Optimum Farm Plans For Beginning Farmers On Tama-Muscatine Soils

(An Application of Linear Programming)

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SUMMARY

Purpose. The purpose of this study is to determine profit-maximizing farm plans for beginning farmers with different amounts and types of available resources. The farm situation selected for study is located in southeastern Iowa with soil types represented by the Tama-Muscatine soil association. Farm size is 160 acres of which 153 acres are under cultivation. Available livestock building space on the farm includes a hog house with 416 square feet of floor space, a cattle barn with 1,600 square feet of floor space and a poultry house sufficiently large to house 100 laying hens. Total man-hours of available labor includes the operator's labor plus some family labor. In addition, it is assumed that housewife's labor supports the poultry enterprise.

Rotations. It was found that beginning farmers could maximize their profits under very limited capital with a cash grain rotation of 2 years of corn and 1 year of soybeans. Fertilizer should be applied at a medium rate, and no forage or livestock is raised. As the beginning farmer obtains more working capital, he would gradually shift to a rotation containing some forage. Even with unlimiting capital, a beginning farmer may not find it profitable to plant more than 25 percent of his farm to forage. Soybeans in the rotation have little effect on the net income and apparently could be a matter of individual preference to the beginning farmer.

Livestock. In general, only those beginning farmers with a medium to good capital position will keep livestock. From a profit-maximizing standpoint, capital used for livestock should be only that capital remaining after the costs of the rotation and fertilizer have been paid. For those beginning farmers who have sufficient capital, hogs should normally be the first livestock enterprise to be expanded, followed by deferred-fed calves and pasture-fed calves in that order. Dairy and poultry enter the optimum farm plan only when the beginning farmer desires to have a steady flow of income and is willing to sacrifice some total income to get it; or when he has unlimiting funds for poultry.

Use of Fertilizer. Under the price relationships and yield responses to fertilizer specified, it always will pay a beginning farmer to apply some fertilizer to all acres planted. If he is very limited on capital, it would return more to plant and fertilize only part of the acreage than to plant all acres and not fertilize.

Profit is maximized for a beginning farmer if he fertilizes all his land to a relatively high level before investing money in livestock and land in forage. The maximum level of fertilization proved to be an excellent investment alternative if the beginning farmer has the managerial ability necessary to secure the full yield response and is willing to take the risk of occasional negative effects of fertilizer in case of a moisture shortage.

Risk and Uncertainty. Since some beginning farmers want to minimize the risk in farming and obtain a steady flow of income, some of the hedges a beginning farmer could make against risk and uncertainty were investigated. All of the adjustments to risk reduced net profit. Other studies have indicated that dairy and poultry have less variance in annual income than other livestock enterprises. This type of uncertainty reduction will cost the beginning farmer a substantial reduction in net profits in all cases. The maximum level of fertilization involves more risk of loss from lack of moisture than the average level.

By limiting himself to the average fertilization level, a beginning farmer would forego only a small potential net profit. Expanding the hog enterprise until large numbers are kept in dry feedlots, without pasture, increases the disease hazard. Placing an arbitrary limit of 11 litters on the hog enterprises, thus reducing the disease hazard, reduces the net revenue at higher capital levels.

Conservation. Beginning farmers, like all farmers, are faced with the problem of deciding whether to use their resource of soil intensively in the present or put off the use of it until some future time. A rotation of corn-corn-soybeans uses the resource of soil intensively for grain production in the present and involves the addition of large amounts of fertilizer to maintain yields. As forage is added to the rotation, the land is used less intensively for grain production, and less fertilizer will be needed for the farm as a whole to maintain grain yields per acre. For a beginning farmer the conservation consideration of including at least 20 percent forage in the rotation reduces net profit substantially at lower capital levels. The use of only a CCOMM rotation or 40 percent forage in the rotation reduces net profit substantially at all capital levels and probably below subsistence for low capital levels. The arbitrary use of only rotations with more than 20 percent forage, makes deferred-fed calves the most profitable livestock enterprise at lower levels of capital. Only as capital becomes more plentiful, relative to land, will adding hogs increase the net revenue of beginning farmers restricting themselves or being restricted by the landlord to rotations of 20 percent or more forage.

Product Price Variation. Given constant factor prices and constant factor productivity between periods, the product price ratios in a particular period determine the combination of enterprises in the farm plan. If all prices rise or all prices fall at the same rate no change in the farm plan will be needed to maximize profits, only the size of the income will be affected. If the price of hogs is sufficiently high relative to grain, and labor is limited, the beginning farmer might maximize his profits by concentrating on hog production and neglecting some of his land.

Alternative Plans. The many plans outlined in this study indicate that different plans are required to maximize profits under the varying conditions found on farms with the same soil type. The optimum farm plan for a farmer with unlimiting capital is quite different from the plan when capital is very limited. Numerous alternative plans may give similar profit levels for the farmer with sufficient capital. However, the farmer with a small amount of capital has few alternative plans which will return similar profits.

Optimum Farm Plans for Beginning Farmers on Tama-Muscatine Soils[1]

(An Application of Linear Programming)

BY EARL O. HEADY, LAUREL D. LOFTSGARD, ARNOLD PAULSEN AND E. R. DUNCAN

Farming has become an increasingly complex and competitive industry. The difficulties of farm planning have increased accordingly for all farmers, but particularly for beginning farmers. Getting started is difficult because of the relatively high capital investment required for purchasing machinery, livestock and other supplies. Too, the problem of finding the most profitable organization of crops, livestock enterprises and farming practices is especially difficult for the beginner because there are many combinations of these possibilities available for different levels of capital. No one of these combinations of enterprises and practices can be used as a standard recommendation to young farmers who have varying amounts of funds. The most profitable crop and livestock plan for the operator with a small amount of capital will not also be the most profitable for the operator with a larger amount of funds.

OBJECTIVES

This study has been made to serve as an aid to extension workers who provide guidance to young farmers. The Agricultural Extension Service of Iowa initiated a Farm and Home Planning Program in 1953. The emphasis in this program is in giving guidance to young farm families in their planning—although it is open to all farmers who seek aid.

This study, which is one of a series being made at different locations in the state, relates particularly to Tama-Muscatine soils in southeastern Iowa. It uses linear programming techniques to determine the optimum plan for a 160-acre unit, judged by extension personnel to be typical of beginning farmers in southeastern Iowa.[2] The specific objective of the study is to determine these plans and show how they differ when the average operator has different amounts of capital, labor and feed or must operate under different restrictions in respect to cropping systems, leasing arrangements or ability to bear risk and uncertainty. Not only does the study show how optimum plans differ between these situations but it also indicates the depression in income which results from various restrictions on farm organization. While the study was made at the request of extension personnel in Washington County, the results have application at other locations with similar soils.

THE FARM SITUATION

The general location of the farm selected for this study is Washington County in southeastern Iowa. The farm is 160 acres in size, with 153 acres in field crops or pasture and the remaining 7 acres for farmstead, roads and fences. Tama-Muscatine soils are the predominant types used as the basis of crop yields and fertilizer responses. Slope of the land is from 1 to 3 percent.

The farm is operated by a tenant who supplies all labor and machinery for operation of the farm. Profit-maximizing plans are in terms of returns to a beginning farmer with average managerial ability, rather than to the farm as a whole. Available labor includes the operator's labor plus some family labor. The housewife's labor is assumed sufficient for a poultry enterprise; hence, poultry does not compete with other enterprises for the use of labor. All enterprises, except poultry, compete freely for the total available man-hours shown in table 1.

The tenant or beginning farmer is considered to have adequate machinery for the farm. Items such as a tractor, plow and disk are completely owned by the tenant; the combine and cornpicker are jointly owned by the tenant and a neighboring farmer. The only machine hired is a hay baler. (A complete analysis of machinery costs is given in a later section under capital levels.)

TABLE 1. AVAILABLE HOURS OF MONTHLY LABOR USED IN DETERMINING OPTIMUM PLANS.

