Farm Planning for Maximum Profits on The Cresco-Clyde Soils in Northeast Iowa,

And Comparison of Farm and Nonfarm Incomes For Beginning Farmers

(An Application of Linear Programming)

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SUMMARY

This study is one of a series being made on different soil areas in Iowa. The purpose of these studies is to determine optimum plans for beginning farmers, from "benchmark" situations in each of the soil localities studied.

The specific soil area selected for this study is the Cresco-Clyde soils in northeastern Iowa: The farm chosen to represent this soil area is located in Howard County. Farm size is 160 acres, with 135 acres cultivated. Service buildings on the farm include: sufficient storage space for all crops raised on the farm; 720 square feet of floor space for fattening hogs plus sufficient farrowing space in portable farrowing houses; barn space for 20 dairy cows; and poultry housing adequate for 200 hens with brooder house space for a corresponding number of baby chicks.

Most of the farm plans computed in this study are based on a 50-50 livestock-share lease; a few plans are given for a crop-share lease. Labor available for farming operations includes the operator's labor plus some family labor. In addition, it is assumed that housewife labor is sufficient for care of the poultry laying flock. For those farm plans with labor as a limiting resource, the alternative of hiring extra labor was included in the farm situation. Other variations of available resources considered in this study are increasing farm size by 80 acres and buying feed grain.

The specific objectives of this study are, given the farm situation, to show profit-maximizing farm plans for various amounts of available capital and other resources, then to compare the returns from these farm plans with potential income from nonfarm employment in the same general area. Optimum farm plans and associated profits are determined by the linear programming technique. Comparisons of farm and nonfarm incomes are made by adjusting both sources of net income to real income figures. The resulting figures are used as the basis for income comparisons.

Throughout the farm plans shown in the text, land use is dependent on the livestock system. For the average manager operating under a livestock-share lease, funds are most profitably invested in dairy cows and a corresponding amount of crops for feed requirements. If available capital is greater than the amount required for a dairying enterprise, additional funds are most profitably invested in hogs, beef cows and poultry, in the order given. With livestock under superior management and a livestock-share lease, optimum investment is made by simultaneously increasing investment in hogs and dairy cows for increasing quantities of capital. With about $6,000 or more of capital, in addition to capital required for machinery investment, a poultry laying flock also is included in the optimum plan. As under average management, land use is adapted to the feed requirements of livestock. The major crop rotation under average management is corn-corn-oats-meadow-meadow; under superior management corn-corn-oats-meadow is the chief rotation.

Because of relatively low grain yields in this soil area, priority use of capital, as increasing quantities of capital are made available, is in contrast with findings for parallel studies on other soil types. On soils such as Tama-Muscatine, Clarion-Webster, Marshall and Sharpsburg, limited funds are first invested in crops, then in livestock as the amount of capital increases. In this study, livestock has more investment priority than crop production.

Results from this study show that tenant profits are considerably higher under a crop-share lease than under a livestock-share lease. Also, a crop-share lease requires greater amounts of tenant capital. Optimum farm organization under both leases is essentially the same, except that similar plans require more of the tenant's capital and give higher tenant profits for a crop-share lease.

For all farm plans computed, the returns to each dollar invested are greater than 7 percent. Consequently, if he were willing or able to bear the risk, the tenant could rationally borrow capital at 7 percent interest to use any of the farm plans shown in the text. Although the family labor supply restricts many of the farm plans computed, hiring extra labor at a wage rate of $1 per hour is not profitable unless farm size is larger than 160 acres and livestock are handled with superior management.

The comparison of real farm income with real income from urban jobs indicates that urban income is higher than incomes for nearly all farm situations considered. The only exceptions to this statement result when the farm situation includes: (1) livestock under superior management, (2) an unlimiting supply of funds and (3) a farm size greater than 240 acres with a livestock-share lease, or 160 acres or greater with a crop-share lease. All three conditions must exist if income from farming for a beginning tenant operator is to be as high as or higher than income from the nonfarm employment opportunities considered in this study. Of course, the family's decision on whether to farm or seek urban employment may depend on many factors other than income. In this study, income comparisons as well as farm plans are given as guides for the benefit of those who wish to use them in arriving at decisions.

Farm Planning for Maximum Profits on the Cresco-Clyde Soils in Northeast Iowa, and Comparison of Farm and Nonfarm Incomes for Beginning Farmers[1]

(An Application of Linear Programming)

BY EARL O. HEADY AND LAUREL D. LOFTSGARD

Recent changes in the farm income situation have placed a premium on efficient farm planning. Costs of farming have remained high, and for some items have increased, while prices of commodities sold have been depressed. This relative change between prices paid and prices received for farmers is likely to continue for several years. The situation stems partly from growth in the national economy. As disposable income per person increases, the consumer spends a greater proportion of his income on nonfarm goods and services. These products compete with farm products and with each other in the use of labor, metals, petroleum, lumber and other items which go into production costs. Consequently, farming costs are kept high. At the same time, the consumer does not place a great price premium on farm products. These factors of demand along with some overproduction and less exports have had a depressing effect on the farm economy.

This situation, high farm costs relative to farm product prices, places a premium on efficient farm planning. The managerial problem perhaps is greatest for the beginning farmer whose limited capital restricts the scale of operations and volume of business. While selected individual farmers may meet the price-cost squeeze by operating on a larger scale and therefore lowering per-unit costs of production, this possibility is not an alternative for the young operator whose resource restrictions place a distinct limit on size of operations. With capital rationed, the young farmer can attempt to meet the price-cost squeeze only by more efficient organization of his existing resources, enterprises and practices.

This study is designed to outline such alternatives for beginning farmers. The organization or plan for the farm, if it is to maximize profits, must, however, fit the resources peculiar to the individual farm. Even though two farmers may have exactly the same soil types, they will need different farm plans, in respect to crops as well as livestock, if they possess different amounts of labor, capital and managerial skill. As part of an attempt by Iowa State College to help young farmers improve their farm and family planning, a series of studies has been initiated to develop benchmark plans for different parts of the state. This study is the third of the series.[2] It outlines plans for young farmers with different amounts of capital, labor, managerial skills and different leases or other restrictions. These studies also are designed to provide information to help young families decide whether they should take advantage of other employment opportunities.

OBJECTIVES OF THE STUDY

The general objective of this study is to determine farm plans which maximize profits for particular farm situations on the Cresco-Clyde type soils in northeast Iowa. The plans are made in particular reference to beginning farmers and are designed for use in the Farm and Home Planning program of the Agricultural Extension Service. The more specific objectives are to (1) determine profit-maximizing farm plans for farms with different amounts of available capital, labor and land, (2) show how optimum plans vary with managerial skills and quantities of resources, (3) estimate the approximate incomes for the optimum farm plans and (4) compare these farm income figures with potential income from nonfarm employment in the area being studied.

The resulting figures can be used in helping young farmers select cropping practices, livestock operations and the general farm organization which are optimum for the resources available to

[1] Project 1085, Iowa Agricultural Experiment Station. The authors are indebted to L. J. Bodensteiner and H. R. Meldrum for suggestions and criticism, and to A. B. Mackie for computing many of the coefficients used in this study.

[2] 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; and Mackie, Arthur B., Heady, Earl O. and Howell, H. B. Optimum farm plans for beginning tenant farmers on Clarion-Webster soils. Iowa Agr. Exp. Sta. Res. Bul. 449. 1957.

the farm family. Also, the results are expected to be of use in vocational guidance for families who are already farming but wish to evaluate possible incomes from farming as compared with nonfarm occupations. Farm plans and expected incomes are computed for situations representing different amounts of resources and managerial skills. Persons falling in these various categories may then wish to compare income expectations from the farm with those from available jobs in towns and cities.

METHOD OF ANALYSIS AND TECHNIQUES OF LINEAR PROGRAMMING

Each farmer can select from a vast number of farm plans since his enterprises and resources can be combined thousands of different ways. From these many alternative farm plans, the farmer must choose the plan and practices which are optimum for the amounts of capital, labor, managerial skill, buildings and soils of various types available to him. The final choice among different plans should, of course, depend on the financial situation and values of the farmer and his family. One farm family may be willing to sacrifice some profits to gain more income security; another family may seek maximum profits regardless of the income variability or risk involved. Also, some families may temper their plan, depending on preferences for particular enterprises, time available at different seasons of the year, need for hiring labor, etc.

A procedure which allows consideration of the many alternatives available to the farmer is linear programming.[3] It allows selection of the plan which maximizes profit, given the resource restrictions of the individual situation. It also allows consideration of personal preferences where the situation is defined to exclude activities which are inconsistent with preferences under particular circumstances.

The emphasis in this study is on changes in optimum farm plans as the amount of available capital changes while labor and land remain constant. However, plans also are computed for different situations with respect to lease, farm size and the possibility of hiring extra labor. The returns from the optimum farm plans for these situations are then compared with potential income from nonfarm employment opportunities.

FARM SITUATION USED FOR STUDY

This study focuses on farms in Howard County, Iowa, considered by extension personnel to be typical of the soil area being studied. Plans and income expectations are computed for beginning farmers operating under a livestock-share lease. However, the results also are applicable for established farmers with the same lease. A few plans also have been computed for farms operated under a crop-share lease.

Land

The particular farm selected as a benchmark guide is located on the Cresco-Clyde soil association in northeast Iowa. Farm size is 160 acres, of which 135 acres are cultivated. No land on the farm has a slope greater than 8 percent.

The most common farm size in Howard County is 160 acres. However, since the 1954 Census of Agriculture shows that the average farm size in Howard County is larger than 160 acres, a few additional plans are computed for a farm size of 240 acres. This farm size is assumed to have 215 cultivated acres. Noncultivated acres for both farm sizes consist of undrained pasture area, farmstead, woodland lots, fences, roads, etc.

Lease

The leasing system considered for the majority of situations is a 50-50 livestock-share lease. The tenant furnishes all labor and machinery and pays all harvesting costs for corn. He owns the poultry enterprise and pays all costs and receives all returns from it. The latter arrangements are common in the area. Aside from poultry, all costs and returns associated with production are shared evenly by the tenant and landlord. The landlord pays real estate costs while the tenant furnishes the labor and machinery. Investment in livestock is shared equally by tenant and landlord.

Some tenants in the area operate under a crop-share lease. A few plans have been worked out accordingly. In the plans for a crop-share lease, all crops except hay are shared 50-50, and all livestock belong to the tenant. The only changes in resource restrictions under the crop-share lease are: (1) The tenant furnishes all capital for livestock and (2) the tenant pays $8 an acre cash rent for meadow. Input-output data for the enterprises, as given in later tables, are the same for both types of leasing except for livestock enterprises. That is, under a crop-share lease an additional charge for hay is made against livestock to pay for meadow rent.

Buildings

The service buildings on the farm include livestock housing and grain storage facilities. Poultry housing is sufficient for a 200-hen laying flock and includes a brooder house for a corresponding number of baby chicks. Barn space is adequate for 20 dairy cows, including replacements. Sufficient shelter is available for a beef feeding enterprise, if the animals are near-yearlings or older. Under average management, where feeder cattle are not considered, a "beef cow and calf" enterprise is permitted to compete with dairy cows for barn space. There are 720 square feet of floor space available for fattening hogs; portable farrowing

[3] An explanation of the theory and logic of linear programming is given in: Bowlen, Bernard and Heady, Earl O. Optimum combinations of competitive crops at particular locations. Iowa Agr. Exp. Sta. Res. Bul. 426. 1955.

houses are available from farrowing to weaning age. Grain storage facilities are considered adequate for the farm's grain production. Since emphasis is on farm organization for the tenant, no charges are made for building use and repair.

Labor and Management

Total available man-hours for each month are given in table 1 and represent those of the operator plus family labor. All activities in the farm plan compete for the labor supply shown, except poultry, which is considered supplemental with respect to labor since the housewife ordinarily manages the poultry flock. Labor supplies are grouped or listed in units of 2 and 3 months each, depending on labor requirements and the time available to complete farming operations. Hence, the labor restrictions are for a certain part of the season rather than for individual months. Extension personnel consider the above procedure to be a realistic method for handling labor restrictions in their effect on the farm plan. This method of aggregating labor supplies supposes the labor requirements within different time groups are relatively flexible. A labor buying activity is included in programming whereby peak-season labor may be hired at the rate of $1 per hour. That is, extra labor will be hired only if it returns more than $1 per hour.

Two levels of management are considered for the dairy, hog and poultry enterprises in this study. The two levels, average management and superior management, are differentiated by: (1) input requirements for feed, labor and housing and (2) output, or production, in terms of meat, milk and eggs. In other words, plans are computed to show outcomes which might be expected when the farm operator possesses average or superior managerial ability. A more detailed explanation of management levels is given in a later section.

Capital Supply

Capital often is the most limiting resource and the resource which determines or specifies the final plan. This situation is especially true for beginning farmers. Since the capital supply varies among farmers, farm plans using different amounts of capital are used to show how farm organization should vary depending on the amount of available capital. For these purposes all resources except capital are held constant, and capital is allowed to vary from a small amount to a point where it becomes unlimiting.

Previous studies using linear programming methods have dealt with plans for discrete levels of capital only.[4] As a result of recent investigation in the linear programming technique, a method has been designed whereby the optimum farm organization can be determined with one resource as a continuous variable, while all other resources are held constant.[5] The application of this method permits the optimum solutions to be graphed—the graph showing how farm organization changes with capital.

The capital requirements for the various enterprises include annual cash expense for crops and livestock plus investment capital needed for equipment and breeding stock for the livestock enterprises. It is assumed that the tenant has adequate machinery for crop production. Therefore, depreciation and insurance on machinery are handled as a fixed cost. Thus, wherever capital figures are shown, an amount can be added to these figures to represent machinery investment. Machinery investment would approximate $9,982 with all new equipment and $3,700 with used equipment. These amounts should be added to those shown in graphs and tables to obtain the total amount of capital required for the particular plan shown.

The returns given for farm plans in subsequent sections are those before fixed costs are subtracted. Net returns or profit, then, is the return figure shown less fixed costs. Returns, as defined here, are used to show the difference in income between plans for these reasons: (1) The difference in net return between two plans after the subtraction of fixed costs is identical with the difference shown in returns before subtracting fixed costs. This difference remains the same because fixed costs do not vary with farming plans. Hence, if plans A and B have returns, as defined here, of $4,000 and $3,200, respectively, the difference is $800. If fixed cost is $1,000, net profit will be $3,000 and $2,200, the difference again being $800. (2) Fixed costs differ between farmers, depending especially on the amount of borrowed capital used. If $1,000 is borrowed at 6 percent, $60 must be added to fixed cost; if $10,000 is borrowed, fixed cost is increased $600.[6] An itemized list of fixed costs,

TABLE 1. HOURS OF AVAILABLE LABOR PER MONTH AND IN MONTHLY GROUPS USED FOR THIS STUDY.

Month	Total available man-hours	Total available man-hours for monthly group
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	

[4] See Bowlen, Bernard and Heady, Earl O. op. cit.

[5] Wilfred Candler. A modified simplex solution for linear programming with variable capital restrictions. Jour. Farm Econ. 38:940-55. 1956.

[6] A few additional computations were made to determine the effect on farm plans if capital were borrowed at 7 percent interest. The resulting plans are not shown since it was found that, *in all situations considered,* the optimum plans were the same with or without an interest charge on capital. The difference under the two alternatives is reflected in the returns alone. Also, providing that capital is available and that the family is going to farm anyway, it is always profitable to borrow capital at 7 percent interest and employ the various farm plans shown later. (To determine the net returns for any one plan and farmer, an interest charge should be subtracted to represent the amount of capital borrowed, and the total fixed costs given in appendix table 1 should de deducted.)

excluding interest charges, is given in appendix table 1.

Prices

The prices used for determining maximum profit plans are given in appendix table 2. Historical price relationships between commodities were used to establish the projected prices used in this study. The actual level of prices used for programming is based on a corn price of $1.20 (net selling price after paying trucking and other marketing costs) per bushel, with other product prices adjusted accordingly to the long-run corn-product price relationship. In other words, the prices used in this study represent a long-term price ratio between corn and the various products. The long-run relative period is 1935 to 1955 for beef cattle, 1951 to 1955 for seed and poultry products, and 1947 to 1955 for hogs. Prices used for dairy products and supplement feeds are current prices in the area being studied.

Although the general price level may fluctuate from the level used here, the maximum profit plans will have the same farm organization for any price level, provided the price ratios explained above remain the same. If, for example, hog prices increase while corn price remains constant, the optimum plans may be different than shown later. Likewise a change in corn price while some product prices remain unchanged may give different optimum plans than the plans determined in this study. When corn and other product prices deviate simultaneously so the same price ratios are maintained, optimum farm plans are the same regardless of price level.

