.63	$ 6.63
Hay equivalent harvest, $5.69 x 1.25 ton[a]	7.11	7.11
Power[b]	1.83	1.83
Equipment replacement[b]	2.88	2.88
Miscellaneous[b]	5.01	5.01
Death loss, 3% of other variable costs	4.14	4.14
Total annual cash expense	$132.67	$132.67
Corn (raised), $1.20 x 15 bu.[a]	18.00	18.00
Value of total inputs	$150.67	$150.67
Other inputs:		
Labor (hours)	9.00	9.00
Building space (sq. ft.)	50.00	50.00
Equipment per head ($)	$ 13.50	$ 13.50
Outputs:		
Market date	May	May
Total gain (lbs.)	300	300
Weight at market (lbs.)	1,000	1,000
Sale price per cwt.[c]	$ 17.58	$ 18.72
Market value	$175.80	$187.20
Manure credit, $1.38 x 3 cwt. gain[b]	4.14	4.14
Total output	$179.94	$191.34
Less inputs cash value	150.67	150.67
Returns per head before deducting fixed costs	$ 29.27	$ 40.67
Capital coefficients:		
Annual cash expense	$132.67	$132.67
Equipment	13.50	13.50
Total	$146.17	$146.17

[a] See footnote a, table A-8.

[b] See footnote b, table A-8.

[c] See footnote c, table A-8.

TABLE A-11. BASIC INPUT-OUTPUT DATA FOR BEEF COWS PER HEAD PLUS REPLACEMENTS.

Item	Unit	Average management	Superior management
Feed			
Corn equivalent[a]	bushels	4.77	5.51
Hay equivalent[b]	tons	5.47	5.47
Protein supplement	pounds	64.00	73.90
Production			
Calf crop[b]	percent	85.00	90.00
Weaning weight[b]	pounds	390.00	425.00
Culling and replacement rate[b]	percent	16.00	16.00
Good and choice calves sold	pounds	278.46	321.30
Cull cow[b]	pounds	160.00	176.00
Manure credit[a]	dollars	3.84	4.43
Labor	hours	15.00	15.00
Buildings	sq. ft.	50.00	50.00
Capital investment			
Cow and replacements	dollars	163.75	163.75
Equipment	dollars	13.13	13.13
Total capital investment	dollars	176.88	176.88
Return per cow[c]	dollars	45.50	55.03
Annual cash expense			
Protein supplement	dollars	2.83	3.27
Power and machinery[a]	dollars	2.14	2.47
Herd bull[b]	dollars	5.00	8.00
Equipment[a]	dollars	0.14	0.16
Buildings[a]	dollars	1.70	1.95
Miscellaneous[a]	dollars	3.59	4.14
General farm expense[a]	dollars	3.79	4.37
Haying expense	dollars	6.54	6.54
Total annual cash expense	dollars	25.73	30.90
Capital coefficient	dollars	202.61	207.78

[a] See footnote a, table A-8.

[b] Taylor, Bruce R., associate professor of animal husbandry, Iowa State University, Ames, Iowa. Information on culling and replacement rates from records of the American Hereford Association and from Iowa State University. (Private communication.) 1956.

[c] Fixed costs have not been deducted.

TABLE A-12. BASIC INPUT-OUTPUT DATA PER HEN PLUS REPLACEMENT FOR POULTRY LAYING FLOCK.

Item	Unit	Average management	Superior management
Outputs			
Eggs[a]	dozen	15.00	19.17
Meat	pounds	4.87	4.87
Inputs			
Grain[b]	pounds	91.09	93.09
Commercial feed[b]	pounds	41.99	45.99
Labor[c]	hours	2.10	2.10
Investment in equipment	dollars	1.15	1.15
Annual cash expense			
Equipment[d]	dollars	0.22	0.22
Sexed chicks	each	0.30	0.30
Commercial feed[d]	dollars	1.73	1.89
Power[d]	dollars	0.06	0.06
Miscellaneous	dollars	0.15	0.15
Total cash expense	dollars	2.46	2.62
Building requirements[e]	sq. ft.	4.12	4.12
Hen mortality	percent	15.00	15.00
Chick mortality	percent	10.00	10.00

[a] Iowa Crop and Livestock Reporting Service, September 1953.

[b] Farm poultry flock returns 1947-1952. Report 212, University of Minnesota; and Iowa poultry demonstration flocks 1948-1953. Iowa State University. Ames, Iowa.

[c] Farm labor and farm costs 1954. Report No. 217, University of Minnesota; and Iowa poultry demonstration flocks 1948-1953. Iowa State University. Ames, Iowa.

[d] Farm labor and equipment costs 1954. Report No. 217, University of Minnesota; and Midwest farm handbook. Iowa State University Press. Ames, Iowa.

[e] Midwest farm handbook. Iowa State University Press. Ames, Iowa.

TABLE A-13. BASIC INPUT DATA FOR LAND BUYING IN ADAMS COUNTY.

Land value	$131.49[a]	Net revenue charge per acre	
		5% interest on purchase price remainder	$ 3.94
Capital coefficient, 40% of value	52.60	Annual taxes	1.95
Purchase price remainder	$ 78.89	Net revenue charge per acre	$ 5.89

[a] Average value per acre of all land in farms, Adams County. 1954 Census of Agriculture.