Month	Total available man-hours	Total housewife's labor
January	275	32
February	275	32
March	335	34
April	350	41
May	350	63
June	350	44
July	350	34
August	350	32
September	300	31
October	300	24
November	275	27
December	275	24

[1]Project 1199, Iowa Agricultural Experiment Station.

[2]For a simplified explanation of the logic and limitations of linear programming, see: Bowlen, Bernard and Heady, Earl O. Optimum combinations of competitive crops at particular locations. Iowa Agr. Exp. Sta. Res. Bul. 426.

TABLE 2. AMOUNTS OF FERTILIZER FOR VARIOUS ROTATIONS UNDER FOUR LEVELS OF FERTILIZATION.*

Rotation	Zero rate			First rate			Second rate			Third rate		
	N	P	K	N	P	K	N	P	K	N	P	K
Corn	0	0	0	10	15	10	30	20	10	50	40	20
Corn	0	0	0	30	15	10	60	20	10	100	20	20
Soybeans	0	0	0	0	0	0	0	0	0	0	40	0
Corn	0	0	0	10	15	10	30	20	10	50	40	20
Soybeans	0	0	0	0	0	0	0	0	0	0	20	0
Corn	0	0	0	30	15	10	60	20	10	100	40	20
Oats / Meadow	0	0	0	10	20	0	20	40	0	0	20	0
Corn	0	0	0	10	15	10	30	20	10	50	40	20
Corn	0	0	0	30	15	10	60	20	10	100	20	20
Oats / Meadow	0	0	0	10	20	0	20	40	0	0	40	0
Corn	0	0	0	10	15	10	30	20	10	50	40	20
Corn	0	0	0	30	15	10	60	20	10	100	20	20
Oats / Meadow / Meadow	0	0	0	10	20	0	20	40	0	0	60	0

* Fertilizer amounts are shown in pounds per acre of available nutrients.

The building space available for livestock includes: a hog house containing 416 square feet of floor space; a poultry house sufficiently large for 100 laying hens; a cattle barn with 1,600 square feet available for housing livestock. The cattle barn also may be used for hogs and, in many of the situations considered, hogs are allowed to compete with cattle for housing in the cattle barn. No charge is made in this study for building maintenance since the tenant ordinarily does not pay these costs.

DESCRIPTION OF ENTERPRISES

The basic enterprises in this study include four crop rotations, six beef enterprises, a two-litter hog system, dairy cows and poultry. These enterprises are typical of the farming area under consideration. However, as outlined later, different techniques or production practices give rise to 70 different investment alternatives or activities. All enterprises (activities) compete freely for the use of resources, except poultry which is supplementary in using only housewife labor. Enterprises such as dairying and a 5-year meadow rotation are not common in this area. However, they are considered as alternatives to determine whether, from an income standpoint, they should be included in the plan for an average beginning farmer. In addition, various resource restrictions are imposed on the enterprises for some of the solutions. The detailed analysis of these restrictions is set forth in the section on situations. The resulting variety of farm plans are applicable to many farm conditions and individual preferences on the part of the farmer.

The resource requirements per unit of output for the livestock enterprises considered in this study are given in tables 4 and 5. The coefficients are of a single value nature (i.e., they include no variability and are assumed to be known with certainty). These figures are based on the abilities of an average manager. Input requirements for crops are of this same general nature (i.e., yields and climatic conditions are for an average of years and reflect average management). It should, of course, be realized that farm planning of any kind involves the use of specific assumptions with regard to price, input-output relationships and available resources. The assumptions of this study are outlined on the following pages.

TABLE 3. ESTIMATED CROP YIELDS FOR VARIOUS ROTATIONS UNDER FOUR LEVELS OF FERTILIZATION.*

Rotation	No fertilizer	First rate	Second rate	Third rate
Corn	50.0	63.0	68.0	72.0
Corn	45.0	60.0	67.0	71.0
Soybeans	28.0	28.0	28.0	32.0
Corn	60.0	69.0	74.0	77.0
Soybeans	28.0	28.0	28.0	32.0
Corn	55.0	65.0	71.0	75.0
Oats	35.0	45.0	48.0	45.0
Meadow	2.1	2.5	2.8	3.0
Corn	60.0	70.0	75.0	78.0
Corn	52.0	67.0	71.0	72.0
Oats	35.0	45.0	48.0	45.0
Meadow	2.1	2.5	2.8	3.0
Corn	62.0	72.0	76.0	78.0
Corn	57.0	70.0	74.0	75.0
Oats	35.0	45.0	45.0	45.0
Meadow	2.1	2.5	2.8	3.0
Meadow	2.0	2.5	2.8	3.0

* Yields are shown in bushels per acre for grain and tons per acre for meadow.

Crop Enterprises

The four crop rotations considered are: corn-corn-soybeans, (CCSb); corn-soybeans-corn-oats-meadow, (CSbCOM); corn-corn-oats-meadow, (CCOM); and corn-corn-oats-meadow-meadow, (CCOMM).

In the remainder of this study, rotations are indicated by the abbreviated forms in the above parentheses. Four rates of fertilization (zero, first, second and third) are considered for each rotation. The fertilization terms used are for simplification of presentation and do not indicate estimates for the area. A subscript following the rotation represents the rate of fertilization. For example, $CCSb_0$ is the particular rotation with zero fertilizer applied; $CCSb_1$ is the particular rotation using the first rate of fertilizer. Subscripts 2 and 3 refer to second and third rates of fertilization respectively. Table 2 shows the levels and nutrient combinations of the four fertilization levels. Table 3 includes the corresponding predicted yield estimates.

TABLE 4. RESOURCE REQUIREMENTS PER UNIT OF OUTPUT FOR LIVESTOCK WHEN PASTURE IS USED AS A PARTIAL FEED REQUIREMENT.*

	Pasture-fed yearlings	Deferred-fed steer calves	Pasture-fed steer calves	Two-litter hog system	Dairy
Capital (dollars) :	168.63	133.95	137.80	8.16	236.62
Feed (lbs.) :					
Corn equiv.	2,828.00	3,007.20	2,800.00	458.40	2,503.20
Hay equiv.	4,837.00	5,547.00	3,206.00	47.80	12,956.00
Protein sup.	214.00	268.10	229.00	45.10	175.00
Building space (sq. ft.) :	30.00	20.00	20.00	2.41	84.00
Labor (man-hours) :					
January	0.60	0.23	1.08	0.17	13.64
February	0.60	0.23	1.06	0.15	13.02
March	0.60	0.23	1.06	0.16	13.64
April	1.00	0.23	1.49	0.14	11.78
May	2.40	0.11	2.42	0.13	9.30
June	2.60	0.11	2.42	0.13	7.44
July	2.60	0.11	2.42	0.12	7.44
August	2.60	0.11	2.42	0.16	8.06
September	0.00	2.18	1.07	0.21	7.44
October	1.00	3.10	1.06	0.20	9.30
November	0.60	2.98	1.06	0.18	10.54
December	0.60	2.86	1.08	0.18	12.40

* A unit of hogs is 100 pounds of pork; all other livestock units on a per-head basis.

Lease Restrictions

Under the lease arrangement used, the most common one of the area, landlord and tenant share the seed and fertilizer costs evenly. There are 10 acres of permanent pasture on this particular farm for which the tenant pays cash rent of $10 per acre. The tenant's share of the crops is half of the corn and soybeans and three-fifths of the oats. All harvesting costs are paid by the tenant. In the analysis which follows, the tenant is allowed to select any rotation which is consistent with maximization of his own profits. The leasing arrangement actually existing on the farm specifies that a CCSb rotation be used. Hence, a few solutions are provided which include this restriction; comparisons of farm organization and profit then are examined with those where the lease is flexible. Input-output coefficients, provided later in the linear programming tableau, are based on the leasing conditions outlined previously (i.e., the tenant's share of resource inputs and crop outputs only).