ENTERPRISES USED IN PROGRAMMING AND RESOURCE RESTRICTIONS

The crop and livestock enterprises considered in this study are those most commonly produced in the area. Two levels of management or production are used for the more predominant livestock enterprises such as dairy, hogs and poultry. Since there is relatively more risk associated with beef-feeding as compared with the livestock above, only superior level of management is considered for the beef enterprise. In other words, it is assumed that cattle should be fed only if the operator has sufficient managerial proficiency. All enterprises, crop and livestock, compete freely for the use of resources, except poultry which uses only housewife labor. The enterprises considered in the various programming situations are explained below.

Livestock Enterprises

The input-output coefficients for livestock are included in table 2. The figures in this table are for the units indicated. In programming, only the tenant's share of the various inputs are included in the input-output matrix. In other words, the plans are made out to attain equation 1, where C is the matrix for the share of the net price or return per unit of activity realized by the tenant, and X is the matrix of activity levels for the farm as a whole. The process of maximizing $f(X)$, or profit, refers to tenant income only. Hence, feasible

$$(1) \quad \text{maximize } f(X) = C'X$$

programs are defined as in equation 2, where P is the matrix of input-output coefficients representing the tenant's share, X is the matrix of activity

$$(2) \quad PX = B$$

levels for the farm as a whole, and B is the matrix of resource restrictions faced by the tenant (including the resources which he owns and the ones for which he has use privileges under the lease). The procedure used is to partition P and X into submatrices as in equations 3 and 4, where X_2 is a matrix including all crops and livestock enterprises to be tried in alternative farm plans, and P_2 is the matrix of input-output coefficients repre-

$$(3) \quad PX = P_1X_1 + P_2X_2 = B$$

senting the tenant's contribution. Hence, X_1 at the outset is a matrix of disposal activities, which keeps unprofitable plans from being forced on the tenant through the use of all his resources (i.e., he may wish to let some labor go unused in the winter rather than to use it on some enterprise which causes a loss). In this sense, P_1 then is an identity matrix. The criterion for selecting enterprises to go into the plan is through computation of a matrix Δ, whose elements show the magnitude of profit to be obtained by increasing the levels in X_2 by one unit each. The matrix Δ is defined as in equation 4, and as each plan is examined,

$$(4) \quad \Delta = C'_2 - C'_1P_1^{-1}P_2$$

indicates the amount of profit from increasing enterprises in X_2 while sacrificing enterprises in X_1.

The coefficients included in P are regarded to be single-valued. That is, only one value is assumed for each coefficient, and no variability is expressed. A more detailed and supplemental presentation of basic data for each livestock enterprise considered is given in appendix tables 3, 4, 5 and 6.

Dairy under average management: This enterprise includes an average dairy cow with annual production of 6,000 pounds of milk and a productive life of 5 years. Annual replacement stock is included in coefficients of feed, labor and capital. The coefficients, on a per-cow basis, include one-third of a calf, one-third of a yearling and one-fourth of a 2-year-old. Returns are derived from fluid milk sold on a Grade-B market, with cull cows and vealers sold as beef. Input-output data are handled on a "per-cow plus replacement" basis. Production and total resource requirements for this enterprise are included in appendix table 3.

TABLE 2. BASIC INPUT-OUTPUT DATA* FOR LIVESTOCK ENTERPRISES† USED IN THIS STUDY.

Item	Unit	Average management				Superior management				Average to superior management	
		Dairy cows (per cow plus replacement)	Poultry (per hen)	Hog litters (per litter system) 1:1 ratio	Hog litters (per litter system) 2:1 ratio	Dairy cows (per cow plus replacement)	Poultry (per hen)	Hog litters (per litter system) 1:1 ratio	Hog litters (per litter system) 2:1 ratio	Beef cows (per cow plus replacement)	Deferred fed calves (per head)
Inputs:											
Basic stock	dol.	153.90	0.36	47.52	95.04	225.00	0.36	47.52	95.04	163.75	79.56
Equipment	dol.	15.92	1.15	27.53	55.05	15.92	1.15	31.23	62.46	13.13	13.50
Misc. variable cost	dol.	54.25	0.43	69.58	104.32	58.99	0.43	74.08	111.09	14.48	18.65
Commercial feed	dol	9.01	1.73	72.93	107.52	20.55	1.89	86.15	127.18	1.28	11.13
Total capital‡	dol.	233.08	3.67	217.56	361.93	320.46	3.83	238.98	395.77	192.64	122.84
Corn equivalent	bu.	44.71	1.63	249.99	368.85	66.05	1.66	202.87	301.19	6.68	53.70
Hay equivalent	ton	6.48	—	0.72	1.44	6.84	—	0.70	1.39	5.47	3.45
Labor:											
Dec.-Jan.-Feb.	hr.	39.06	0.44	15.26	20.12	40.64	0.44	13.96	18.61	5.61	3.31
March-April	hr.	25.42	0.38	13.32	21.82	26.45	0.38	12.10	20.11	3.80	0.45
May-June	hr.	24.15	0.54	5.31	7.29	26.09	0.54	6.41	9.56	3.61	2.27
July-Aug.	hr.	21.81	0.33	8.68	12.00	23.52	0.33	8.20	12.05	3.30	1.97
Sept.-Oct.-Nov.	hr.	32.61	0.41	17.43	23.78	34.62	0.41	18.32	24.67	4.03	9.72
Outputs:											
Meat	dol.	53.49	0.72	495.28	739.93	53.49	0.72	572.14	863.42	87.29	237.39
Milk	cwt.	60.00	—	—	—	94.30	—	—	—	—	—
Eggs	doz.	—	15.00	—	—	—	19.17	—	—	—	—
Manure	ton	11.40	0.02	6.90	10.30	11.40	0.02	7.50	11.30	4.42	2.50
Total	dol.	216.45	4.91	495.28	739.93	309.60	6.07	572.14	863.42	87.29	237.39
Returns§	dol.	88.94	0.43	32.64	55.30	140.20	1.39	146.40	230.60	59.40	65.94
Tenant's return**	dol.	44.47	0.43	16.32	27.65	70.10	1.39	73.20	115.30	29.70	32.97

* Sources for these data are given in appendix tables 3, 4, 5 and 6.

† Only those livestock enterprises which came into the farm plans are shown here.

‡ Total inputs include capital investment in basic stock and equipment.

§ Return does not include capital investment for (1) equipment for all enterprises and (2) basic stock for dairy, hog and beef cow enterprises.

** Tenant's return based on a 50-50 livestock-share lease except for poultry enterprise which the tenant produces on his own.

Dairy under superior management: This enterprise includes cows with a higher production capacity than the one described above. Annual production per cow is 9,500 pounds of milk, sold as Grade-B milk. Annual replacements are the same as for the average cow above. As indicated in appendix table 3, the differences between the management levels, or production techniques, for dairy enterprises under the two management levels are reflected in milk production and feed and labor requirements per cow. Actually, several levels of production are possible for dairying or other enterprises. However, only two levels are considered in this study.

Two-litter hog system under average management (1:1 ratio): Under this system, two litters of pigs are farrowed annually from each sow. A spring litter is farrowed in April and marketed in October; a fall litter is farrowed in October and marketed the following April. Each sow is replaced by a gilt saved from the spring litter. From each two litters (i.e., fall plus spring) an average of 13.46 pigs are weaned and 3,051 pounds of pork are marketed. The input-output data for this hog system combine the data for spring and fall litters and are included in appendix table 4. The requirements per hog for a two-litter system are less than under the one-litter system explained later. This difference is due to the fact that many of the items of equipment for spring and fall litters are the same and each sow farrows twice annually under the two-litter system.

Two-litter hog system under superior management (1:1 ratio): Under this system each sow farrows in March and September. The respective marketing months are September and March. An average of 14.56 pigs are farrowed annually from each sow; annual pork production is 3,352 pounds. As under average management, one gilt is kept from each spring litter to replace the sow. Basic data for this system represent the same aggregation process outlined under average management.

The differences for the 1:1 ratio hog system under the two management systems are reflected in farrowing dates, death loss at farrowing time, feed inputs per hundredweight of pork, labor requirements and building space requirements.

Three-litter hog system under average management (2:1 ratio): This hog system requires two sows for each three litters of pigs. Two sows farrow in April; one sow is bred back and farrows again in October. That is, for every fall litter there are two spring litters. One gilt is kept from each spring litter; hence two sows are marketed annually for each three litters of pigs. From each three litters an average of 20.24 pigs are weaned, and total annual pork production is 4,575 pounds. For all hog systems used in this study, the assumed market weight for fattening hogs is 225 pounds. The marketing months for hogs in this enterprise are October and April. Resource requirements and output for the three-litter hog system were determined by the same manner as for the two-litter hog system above. The basic input-output data for hogs are included in appendix table 4.

Three-litter hog system under superior management (2:1 ratio): Under superior management, the three-litter hog system is similar to the same system under average management given above. The changes under superior management

assume: All farrowing and marketing is done a month earlier than under average management; an average of 21.89 pigs are weaned for each three litters of pigs; total annual pork production is 5,027 pounds; feed inputs per hundredweight of pork are less than under average management; and building requirements are less under superior management because of ability to cope with disease hazards, etc.

One-litter hog system under average management (0:1:0 ratio): The one litter under this system is farrowed in June and marketed in December. An average of 6.78 pigs are weaned per litter; total annual pork production is 1,524 pounds. The sow is replaced each year by a gilt kept from the spring litter of the previous year. The input-output data for this enterprise also are given in appendix table 4. That is, the same input-output data are used for spring pigs farrowed in, say, March and April as for summer pigs farrowed in May and June.

One-litter hog system under superior management (0:1:0 ratio): This hog enterprise is the same as under average management above, except more efficient production is assumed. For each summer litter under superior management, an average of 7.33 pigs are weaned and total annual pork production is 1,675 pounds. The hogs are farrowed in May and marketed in November. As compared with the same hog system under average management, superior management involves less feed inputs per hundredweight of pork and less building space requirements per hog. The basic data used for the hog system in this section are the same as for spring pigs under superior management given in appendix table 4.

Four-litter hog system under average management (1:2:1 ratio): In this hog enterprise the ratio of litters is one spring litter, two summer litters and one fall litter. Three sows are required for each four litters. One sow farrows in the spring and again in the fall; the other two sows farrow in the summer. Farrowing months are April, June and October; the respective marketing months are October, December and April. For each four litters, an average of 27.02 pigs are weaned and 6,099 pounds of pork are marketed annually. Basic data for this hog system were determined by the same methods as described previously for other hog systems.

Four-litter hog system under superior management (1:2:1 ratio): This enterprise is the same as the latter hog enterprise, except for assumptions explained previously under superior management. An average of 29.22 pigs are weaned from each four litters which produce 6,699 pounds of pork annually. Farrowing months are March, May and September. The hogs are marketed in September, November and March.

Three-litter hog system under average management (1:1:1 ratio): The three-litter system in this hog enterprise differs from the three-litter system discussed earlier. Under the current system, there is an equal number of spring, summer and fall litters; the previous three-litter system assumed two spring litters for each fall litter. Under the hog enterprise in this section, pigs are farrowed in April, June and October. One sow farrows one spring and one fall litter; a second sow farrows only one summer litter. An average of 20.24 pigs are weaned per each three litters. Marketing months are October, December and April. Annual pork production per three litters is 4,575 pounds. Data concerning inputs and outputs are those for spring and fall pigs under average management in appendix table 4.

Three-litter hog system under superior management (1:1:1 ratio): This hog enterprise includes more efficient production than the one just discussed. An average of 21.89 pigs are weaned per three litters. Feed requirements and other basic data are those for spring and fall pigs under superior management in appendix table 4. Farrowing months are March, May and September; the respective marketing months are September, November and March. Total annual pork production per three litters is 5,027 pounds.

Poultry under average management: The poultry enterprise is a farm laying flock, replaced each year with sexed chicks. Annual output per hen includes an average of 15 dozen eggs and 4.87 pounds of meat. Culling and mortality rates for hens are 11 percent and 15 percent, respectively; chick mortality rate is 10 percent. Resource requirements for poultry are given in appendix table 5. The poultry enterprise does not compete with other enterprises for labor, since it is assumed that the housewife takes care of this enterprise.

Poultry under superior management: Under superior management, annual output per hen includes an average of 19.17 dozen eggs and 4.87 pounds of meat. Mortality rates are 10 percent for chicks and 15 percent for hens; culling rates are 11 percent of the total number of hens. Resource requirements are given in appendix table 5. As under average management, this enterprise is considered supplementary with respect to labor.

Beef cow-calf enterprise: The breeding stock in this enterprise is replaced every 8 years with heifer calves kept from the herd. With the exception of replacements, calves are sold in October as good to choice feeder stock. The cow and calf are pastured throughout the grazing season. On the basis of a 90-percent calf crop, total annual meat production per cow includes 137.5 pounds of cull cow and 354.4 pounds of choice calf. Other data are given in appendix table 6.

Deferred-fed calf enterprise: In this enterprise, good to choice feeder calves weighing about 400 pounds are purchased in October. They are wintered on roughage and pastured from May to August. Grain feeding begins after they are taken

off pasture and continues until marketing date in late November. Assuming a 3-percent death loss, average gain per head is 654 pounds. Input-output data for this enterprise are given in appendix table 6.

Crop Enterprises

The crop rotations considered in this study are: corn-oats-meadow (COM); corn-corn-oats-meadow (CCOM); corn-oats-meadow-meadow (COMM); corn-soybeans-oats-meadow (CSbOM); and corn-corn-oats-meadow-meadow (CCOMM). For each rotation, three levels of fertilization are considered: (1) a starter fertilizer on corn, (2) a medium application of phosphorus and potash on corn and small grains and (3) the same application of commercial fertilizer as in the second level plus 2 tons of barnyard manure per year per acre of rotation. By combining the three fertilization levels with each of the five rotations, there are 15 crop activities, or crop investment alternatives, to choose from for the farm plan.

In the remainder of this study, a subscript following the rotation indicates the rate of fertilization. That is, $CCOM_1$ is a corn-corn-oats-meadow rotation with the first fertilization rate, whereas $CCOM_2$ and $CCOM_3$ are, respectively, the same rotation with second and third rates of fertilizer application.

The fertilizer response and yield estimates given in table 3 are adapted from the crop trials on the Howard County Experimental Farm in Howard County, Iowa. Some of the crop problems unique to the area being studied are poor subsoil drainage and difficulty in controlling quackgrass. Some field tiling has been done in the area to improve drainage, but no data were available to make tiling a consideration in this study.

TABLE 3. FERTILIZER TREATMENTS AND ESTIMATED YIELD RESPONSE FOR VARIOUS ROTATIONS IN HOWARD COUNTY.*

Rotation	Treatment and response†		
	First rate‡ (N, P and K)	Second rate§ (P and K)	Third rate** (P, K and manure)
Corn	42.0	54.0	64.0
Oats	32.0	40.0	41.0
Meadow	1.5	2.4	2.6
Corn	42.0	54.0	65.0
Corn	37.0	45.0	49.0
Oats	31.0	42.0	43.0
Meadow	1.8	2.6	2.8
Corn	43.0	54.0	63.0
Oats	32.0	40.0	39.0
Meadow	1.6	2.5	2.6
Meadow	1.8	2.3	2.6
Corn	42.0	54.0	64.0
Soybeans	15.0	20.0	19.0
Oats	33.0	43.0	46.0
Meadow	1.9	2.6	2.7
Corn	43.0	54.0	65.0
Corn	39.0	49.0	51.0
Oats	35.0	43.0	46.0
Meadow	1.9	2.7	2.8
Meadow	1.9	2.3	2.6

*These data are based on rotation-fertility experiments from 1950-54 at the experimental farm in Howard County. Data for yield response for other fertilizer treatments were not available.

†Bushels per acre for grain and tons per acre for meadow.

‡80 lbs. of 5-20-20 per acre per year of rotation.

§150 lbs. of 0-20-20 per acre per year of rotation.

**150 lbs. of 0-20-20 and 2 tons of mixed barnyard manure, per acre per year of rotation.

Since many farmers have difficulty in controlling quackgrass, especially when a 2-year meadow rotation is used, supplementary farm plans were computed which did not include the rotations COMM and CCOMM. In other words, the returns for a farm plan containing a 2-year meadow rotation may necessarily be lower if quackgrass creates a serious problem. Hence, parallel plans were computed for rotations which include only 1 year of meadow to determine optimum plans where quackgrass is so serious that it excludes the possibilities of some cropping systems.

The low (and in some cases negative) returns for crop rotations given in appendix table 7 indicate part of the problem farmers are subjected to on the soil type studied. Because of drainage and similar problems, yields are relatively low and costs are high in relation to crop returns. Hence, the farm plan is determined largely by the livestock system which most profitably utilizes the forages and grains and allows a greater volume of business from a given land area. This problem explains the predominance of livestock-share leasing and, perhaps, the prevalence of dairying in this area. The subsequent farm plans in this study indicate the crop-livestock combinations which maximize profit for each of the farm situations considered.

Resource Restrictions

Every farm plan must be selected within the framework of restricting or limiting resources. On some farms, capital and labor are freely available, while land is the most limiting resource. In this case the optimum plan more nearly becomes the one which will maximize returns to the fixed land area. On other farms, capital is highly limiting and the optimum plan is one which maximizes returns on investment. Also, the fixed family labor supply, particularly at seasons of peak labor requirements, necessitates a plan which maximizes returns to labor. However, on the majority of farms several resources are limitational and require a plan which considers restrictions accordingly.

Resource restrictions and the empirical nature of the enterprises have been discussed in previous sections. These data have been used in the linear programming procedure to determine which farm plan is most profitable under the various price and resource situations of this study. Optimum plans have been computed with maximum tenant profit as the criterion. That is, for each enterprise, only the tenant's share of inputs and outputs differs under livestock-share and crop-share leases.

The resource restrictions imposed on the plans of this study are those indicated by the equations below where a_{ij} refers to the quantity of the i^{th} resource required for the j^{th} enterprise and X_j re-

fers to the amount of the j^{th} enterprise produced.[7] Where the relationship is indicated by $=$, the amount of the resource used must just equal the original supply (i.e., owned, produced and purchased) available.[8] In other words, none of the resources (e.g., feed grain) will be left unused, but will be sold if surplus. For programming, farms are allowed to purchase grain and seasonal labor. Where the relationship is indicated by $\leq$, the amount of the resource used (e.g., family labor) need not be as great as the supply originally available, although it can be as great.

$$(5)\quad \sum_{j=1}^{n} a_{ij} X_j \leq 135 \text{ acres of cropland}$$

$$(6)\quad \sum_{j=1}^{n} a_{ij} X_j \leq 215 \text{ acres of cropland}$$

$$(7)\quad \sum_{j=1}^{n} a_{ij} X_j \leq 824 \text{ square feet of poultry space}$$

$$(8)\quad \sum_{j=1}^{n} a_{ij} X_j \leq 720 \text{ square feet of hog space}$$

$$(9)\quad \sum_{j=1}^{n} a_{ij} X_j \leq 1{,}680 \text{ square feet of barn space}$$

$$(10)\quad \sum_{j=1}^{n} a_{ij} X_j \leq \text{December, January, February family labor}$$

$$(11)\quad \sum_{j=1}^{n} a_{ij} X_j \leq \text{March, April family labor}$$

$$(12)\quad \sum_{j=1}^{n} a_{ij} X_j \leq \text{May, June family labor}$$

$$(13)\quad \sum_{j=1}^{n} a_{ij} X_j \leq \text{July, August family labor}$$

$$(14)\quad \sum_{j=1}^{n} a_{ij} X_j \leq \text{September, October, November family labor}$$

$$(15)\quad \sum_{j=1}^{n} a_{ij} X_j \leq \text{total forage supply}$$

$$(16)\quad \sum_{j=1}^{n} a_{ij} X_j = \text{total grain supply} = 0 \text{ at outset}$$

$$(17)\quad \sum_{j=1}^{n} a_{ij} X_j = \text{hired labor} = 0 \text{ at outset}$$

[7] The sum of coefficients refers only to nondisposal activities. Hence the equalities or inequalities (i. e., the relationships) relate the resource restrictions only for requirements of commercial enterprises that are considered in the plan.

[8] In the case of grain supply and hired labor, this equality is accomplished by making a_{ij} positive for activities which use resources (i. e., grain selling and livestock production), but negative for activities which supply them (i. e., grain buying, crop production and labor buying). In equation 15 a_{ij} values are negative for crop activities but positive for livestock activities.

OPTIMUM PLAN OF FARM

The profit-maximizing or optimum farm plans for various farm situations are presented in this section. All plans are restricted to forage produced on the farm. However, extra feed grain may be purchased under the assumption that the purchase price is 10 cents per bushel higher than the net price (market price less transportation and handling charges) at which farmers sell grain. While the resource restrictions generally include the land, buildings, labor and capital discussed in previous sections, some plans are computed with individual restrictions lifted to determine the effects of a particular limiting resource on farm plans.

Since the farm plans are computed for average price relationships, they are not designed to conform with price fluctuations of individual years. The plans are looked upon as guideposts or benchmarks for recommendations to farmers. The circumstances of the individual farm which differ from those outlined must be recognized where decisions or recommendations are to be made for a particular family.

Farm Plans for Livestock-Share Lease With Livestock Under Average Management; 135 Cultivated Acres

The farm plans presented in this section are for the labor, land and building restrictions outlined earlier and a farm operator of average managerial ability. The optimum plans were selected from a set of alternative enterprises which included: the five crop rotations (COM, CCOM, COMM, CSbOM and CCOMM), each with three possible levels of fertilization; dairy, hog and poultry enterprises under average management; and a beef cow-calf enterprise. The beef cow-calf enterprise competes with dairy cows for barn space. Other restrictions and assumptions are those discussed previously.

Optimum plans are shown in table 4 for the farm situations considered in this section. A visual indication of the relative importance of enterprises for different capital levels is shown in fig. 1. The farm plans for the points (P_1 through P_7) in fig. 1 are those indicated in table 4 by the same notations. For example, the plan at P_1 in fig. 1 is 120 acres of CCOMM rotation and 20 dairy cows, with the remainder of the land as undergrazed pasture. Although separate plans exist for all quantities of capital in fig. 1, each consecutive plan labeled and correspondingly shown in table 4 is a plan representing a different amount of capital than the previous plan. For example, in fig. 1, from zero to $3,956 of capital (with capital excluding investment in machinery), dairy cows and a CCOMM rotation command use of resources at the constant or linear rate indicated by the slope of the two lines above the area for each. Between $3,956 of capital and $4,252 of capital (point P_2), income is increased, as the height of P_2 in-

TABLE 4. OPTIMUM FARM PLANS FOR LIVESTOCK-SHARE LEASE WITH LIVESTOCK UNDER AVERAGE MANAGEMENT; 135 CULTIVATED ACRES.

Point on graph 1	Operating capital*	Tenant return†	Enterprises in the farm plan	Limiting resources	Corn surplus or deficit	Idle land or underutilized pasture
P_1	$3,956	$1,273	114 acres CCOMM$_3$ 6 acres CCOMM$_2$ 20 dairy cows	Capital Dairy building space Forage Manure	+2,424 bu.	15 A
P_2	$4,252	$1,339	76 acres CCOMM$_3$ 21 acres CCOMM$_2$ 38 acres CCOM$_3$ 20 dairy cows	Capital Land Dairy building space Forage Manure	+3 020 bu.	0
P_3	$4,451	$1,375	85 acres CCOMM$_3$ 15 acres CCOMM$_2$ 35 acres CCOM$_3$ 20 dairy cows 3 hog litters (2:1 ratio)	Capital Land Dairy building space Forage Manure Dec.-Jan.-Feb. labor	+2,599 bu.	0
P_4	$5,210	$1,489	131 acres CCOMM$_3$ 4 acres CCOM$_3$ 17 dairy cows 15 hog litters (2:1 ratio) 5 beef cows	Capital Land Dairy building space Forage Manure Dec.-Jan.-Feb. labor	+1,080 bu.	0
P_5	$5,309	$1,501	135 acres CCOMM$_3$ 17 dairy cows 16 hog litters (2:1 ratio) 5 beef cows	Capital Land Dairy building space Forage Dec.-Jan.-Feb. labor	+870 bu.	0
P_6	$6,043	$1,587	135 acres CCOMM$_3$ 17 dairy cows 16 hog litters (2:1 ratio) 5 beef cows 200 hens	Capital Land Dairy building space Poultry building space Forage Dec.-Jan.-Feb. labor	+545 bu.	0
P_7‡	$6,286	$1,610	135 acres CCOMM$_3$ 16 dairy cows 21 hog litters (2:1 ratio) 6 beef cows 200 hens	Land Dairy building space Poultry building space Forage, feed grain Dec.-Jan.-Feb. labor	0	0

*Operating capital does not include investment in machinery which would amount to $3,700 for used machinery and $9,982 for new machinery.

†Return before fixed costs and interest on borrowed capital are subtracted.

‡P_7 represents the amount of capital required for maximum returns with limiting resources indicated in column 5.

dicates, by adding some CCOM rotation at the expense of CCOMM rotation; income from dairying and the number of dairy cows is held constant at the P_1 level. The rate at which CCOM substitutes for CCOMM is constant and is equal to a quantity defined by the slope of the lines above the CCOMM area and the CCOM area in fig. 1. Between any two "corner" points on the lines in fig. 1 the rate of substitution is different than between any other two "corner" points.

In the following discussion, all plans representing "corner" points on the returns line, as P_1

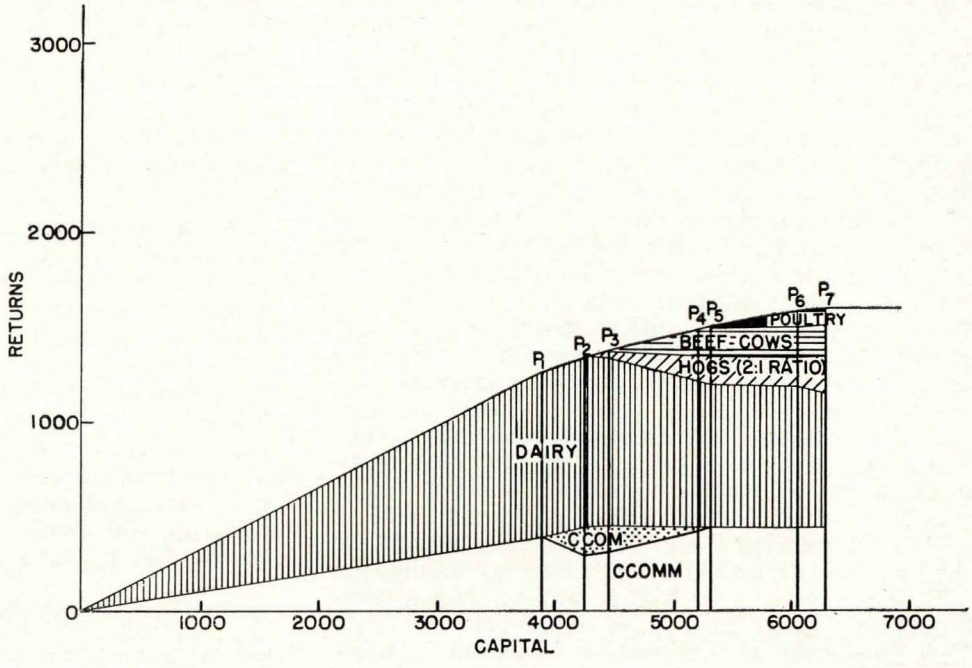

Fig. 1. Optimum farm plans for livestock-share lease with livestock under average management; 135 cultivated acres.

through P_7 in fig. 1, are presented. As a result, some plans are included which represent underutilization of the acreage specified. Those plans which represent underuse of some land are not considered as plans which a farmer would actually use. A tenant farmer would be required to obtain enough funds to cultivate the entire farm. All plans representing "corner" points are included to indicate the capital level at which the farm plan changes because a resource other than capital becomes restricting. While tenant operators generally could not operate a farm with some acres underused or idle, the plans which include underutilized or idle land are optimum for the amount of capital represented. In other words, with this small amount of funds, returns are greater by applying them on fewer acres than by putting the entire farm into unfertilized crops or into a low-profit crop such as oats which uses little capital per acre. However, for recommendations to farmers, only those plans which represent cultivation of the entire acreage should be considered feasible.

Total distance to the uppermost line, or the points $P_i (i = 1 \text{ to } 7)$, in fig. 1 represents the total returns (on the vertical axis) associated with the amount of capital indicated on the horizontal axis. The returns contributed by each enterprise to the optimum plan are indicated by the distance within the shaded area for each enterprise. For example, at P_1 in fig. 1 the total returns are made up of dairying and crop returns and amount to $1,273. Of this amount, $384 is credited to the rotation enterprise and the remainder contributed by the dairy enterprise. At P_7, total returns include income from crops, dairy cows, hogs, beef cows and poultry in the amounts indicated by the length of the portion of the vertical line within the area for each enterprise. Likewise, for any quantity of capital the returns from each enterprise in the optimum plan are illustrated by the same manner in fig. 1. (Plans are not restricted to discrete points $P_1 \ldots . P_7$.) At the last point in fig. 1 (P_7), and in subsequent figures, the OP_i line becomes parallel with the horizontal axis. The OP_i line becomes horizontal when further additions of capital cannot cause the given noncapital resources to be reallocated in a more profitable manner. In other words, resources other than capital now restrict the program. Also, the amount of returns from each enterprise remains constant beyond point P_7. Point P_7 represents maximum profits from fixed resources other than capital; the amount of capital ($6,286) used at this point defines the magnitude where capital is unlimiting.

Under average management and with very limited amounts of capital, dairy cows and a rotation to provide adequate forage utilize resources most efficiently. Below $3,956, sufficient acres of a CCOMM rotation are grown to supply forage for the livestock. The CCOMM rotation in combination with dairy cows gives higher profits than a combination of dairy cows with a different rotation. The two levels of fertilization indicated in table 1 have this meaning: All acres are fertilized at the second level, and with 20 dairy cows there is sufficient manure to fertilize 114 acres at the third level.[9]

Dairy cows have priority over hogs for investment of capital because of low crop yields, particularly grains, on the Cresco-Clyde type soils which serve as a basis for this study. The return per dollar of investment in crops is lower than for livestock. Because of soil conditions, poor drainage and low grain yields but favorable hay yields, maximum profits from land are attained by investing first in high forage-consuming livestock such as dairy cows. For all capital levels, the makeup of farm plans is influenced more by livestock than by crops. Up to about $4,000 of capital, the cropping system is determined by the dairy enterprise alone. Above $4,000 of capital, the cropping system is dependent on dairy cows plus other livestock enterprises coming into the farm plan. In all cases the selected rotation is one which supports the livestock in terms of hay or grain.

In most soil areas of Iowa, crops have the investment priority at low levels of capital. On soils such as Tama-Muscatine, Clarion-Webster, Marshall and Sharpsburg, optimum farm plans call for capital use in crops before livestock. Hence, the first concern of the farm operator is optimum investment in seed and fertilizer. Capital beyond the amount required for crops can then be invested profitably in livestock. This sequence in investment and farm planning is in contrast with the order of this study; the optimum plans here call first for consideration of the most profitable livestock, with crops adapted to feed needs.

Since building space limits the dairy herd to 20 head in plan P_1 (table 4), the next best investment comes from utilizing all land and diverting some acres to a CCOM rotation. The resulting plan, with $4,252 in capital, P_2 in fig. 1, supplies sufficient forage for the dairy cows and gives 3,020 bushel of corn sold as cash grain. With this amount of capital, funds cannot profitably be diverted to hogs since they do not utilize the favorable forage yields as advantageously as dairy cows.

As capital is increased from P_2 to P_3 in fig. 1 (i.e., $4,252 to $4,451 in table 1), a 2:1 ratio hog system comes into the plan. At P_3, labor during December, January and February is used up. Hence, expanding the farm plan beyond the capital level at P_3 requires a combination of enterprises that utilize labor more profitably than the enterprises already in the plan.

The livestock system, giving maximum returns to labor when capital is increased from P_3 to P_5 in fig. 1, includes dairy and beef cows up to the limitations of barn space and a 2:1 ratio hog system. With this number of livestock, there is

[9] The reader is reminded here that the second and third rates of fertilization include the same amounts of commercial fertilizer. The two rates are distinguished by manure application included in the third rate.

ample manure to fertilize all acres at the third rate. To meet the forage requirements for the increased number of livestock, all acres are included in a CCOMM rotation.

Increases in capital, beyond point P_5, bring the poultry enterprise into the farm plan up to the space limitations of the hen house. Poultry do not come into the plan until capital is increased to $6,043 because other enterprises give a higher return on funds. At this level of capital, however, the most favorable investment opportunities are exhausted in other livestock enterprises; poultry then gives more return than other livestock. With 200 hens in the plan, 545 bushels of corn remain and are more profitably marketed through hogs than sold as cash grain when capital is available for further hog investment. Hence, hogs are expanded to 21 litters for the plan at point P_7 in fig. 1. Point P_7 requires $6,286 capital. At this point, capital is no longer limiting for the non-capital restrictions used in this section. In other words, additional capital will give the same plan as for point P_7 when the amounts of building space, labor and land are restrictive in the amounts mentioned earlier.