Livestock Enterprises

Two general types of livestock enterprises are considered: (1) strict drylot feeding and (2) a combination of drylot and pasture feeding. The later method is considered in all situations, except those incorporating current leasing restrictions on the farm. Since the existing lease specifies a rotation without meadow, the drylot-fed livestock enterprises are used in situations including this restriction. Enterprises which use pasture as a partial feed requirement are:

Two-litter hog system. Two litters of hogs are farrowed annually from each sow. Fall litters are farrowed in August and marketed in March; spring litters are farrowed in April and marketed in October. An average of 13.5 pigs are weaned from each sow (i.e., two litters). The annual production of pork is 3,051 pounds per sow. One gilt is kept from the fall litter for farrowing in the following year. Therefore, annual sales of pork per litter include the remainder of the fall litter, all of the spring litter and one sow.

TABLE 5. RESOURCE REQUIREMENTS PER UNIT OF OUTPUT FOR LIVESTOCK PRODUCED ON A DRYLOT BASIS.*

	Choice yearlings	Choice calves	Medium yearlings	Two-litter hog system	Poultry
Capital (dollars) :	174.92	138.97	148.34	7.92	6.32
Feed (lbs.) :					
Corn equiv.	3,080.00	3,416.00	1,848.00	468.38	93.09
Hay equiv.	3,400.00	1,409.00	1,338.00	0.00	0.00
Protein sup.	200.00	257.00	134.00	46.08	45.99†
Building space (sq. ft.)	40.00	30.00	40.00	2.41	4.12
Labor (man-hours) :					
January	0.63	1.01	2.10	0.18	0.16
February	0.61	0.99	2.10	0.13	0.16
March	0.61	0.99	2.10	0.09	0.17
April	0.61	1.39	2.10	0.30	0.21
May	2.72	2.51	1.05	0.22	0.32
June	2.72	2.51	0.00	0.14	0.22
July	2.72	2.51	0.00	0.13	0.17
August	2.72	2.51	0.00	0.27	0.16
September	2.72	0.00	0.00	0.20	0.15
October	0.00	0.99	0.00	0.16	0.12
November	0.48	0.99	2.10	0.18	0.14
December	0.46	1.01	2.10	0.18	0.12

* A unit of hogs is 100 pounds of pork; all other livestock units are on a per-head basis.
† Total commercial feed.

Fall litters are fed on drylot, whereas, spring litters use pasture as part of their feed requirements.

Pasture-fed yearlings. This enterprise consists of good to choice yearling steers purchased in October at an average weight of 621 pounds. They are wintered in drylot with roughage and a small amount of grain. They are put on pasture about May 1, and grain feeding is increased to full feed. They are taken off pasture in July and finished off in drylot. The animals are marketed in August at an average weight of 1,108 pounds. Death loss is estimated at 1.6 percent.

Deferred-fed steer calves. Good to choice steer calves are purchased in October at an initial weight of 402 pounds. They are wintered on roughage and put on pasture from May to August. They are fed no grain until they are taken off pasture. Grain feeding which begins in drylot is continued until the latter part of November when the calves are marketed. Average gain per head is 654 pounds, making a marketing weight of 1,056 pounds. The death loss is estimated as 3 percent.

Pasture-fed steer calves. This enterprise involves the same feeding practices as pasture-fed yearlings above. The calves are purchased in October and sold the following September. They are wintered in drylot on roughage and a limited amount of grain. Feed is increased after the calves are put on pasture, from May to July, and full feeding is continued in drylot until the calves are finished. Initial weight is 430 pounds, and market weight is 990 pounds; death loss is 2.5 percent.

Dairy. Cows are average in ability with an annual production of 228 pounds of butterfat and 4,569 pounds of skim milk. The productive life of each cow is 4 to 5 years. The annual replacement stock for each cow includes one-third of a calf, one-third of a 1-year-old and one-fourth of a 2-year-old. Feed costs and net return for this enterprise are calculated on a basis of milk production of the cow and feed requirements for replacement stock.

The drylot feeding enterprises considered in this study are:

Two-litter hog system in drylot. This enterprise is the same as the previous hog enterprise, except the spring litters are also produced in drylot. Output remains the same as before but different feed requirements are used. Tables 4 and 5 show the changes in input for the two hog-feeding systems.

Choice calves fed in drylot. Choice calves are bought in October at 430 pounds. They are wintered on roughage and a limited amount of grain. In early summer they are put on full feed and finished by August at a market weight of 980 pounds. Death loss is 2.5 percent.

Choice yearlings fed in drylot. The purchase weight of these animals is 650 pounds. They are bought in November and kept on the farm until September. Feeding practices are the same as for choice calves fed in drylot above. With a death loss of 1.5 percent, the average gain per animal is 420 pounds for a market weight of 1,070 pounds.

Medium yearlings fed in drylot. Medium yearlings are purchased in November at an average weight of 670 pounds. They are put on a moderately high grain rotation as soon as possible and are marketed the following April or May. Market weight averages 957 pounds per head, and death loss is 1.5 percent.

Poultry. The poultry enterprise is replaced with new stock each year. Sexed chicks are purchased and kept for laying hens. Cull hens are estimated as 11 percent of the total; therefore, an average of about 1.25 chicks must be purchased for each potential laying hen. Mortality rates are 10 percent for chicks and 15 percent for hens. The annual egg production per hen is 180 eggs.

PRICES USED

Prices used in this study have been adjusted to represent (1) the 1954 general level of prices and (2) the long-term ratio of prices between products. Hence, while the general level of prices and farming profits may vary from this level, the farm plan which maximizes profit will be the same under any price level, as long as price ratios between products are at the average levels explained below. These prices (table 6) have been used in determining the optimum plans for all of the main situations of the study.

The average prices used were obtained in the following manner: The average price of a product during its "price cycle period" was divided by the average price of corn during the same period thus giving the ratio of the price of the particular product

TABLE 6. AVERAGE ADJUSTED PRICES USED IN DETERMINING OPTIMUM PLANS.

Item	Unit	Purchase price	Selling price
Seed and fertilizer:			
Corn	bu.	11.50	----
Soybeans	bu.	4.30	----
Oats	bu.	1.00	----
Nitrogen (N)	lb.	0.15	----
Phosphorus (P_2O_5)	lb.	0.11	----
Potassium (K_2O)	lb.	0.06	----
Feed and grain:			
Corn	bu.	1.53	1.43
Oats	bu.	0.78	0.78
Soybeans	bu.	----	2.74
Hay (baled)	ton	17.40	----
Cattle supplement	cwt.	4.80	----
Hog supplement	cwt.	5.60	----
Livestock and livestock products:			
Pasture-fed yearlings	cwt.	22.00	25.77
Deferred-fed steer calves	cwt.	24.10	26.61
Pasture-fed steer calves	cwt.	24.10	25.98
Choice feeder calves	cwt.	24.10	25.87
Choice yearlings	cwt.	22.21	26.47
Medium yearlings	cwt.	18.35	21.60
Veal calves	cwt.	----	21.87
Sow	cwt.	19.47	18.75
Composite hog prices*	cwt.	----	19.83
Medium dairy cow	head	188.95	----
Cull cow	cwt.	----	14.88
Butterfat	lb.	----	0.61
Sexed chicks (laying breed)	each	0.30	----
Cull hens	lb.	----	0.18
Eggs	doz.	----	0.34
Oct.-Nov. market pigs	cwt.	----	19.15
March-April market pigs	cwt.	----	20.15

* Hog price is the composite price per cwt. of fall hogs, spring hogs and the sow.

to the corn price. This ratio was then multiplied by the price of corn in 1954, giving a product price which has the same relationship to the 1954 corn price over a longer period of time.