As indicated earlier, the alternative of buying corn was included for all plans, but closer inspection of the optimum plan for point P_7 where corn is limiting shows that no corn was purchased. Instead, the enterprises in the final plan are combined to utilize the exact amounts of hay and corn raised on the farm. The alternative of hiring extra labor also was considered. However, the returns to labor, and the fact that capital is highly restricting for some situations, do not warrant the hiring of extra labor at $1 per hour. Other computations showed that the return on capital for all plans in table 4 was greater than 7 percent. Therefore, if capital is available for 7 percent interest, the tenant could profitably borrow any amount of the required capital to use any plan up to point P_7 in fig. 1.

The graphical presentation in fig. 1 (of the farm plans in table 4) indicates that dairying is the most important enterprise from the standpoint of profits, especially for low levels of capital (i.e., the portion of the area under the OP_1 line in fig. 1, representing the contribution by dairying, is larger than the portion contributed by all other enterprises). Barn space restricts the dairy herd to 20 head. Therefore, the optimum plan includes hogs and poultry when capital is increased beyond the amount required for 20 dairy cows. Too, the plans for P_4 through P_7 include five or six beef cows and a corresponding number of dairy cows to utilize all the barn space. The difference in profits between (1) a plan including 20 dairy cows and (2) a plan with 17 dairy cows and 5 beef cows, is very small. Because of little difference in income, the farmer's choice between the two latter plans may depend on criteria other than profits.

If barn space were available to expand the dairy herd beyond 20 head, the optimum plans for high capital levels would still include hogs. The reason is that labor becomes limiting and hogs give a higher return on labor than dairy cows. However, the optimum plan is geared to utilize the combination of all limiting resources most profitably, rather than to give the highest return to any one limiting resource. This "interaction effect" of the limiting resources finally specifies the optimum combination of enterprises in the farm plan.

Although fig. 1 shows the farm plan "make-up" for capital levels ranging from zero to an unlimiting amount, the rational farm plans fall within a narrower capital range. Since most farmers prefer to fully utilize all acres, the relevant farm plans in fig. 1 would be between points P_2 and P_7 (P_2 represents the minimum amount of capital at which all acres are fully utilized). This interval gives a capital range of $4,252 to $6,286. The entire capital range is shown in fig. 1, and subsequent figures throughout the text, to indicate the basis of developing the farm plans which would actually be used.

For the average manager operating under a livestock-share lease, dairying not only gives the highest portion of profits in the plan but also provides plans with low risk and uncertainty.[10] The income stability associated with dairying permits the operator to continue farming even though total profits are near a subsistence level. Plans with similar profits but including enterprises with high income variability may well put the farmer out of business if prices are low for a few consecutive years. Of course, in other areas, a farm plan with high income variability may give higher average profits as compared with a plan with relatively stable income. For this situation, the selection of one plan over the other depends on the family's finances and their aversion to risk and uncertainty.

EFFECTS OF NOT USING 2-YEAR MEADOW ROTATIONS

The plans in the previous section included the CCOMM rotation as the main cropping system. Since quackgrass is not easily controlled in a rotation with 2 years of meadow on Cresco-Clyde soils, some plans were computed which do not include 2-year meadow rotations. Other assumptions and restrictions for the resulting plans in this section are identical with those for the plans in the previous section.

Optimum farm plans omitting 2-year meadow rotations and with livestock under average management are included in table 5. A graphical presentation of the returns and capital requirements for the plans in table 5 is given in fig. 2. Again, dairying is the first livestock enterprise coming into the plan when limited amounts of capital are used. However, when a 2-year meadow rotation is not allowed to come into the plan, the forage supply limits the dairy herd to 14 cows. In either case, with or without a crop restriction, dairying

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

TABLE 5. OPTIMUM FARM PLANS FOR LIVESTOCK-SHARE LEASE WHEN 2-YEAR MEADOW ROTATIONS ARE NOT USED; LIVESTOCK UNDER AVERAGE MANAGEMENT; 135 CULTIVATED ACRES.

Point on graph 2	Operating capital*	Tenant return†	Enterprises in the farm plan	Limiting resources	Corn surplus or deficit	Idle land or underutilized pasture
P_1	$3,816	$1,106	54 acres $CCOM_2$ 81 acres $CCOM_3$ 14 dairy cows	Land Forage Manure	+3,729 bu.	0
P_2	$4,796	$1,278	25 acres $CCOM_2$ 110 acres $CCOM_3$ 13 dairy cows 20 hog litters (1:1 ratio)	Land Forage Manure Hog building space	+1,424 bu.	0
P_3	$5,112	$1,318	21 acres $CCOM_2$ 114 acres $CCOM_3$ 13 dairy cows 24 hog litters (2:1 ratio)	Land Forage Manure Hog building space	+944 bu.	0
P_4‡	$5,849	$1,409	19 acres $CCOM_2$ 116 acres $CCOM_3$ 13 dairy cows 24 hog litters (2:1 ratio) 200 hens	Land Forage Manure Hog building space Poultry building space	+626 bu.	0

* Operating capital does not include investment in machinery which would amount to $3,700 for used machinery and $9,982 for new machinery.

†Return before fixed costs and interest on borrowed capital are subtracted.

‡P_4 represents the amount of capital required for maximum returns with limiting resources indicated in column 5.

has the "first call" on investment, and the crops selected become those which support livestock in terms of hay or grain.

As capital is increased from P_1 to P_2 in fig. 2 (i.e., $3,816 to $4,796) the additional funds are most profitably invested in a 1:1 ratio hog system up to the limits of hog building space. Then, further increases in capital (beyond point P_2) cause a switch in hog systems because a 2:1 ratio hog system allows a greater number of hogs, for the same building space, than a 1:1 ratio hog system.

The plan for P_3 in fig. 2 includes 13 dairy cows and 24 hog litters; the respective restrictions for these enterprises are forage and hog building space. When dairying and hogs are restricted by resource limitations other than capital, a poultry enterprise comes into the farm plan because it does not compete for the resources that limit dairy cows and hogs. Also, because of relatively lower returns to investment, poultry does not enter the farm plan until capital becomes unlimiting. The resulting plan (P_4 in table 5) has the same number of hogs and dairy cows as the plan for P_3, plus 200 hens. Since the farm plans in table 5 eliminate 2-year meadow rotations from land use, more corn is marketed as cash grain than in the plans of table 4 where about half the acres are in meadow.

By comparing the plans in table 5 (fig. 2) with the plans in table 4 (fig. 1), one can determine the effects on farm organization and profit when land use is specified to omit 2-year meadow rotations. Returns are comparatively lower for all plans in table 5 where 2-year meadow rotations are omitted (i.e., only one-fourth of the acres are in meadow). This difference in returns is because (1) a CCOM rotation gives proportionally less forage and more grain that a CCOMM rotation, (2) the assumption is used that hay must be marketed through livestock and, hence, (3) the optimum livestock system is one which consumes relatively more grain

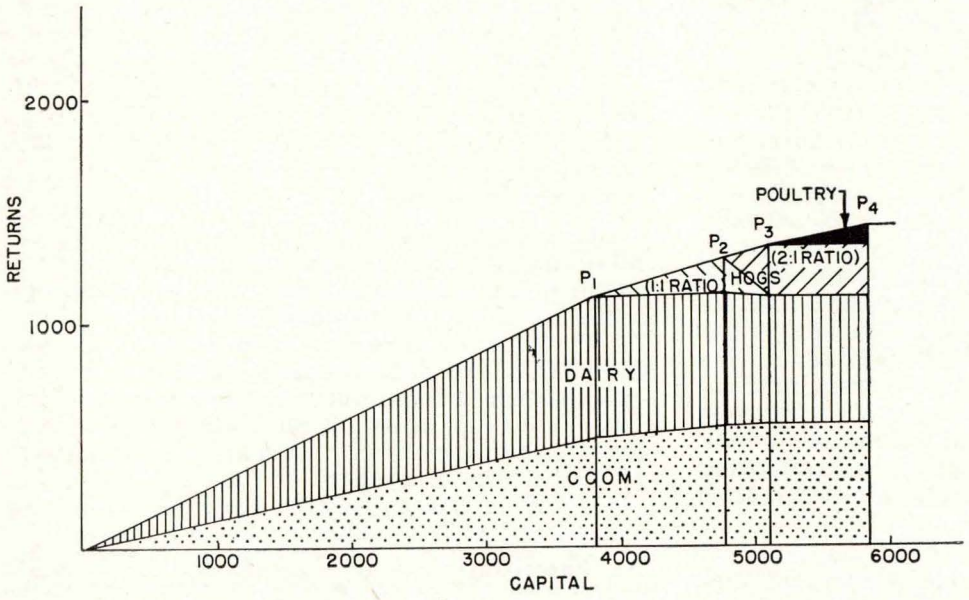

Fig. 2. Optimum farm plans for livestock-share lease when 2-year meadow rotations are not used; livestock under average management; 135 cultivated acres.

TABLE 6. OPTIMUM FARM PLANS FOR LIVESTOCK-SHARE LEASE WITH LIVESTOCK UNDER AVERAGE MANAGEMENT; 215 CULTIVATED ACRES.

Plan	Operating capital*	Tenant return†	Enterprises in the farm plan	Limiting resources	Corn surplus or deficit	Idle land or underutilized pasture
A	$6,000	$1,663	121 acres $CCOM_3$ 54 acres $CSbOM_2$ 23 acres $CCOMM_2$ 17 dairy cows 6 beef cows 8 hog litters (2:1 ratio)	Capital Dairy building space Forage May-June labor Sept.-Oct.-Nov. labor Manure	+3,937 bu.	17 A.
B	$8,256‡	$1,994	140 acres $CCOM_3$ 21 acres $CCOM_2$ 54 acres $CCOMM_3$ 11 dairy cows 15 beef cows 24 hog litters (2:1 ratio) 200 hens	Land Dairy building space Hog building space Poultry building space Forage Manure Sept.-Oct.-Nov. labor	+2,814 bu.	0

*Operating capital does not include investment in machinery which would amount to $3,700 for used machinery and $9,982 for new machinery.

†Return before fixed costs and interest on borrowed capital are subtracted.

‡Amount of capital required for maximum returns with limiting resources indicated in column 5.

and less forage (i.e., more hogs and fewer dairy cows with a CCOM rotation and vice versa for a CCOMM rotation). Since dairying shows more return than hogs, the plans including fewer dairy cows are less profitable.

Figures 1 and 2 not only show differences in total returns for parallel capital quantities but also indicate the proportion of returns contributed by each enterprise under the two situations. In both situations, dairying renders more returns than any other livestock enterprise in the optimum plans. In fig. 2, crops appear more favorable from an income standpoint than in fig. 1. This picture of comparative crop returns is distorted somewhat because all hay is marketed through livestock and so credited. Hence, the relevant comparison of returns between figs. 1 and 2 is the amounts of total returns for parallel quantities of capital.

The manager's choice between plans in table 4 and plans in table 5 depends partly on the quackgrass problem on his farm and the measure of quackgrass control credited to rotation or cropping practices. If controlling quackgrass is a serious problem, the farm manager may choose not to use 2-year meadow rotations. On other farms, cultivation may give adequate control even where 2-year meadow rotations are used. Although the plans including 2-year meadow rotations show more profit in this study, it is possible that profits may be depressed in the long run where land use is important in controlling quackgrass. Final selection of one rotation versus another rotation depends on the seriousness of the quackgrass problem on any particular farm and the farmer's choice and ability of control.

EFFECTS OF INCREASING FARM SIZE TO 215 CULTIVATED ACRES

The changes in farm plans and returns when farm size is increased to 215 cultivated acres are examined in this section. One of the questions arising from the plans in table 4 is: How much increase in return would the tenant realize if he could expand farm size by, say, 80 acres (i.e., 135 cultivated acres to 215 cultivated acres)? To answer this question, the plans in table 6 were computed for $6,000 capital and unlimiting capital. Plan A in table 6 can be compared with plan P_6 in table 4. Plan B in table 6 and plan P_7 in table 4 are comparable since both plans assume unlimiting capital.

With $6,000 of capital and 215 acres of cultivated land, returns are maximized by having less hogs and more cash grain, as compared with a similar capital level with 135 acres of cultivated land. The capital and labor restrictions in plan A (table 6) determine the proportion of hogs and amount of grain sold for cash. As in previous plans, land use is dependent on the forage requirements of beef and dairy cows. Even though the optimum plan (plan A, table 6) includes three different rotations and 17 acres of underutilized pasture, a farmer actually using the plan would likely use only the CCOM rotation and fully utilize all acres. Under both land situations (plan A in table 6 and plan P_6 in table 4) the number of dairy and beef cows remains the same. The only change, as indicated above, is a shift to higher grain rotations when more land is available to furnish forage for livestock. The difference in returns between plan A in table 6 and plan P_6 in table 4 is negligible.

When capital is unlimiting, the optimum plan for 215 cultivated acres (plan B in table 6) gives $1,994 in returns as compared with $1,610 from the optimum plan for 135 cultivated acres (plan P_7 in table 4). Of course, the former plan with higher profits requires nearly $2,000 more capital than the latter plan. If sufficient funds are not available to fully utilize extra acres, the farm operator may realize higher profits from a smaller farm and optimum capital investment rather than spreading his funds over many acres and getting less returns on capital. The labor limitations, in September, October and November, combined with unlimiting capital specify more beef cows than dairy cows in plan B. Also, the labor limitations cause two crop rotations in the final plan. Even though the CCOM rotation gives higher returns per acre, the CCOMM rotation is included to provide sufficient forage for the livestock.

It should be remembered that the returns from adding 80 acres refer to the same labor and

building space as for 135 cultivated acres. With livestock limited by labor and buildings, tenant income is increased only by a small amount by adding 80 acres of land. Expanding the plan in this manner gives low returns from crops and depends largely on livestock enterprises for increased profit. If, however, building space, annual expenses and labor were increased in proportion to the increase in land, tenant income would increase by the same proportion. Consequently, addition of 80 acres then would increase income by $954. In other words, with complementary quantities of labor, buildings and capital inputs, an increase of land by 80 acres would increase income by over 50 percent, rather than by the smaller amount suggested when buildings and labor are held constant at previous levels. The figures presented simply illustrate that cultivation of more of this type of soil adds little to income, unless labor and buildings also can be added to allow more livestock to utilize the crops.

For all farm plans computed with livestock under average management, the returns to capital are greater than 7 percent. Even though capital is available at 7 percent interest, the farm operator may use other criteria for selecting his farm plan. For example, the farmer's preference for one type of livestock and a specific rotation may cause him to forego a few dollars in profits to use a suitable farm plan. Or, the farmer's aversion to risk and uncertainty may be a determining factor in selecting his farm plan.

Additional computations, for all plans with livestock under average management, showed (1) returns to labor are less than $1 per hour—that is, when family labor restricts further expansion of the farm plan, it does not pay to hire extra labor at a wage rate of $1 per hour; and (2) returns to feed grain do not warrant off-farm corn buying when the purchase price for corn bought off the farm is 10 cents per bushel more than corn price on the farm.

Farm Plans for Livestock-Share Lease With Livestock Under Superior Management; 135 Cultivated Acres

The optimum farm plans in this section were computed from the alternative livestock enterprises with superior management and the five alternative crop rotations as given in a previous section. All resource restrictions are the same as in the foregoing section, except that beef cows do not compete with dairy cows for barn space. The superior management techniques for livestock are reflected in resource requirements (housing, feed and labor) and output or production such as meat, milk and eggs. The optimum farm plans with livestock under superior management are given in table 7 and fig. 3. As before, the plans in table 7 are for given points on the total returns curve in fig. 3. Also, as mentioned previously, all plans representing "corner" points are presented. "Corner" points with small amounts of capital including some underutilized land are not plans which a tenant farmer could use. He would be required, or would desire, to obtain capital to put the entire farm into rotation. Hence, only plans with no underutilized land are those which would be employed. However "corner" point plans are presented to illustrate the amounts of capital at which plans do change and the nature of the plans at these points.

With livestock under superior management (fig. 3 and table 7), both dairy cows and hogs come into the plan when capital is very limited. For the same resource situation and average manage-

TABLE 7. OPTIMUM FARM PLANS FOR LIVESTOCK-SHARE LEASE WITH LIVESTOCK UNDER SUPERIOR MANAGEMENT; 135 CULTIVATED ACRES.

Point on graph 2	Operating capital*	Tenant return†	Enterprises in the farm plan	Limiting resources	Corn surplus or deficit	Idle land or underutilized pasture
P_1	$3,734	$1,637	81 acres $CCOM_3$ 7 dairy cows 22 hog litters (1:1 ratio)	Capital Hog building space Feed grain Manure	0	54 A.
P_2	$5,090	$2,210	106 acres $CCOM_3$ 9 dairy cows 30 hog litters (2:1 ratio)	Capital Hog building space Feed grain Manure	0	29 A.
P_3	$6,089	$2,587	29 acres $CCOM_3$ 106 acres $CCOMM_3$ 14 dairy cows 30 hog litters (2:1 ratio)	Capital Land Hog building space Feed grain Manure	0	0
P_4	$6,937	$2,889	80 acres $CCOM_3$ 55 acres $CCOMM_3$ 13 dairy cows 30 hog litters (2:1 ratio) 200 hens	Capital Land Hog building space Poultry building space Feed grain Manure	0	0
P_5‡	$6,979	$2,904	106 acres $CCOM_3$ 29 acres $CCOMM_3$ 13 dairy cows 30 hog litters (2:1 ratio) 200 hens	Land Hog building space Poultry building space Sept.-Oct.-Nov. labor Manure Forage	+144 bu.	0

*Operating capital does not include investment in machinery which would amount to $3,700 for used machinery and $9,982 for new machinery.

†Return before fixed costs and interest on borrowed capital are subtracted.

‡P_5 represents the amount of capital required for maximum returns with limiting resources indicated in column 5.

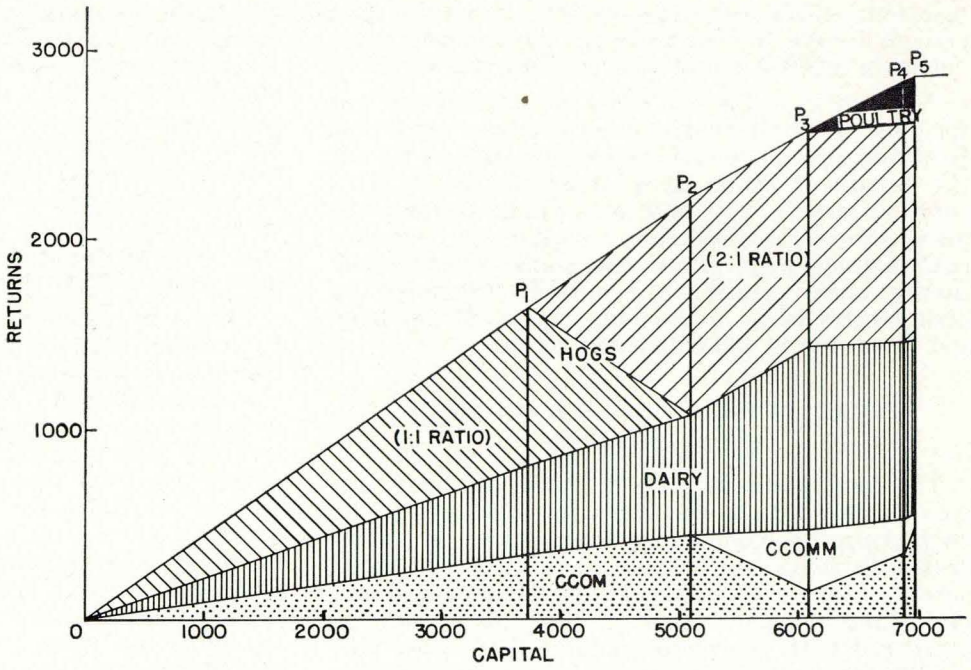

Fig. 3. Optimum farm plans for livestock-share lease with livestock under superior management; 135 cultivated acres.

ment on livestock (fig. 1), dairying is the only livestock in the farm plan. In fig. 3, the combination of hogs and dairy cows for very limited amounts of capital causes CCOM to be the most profitable rotation. This crop selection results because of the low forage requirements for the livestock system at points P_1 and P_2. However, as capital is increased beyond point P_2, it pays to expand the dairy enterprise which, in turn, requires additional forage. For this reason, the CCOMM rotation comes into the plan at points P_3, P_4 and P_5. At point P_3, the optimum livestock plan includes 14 dairy cows and 30 hog litters. Instead of investing in a larger dairy enterprise (hogs cannot be expanded since hog building space is used up with 30 litters), returns are maximized by adding a poultry flock to the farm plan when capital is increased beyond $6,089.

The resources which finally limit the plan at point P_5 are labor, building space and land. Hence, the capital level ($6,979) for plan P_5 is equivalent to unlimiting capital, since further increases in capital (i.e., more than $6,979) will give the same plan as at point P_5.

As in figs. 1 and 2, the relevant capital range in fig. 3 would include those capital levels for farm plans with land as a limiting resource. Hence, according to the results in table 7, the superior livestock manager requires a minimum of $6,089 and not more than $6,979 in capital to fully utilize 135 cultivated acres.

The major difference between plans with livestock under average management (fig. 1 and table 4) and plans with livestock under superior management (fig. 3 and table 7) is the portion of total returns contributed by dairy cows and hogs. Under average management, dairying provides at least half the return for the farm plans throughout the capital range (i.e., from zero to unlimiting capital). On the other hand, with livestock under superior management, hogs give more returns, throughout the capital range, than any other enterprise in the farm plan. However, dairying is still a major enterprise in the plans under superior management and gives nearly as much return as hogs, when capital supply is $6,000 or above.

Under both levels of management, hog systems that include summer litters (i.e., litter ratios of 0:1:0, 1:1:1 and 1:2:1) never come into the farm plan. The reason is that summer pigs are assumed to be marketed in November and December; since the seasonal hog price is usually lowest during these months, the average price for summer-farrowed pigs does not warrant any of these systems.

For some farmers, there may be certain advantages in summer pigs that offset their relatively lower market price. For example, the labor distribution for the farm may be more favorable when pigs are farrowed in May or June rather than early spring or late fall. Too, some farmers maintain that summer pigs give higher feed efficiency because they can be turned out to utilize part of the harvest loss during corn picking. These and other factors apply to a specific farm situation, and the individual operator must make the final decisions as they pertain to his optimum farm plan.

The cropping system for plans with livestock under superior management is mainly a CCOM rotation. When capital supply is around $6,000 ($P_3$ in fig. 3), the "interaction effect" of resource use causes a CCOMM rotation to be the dominant crop enterprise. As capital approaches an unlimiting amount (P_5 in fig. 3) labor becomes limiting, and the plan giving maximum returns includes 106 acres of CCOM rotation and 29 acres of CCOMM

rotation. This cropping system provides just enough forage for the livestock system and gives optimum utilization of the limiting resources.

At point P_5 in fig. 3, a labor buying activity was included as an alternative for the labor restriction. However, again the returns to labor did not permit the hiring of extra labor at $1 per hour. This result is parallel with the same condition for plans under average management. In other words, under both management levels, the plans restricted by family labor cannot be profitably expanded by hiring extra labor, if the wage rate is $1 per hour and farm size is 135 cultivated acres.

EFFECTS OF INCREASING FARM SIZE TO 215 CULTIVATED ACRES

The farm plans in table 8 include the same resource conditions as the plans just discussed. The only change considered in this section is an increase in land size to 240 acres (215 cultivated acres). Plans are computed for $6,000 capital and unlimiting capital. Hence, these plans can be compared with the plans in table 6 to show how management affects income and farm organization on a farm with 215 cultivated acres.

As mentioned at a previous point, the plans shown examine income effects only when land is increased; building space and labor are held constant at the amount for 135 acres. If building space and labor were increased in proportion to land, income would also increase by approximately this same proportion. In this case, land increased by 80 acres and other limiting resources increased by the same proportions, income would be increased by $1,721. However, the plans in table 8 have been computed with restricting resources, other than land, held at the previous level. This step was completed to see whether a tenant farmer with limited labor and buildings, as they exist on his present unit, could increase profits by renting more of the same kind of land. Again the results show that for the particular soil type, income premium is in livestock investment to utilize crops from the given acreage, rather than investing in more crops that return relatively little on the particular soil type. The idle acres indicated under plan A in table 8 are presented to illustrate this point, rather than to suggest that a farmer would rent 80 more acres and leave it idle. Or, stated another way, the underutilization figure simply means that the opportunity to rent 80 more acres does not increase returns unless sufficient capital is available to make added investment in livestock. Even when the plan is expanded by increasing both acres and livestock, income increases only a small amount because added cropland, with livestock restricted by labor and buildings, gives a high rate of diminishing returns.

Plan A in table 8 is essentially the same as plan P_3 in table 7. There is some difference in the number of acres in each rotation and one less dairy cow under plan A. Also, the capital level for P_3 in table 7 is a few dollars higher than the capital level for plan A in table 8. Conclusions from comparing the two plans are: (1) Land is not a serious limitation for P_3 in table 7 and (2) with about $6,000 capital, a larger farm, with labor and building space remaining constant, does not give materially greater profits. Or, under the assumptions and restrictions used in this study, the tenant must use more than $6,000 to realize an increase in profits from a farm larger than 160 acres.

When farm size is 135 cultivated acres, the amount of capital used for maximum profits is $6,979 ($P_5$ in table 7); by increasing farm size to 215 cultivated acres, $9,243 of capital is required for maximum profits (plan B in table 8).[11] The profits from the two plans are $2,904 and $3,475, respectively. In other words, an 80-acre increase in farm size, with labor and buildings restricted as mentioned earlier, increases returns by $471 and requires $2,264 additional investment. The difference in livestock enterprises for plan B in table 8 and plan P_5 in table 7 explains part of the change in returns and investment between the two plans.

The larger acreage in plan B brings beef cows into the plan and decreases the dairy enterprise to eight cows because of building and labor restrictions. Too, all acres are utilized by the CCOMM rotation. The reason for these changes is that returns are higher when most of the crops are marketed through livestock. Hence, less corn

[11]The reader is reminded that these figures do not include machinery investment. See earlier discussion.

TABLE 8. OPTIMUM FARM PLANS FOR LIVESTOCK-SHARE LEASE WITH LIVESTOCK UNDER SUPERIOR MANAGEMENT; 215 CULTIVATED ACRES.

Plan	Operating capital*	Tenant return†	Enterprises in the farm plan	Limiting resources	Corn surplus or deficit	Idle land or underutilized pasture
A	$6,000	$2,567	75 acres $CCOM_3$ 49 acres $CCOMM_3$ 13 dairy cows 30 hog litters (2:1 ratio)	Capital Hog building space Forage Manure Feed grain	0	91 A.
B	$9,243‡	$3,475	170 acres $CCOMM_3$ 45 acres $CCOMM_2$ 8 dairy cows 29 beef cows 30 hog litters (2:1 ratio) 200 hens	Land Hog building space Poultry building space Forage Manure Sept.-Oct.-Nov. labor	+1,744 bu.	0

*Operating capital does not include investment in machinery which would amount to $3,700 for used machinery and $9,982 for new machinery.

†Return before fixed costs and interest on borrowed capital are subtracted.

‡Amount of capital required for maximum returns with limiting resources indicated in column 5.

TABLE 9. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS WHICH INCLUDE BEEF FEEDING AND LABOR BUYING: SUPERIOR MANAGEMENT AND UNLIMITING CAPITAL.*

Situation	Operating capital†	Tenant return‡	Enterprises in the farm plan	Limiting resources	Corn surplus or deficit	Labor hired
135 cultivated acres land; beef feeding and labor buying	$8,080	$3,044	135 acres CCOMM$_3$ 8 dairy cows 30 hog litters (2:1 ratio) 200 hens 23 calves (deferred-fed)	Land Sept.-Oct.-Nov. labor Hog building space Poultry building space Forage	−1,348 bu.	0
215 cultivated acres land; labor buying	$9,300	$3,481	172 acres CCOMM$_3$ 43 acres CCOMM$_2$ 9 dairy cows 28 beef cows 30 hog litters (2:1 ratio) 200 hens	Land Hog building space Poultry building space March-April labor Forage Manure	+1,707 bu.	23 hrs. in Sept., Oct., Nov.
215 cultivated acres land; beef feeding	$8,879	$3,557	139 acres CCOMM$_3$ 76 acres CCOMM$_2$ 30 hog litters (2:1 ratio) 17 beef cows 35 calves (deferred-fed) 200 hens	Land Hog building space Poultry building space Sept.-Oct.-Nov. labor Forage Manure	+431 bu.	0
215 cultivated acres land; beef feeding and labor buying	$8,944	$3,595	138 acres CCOMM$_3$ 77 acres CCOMM$_2$ 30 hog litters (2:1 ratio) 12 beef cows 43 calves (deferred-fed) 200 hens	Land Hog building space Poultry building space Feed grain Forage Manure	0	62 hrs. in Sept., Oct., Nov.

*Unlimiting capital is used since labor buying and beef feeding did not enter the farm plan at capital levels of $6,000 or less.
†Operating capital does not include investment in machinery which would amount to $3,700 for used machinery and $9,982 for new machinery.
‡Returns before fixed costs and interest on borrowed capital are subtracted.

is sold as cash grain when a CCOMM rotation is used (compared with CCOM), and beef cows provide the most profitable outlet for forage when farm size is 215 cultivated acres, capital is not limiting and building space and labor are highly restrictive. It should be remembered, of course, that grain yields are low and hay yields are relatively high on the problem soil studied. Labor is a resource restriction in plan B which specifies the number of beef and dairy cows. If labor supplies and building space were larger, the addition of 80 acres would provide a greater increment to income.

Regardless of farm size, hogs and poultry are included in the plans for unlimiting capital up to the limits of building space. This condition is the same whether livestock are under average management or under superior management.

The differences between plan B in table 8 and plan B in table 6 reflect differentials in average and superior livestock management on a farm with 215 cultivated acres. With livestock under average management (plan B in table 6), it pays to grow a higher grain rotation than when livestock are under superior management (plan B in table 8). Consequently, more corn is marketed as cash grain under average livestock management and more dairy cows are kept as compared with the plan with livestock under superior management. Throughout all plans examined so far in this study, dairying is an important enterprise in terms of profits for the average livestock manager. Not only does it rank high in profits, but the enterprise also gives a relatively steady income with little variability in price. Under superior management, dairying is still included in all farm plans; but for maximum profits, fewer cows and more hogs are kept as compared with plans under average management.

ADDITIONAL PLANS THAT INCLUDE LABOR HIRING AND BEEF FEEDING

In all plans discussed previously, the beef feeding enterprise, described in an earlier section, has been omitted as an investment alternative. Because of higher risk and uncertainty associated with beef feeding, as compared with the other livestock enterprises considered in this study, the deferred-fed calf enterprise is included under superior management only.

Hiring extra labor is the other additional situation considered in this section. The only situation which warrants hired labor at $1 per hour is when farm size is more than 135 cultivated acres and livestock are produced under superior management.

The plans in table 9 show the effect on farm organization when beef feeding and labor buying are considered. All plans in table 9 are computed for unlimiting capital because (1) previous plans under superior management show labor as a limiting resource only when capital is unlimiting and (2) other computations, not given here, showed that the beef enterprise could not compete with other livestock for resources until capital was near an unlimiting amount.

The first plan in table 9 is for 135 cultivated acres of land, beef feeding and labor buying. As in previous plans, with high capital levels and superior management, hogs and poultry are included in the plan up to the limitations of building space. The remaining resources (i.e., after hog and poultry requirements are satisfied) are most profitably used by eight dairy cows and 23 deferred-fed calves. The size of the latter two enterprises is determined by the optimum use of forage and labor; farm size restricts the amount of forage produced and low returns to labor do not permit hired labor to supplement the family labor

supply. Feed grain is not a restriction in this plan because returns to feed grain allow corn to be purchased at 10 cents per bushel more than corn price on the farm.

By comparing the first plan in table 9 with the plan for P_5 in table 7, one can see the changes in returns and capital requirements for the farm plan when a beef feeding enterprise is kept on a 160-acre farm. When deferred-fed calves are included in the plan, returns are increased $140. However, capital requirements also are increased about $1,100. Whether or not the farm operator would choose a plan including beef feeding depends on his capital situation and his risk preference for the amounts of profit and risk involved.

The second plan in table 9 considers labor buying for a farm with 215 cultivated acres and livestock under superior management. The deferred-fed calf enterprise is not considered in this plan. Plan B in table 8 is the same farm situation as for the second plan in table 9 except that the latter situation includes labor buying. That is, given the farm plan B in table 8, how much can returns be increased by hiring extra labor?

A comparison of the latter two plans shows a negligible difference in returns, capital requirements and enterprises between the two plans. Hiring extra labor results in a very slight reorganization of the farm plan and increases returns only $6. Hence, labor is not a serious limitation for plan B in table 8.

Now, by examining the third plan in table 9, one can determine the changes in the farm plan when a beef enterprise is added to the farm situation used for plan B in table 8. The objective for computing the third plan in table 9 is to make a comparison between a resource situation not including beef feeding (plan B in table 8) and the same resource situation that includes beef feeding (third plan in table 9). Some farmers may have a definite preference for one plan over the other; but for other farmers a comparison of the two plans may help them decide which is optimum for them.