By using the price of corn as the basis for adjusting all product prices, the historical average price ratios between all other products are maintained. The length of the period used for determining the price ratios for the particular products varies with each product. For example, beef has a relatively long price cycle of about 20 years. Hence, its historical average price ratio is based on the period 1935-54. Since the hog price cycle is about 7 years, the period used for hogs is 1947-54. Other "price cycle periods" are 5 years for grain and chickens and 10 years for dairy products. To illustrate the method of adjusting prices:

$$\text{Average Adjusted Price of Hogs} = \text{1954 Corn Price} \frac{\text{Average Hog Price 1947 to 1954}}{\text{Average Corn Price 1947 to 1954}}$$

Since price ratios vary from historic relationships, the effects of certain extreme fluctuations in hog and beef prices have been analyzed. Plans have been worked out for situations when hog and beef prices are high or low, as compared to the historic ratios. The period used to represent high hog prices in relation to other product prices is March-April of 1954 and October-November of 1953. Low hog prices are represented by March-April of 1955 and October-November of 1954. Prices which give a less favorable ratio for beef were obtained by using a purchase price from the market levels in October-November 1952 and a sale price at 1953 levels. For prices to represent a favorable ratio for beef, the purchase price used is the average adjusted price (explained earlier in this section) while the sale price was computed by arbitrarily using a margin (marketing price minus purchase price) twice as large as the 20-year historical base average. The prices of all other factors and products remain constant throughout the study.

The optimum plans computed for these collateral price situations, with hog and beef prices fluctuating as explained above, illustrate the significance of price changes in farm planning. Incomes are calculated under these price changes to show (1) the sacrifice in income if plans are made in terms of average prices while higher or lower prices are actually realized and (2) the gain in income from accurate prediction of changes in individual prices and price ratios.

CAPITAL LEVELS

Capital is the extremely limiting resource for beginning farmers. Too, the amount of capital possessed varies among beginners. Hence, to determine how optimum plans differ, depending on capital availability, solutions have been computed for different amounts of capital. These solutions indicate that not only the livestock system but also the crop rotation should differ, depending on the funds available for a specific type of soil and size of farm.

The five capital levels considered for planning are: $3,000, $5,000, $7,500, $10,000 and unlimiting funds. These amounts of "planning" capital are available for investment and operating costs beyond the normal investment in power, machinery and certain fixed costs of the farm. If the farm machinery is purchased new, it has an approximate cost of $13,260; if purchased second-hand, it has an "average value" of $6,630. Hence, with an "average value" of machinery, the $3,000 capital for planning corresponds to a $9,630 total capital level; the $5,000 capital for planning corresponds to $11,630, etc. With all new machinery, the $3,000 for planning would correspond to $16,260 total capital. Since it is assumed that the tenant owns sufficient machinery for crop operations, he will have certain fixed costs, regardless of the production plan to be adopted or the volume of production. These fixed costs include depreciation and insurance on farm machinery.[3] They also include: personal property taxes; the farm share of the auto, electricity and telephone; farm organization dues and other miscellaneous costs. The fixed costs are not considered in the capital requirements outlined later since they occur regardless of the farm plan selected. The net return figures for each of the farm plans, explained later, is the profit before fixed costs are paid. Therefore the net taxable return to the tenant in each plan is this net return minus fixed costs of $1,379.84 per year (see table 7).

The capital requirements (for investment and

[3]Depreciation on farm machinery is figured by the straight line method. Personal property taxes and insurance are determined by taking 1.5 percent of the total value of machinery. The value of machinery is based on new machinery; however, the only item in the fixed costs which changes as machinery gets older is the figure for personal property taxes and insurance. Since straight line depreciation is used, annual depreciation remains the same despite the age of the machinery.

TABLE 7. MACHINERY INVESTMENT, MACHINE LIFE, DEPRECIATION AND FIXED COSTS FOR TENANT.

Description of farm machinery	1954 value (dollars)	Estimated life (years)	Annual depreciation (dollars)
Full ownership:			
Tractor—3-bottom	$2,604.43	12	$ 217.04
Plow—3-bottom	397.19	17	23.36
Tandem disk—10-ft.	380.88	20	19.04
Corn planter—4-row	705.85	15	47.06
Fertilizer spreader—10-ft.	268.48	6	44.75
Elevator—50-ft.	700.00	15	46.67
Cultivator—4-row	539.29	12	44.94
Power mower—7-ft.	298.18	12	24.85
Side delivery rake—8-ft.	308.66	12	25.72
Drag harrow—24-ft.	186.36	15	12.42
2 flare box wagons	500.00	20	25.00
Manure spreader	514.00	10	51.40
Endgate seeder	80.37	12	6.70
Pickup	1,800.00	10	180.00
Auto (farm-share)	2,000.00	10	100.00
Total	$11,283.69	--	$ 868.95
Half ownership:			
Combine—6-ft.	2,073.29	10	207.33
Cornpicker—2-row	1,878.77	12	156.56
Total	$ 3,952.06	--	$ 363.89
Tenant's share	$ 1,976.03	--	$ 182.00
Fixed cost for tenant:			
Total depreciation for tenant			$1,050.95
Total personal property taxes and insurance			$ 198.89
Electricity			30.00
Telephone			25.00
Farm papers			10.00
Farm organization dues			15.00
Miscellaneous items			50.00
Total fixed cost			$1,379.84

operating costs) for each enterprise are listed in tables 8 and 9. Annual cash expense includes such items as seed, fertilizer, insecticides, seed treatment, fuel and machine repairs for crop production; it includes feed supplements, breeding fees, depreciation on livestock equipment, veterinary fees, insurance, replacement stock for beef and poultry and other miscellaneous expenses for livestock. Investment for crop production is zero since it is included under machinery in the manner outlined above. However, for livestock, equipment is part of the capital investment since it is not required unless the farm plan includes livestock.[4]

The levels of capital used in this study illustrate how farm plans need to differ, depending on available capital. The optimum farm plan for a farmer with $3,000 of available capital is quite different from the plan for a farmer with unlimiting capital. Both farms may have access to the same resources other than capital. Yet, they should combine their resources and enterprises in different manners if they wish to maximize profits. However, the optimum farm plan is not a function of capital alone. Each resource has an effect on the optimum farm plan.

SITUATIONS STUDIED

Beginning or young farmers are faced with numerous situations in respect to capital, labor, prices, leasing arrangements and ability to stand risk or uncertainty. To make this study have a wide application, optimum farm plans have been computed for many situations in respect to amounts and combinations of prices, capital, labor, crop restrictions and leasing arrangements. The situations for which optimum plans are computed include (1) *main situations* and (2) *collateral situations*. The *main situations* are those selected to be "standard" resource, price and lease arrangements under which many young farmers operate. The *collateral situations* parallel the *main situations* in respect to capital but changes are made in other characteristics of the decision-making environment. This procedure allows examination of restrictions of cropping plans, leases, uncertainty precautions and price alternatives on the optimum farm plan. In all situations (main and collateral) all activities or enterprises, except dairy, poultry and drylot feeding, are competitive for all resources and are considered for an average level of management.

[4] In some of the collateral situations explained later, the $10,000 level of capital alone is used. This level is selected because it represents one where all resources are used. Therefore, the farm plan is a function of all resources, rather than of land and capital alone as in the case when capital is highly restricted.

TABLE 8. VARIABLE COST (CAPITAL COEFFICIENT) PER ACRE OF ROTATION FOR DIFFERENT LEVELS OF FERTILIZATION.

Rotation	Fertilization level	Variable cost* (dollars)
CCSb	Zero rate	17.14
CCSb	First rate	19.50
CCSb	Second rate	21.19
CCSb	Third rate	24.17
CSbCOM	Zero rate	15.75
CSbCOM	First rate	17.41
CSbCOM	Second rate	18.79
CSbCOM	Third rate	20.04
CCOM	Zero rate	14.92
CCOM	First rate	17.11
CCOM	Second rate	18.78
CCOM	Third rate	20.03
CCOMM	Zero rate	14.19
CCOMM	First rate	15.91
CCOMM	Second rate	17.24
CCOMM	Third rate	18.44

* Includes cost of seed, seed treatment, fertilizer and its application, insecticides, fuel and machine repair for crop production and harvesting costs.

TABLE 9. VARIABLE COSTS AND INVESTMENT (CAPITAL COEFFICIENTS) FOR LIVESTOCK, INCLUDING INVESTMENT AND ANNUAL COST PER UNIT.