With 215 acres of cultivated land and unlimiting capital, the optimum farm plan including deferred-fed calves (third plan in table 9) gives $3,557 return; the optimum plan for the same amount of resources, other than capital, but not including deferred-fed calves (plan B in table 8) gives $3,475 return. Not only does the plan including calves give slightly higher returns, but also it requires about $364 less capital. When the beef feeding enterprise comes into the plan, dairy cows are forced out and only about half as many beef cows are kept; however, the same amounts of hogs and poultry are included in both plans. The reason for deferred-fed calves replacing dairy cows is that when sufficient capital is available, the added forage from a larger farm (215 cultivated acres) is more profitably marketed through high-forage-consuming livestock such as feeder calves. For the third plan in table 9, the limiting resources which finally specify the numbers of beef cows and deferred-fed calves are forage and labor.

Since labor restricts the plan just discussed, the fourth plan in table 9 was computed to determine the optimum farm plan when labor buying is considered in combination with a plan including deferred-fed calves. The results for this resource situation show that the optimum plan occurs when 62 hours of extra labor are hired during the fall months. With this much hired labor, other resources restrict further expansion of the plan. The difference in returns between the third and fourth plans in table 9 is very slight. Too, the kind and amount of enterprises in each plan are nearly identical. Final selection would depend on the farm operator's criteria in selecting between the two plans.

The beef enterprise discussed in the plans for this section affects returns most when farm size is 215 cultivated acres. Beef are more important on the larger farm because large quantities of forage can be profitably utilized by high-forage-consuming animals and because labor and building requirements are less. For all plans including the beef enterprise, the change in capital requirements must be considered along with the return increases. For example, when farm size is 135 cultivated acres, both capital requirements and returns are increased; but, on a larger farm, capital requirements are decreased and returns are increased when the optimum plan includes a beef enterprise. The latter situation appears favorable from a profit standpoint, but it does not account for the risk and uncertainty associated with feeding beef cattle. Again, the final selection of any plan depends on the individual's preferences and capabilities.

Other considerations relating to feeding cattle must be those unique to each farm or community. Some farmers may occasionally purchase one or two head of feeder stock at local sales or livestock auctions and build their herds accordingly. Some operators may realize returns from a beef enterprise greater than those shown in previous plans. On the other hand, in years of low selling prices and high costs, a beef enterprise will decrease returns when included in the farm plan. The returns from beef cattle shown in the data presented assume that the entire herd is purchased and marketed as a group, rather than by picking up a few animals at a time.

Farm Plans for Crop-Share Lease With Livestock Under Average Management; 135 Cultivated Acres

The optimum farm plans above are for a livestock-share lease. Although most of the leasing systems for the soil area studied are livestock-share, some plans also were computed for a crop-share lease. Many variations of the two leasing systems exist; however, the 50-50 livestock-share used above and a 50-50 crop-share used for the following plans are the common leasing systems found in this area.

TABLE 10. OPTIMUM FARM PLANS FOR CROP-SHARE LEASE WITH LIVESTOCK UNDER AVERAGE MANAGEMENT; 135 CULTIVATED ACRES.

Point on graph 4	Operating capital*	Tenant return†	Enterprises in the farm plan	Limiting resources	Corn surplus or deficit	Idle land or underutilized pasture
P_1	$5,468	$1,614	54 acres $CCOM_2$ 81 acres $CCOM_3$ 14 dairy cows	Land Forage Manure	+3,729 bu.	0
P_2	$7,412	$1,899	25 acres $CCOM_2$ 110 acres $CCOM_3$ 13 dairy cows 20 hog litters (1:1 ratio)	Land Forage Manure Hog building space	+1,424 bu.	0
P_3	$8,151	$1,990	23 acres $CCOM_2$ 112 acres $CCOM_3$ 13 dairy cows 20 hog litters (1:1 ratio) 200 hens	Land Forage Manure Hog building space Poultry building space	+1,106 bu.	0
P_4‡	$8,783	$2,328	19 acres $CCOM_2$ 116 acres $CCOM_3$ 13 dairy cows 24 hog litters (2:1 ratio) 200 hens	Land Forage Manure Hog building space Poultry building space	+626 bu.	0

*Operating capital does not include investment in machinery which would amount to $3,700 for used machinery and $9,982 for new machinery.

†Returns before fixed costs and interest on borrowed capital are subtracted.

‡P_4 represents the amount of capital required for maximum returns with limiting resources indicated in column 5.

Under the crop-share lease, the tenant provides all capital and other resources required for livestock production. The tenant pays $8 an acre cash rent for meadow; all other resources are available as under the plans above for a livestock-share lease. Since the landlord's profits are from crops only, the rotations including 2 years of meadow are omitted as cropping alternatives for the crop-share plans. The alternative livestock enterprises in this section are the same as for previous plans.

The plans in table 10 are optimum for the tenant operating a 160-acre farm on a crop-share lease, with livestock under average management. Figure 4 shows the returns from different quantities of capital used for the plans in table 10. These plans can be compared with the plans in table 4 to show the leasing effects on farm planning when livestock are produced under average management. Should the tenant invest in the same amount of livestock under the two leasing systems? Do the increased capital requirements for livestock under a crop-share lease (i.e., where the landlord does not pay half the cost) cause a different pattern of resource use?

The plan for P_1 in table 10 shows dairying as the most profitable livestock investment for small amounts of capital. The optimum cropping system is a CCOM rotation. This rotation supplies enough forage for 14 dairy cows when farm size is 135 cultivated acres. Hence, the major restriction for plan P_1 is land, which in turn limits the amount of forage.

By increasing capital, the farm plan is reorganized to include a 1:1 ratio hog system (plan P_2 in table 10). With $7,412 capital, the hogs in the plan use up all the building space. The forage required for 20 pig litters is obtained by decreasing the dairy herd to 13 cows. Also, the amount of

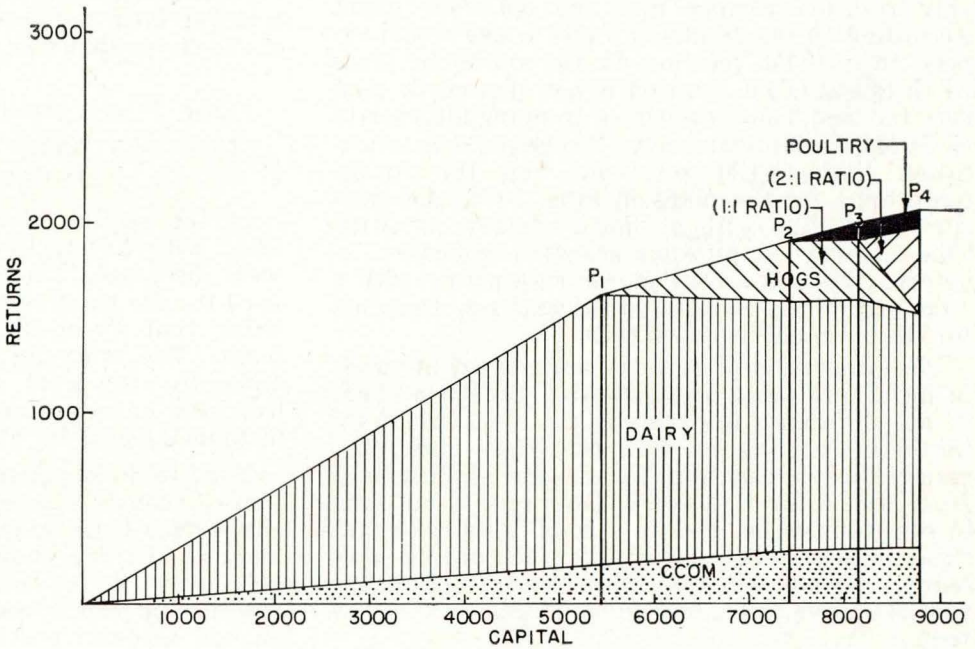

Fig. 4. Optimum farm plans for crop-share lease with livestock under average management; 135 cultivated acres.

salvaged manure in plan P_2 is sufficient to fertilize 110 acres at the third rate. The increased crop yields from a higher fertilization rate explain how forage requirements for hogs can be met by omitting only one cow from the dairy herd. The critical resource limitations in plan P_2 are land and hog building space.

The next most profitable investment alternative, when adding more capital to the farm plan (beyond P_2 in fig. 4), is poultry. Because the plans for P_1 and P_2 in fig. 4 include corn marketed as cash grain, the plan for P_3, which includes poultry, does not change the number of hogs and dairy cows in the plan. Hog and dairy cow numbers are not changed because the only resources for which poultry competes with other livestock are feed grain and capital. Hence, plan P_3 in table 10 includes the same livestock as plan P_2 plus 200 hens. The new resource restriction for plan P_3 is poultry building space. The amount of corn sold as cash grain is 1,106 bushels.

For an unlimiting amount of capital (plan P_4 in table 10), the limiting resources in column 4 are most profitably utilized by 13 dairy cows, 200 hens, all land in a CCOM rotation and a 2:1 ratio hog system. The change in the hog system from plan P_3 to plan P_4 is caused by the restrictions of hog building space. In other words, (1) a 1:1 ratio hog system is most profitable when the capital supply is low, (2) when hog building space limits a 1:1 ratio hog system, the next most profitable investment is poultry and (3) when poultry building space limits the size of the poultry flock, additional capital is used by switching to a 2:1 ratio hog system which allows more hogs, for the same building space, than the 1:1 ratio hog system. In plan P_4, the maximum amount of capital required for maximum returns with the limiting resources indicated in column 5 is $8,783.

Throughout the plans in table 10, CCOM is the only rotation coming into the optimum plans. According to the results in table 4, one would expect the CCOM rotation in the optimum plans when the CCOMM rotation is not allowed to compete for land use. However, a cropping alternative of COM rotation gives more forage per acre of rotation than CCOM rotation. Yet, the forage limitations for the plans in table 10 do not warrant a rotation with as much meadow as COM. This manner of rotation selection indicates, as before, livestock as the major enterprises with a cropping system adapted to the feed requirements for the optimum livestock plan.

The proportion of returns contributed by crops in fig. 4 and fig. 1 are somewhat different. Part of the difference is explained by the kind of rotation in each figure; but, the major difference results because cash rent for meadow is subtracted from crop returns in fig. 4. Cash rent is not paid in the plans of fig. 1 since a 50-50 livestock-share lease is used. Although other accounting procedures are possible, total returns are the same regardless of which enterprise is charged for meadow rent.

With average livestock management and both types of leasing, dairying is the only livestock enterprise coming into the plan when small amounts of capital are used. Returns from dairy cows are greater than from other livestock for all plans in fig. 4. This result is similar to the plans in fig. 1 where livestock are under average management but a livestock-share lease is used.

Under a crop-share lease, the capital outlay for the tenant is greater than under a livestock-share lease because the tenant furnishes all capital for livestock. However, the tenant's returns also are greater under a crop-share lease. In fact, if the tenant can acquire sufficient capital to use plan P_4 in table 10, it gives higher average returns per dollar than plan P_7 in table 4. Actually, the difference in average returns per dollar for the two plans is negligible. For many tenants, the smaller capital requirements under a livestock-share lease may cause a preference for a livestock-share lease over a crop-share lease, even though the latter provides more potential income for the tenant. Of course, in most cases the tenant must accept the lease preferred by the landlord, and the planning decisions for the tenant must be adapted to the situation under which he operates.

If farm size were increased to 215 cultivated acres for the plans in table 10, a greater amount of capital would be necessary to maximize profits with the resources available for these situations. More acres would supply more forage. Additional forage would allow the dairy cow enterprise to expand to the limits of barn space. Consequently, the optimum plans for increasing amounts of capital would bring into the plan 20 dairy cows, hogs and poultry in that order, as capital is increased from the amount required for 20 dairy cows to the amount required for maximum returns with the limiting resources on the farm. If sufficient capital is available to utilize resources other than land, a larger farm would increase the tenant's returns above those shown in table 10.

Farm Plans for Crop-Share Lease With Livestock Under Superior Management; 135 Cultivated Acres

In the section above, plans for a crop-share lease with livestock under average management were discussed. The same resource situations are used for the plans in this section, the only change being that livestock is under superior management. The optimum farm plans for a farm of 135 cultivated acres with a crop-share lease and livestock under superior management are given in table 11 and fig. 5.

The livestock system coming into the farm plans with livestock under superior management is similar for both lease types. Plan P_1 in table 11 shows a 1:1 ratio hog system as the most profitable livestock for low amounts of capital. The rotation in plan P_1 (table 11) is CCOM, and only enough acres to provide feed grain for hogs are

TABLE 11. OPTIMUM FARM PLANS FOR CROP-SHARE LEASE WITH LIVESTOCK UNDER SUPERIOR MANAGEMENT; 135 CULTIVATED ACRES.

Point on graph 5	Operating capital*	Tenant return†	Enterprises in the farm plan	Limiting resources	Corn surplus or deficit	Idle land or underutilized pasture
P_1	$3,817	$1,750	29 acres $CCOM_2$ 42 acres $CCOM_3$ 22 hog litters (1:1 ratio)	Hog building space Feed grain Manure	0	64 A.
P_2	$6,159	$2,845	81 acres $CCOM_3$ 22 hog litters (1:1 ratio) 7 dairy cows	Hog building space Feed grain Manure	0	54 A.
P_3	$8,576	$3,900	108 acres $CCOM_3$ 30 hog litters (2:1 ratio) 9 dairy cows	Hog building space Manure Forage	+35 bu.	27 A.
P_4	$9,886	$4,347	12 acres $CCOM_2$ 123 acres $CCOM_3$ 30 hog litters (2:1 ratio) 12 dairy cows	Land Hog building space Manure Forage	+738 bu.	0
P_5‡	$10,658	$4,631	10 acres $CCOM_2$ 125 acres $CCOM_3$ 30 hog litters (2:1 ratio) 12 dairy cows 200 hens	Land Hog building space Manure Forage Poultry building space	+412 bu.	0

*Operating capital does not include investment in machinery which would amount to $3,700 for used machinery and $9,982 for new machinery.

†Return before fixed costs and interest on borrowed capital are subtracted.

‡P_5 represents the amount of capital required for maximum returns with limiting resources indicated in column 5.

included. Hog building space is the critical resource restriction for this plan.

The plan for P_2 in table 11 shows a combination of 22 hog litters and 7 dairy cows. With this livestock combination, there is sufficient manure to fertilize 81 acres at the third fertilization rate. When more capital is added to the plan (i.e., more than $6,159), a 2:1 ratio hog system is substituted for the 1:1 ratio and two more dairy cows are included. The resulting plan at P_3 includes 108 acres of CCOM rotation, and forage becomes a limiting resource instead of feed grain. This plan allows 27 acres of idle land or underutilized pasture and 35 bushels of corn marketed as cash grain.

The farm organization is expanded to plan P_4 by fully utilizing all the land and increasing the dairy herd to 12 head. For all plans in table 11, hogs are included up to the limits of hog building space. Since forage and hog building space are limiting resources in plan P_4, further increases in dairy cows and hogs are not permitted. However, 738 bushels of corn are sold as cash grain and, for this reason, poultry are added to the optimum plan when capital is increased beyond the amount required for plan P_4. Plan P_5 gives maximum returns for the limiting resources on the farm. This plan includes 30 hog litters, 12 dairy cows, 200 hens and all acres in a CCOM rotation. (The only relevant farm plans in table 11 may be P_4 and P_5 since the plans using less capital than plan P_4 do not fully utilize all cropland.) Plans P_1, P_2 and P_3 are shown as optimum plans because of the linear assumptions used in the technical coefficients and other reasons stated previously.

The capital requirements for crop-share plans in table 11 are considerably higher than for plans

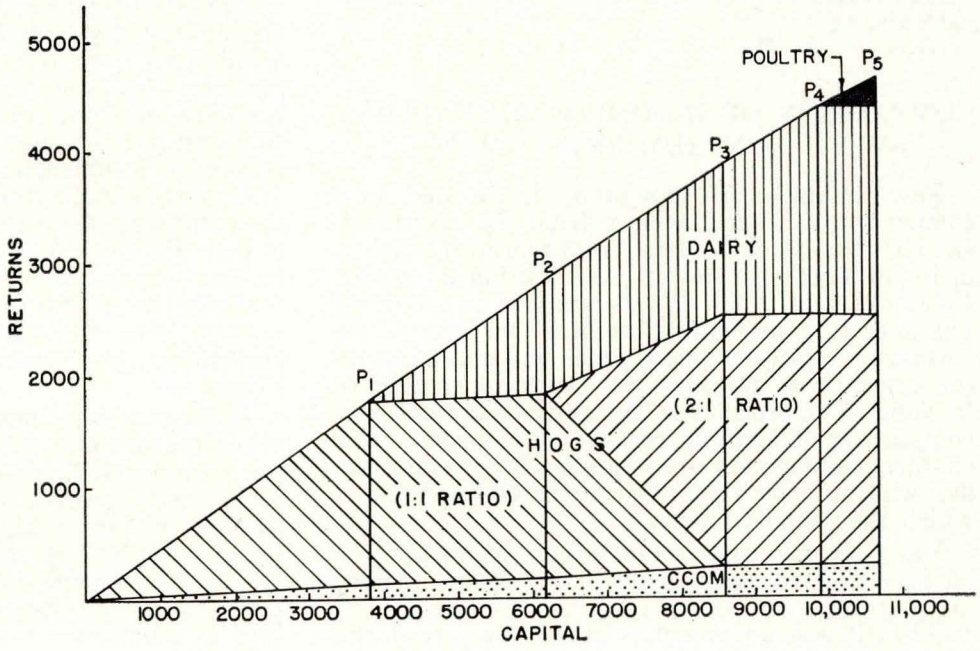

Fig. 5. Optimum farm plans for crop-share lease with livestock under superior management; 135 cultivated acres.

in table 7 where a livestock-share lease is used. The difference in leases is reflected in increases of both capital requirements and returns when a crop-share lease is used. The tenant's optimum plans are essentially the same for comparable acres of land under both leasing systems.

If the tenant could provide more capital than the amount used for plan P_5 in table 11, returns could be increased by farming more acres or including a beef feeding enterprise in his plan. The relative return increases would be similar to previous plans which included beef feeding and a larger farm size (with livestock under superior management).

Labor is not a limiting resource for any of the plans in tables 10 and 11 where a crop-share lease is used. However, if farm size was increased or a beef feeding enterprise was added, labor would become limiting during the fall months.

Conclusions for Selecting the Optimum Plan

The farm plans discussed in previous sections are for one set of prices and resource situations (other than capital). By varying the amounts of resources or prices, many other optimum plans could be computed. The farm plans given in this study are to provide "benchmark" situations for the soil area being studied. In figs. 1 through 5 optimum plans are not confined to the specific plans given in parallel tables. The plans discussed are those plans where resource use specifies a shift in farm planning as available capital is increased. For example, in fig. 2 the increase in capital from P_1 to P_2 represents a continous and constant substitution from a 1:1 ratio hog system to a 2:1 ratio hog system. In other words, any point on the OP_i ($i = 1$ to n) line represents an optimum farm plan corresponding to the amount of capital shown on the horizontal axis and provides the return level shown on the vertical axis.

COMPARISON OF INCOME FROM FARMING WITH NONFARM EMPLOYMENT

The remainder of this study is devoted to a comparison of farm income, from plans outlined earlier, with wage returns from nonfarm employment in northeast Iowa. As mentioned earlier, there are two types of information in providing guidance to young farm families. One type of information relates to plans which will maximize income for those families who wish to remain in farming. The other type of information relates to comparison of farming returns with income from off-farm employment opportunities for young families who still are undecided about the occupation which they should follow.

Many income comparisons might be made. The off-farm employment opportunity could include many types of work or professional activity. It could include employment at many locations in the country or proprietorship in other types of business. Farm incomes used for comparison might be those resulting from varying types of farm organization, different amounts of assets, or capital, and varying tenure structures. Or numerous managerial capacities may be reflected in farm incomes. However, to keep the analysis manageable, farm incomes from optimum plans presented previously are compared with the average income from several types of manufacturing in the general area under study.

In comparing the two sets of income, it should be remembered that the farm returns are for a tenant farmer and not an owner-operator. The farm returns do not include a charge for interest on any borrowed capital. Also, they represent the optimum plans under the resource and price situations outlined earlier. Farmers who own more assets would have greater incomes than those shown; farmers who do not use an optimum plan, as is often the case, would have less income than shown. Finally, neither the farm nor nonfarm incomes shown are those which a young farm family would expect over their remaining life. The farm family would expect to accumulate capital, produce a greater volume and have more income. The urban family might expect promotions which would provide progressing incomes. The figures shown are, however, those which might be expected in the near future.

Money income is not the only criterion people use when choosing an occupation. Family preferences for farm and town living represent types of nonmoney income which must be considered. Items relating to living conditions which also are important include recreation facilities, medical services, schools, climate and nationality group. Many families may maximize utility, or their welfare, by living on a farm, even though their money income might be lower than had they chosen an urban occupation. For other families, the merits of city living may outweigh the rural advantages even if the former gives less money income. However, there are always some farm families "on the fence." Farm profits may be less than required to satisfy their goals. Yet, they may have insufficient knowledge, and uncertainty of employment elsewhere may be too great to allow them to move from the farm. Hence, this section is directed toward providing information helpful to this group. It is designed to aid extension personnel in giving answers to families in northeastern Iowa who seek advice on real income opportunities in farming as compared with city living.

Average annual nonfarm wage rates for Iowa are given in table 12. Figures are provided only for major industries employing both skilled and nonskilled workers. Other off-farm jobs exist; some with returns higher than shown in table 12. However, for the income comparisons in this study, the average annual wage rate for all nonagricultural industries in 1955 (i.e., $3,935) is used as a basis for nonfarm income.

TABLE 12. ESTIMATED AVERAGE HOURS AND EARNINGS IN SELECTED INDUSTRIES IN IOWA.*

Industry	Average weekly hours					Average weekly earnings				
	Years					Years				
	1955	1954	1953	1952	1951	1955	1954	1953	1952	1951
Machinery (except electrical)	41.10	40.30	40.80	40.90	41.60	$82.45	$76.66	$75.62	$73.42	$72.54
Agricultural machinery	39.95	39.60	29.80	39.10	39.90	86.30	80.86	79.78	76.54	76.11
Construction	42.00	40.60	40.10	40.70	45.00	79.78	74.53	70.95	73.17	74.43
Food products	41.88	41.20	41.40	42.50	42.90	77.88	72.99	70.59	68.22	64.73
Meat products	41.31	40.30	40.30	41.90	42.90	81.41	74.84	71.32	70.41	67.77
All manufacturing	41.10	40.40	40.80	41.50	41.80	75.67	71.01	69.08	67.08	64.81
Annual income (all mfg.)†						$3,934.84	$3,692.52	$3,592.16	$3,488.16	$3,370.12

*The Iowa Employment Security Commission, Des Moines, Iowa.

†Annual income for all manufacturing includes the average income for all nonagricultural industries as reported by the Iowa Employment Commission.

Because of differences in cost of living, a comparison of farm income and average wage earnings does not indicate differences in real income. The farm family produces much of its own food, and, for most tenants, housing is "free." Or, it might be said that for the family with sufficient capital to invest in farm equipment, housing does not involve a cash outlay. In contrast, the urban family must either invest in housing or pay rent.

To compensate for differences in cash outlay or prices paid for items entering family expenditures, an attempt is made to adjust farm incomes and urban wage earnings to represent comparable levels of real income. The adjusted incomes are presented in table 13. Column 2 shows the capital requirements (not including machinery) for farm plans presented in the previous section. Columns 3 and 4 show total capital requirements (column 2 plus machinery investment figures from appendix table 1) when machinery is purchased new or second-hand. If the family had full equity in this capital, it could be used for purchase of, or part payment for, a house in town. Also, full or part equity could be used for investment in stocks or bonds, to provide income in addition to wage earnings.

Column 5, in table 13, shows the maximum returns (before fixed costs are subtracted) from optimum plans for the farm situations as indicated. The farm incomes in columns 6 and 7 have been adjusted, to be comparable to nonfarm wage rates as follows: The income figures in column 5 were adjusted by (1) subtracting the fixed costs given in appendix table 1 and (2)

TABLE 13. CAPITAL REQUIREMENTS AND ADJUSTED INCOMES FOR VARIOUS FARM SITUATIONS ON CRESCO-CLYDE SOILS AND ADJUSTED WAGE INCOME FOR NONFARM EMPLOYMENT.

Farm situations	Capital requirements			Maximum returns before fixed costs are subtracted	Adjusted real farm income‡		Adjusted real income from nonfarm employment—1955§	
	Without machinery	With new* machinery	With used† machinery		With new machinery	With used machinery	Including 4% returns on capital figs. in col. 3	Including 4% returns on capital figs. in col. 4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1. Livestock-share lease with livestock under average management; 135 cultivated acres	$6,286	$16,268	$9,986	$1,610	$ 868	$1,111	$3,686	$3,434
2. Livestock-share lease with livestock under average management; 215 cultivated acres	$8,256	$18,238	$11,956	$1,994	$1,252	$1,495	$3,765	$3,513
3. Crop-share lease with livestock under average management; 135 cultivated acres	$8,783	$18,765	$12,483	$2,328	$1,586	$1,829	$3,786	$3,534
4. Livestock-share lease with livestock under superior management; 135 cultivated acres	$6,979	$16,961	$10,679	$2,904	$2,162	$2,405	$3,713	$3,462
5. Livestock-share lease with livestock under superior management; 215 cultivated acres	$9,243	$19,225	$12,943	$3,475	$2,733	$2,976	$3,804	$3,553
6. Crop-share lease with livestock under superior management; 135 cultivated acres	$10,658	$20,640	$14,358	$4,631	$3,889	$4,132	$3,861	$3,609

*Capital requirements in col. 2 plus $9,982 investment for new machinery.

†Capital requirements in col. 2 plus $3,700 investment for used machinery.

‡Maximum returns in col. 5 minus $1,007 fixed costs under new machinery and $764 fixed costs under used machinery. The resulting figures were increased by 10 percent of total cash living expense ($2,651) for Iowa farm families (appendix table 8), to adjust for a 10-percent decrease in cost of living on the farm.

§Average annual income from all manufacturing in 1955 (table 12) plus 4 percent returns on the capital figures shown in columns 3 and 4, minus $900 per annum housing costs.

adding 10 percent of the average farm family living expenditures for 1955 (see appendix table 8). The latter step is taken to account for the proportion of food produced by the farm family and to account for lower prices paid on some purchases for living expense. For example, items such as fuel, furniture, clothing, education, etc., are expected to cost more at the urban level than on the farm. This difference in costs is due to quality as well as prices. The 10-percent adjustment for living expenditures (i.e., the estimate that the items entering family expenditures cost 10 percent more in town than on the farm) is based on numerous studies.[12]

However, in addition to adjusting farm incomes, urban incomes also must be adjusted to account for housing costs and income from capital investments.

The adjusted real income figures from nonfarm employment (table 13, columns 8 and 9) are obtained by taking the annual average wage rate in 1955 (i.e., $3,935), adding a 4-percent return from the corresponding capital figures shown in columns 3 and 4, and subtracting $900 per annum housing costs. The resulting figures represent returns from labor and capital investment for nonfarm employment.

Housing costs and investment abilities vary with location and families; consequently, the real urban incomes shown in columns 8 and 9 will vary accordingly. Some families may realize more than 4 percent return on their capital investments. On the other hand, if a family pays 6 percent interest to borrow the capital amounts shown in columns 3 and 4, their potential urban income would include wage returns only. Too, if housing is owned instead of rented, payments may be greater than $900 per year; other families may pay less than $900 for housing. However, since this study focuses on benchmark situations, only the real income figures in columns 8 and 9 are used for urban living.

As table 13 shows (columns 6, 7 and 8), income from farming is considerably less than income from off-farm wage earnings, through situation 3 with $12,483 total capital (or $18,765 if new machinery is figured) and average management. In other words, real income is clearly lower from farming than from off-farm employment for the beginning tenant family with average managerial abilities operating on a 160-acre farm. If the family's main goal is rapid capital accumulation, with a larger farm enterprise at a later time, this goal might be attained through off-farm employment at the outset. With superior management, 215 cultivated acres and $12,943 (using second-hand machinery) under situation 5, real income from farming still is less than real income for 1955 nonfarm wage rates in Iowa. Not until farm situation 6 does real income from farming push above the nonfarm wage rate. The latter situation supposes superior management, a crop-share lease and $20,640 in capital, if new machinery is used.

Given the assumptions used in adjusting the income figures in table 13, the family of the average manager, operating as a beginning tenant unit, will have greater real income by choosing an urban occupation. The family of the superior manager also is financially better off in nonfarm employment unless operating under a crop-share lease or on a sufficiently large farm (i.e., farms with more cultivated acres than the ones used in this study). (For the established farmer who owns his land, the real farm income figures would be different than shown in table 13.)

In previous sections of this study, it was shown that farm returns vary according to managerial ability, amounts of available resources, types of leases, etc. Wage income also will vary depending on the individual position available and business possibilities in towns or cities. In some areas of the state, farmers have opportunity for part-time jobs in town and can increase their real incomes accordingly.

The availability of nonfarm jobs is, of course, important to the family weighing the alternatives of farming with nonfarm employment. Since Iowa is primarily an agricultural state, permanent nonfarm employment is sometimes scarce. The current situation in the northeastern quarter of Iowa is not very optimistic for any large numbers of farm families who might seek employment in town. Employment offices give little if any encouragement, in terms of permanent local employment, for families who wish to quit farming and move to town.[13] On the other hand, there are instances where farmers have been placed in positions with wage rates of $400 to $500 per month (urban wage income shown in table 12 is less than $350 per month). Too, some families are reported to have quit farming to accept nonfarm employment in other localities in the nation. This opportunity will undoubtedly grow in importance as national economic development continues. Also, it is not impossible that economic growth within various parts of Iowa might be accentuated in a full employment economy.

Security in nonskilled off-farm employment is questioned by many farm families. Whether or not nonfarm employment of the future will carry more security than tenant farming will depend upon fiscal policies and the extent to which business cycles can be prevented in the future. Employment offices in the area of study indicate that

[12]See: Koffsky, Nathan. Farm and urban purchasing power. Studies in Income and Wealth. National Bureau of Econ. Res., New York. 1949. Vol. II:153-78. By increasing net farm income by this amount, and subtracting fixed costs of farming which were not deducted in the previous section, the resulting figure can be more nearly compared with urban income, with the two figures being expressive of real income opportunities. Although variation in living expenditures exist, the objective of this study is to provide "benchmark" comparisons of real income in town and on the farm. Some farm families may require more than 10 percent of their living expenditures to give a comparable level of living in town; other families may require less. The major items of goods and services in the family budget which account for the differential in living costs between farm and city are food and housing.

[13]Private communication with employment offices in northeastern Iowa.

demand for seasonal employment is much greater than demand for permanent employment. Also, for permanent jobs, there are frequent layoffs and, until the worker has attained sufficient tenure on any one job, certainty of steady employment does not exist.

The final decision with respect to type of employment, and consequent pattern of living, must be made by the family concerned. Intangibles other than money income may hold families in farming, even where real income is less than for nonfarm opportunities. When real income is below subsistence levels, the family is forced to move regardless of intangibles associated with present occupations. However, decisions can be improved if families are furnished with relevant information on farm and nonfarm income opportunities.

APPENDIX

The basic data used in programming the farm situations for this study are given in the tables below. In some instances, data were not available for specific inputs or outputs. For example, the amount of manure salvaged from livestock is a conservative estimate based on the judgment of persons familiar with livestock farming.

The value of new machinery listed in appendix table 1 is dealers' current list price. Although most young farmers are equipped with used machinery, the straight line depreciation method gives the same fixed costs regardless of machine age. The only item in fixed costs that varies with age of machinery is the property taxes and insurance. New value of machinery varies also among different makes of machinery. Hence, total fixed costs may vary among farmers with the same amount of machinery but with different makes of machinery.

The average adjusted prices used in this study are given in appendix table 2. To determine the average adjusted price for a product, the average price of the product during its price cycle period was divided by the average price for corn

APPENDIX TABLE 1. ESTIMATED FIXED COSTS FOR TENANT.