Enterprise	Unit	Variable cost* (dollars)
Pasture-fed yearlings	head	168.63
Deferred-fed steer calves	head	133.95
Pasture-fed steer calves	head	137.80
Choice yearlings on drylot	head	174.92
Choice calves on drylot	head	138.97
Medium yearlings on drylot	head	148.34
Two-litter hog system (on pasture)	100 lbs. of pork	8.17
Two-litter hog system (drylot)	100 lbs. of pork	7.92
Dairy	head	236.62
Poultry	each	6.32

* Includes (1) annual cash expenses such as feed supplements, breeding and veterinary fees, insurance, depreciation on investment and purchase price of basic stock for beef and poultry; and (2) investments such as equipment and basic stock for hogs and dairy.

Main Situations

In the main situations, it is assumed that the tenant may use the farm's resources in a manner to maximize his own profits. That is, he may use a rotation including meadow if it fits into the optimum farm plan. Seed costs and crop share are the same as for the share arrangements in the existing lease, mentioned in a previous section. However, when the farm plan includes meadow, the landlord pays all of the cost for grass seed, and the tenant pays $10 an acre cash rent for all of the forage. In the main situations, hay cannot be marketed, except through livestock, and all forage requirements for the production of livestock must be raised on the farm. A further condition in the main situations is that hogs can compete with beef for the use of barn space. All factors and product prices in these situations are average prices as outlined in the section on prices. With the above conditions, the resource limitations for each main situation are as follows where S refers to a situation and the subscript refers to a particular capital level. It should be remembered that capital indicated is above the machinery investment mentioned earlier.

S_1—Available resources include $3,000 capital; 153 acres of land; labor as indicated in table 1; 416 square feet of building space for hogs; 1,600 square feet of building space for beef and 412 square feet for poultry.
S_2—Same as S_1, except capital is increased to $5,000.
S_3—Same as S_1, except capital is increased to $7,500.
S_4—Same as S_1, except capital is increased to $10,000.
S_5—Same as S_1, except capital is unlimiting.

Collateral Situations

The collateral situations differ from the main situations above in that a specific condition is changed or a restriction is applied to determine its effect on the optimum farm plans. The purpose of considering the collateral situations is to formulate farm plans that are adaptable to a variety of farms and farmers whose conditions should fit into at least one of the following considerations.

Fertility considerations: The collateral situations under fertility considerations include the same conditions and resource restrictions as in the main situations, except that the activities which include the third or highest rate of fertilization are omitted. These activities are not allowed to come into the farm plan because the highest rate of fertilization supposes that superior crop management is used with the higher inputs of fertilizer. If such were not true, the highest level of fertilization would be little if any more productive than the next lower level. Since some farmers may not use the superior crop practices, plans are computed which consider this condition. The collateral fertility situations considered are:

F_1—Same as S_1, except all activities which include the third rate of fertilization are not allowed to come into the farm plan.
F_2—Same as F_1, except capital is increased to \$5,000.
F_3—Same as F_1, except capital is increased to \$7,500.
F_4—Same as F_1, except capital is increased to \$10,000.
F_5—Same as F_1, except capital is unlimiting.

Rotation considerations: As mentioned elsewhere, the question has been posed as to whether a CCOMM rotation is profitable, or if it lowers income materially on a rented farm. Hence, the collateral situations in this section determine the effect on farm planning when the CCOMM rotation is forced into the farm plan. That is, only the activities including CCOMM are allowed to compete for the use of resources. The resulting farm plans for these situations would apply to a farm where soil and topography warrant a large amount of meadow in the rotation or to the farmer who may choose this rotation for conservation purposes.

The collateral situations considered when a CCOMM rotation is forced into the plan are:

R_1—Same as S_1, except only activities which include CCOMM are allowed to come into the farm plan.
R_2—Same as R_1, except capital is increased to \$5,000.
R_3—Same as R_1, except capital is increased to \$7,500.
R_4—Same as R_1, except capital is increased to \$10,000.
R_5—Same as R_1, except capital is unlimiting.

Further rotation considerations: The above situations consider only one rotation, which is 40-percent meadow, for the farm plan. The collateral situations in this section consider all three of the meadow rotations (i.e., CCOM, CSbCOM and CCOMM). A non-meadow rotation is excluded from crop possibilities. Therefore, the resulting farm plans will always include some meadow in the rotation but not necessarily 40-percent meadow. The primary purpose for considering these collateral situations is to determine the effect on profits when the meadow rotations do not have to compete with a CCSb rotation for the use of resources. The situations for the rotation considerations in this section are:

$S_{2\text{-}r}$—Same as S_2, except the activities which include CCSb are not allowed to come into the farm plan.
$S_{4\text{-}r}$—Same as $S_{2\text{-}r}$, except capital is increased to \$10,000.

Uncertainty considerations: The collateral situations for uncertainty considerations allow consideration of plans which give the farmer a steadier or less risky income than the other situations in this study. Since a crop failure, price fluctuation or other uncertainties could seriously decrease the farm profits, some farmers may prefer, or require, a relatively steady income stream. They may prefer a plan with "steady" or "more certain" income to a plan which gives higher returns. How much do such plans depress profits? In the collateral situations for uncertainty considerations, small dairy and poultry enterprises are forced into the farm plan to give the farmer a source of low risk income. Since dairy and poultry are forced into the plan, they can be termed "fixed" activities. That is, the amount of resources required to support these activities are subtracted from the basic amounts of resources, as stated in the main situations. For example, if 10 dairy cows require 12 acres of corn and 27 acres of meadow for feed, the amount of land remaining for other activities is 153 acres minus 39 acres, or 114 acres. Labor, capital and building space are handled in the same way. Likewise, the revenue resulting from dairy and poultry is added to the revenue obtained from the other activities in the farm plan, which gives an aggregate or total net return for the farm plan. The situations for the uncertainty considerations are:

$S_{2\text{-}u}$—Same as S_2, except 5 dairy cows and 100 hens are forced into the farm plan. Available resources for competing activities are those remaining after the allocation of resources to fixed activities.
$S_{4\text{-}u}$—Same as S_4, except 10 dairy cows and 200 hens are forced into the farm plan. Available resources for competing activities are those remaining after the allocation of resources to fixed activities.
$F_{2\text{-}u}$—Same as F_2, except 5 dairy cows and 100 hens are forced into the farm plan. Available resources for competing activities are the same as in $S_{2\text{-}u}$.
$F_{4\text{-}u}$—Same as F_4, except 10 dairy cows and 200 hens are forced into the farm plan. Available resources for competing activities are the same as in $S_{4\text{-}u}$.

Price considerations: The prices used for the main situations are those which represent long-run or average ratios of the price of one product in respect to the price of another product. It is the ratio of product prices, rather than the absolute level, which determines the best plan for a farm. Prices may rise or

fall, but if the ratio remains the same, the optimum plan is not changed. However, price ratios between products do vary in short-run periods such as a year or two. For example, fed cattle prices were relatively high in 1951 but low in 1952. Hog prices were relatively high in 1954 but low in 1955. To determine how changes in ratios of hog and beef prices, such as those in 1951, 1952, 1954 and 1955 affect the optimum plan, the collateral situations below have been included.

$S_{4\text{-}LH}$—Same as S_4, except low hog prices are used ($17.07 per cwt.).

$S_{4\text{-}HH}$—Same as S_4, except high hog prices are used ($22.85 per cwt.).

$S_{4\text{-}LB}$—Same as S_4, except low beef prices are used. (Purchase prices per cwt. are: $28.39 for pasture-fed yearlings; $28.65 for deferred-fed calves and pasture-fed calves. Selling prices per cwt. are: $25.66 for pasture-fed yearlings; $25.50 for deferred-fed calves and $26.12 for pasture-fed calves.)

$S_{4\text{-}HB}$—Same as S_4, except high beef prices are used. (Purchase prices per cwt. are same as average prices in table 6, but selling prices per cwt. are: $29.54 for pasture-fed yearlings; $29.12 for deferred-fed calves and $27.86 for pasture-fed calves.)