Farm machinery	Value (dollars)		Estimated life (years)		Annual depreciation (dollars)	
	New	Used	New	Used	New	Used
Tractor, 2-plow	2,642	1,000	12	5	220.17	200.00
Plow, 2-bottom 14-inch	235	150	17	12	13.82	12.50
Disk, 15-ft. single	200	125	20	14	10.00	8.93
Drag harrow, 24-ft.	165	50	15	7	11.00	7.14
Seeder, endgate	80	35	12	7	6.67	5.00
Corn planter, 2-row	350	175	15	9	23.33	19.44
Cultivator, 2-row	335	175	12	8	27.92	21.88
Corn picker, 1-row pull	860	400	12	6	71.67	66.67
Manure spreader	525	100	10	4	52.50	25.00
Mower, 7-ft.	320	125	12	6	26.67	20.83
Side rake	360	75	12	5	30.00	15.00
2 flare box wagons	500	300	20	12	25.00	25.00
Hammer mill	160	90	12	8	13.33	11.25
Small tools	100	100	10	10	10.00	10.00
Pickup truck	1,800	800	10	5	180.00	160.00
Combine, 6-ft.	1,350	700	10	7	135.00	100.00
Total	9,982	3,700			857.08	708.64
Total personal property taxes and insurance for tenant (1.5% × total value)					149.73	55.50
Estimated total fixed costs					1,006.81	764.14

APPENDIX TABLE 2. AVERAGE ADJUSTED PRODUCT PRICES ASSUMED FOR THIS STUDY.*

Item	Unit	Purchase price	Selling price
		(dollars)	(dollars)
Seed and fertilizer:			
Corn	bu.	12.00	——
Soybeans	bu.	4.63	——
Oats	bu.	0.90	——
Mixed grass	acre	6.42	——
Nitrogen (N)	lb.	0.15	——
Phosphate (P_2O_5)	lb.	0.10	——
Potash (K_2O)	lb.	0.05	——
Feed and grain:			
Corn	bu.	1.30	1.20
Oats	bu.	——	0.63
Soybeans	bu.	——	2.20
Cattle supplement	cwt.	4.42	——
Hog supplement	cwt.	5.30	——
Poultry laying mash	cwt.	4.12	——
Livestock and livestock products:			
Deferred-fed steer calf	cwt.	19.79	22.48
Beef cow	head	144.27	——
Medium dairy cow	head	153.90	——
Superior dairy cow	head	225.00	——
Cull cow	cwt.	——	12.47
Veal calf	cwt.	——	18.54
Dairy heifer (2-yr.-old)	cwt.	——	16.03
Medium yearling	cwt.	——	15.42
Breeding sow	cwt.	15.84	14.61
March market hogs	cwt.	——	16.88
April market hogs	cwt.	——	16.53
Sept. market hogs	cwt.	——	18.00
Oct. market hogs	cwt.	——	16.41
Nov. market hogs	cwt.	——	16.66
Dec. market hogs	cwt.	——	15.00
Sexed chicks (laying breed)	each	0.30	——
Cull hens	lb.	——	0.14
Cockerels	lb.	——	0.22
Eggs	doz.	——	0.28
Grade B milk	cwt.	——	2.72

*Based on past price relationships and adjusted to a net selling price of $1.20 per bu. for corn.

APPENDIX TABLE 3. BASIC INPUT-OUTPUT DATA FOR THE DAIRY ENTERPRISE ON A COW BASIS (INCLUDING REPLACEMENTS).

Production and resource requirements per head	Milking herd	
	Average management	Superior management
Pounds of feed		
Corn equivalent	2,504.00*	3,698.90†
Supplement	175.00*	436.00†
Hay equivalent	12,956.00*	13,672.00†
Labor (hrs.)	124.00	129.00
Building (sq. ft.)	84.00	84.00
Production (lbs.)		
Milk	6,000.00‡	9,429.70†
Cull cow §	268.46	268.46
2-year-old§	74.00	74.00
Yearling§	5.23	5.23
Veal§	39.60	39.60
Manure**	22,800.00	22,800.00
Capital expense (dollars)††		
Use of equipment	0.88	0.88
Taxes and insurance on cows	0.95	0.95
Breeding fees	6.00	6.00
Commercial feed	9.01	20.53
Haying expense	23.94	28.03
Power	4.12	4.77
Miscellaneous	18.36	18.36
Total annual cash expense	63.26	79.52
Capital investment‡‡		
Cows	153.90	225.00
Equipment	15.92	15.92
Total capital investment	169.82	240.92

*U. S. Dept. Agr., Bureau of Agr. Econ. Rations fed to milk cows (data for Iowa 1948-52). The total concentrates fed for the state was adjusted by the amount of milk production per cow assumed for Howard County.

†Farm labor and farm cost 1953. Minnesota Report No. 217. September 1954.

‡Iowa Crop and Livestock Reporting Service.

§The mortality of calves in the Iowa State College dairy herd. Proc. Amer. Soc. Anim. Prod. 1936. A 29-year average of culling and mortality rates.

**Manure production is a judgment estimate of salvaged manure based on total annual manure production for dairy cows in: Morrison, F. G. Feeds and feeding. 21st ed. The Morrison Publishing Company, Ithaca, N. Y. 1951.

††Adapted from Iowa Tech. Bul. 390. September 1952, Iowa State College and Farm labor and farm cost, 1953. Minnesota Report No. 217. 1954.

‡‡Adapted from Iowa Tech. Bul. 390. 1952, and adjusted to 1955 price level.

APPENDIX TABLE 4. BASIC INPUT-OUTPUT DATA FOR HOG FEEDING SYSTEMS USED IN THIS STUDY.*

Production and resource requirements	Spring pigs		Fall pigs	
	Average mgt.	Superior mgt.	Average mgt.	Superior mgt.
Lbs. of feed per 100 lbs.†				
Corn equivalent	436.89	322.78	480.58	355.06
Protein supplement	43.90	46.00	47.30	51.00
Hay equivalent	94.30	83.30		
Labor per litter (hrs.)‡	26.00	26.00	33.00	33.00
Capital investment per cwt. ($)				
Sow	3.12	2.84	3.16	2.88
Equipment	1.49	1.89	1.61	1.62
Total capital investment	4.61	4.73	4.77	4.50
Annual cash expense per cwt. ($)§				
Protein supplement	2.28	2.44	2.51	2.70
Power	0.65	0.65	0.65	0.65
Use of equipment	0.67	0.67	0.67	0.67
Miscellaneous	0.99	0.96	1.04	1.01
Boar service	0.13	0.09	0.13	0.09
Total annual cash expense	4.72	4.81	5.00	5.12
No. pigs weaned per litter**	6.78	7.33	6.68	7.23
No. pigs sold per litter	5.44	6.11	5.35	6.01
Total production (lbs.)				
Market hogs	1,223.78	1,374.75	1,202.85	1,352.25
Sow	300.00	300.00	300.00	300.00
Total annual production	1,523.78	1,674.75	1,502.85	1,652.25
Building space (sq. ft. per hog)	6.00	6.00	10.00	8.00
Manure (lbs. salvaged per cwt. of hogs)††	350.00	350.00	450.00	450.00

*The data for "litter systems" used in this study were determined by combining the data in this table and deleting items in part, such as equipment where one purchase will suffice for a 2-litter system. Data for summer litters were assumed to be the same as for spring litters.

†Minnesota Reports 206, 214 and 215. 1953-54. University of Minnesota. Adjusted 5-year average (1947-51) of farm business records in southwestern Minnesota based on percent fall pigs and spring pigs as reported by Iowa Crop Reporting Service.

‡Heady, E. O. and Olson, R. O. Substitution relationships, resource requirements and income variability in the utilization of forage crops. Iowa Agr. Exp. Sta. Res. Bul. 390. 1952.

§Adapted from detail cost report for central Illinois 1952, 1953. AE 2969. Dept. Agr. Econ. University of Illinois.

**Iowa Crop Reporting Service.

††Manure production is a judgment estimate of salvaged manure based on total annual manure production for hogs in: Morrison, F. G. Feeds and feeding. 21st edition. The Morrison Publishing Company, Ithaca, New York. 1951.

during the same period; then, the resulting ratio was multiplied by $1.20, the net selling price of corn after deducting hauling and handling charges. This method maintains the historical average price ratios between all products. The length of price cycle periods used in determining ratios for the various products is not the same for all products. For example, the hog price cycle is about 7 years, but the price cycle for beef is about 20 years. Following is an illustration of computing the average adjusted price for hogs.

$$\text{Average adjusted price of hogs} = \frac{\text{Average hog price 1948 to 1955}}{\text{Average corn price 1948 to 1955}} \times \$1.20$$

Basic data for the livestock enterprises are given in appendix tables 3, 4, 5 and 6; crop data are given in appendix table 7. Although many sources and variations of data exist, the data given in the following tables are believed to be the most representative estimates for the soil area under consideration.

Appendix table 8 gives Iowa farm family living expenditures by years. Although the figures in this table may be somewhat higher than one would expect for the average of Iowa farm families, these figures are used only as a guide for making farm and nonfarm income comparisons.

APPENDIX TABLE 5. BASIC INPUT-OUTPUT DATA FOR POULTRY LAYING FLOCK.

Item	Unit	Per hen plus replacement	
		Average management	Superior management
Output:			
Eggs*	doz.	15.00	19.17
Meat	lbs.	4.87	4.87
Manure**	lbs.	40.00	40.00
Inputs:			
Grain†	lbs.	91.09	93.09
Commercial feed†	lbs.	41.99	45.99
Labor††	hrs.	2.10	2.10
Investment in equipment	dol.	1.15	1.15
Annual cash expense			
Sexed chicks	each	0.30	0.30
Commercial feed‡	dol.	1.73	1.89
Power‡	dol.	0.06	0.06
Equipment‡	dol.	0.22	0.22
Miscellaneous	dol.	0.15	0.15
Total cash expense	dol.	2.52	2.68
Building requirements‡‡	sq. ft.	4.12	4.12
Hen mortality	percent	15.00	15.00
Chick mortality	percent	10.00	10.00

* Iowa Crop and Livestock Reporting Service, September 1953.

** Manure production is a judgment estimate of salvaged manure based on total annual manure production for livestock in Morrison, F. G. Feeds and feeding. 21st ed. The Morrison Publishing Co., Ithaca, N. Y. 1951.

† Farm poultry flock returns, 1947-1952. Report No. 212, University of Minnesota; and Iowa poultry demonstration flocks 1948-1953. Iowa State College, Ames, Iowa.

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

‡ Farm labor and farm costs 1954. Report No. 217. University of Minnesota; and Midwest farm handbook. Iowa State College Press, Ames, Iowa.

‡‡ Midwest farm handbook. Iowa State College Press, Ames, Iowa.

APPENDIX TABLE 6. BASIC INPUT-OUTPUT DATA FOR CATTLE FEEDING ENTERPRISES.

Item	Unit	Deferred-fed calves (per head)*	Beef cows (per head plus replacement)†
Purchase date	month	October	——
Marketing date	month	November	——
Initial weight	lbs.	402.00	——
Market weight	lbs.	1,056.00	——
Net gain	lbs.	654.00	——
Death loss	percent	3.00	10.00
Feed			
Corn equivalent	bu.	53.70	6.68
Hay equivalent	tons	3.45	5.47
Supplement	lbs.	268.10	——
Production			
Fat cattle	lbs.	654.00	——
Choice calf	lbs.	——	354.40
Cull cows	lbs.	——	137.50
Manure‡	tons	2.50	4.42
Labor	hrs.	12.50	15.00
Buildings	sq. ft.	20.00	50.00
Capital investment			
Cows and replacements	dol.	——	163.75
Equipment	dol.	13.50	13.13
Total capital investment	dol.	13.50	176.88
Annual cash expense			
Supplements	dol.	11.13	1.28
Power	dol.	2.74	1.77
Equipment	dol.	2.88	0.39
Miscellaneous§	dol.	5.01	5.60
Feeder stock	dol.	79.56	——
Death loss	dol.	2.42	11.13
Haying expense	dol.	5.60	6.72
Total annual cash expense	dol.	109.34	26.89

* Adapted from: Annual report of feeder cattle. The Farm Bureau Farm Mgt. Service, Agr. Exp. Sta. 12th to 15th annual reports.

† Adapted from: Heady, E. O. and Olson, R. O. Substitution relationships, resource requirements and income variability in the utilization of forage crops. Iowa Agr. Exp. Sta. Res. Bul. 390. 1952.

‡ Manure production is a judgment estimate of salvaged manure based on total annual manure production for livestock in: Morrison, F. G. Feeds and feeding, 21st ed. The Morrison Publishing Company, Ithaca, N. Y. 1951.

§ Includes cost of hauling manure.

APPENDIX TABLE 7. TENANTS SHARE* OF BASIC INPUT-OUTPUT DATA FOR VARIOUS CROP ROTATIONS IN HOWARD COUNTY, IOWA.

Item	Unit	Rotations† (per acre unit)														
		COM_1	COM_2	COM_3	$CCOM_1$	$CCOM_2$	$CCOM_3$	$COMM_1$	$COMM_2$	$COMM_3$	$CSbOM_1$	$CSbOM_2$	$CSbOM_3$	$CCOMM_1$	$CCOMM_2$	$CCOMM_3$
Inputs:																
Seed	dol.	1.71	1.71	1.71	1.53	1.53	1.53	1.28	1.28	1.28	1.87	1.87	1.87	1.22	1.22	1.22
Fuel and repairs	dol.	7.02	7.02	7.02	8.35	8.35	8.35	5.27	5.27	5.27	8.10	8.10	8.10	6.68	6.68	6.68
Harvesting costs	dol.	2.21	2.82	3.28	2.84	3.62	4.10	1.68	2.12	2.41	1.81	2.36	2.68	2.41	3.01	3.36
Nitrogen	lb.	0.30	—	—	0.30	—	—	0.30	—	—	0.30	—	—	0.30	—	—
Phosphate	lb.	0.80	1.50	1.50	0.80	1.50	1.50	0.80	1.50	1.50	0.80	1.50	1.50	0.80	1.50	1.50
Potash	lb.	0.40	0.75	0.75	0.40	0.75	0.75	0.40	0.75	0.75	0.40	0.75	0.75	0.40	0.75	0.75
LABOR:																
Dec.-Jan.-Feb.	hr.	0.12	0.12	0.12	0.18	0.18	0.18	0.09	0.09	0.09	0.09	0.09	0.09	0.15	0.15	0.15
March-Apr.	hr.	0.79	0.79	0.79	0.80	0.80	0.80	0.59	0.59	0.59	0.74	0.74	0.74	0.64	0.64	0.64
May-June	hr.	0.90	0.90	0.90	1.36	1.36	1.36	0.68	0.68	0.68	1.31	1.31	1.31	1.08	1.08	1.08
July-Aug.	hr.	1.50	1.50	1.50	1.31	1.31	1.31	1.21	1.12	1.12	1.29	1.29	1.29	1.05	1.05	1.05
Sept.-Oct.-Nov.	hr.	0.99	0.99	0.99	1.30	1.30	1.30	0.65	0.65	0.65	1.25	1.25	1.25	1.04	1.04	1.04
Total	dol.	12.44	13.80	14.26	14.22	15.75	16.23	9.73	10.92	11.21	13.28	14.58	14.90	11.81	13.16	13.51
Outputs:																
Corn	bu.	6.97	8.93	10.63	9.80	12.45	14.25	5.33	6.70	8.00	5.22	6.80	7.98	8.26	10.30	11.56
Oats	bu.	5.27	6.67	6.80	3.83	5.23	5.33	3.95	5.00	4.90	4.15	5.43	5.75	3.50	4.34	4.60
Soybeans	bu	—	—	—	—	—	—	—	—	—	1.93	2.45	2.35	—	—	—
Hay	ton	0.25	0.40	0.44	0.23	0.33	0.35	0.43	0.60	0.65	0.24	0.33	0.34	0.38	0.50	0.54
Total	dol.	11.68	14.92	17.04	14.17	18.23	20.46	8.89	11.19	12.69	13.12	16.97	18.37	12.12	15.09	16.77
Return	dol.	—0.76	1.12	2.78	—0.05	2.48	4.23	—0.84	0.27	1.48	—0.16	2.39	3.47	0.31	1.93	3.26

* Based on a 50-50 crop-livestock share lease except that tenant pays harvesting costs on all corn and furnishes all labor.

† Subscripts on each rotation indicate rate of fertilization.

APPENDIX TABLE 8. FARM FAMILY LIVING EXPENDITURES FOR A SELECTED GROUP OF IOWA FARM FAMILIES BY YEARS.*

Cash expenditures for living	1954 percent of total	Years				
		1955	1954	1953	1952	1951
Food purchase	27	$ 711	$ 743	$ 689	$ 686	$ 680
Clothing	17	440	457	447	444	498
Household operations	12	376	317	281	290	290
Repairs	4	129	122	119	110	124
Health	9	244	245	243	232	215
Recreation	4	105	114	115	165	114
Education	6	160	177	149	149	130
Giving	13	288	358	313	300	327
Auto-operative	8	198	221	240	205	209
Total cash living expense	100	$2,651	$2,754	$2,596	$2,581	$2,587
Number of farms	86	86	72	94	95	97
Percent owners		66%	76%	72%	68%	68%

* Farm and home accounts of Iowa farm families. Ag. Ext. Serv., Dept. Econ. and Soc., Iowa State College. FM-1207. 1956. It is expected that these figures are somewhat higher than for the mean of all Iowa farmers.