Lease considerations: To determine the effect on farm planning when certain lease restrictions are imposed, the situations in this section allow the use of only one crop rotation. When the lease excludes the landlord from sharing in livestock enterprises, it is conceivable that the landlord will specify a strict grain rotation. Therefore, the leasing arrangements of these collateral situations require 143 acres of $CCSb_2$ and 10 acres of permanent pasture as fixed activities. (A lease restriction which specifies a CCSb rotation is quite common in the area for which this study is made. The particular farm referred to in this study has 10 acres in permanent pasture and a lease restriction specifying a CCSb rotation on the remaining acres.) Since 10 acres of permanent pasture is the only source of hay on the farm, it is considered as an input for dairy only. If the number of dairy cows in the final plan does not use all of the pasture, the remainder may be used as drylot space for feeding beef. All livestock activities in the leasing situations are on a drylot basis, except dairy. All hay is purchased for drylot livestock at $17 per ton. Additional limitations are outlined in the situations below. When a situation does not allow the purchase of corn, the supply of corn available for livestock is the tenant's share of corn produced on the farm; when a situation specifies that additional corn may be purchased from off the farm, the purchase price on the "extra" corn is arbitrarily increased 10 cents per bushel to cover the costs of handling and transportation. The collateral leasing situations are:

$L_{2\text{-}a}$—Available resources for the farm plan are the same as in the main situation, S_2. The farm plan includes 143 acres of $CCSb_2$ and 10 acres of permanent pasture, which are fixed activities by lease specification. Therefore, available resources for the variable, or competing activities (dairy, poultry and drylot livestock enterprises), are those remaining after the allocation of resources to the fixed activities. All factor and product prices are average; cash rent of $10 per acre is paid for permanent pasture. The corn supply for livestock is limited to the tenant's share of corn produced on the farm. Hogs are limited to the space limitations of the hog house because of potential disease hazards when a large number of hogs are raised on drylot.

$L_{3\text{-}a}$—Same as $L_{2\text{-}a}$, except capital is increased to $7,500.

$L_{4\text{-}a}$—Same as L_{2a}, except capital is increased to $10,000.

$L_{5\text{-}a}$—Same as $L_{2\text{-}a}$, except capital is unlimiting.

$L_{2\text{-}b}$—Same as $L_{2\text{-}a}$, except hogs may compete with beef and dairy for barn space.

$L_{3\text{-}b}$—Same as $L_{2\text{-}b}$, except capital is increased to $7,500.

$L_{4\text{-}b}$—Same as $L_{2\text{-}b}$, except capital is increased to $10,000.

$L_{5\text{-}b}$—Same as $L_{2\text{-}b}$, except capital is unlimiting.

$L_{2\text{-}c}$—Same as $L_{2\text{-}a}$, except corn may be purchased from off the farm and dairy cows use permanent pasture for grazing only. Other forage requirements for dairy cows are purchased, as for the drylot beef activities.

$L_{3\text{-}c}$—Same as $L_{2\text{-}c}$, except capital is increased to $7,500.

$L_{4\text{-}c}$—Same as $L_{2\text{-}c}$, except capital is increased to $10,000.

$L_{5\text{-}c}$—Same as $L_{2\text{-}c}$, except capital is unlimiting.

$L_{2\text{-}d}$—Same as $L_{2\text{-}c}$, except hogs may compete with beef and dairy for barn space.

$L_{3\text{-}d}$—Same as $L_{2\text{-}d}$, except capital is increased to $7,500.

$L_{4\text{-}d}$—Same as $L_{2\text{-}d}$, except capital is increased to $10,000.

$L_{5\text{-}d}$—Same as $L_{2\text{-}d}$, except capital is unlimiting.

Labor considerations: The collateral situations included in this section do not require labor to be limited in quantity, as was true in previous situations. Plans for the collateral labor situations and other situations with limited labor can be compared to determine the effect of labor restrictions on the most profitable plan. Also, the net return per hour for "extra" labor may be estimated from these comparisons. The collateral situations for labor are some of the previous situations which required a capital level of $10,000 and are as follows:

$S_{4\text{-}w}$—Same as S_4, except labor is unlimiting.

$F_{4\text{-}w}$—Same as F_4, except labor is unlimiting.

$L_{4\text{-}a\text{-}w}$—Same as $L_{4\text{-}a}$, except labor is unlimiting.

$L_{4\text{-}c\text{-}w}$—Same as $L_{4\text{-}c}$, except labor is unlimiting.

(In the next section, it is shown that labor is seldom limiting when available capital is $7,500 or less.)

Alternative considerations: The farm plans resulting from the previous situations (main and collateral) are optimum in respect to profit maximization. Since

a certain amount of variation in each plan is possible without a significant decrease in profits, some alternative plans are determined which do not result in maximum profits under a particular situation but nearly do so. The alternative plans indicate the degree of flexibility in farm organization for a given collection of resources without great depression of profit as compared to the optimum plan. No effort is made to list a complete set of alternative plans for each situation; a few are selected to show how somewhat different organizations can result in similar profit levels. The alternative plans for given situations are indicated by a prime (′) sign following the symbols indicating situations mentioned earlier and are as follows:

S'_4—Same as S_4, except resulting plan is not optimum in respect to profits.
F'_4—Same as F_4, except resulting plan is not optimum in respect to profits.
$S'_{4\text{-HB}}$—Same as $S_{4\text{-HB}}$, except resulting plan is not optimum in respect to profits.
$S'_{4\text{-LH}}$—Same as $S_{4\text{-LH}}$, except resulting plan is not optimum in respect to profits.
$F'_{4\text{-u}}$—Same as $F_{4\text{-u}}$, except resulting plan is not optimum in respect to profits.

The alternative plans listed above are determined by the same linear programming steps as the optimum plans for the parallel situation. The only difference is: Reiterations are not carried to the point where the Z_j-C_j row has all positive quantities.[5] However, in all cases, only slight increases in profits could be attained by proceeding until all Z_j-C_j quantities are greater than zero. Some of these alternative plans may have special appeal to farmers. While they give only slightly less profit, they may have enterprises which correspond best to the personal preferences or risk position of the operator.

[5]See: Heady, Earl O. Simplified presentation and logical aspects of linear programming technique. Jour. Farm Econ. 36:1035-50. 1954.

ANALYSIS OF RESULTS

The optimum or most profitable plans for each capital and price situation are presented in this section. The results are based on the assumptions and restrictions outlined for each situation in the preceding section. The resulting farm plans are not designed to fit a particular set of price conditions in a particular year. Instead, they serve as guideposts applicable under conditions of average price ratios. In the tables which follow, the "corn surplus or deficit" column shows the bushels of corn which are bought or sold for the farm plan of each situation. A plus sign signifies corn sold whereas a minus sign indicates the number of bushels purchased. The net sales or purchases of corn are taken into account in the net return figures.

As stated previously, the income figure for each situation is net return to the tenant and does not include fixed costs. Therefore, the net taxable return for each farm plan is net return minus fixed costs ($1,379.84).

Profit-Maximizing Plans for Main Situations

A summary of the farm plans for the main situations is given in table 10. The CCSb rotation uses land and capital with $3,000 of capital ($S_1$) more profitably than any of the other activities. The first rate of fertilization is most profitable for this very limited amount of capital. Even with $3,000 in capital, 10 acres can be fertilized at the second rate. However, fertilization of 10 acres at a different rate than the remainder of the cropland may be somewhat impractical on some farms. Hence, if the total acreage is fertilized at slightly above the first rate, the plan is essentially the same. With only $3,000 in capital (be-

TABLE 10. OPTIMUM FARM PLANS FOR MAIN SITUATIONS S_1 THROUGH S_5 WHERE ALL ACTIVITIES COMPETE FREELY FOR RESOURCE USE; HOGS COMPETE WITH BEEF FOR CATTLE BARN SPACE.

Situation	Capital level*	Net returns†	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit
S_1	$3,000	$3,468	143 acres $CCSb_1$ 10 acres $CCSb_2$	Capital Land	+3,157 bu.
S_2	$5,000	$4,257	144 acres $CCSb_2$ 9 acres $CSbCOM_3$ 14 litters of hogs	Capital Land	+1,552 bu.
S_3	$7,500	$5,138	132 acres $CCSb_2$ 21 acres $CSbCOM_3$ 34 litters of hogs	Capital Land	−969 bu.
S_4	$10,000	$5,820	78 acres $CCSb_2$ 75 acres $CSbCOM_3$ 40 litters of hogs 13 calves (deferred-fed)	Capital Land April labor	−2,551 bu.
S_5	Unlimiting ($14,724)‡	$6,513	108 acres $CCOM_2$ 45 acres $CCOM_3$ 23 litters of hogs 47 calves (pasture-fed) 11 calves (deferred-fed) 100 hens	Land All building space July labor November labor	−2,441 bu.

* Capital above machinery investment (see discussion in text).
† Net returns before fixed costs of $1,379 are subtracted.
‡ Amount of capital used for maximum profits with limiting resources indicated in column 5.

yond machinery investment) no resources should be used for livestock. Profit is at a maximum to a tenant farmer with a cash grain operation including production of corn and soybeans alone. The cropping system and rate of fertilization specified gives a greater return on capital (the most limiting resource) than any other rotation, enterprise or investment alternative. Labor is not completely used in any month. However, an attempt to use more labor, other resources remaining constant, by adding livestock enterprises would lower profits. All grain is sold under the optimum plan for S_1.

As capital is increased to \$5,000 under S_2, the second rate of fertilization becomes most profitable. The greater amount of capital allows some investment in livestock to be profitable. The farm plan includes 144 acres of $CCSb_2$ rotation, 9 acres of $CSbCOM_3$ rotation, 14 litters of pigs and sale of 1,552 bushels of grain. At this capital level it is more profitable to use funds for livestock, instead of applying fertilizer at a rate higher than the second level on the CCSb rotation. Since the hog system requires some pasture, a small amount of meadow rotation is introduced into the farm plan for Situation S_2. With \$5,000 of capital available, 9 acres of CSbCOM rotation fertilized at the third or highest rate of fertilization provides sufficient meadow for the seven litters of hogs (the other seven litters are farrowed in the fall since the two-litter system is used) included in the farm plan. However, it may be impractical to use a 5-year rotation on only 9 acres. Therefore, a plan which included the same number of hogs but all acres in a CCSb rotation except for a sufficient amount of hog pasture, would be essentially the same farm plan, yet more realistic for the individual farmer.

With capital increased to \$7,500 under Situation S_3, the cropping plan is generally the same. The farm plan for \$7,500 in capital includes 132 acres of CCSb rotation fertilized at the second level, 21 acres of CSbCOM rotation fertilized at the third or highest level and 34 litters of pigs. The plan still does not include cattle or poultry. Nearly 1,000 bushels of corn would need to be purchased, but soybeans would be sold for cash. Since hogs are increased to 34 litters, a corresponding increase in meadow rotation is included as compared to the plan for S_2. For the farm plans under situations S_1, S_2 and S_3, the resources which are limiting and finally specify the farm organization are capital and land. Labor is not limiting in any single month.

Under Situation S_4, the optimum plan calls for 78 acres of $CCSb_2$ rotation and 75 acres of $CSbCOM_3$, 40 litters of hogs and 13 deferred-fed calves. The higher capital level allows an expansion in the number of acres fertilized at the higher rate and in the number of hog litters; it also allows addition of a small cattle feeding enterprise. However, limiting labor also is a reason for addition of cattle feeding rather than even greater expansion of the hog enterprise.

With a capital level of \$10,000, April labor also is limiting (the expansion of the hog enterprise requires a large amount of April labor for farrowing). The greater amount of the meadow rotation comes into the plan, as compared to S_3, to provide pasture and hay for the hogs and cattle. However, it is the shortage of April labor which causes part of this increase in the meadow rotation. Since labor is scarce in this month, cattle become profitable and hay is required accordingly. Slightly over 2,500 bushels of purchased corn are needed for this plan, but some would be purchased with soybean receipts.

The plan for Situation S_5, when capital is unlimiting, is significantly different from the previous plans. The optimum plan no longer includes the CCSb rotation. Instead, all land is used for CCOM at two different fertilization rates. The change from CSbCOM to CCOM results because the latter rotation is more profitable when sufficient capital is available to use the forage in terms of a larger cattle enterprise. As was stated in the previous section, the hog enterprise competes with beef for the use of building space in all of the main situations. When capital is unlimiting, all building space, land, July and November labor are all limiting resources. These additional limitations reduce the size of the hog and deferred-fed calf enterprises as compared to S_4 and replace them with pasture-fed calves. Since poultry does not compete with other activities for the use of resources, except capital, hens come into the plan under this situation to use all of the poultry building space. In other words, the poultry enterprise cannot compete with other enterprises for scarce capital under the previous situations.

Two levels of fertilization come into this plan because of the needs of various livestock enterprises for feed. The third or highest rate of fertilization is most profitable when the CCOM rotation supports hogs and deferred-fed calves. However, pasture-fed calves are most profitably supported by the second rate of fertilization. (The last statement holds true only as it applies to the combination of activities and resource limitations resulting under Situation S_5.) Less corn is purchased under S_5 since the number of hogs is decreased. The somewhat larger deficit of corn in Situation S_4 is due to the large number of hogs. (Since the CCSb rotation does not include forage, it lessens the amount of corn purchased off the farm.)

PLANS VARY WITH RESOURCE SITUATIONS

The various farm plans for the main situations outlined above and in subsequent situations are based on average management techniques. That is, it is assumed the operator possesses average managerial ability for each of the enterprises considered throughout the study. Therefore, management skill is a fixed resource to which any of the resulting farm plans are adapted equally well. A farmer with special ability for any one enterprise may increase profits, as compared to the farm plans in this study, by substituting enterprises in his farm plan which are consistent with his managerial skill. For example, the corn requirement per unit of hogs in table 4 may be 350 pounds for an above average manager as compared to 458.40 pounds for an average manager. Since the production coefficients vary with managerial ability the optimum farm plan also will vary accordingly.

The beginning farmer must, if he wishes to maximize profits, plan according to his own conditions and resource limitations. When capital is the limiting resource, the rotation and level of fertilization must be selected to use funds most profitably. When two or more resources are limiting, the farm plan must be constructed to select enterprises or activities which consider the "interaction" of the several limiting resources. For example, in Situation S_4, limited April labor specifies the entrance of deferred-fed calves in the plan. With unlimiting capital in S_5, the deferred-fed calves could expand to the extent of November labor. However, when capital is available, the labor limitations cause pasture-fed calves to replace hogs and deferred-fed calves to the extent of July labor. This combination of livestock causes a switch in rotations to use fertilization rates which support the most profitable livestock plan. The resulting plan is one with each enterprise dependent on the other and all enterprises dependent on available resources. No one plan is best for all farmers on the same soil type.

Collateral Plans

The plans outlined above are for the basic or main situations considered in this study. The plans under the collateral situations are now discussed. As pointed out previously, collateral situations include the same conditions or restrictions as the main plans; however a change is made in a particular item to determine how it affects the optimum farm plan. Each plan may be compared to the plan under main situations with a parallel capital level to determine the effect on farm organization and profit of changes in fertilization methods, prices, uncertainty considerations, lease arrangements or labor supplies.

Fertility considerations (table 11)

The first collateral situations to be examined are those where the third level of fertilization is not considered. Use of the third level is recommended only if seeding rates, seed varieties, cultural methods and other practices are used in a manner to get high yields from the highest fertilization level. In case the complementary practices are not used, fertilization should not be above the second level. (Even with fertilization at the third level, yields little higher than the second level would be expected without the complementary management practices.) Hence, the collateral situations under discussion show the optimum plan when the farmer cannot or will not use all superior crop management practices.

Since only the third or highest rate of fertilization is omitted in F_1, the optimum plan with $3,000 capital is the same as for S_1; the highest rate of fertilization did not come into the plan under S_1 because of capital limitations. Therefore, the plans for situations S_1 and F_1 are the same. With capital at $5,000 under F_2, $CCOM_2$ under F_2 replaces $CSbCOM_3$ under S_2. The two rotations are close substitutes in providing pasture for hogs, and the difference in income for the two plans is only $2.40. Hence, final selection between the plans might well depend on the farmer's personal preference. Similarly the most profitable plan under F_3 is practically the same as the one under S_3, except that $CCOM_2$ replaces $CSbCOM_3$. In all of the F plans (without the third rate of fertilization) CCOM replaces CSbCOM. Again the difference in net return is unimportant, and both plans support the same amount of livestock. An acre of CCOM supports more livestock, on the basis of hay, than an acre of CSbCOM. Hence, when CCOM is used, there are more acres in CCSb and a smaller deficit of corn. Also, more realistic plans for situations F_1, F_2 and F_3 may include all acres in a CCSb rotation except for a sufficient amount of hog pasture.

The same pattern of similarity follows through the F_4 and F_5 situations. The number of livestock in these

TABLE 11. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS F_1 THROUGH F_5 WHERE THE THIRD OR HIGHEST FERTILIZATION RATE IS OMITTED FOR ALL ROTATIONS.

Situation	Capital level*	Net returns†	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit
F_1	$3,000	$3,468	143 acres $CCSb_1$ 10 acres $CCSb_2$	Capital Land	+3,157 bu.
F_2	$5,000	$4,254	146 acres $CCSb_2$ 7 acres $CCOM_2$ 14 litters of hogs	Capital Land	+1,759 bu.
F_3	$7,500	$5,132	135 acres $CCSb_2$ 18 acres $CCOM_2$ 34 litters of hogs	Capital Land	−887 bu.
F_4	$10,000	$5,799	88 acres $CCSb_2$ 65 acres $CCOM_2$ 40 litters of hogs 13 calves (deferred-fed)	Capital Land April labor	−2,365 bu.
F_5	Unlimiting ($14,585)‡	$6,488	153 acres $CCOM_2$ 24 litters of hogs 47 calves (pasture-fed) 10 calves (deferred-fed) 100 hens	Land All building space July labor	−2,543 bu.

* Capital above machinery investment (see discussion in text).
† Net returns before fixed costs of $1,379 were subtracted.
‡ Amount of capital used for maximum profits with limiting resources indicated in column 5.

situations is practically the same as in situations S_4 and S_5, respectively. The limiting resources are the same, except in F_5 where November labor does not limit the activities because fewer calves are produced than in S_5. Examination of the F plans leads to this conclusion: The added return for the third fertilization rate is small compared to use of capital for other investment opportunities. While some income is sacrificed in not using the highest level of fertilization, most of this sacrifice is offset by investment of limited funds in other enterprises. For this reason, many beginning farmers might wish to spread their risks by fertilizing at the second level and investing the remaining capital in a more diversified manner. The risk of returns for higher levels of fertilization is greater than for lower levels, considering the possibility of rainfall deficits.

ROTATION CONSIDERATIONS (TABLES 12a AND 12b)

Extension personnel and farmers in southeastern Iowa have posed the question of whether a "higher forage" rotation of CCOMM is most profitable on the soils studied. Hence, the set of collateral situations now to be examined includes this rotation to the exclusion of all others. Otherwise, the situations are the same as for the main situations in table 10. The current collateral situations include forcing a CCOMM rotation (applied to the entire farm) into the plan, with livestock activities variable as under the S or

TABLE 12a. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS R_1 THROUGH R_5, WHERE THE CCOMM ROTATION IS "FORCED" INTO THE FARM PLAN.

Situation	Capital level*	Net returns†	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit
R_1	$3,000	$960	153 acres $CCOMM_1$ 4 calves (deferred-fed)	Capital Land	+2,375 bu.
R_2	$5,000	$2,051	153 acres $CCOMM_1$ 18 calves (deferred-fed)	Capital Land	+1,602 bu.
R_3	$7,500	$3,415	153 acres $CCOMM_1$ 36 calves (deferred-fed)	Capital Land	+665 bu.
R_4	$10,000	$4,778	153 acres $CCOMM_1$ 54 calves (deferred-fed)	Capital Land	−293 bu.
R_5	Unlimiting ($15,727)‡	$6,314	71 acres $CCOMM_2$ 82 acres $CCOMM_1$ 35 calves (deferred-fed) 45 calves (pasture-fed) 10 litters of hogs 100 hens	Land Poultry building space Beef building space November labor	−2,687 bu.

* Capital above machinery investment (see discussion in text).
† Net returns before fixed costs of $1,379 are subtracted.
‡ Amount of capital used for maximum profits with limiting resources indicated in column 5.

TABLE 12b. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS R_1 THROUGH R_5 WHERE CCOMM IS THE ONLY ROTATION ALLOWED TO COME INTO THE FARM PLAN.

Situation	Capital level*	Net returns†	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit	Acres of land not used
R_1	$3,000	$1,465	39 acres $CCOMM_1$ 17 calves (deferred-fed)	Capital	−254 bu.	114
R_2	$5,000	$2,441	65 acres $CCOMM_1$ 28 calves (deferred-fed)	Capital	−424 bu.	88
R_3	$7,500	$3,662	97 acres $CCOMM_1$ 42 calves (deferred-fed)	Capital	−632 bu.	56
R_4	$10,000	$4,883	129 acres $CCOMM_1$ 56 calves (deferred-fed)	Capital	−841 bu.	24
R_5	Unlimiting ($15,822)‡	$6,340	71 acres $CCOMM_2$ 77 acres $CCOMM_1$ 35 calves (deferred-fed) 11 litters hogs 45 calves (pasture-fed) 100 hens	Poultry building space Hog building space Beef building space November labor	−2,988 bu.	5

* Capital above machinery investment (see discussion in text).
† Net returns before fixed costs of $1,379 are subtracted.
‡ Amount of capital used for maximum profits with limiting resources indicated in column 5.

main situations of table 10. The CCOMM rotation did not come into the most profitable plans when all rotations were allowed to compete for the use of resources. As mentioned previously, this rotation is sometimes recommended for conservation purposes on particular soil types, and some of the questions to be answered are: How much will its use affect profits to a beginning farmer who rents his farmland? How will it change his optimum livestock plan, if selected as the land use basis?

Since it includes so much forage, the CCOMM rotation must have livestock with it if capital is to be used most profitably. Under R_1 with only \$3,000, capital is sufficient to support only four calves and fertilization must be held to the second level. The first rate of fertilization is most profitable when a CCOMM rotation is forced into the plan for the entire farm. Because of the limitation of capital and the necessity of using limited funds for livestock to use forage, the plans under the R situations generally have a lower level of fertilization than those under the S situations in table 10.

The need for forage-utilization causes capital investment in cattle feeding rather than in hogs. Hogs are not included in the optimum plan under the collateral rotation situations until capital becomes unlimiting under R_5. Thus the organization of the farm under R_1, R_2, R_3, R_4 and R_5 differs greatly from the organization under the same capital levels of S_1, S_2, S_3, S_4 and S_5. The only limiting resources are land and capital for situations R_1 through R_4. As capital becomes less limiting and allows an increase in volume up to the limits of labor, it becomes profitable to decrease the number of deferred-fed calves (as compared to R_4) and substitute some pasture-fed calves and hogs for the use of resources under R_5. The entry of pasture-fed calves into the plan where capital is not limiting results from the limitations of building space and November labor. When these two resources become limiting, the optimum plan is a combination of the two calf enterprises, rather than deferred-fed calves alone, because of the manner in which the two feeding enterprises use labor.

Net return is considerably less under the R situations, as compared to the S and F situations which do not require so much meadow in the plan. At the \$3,000 level, where capital is greatly limited for the beginning farmer, net return under R_1 is about \$2,500 less than for S_1 and F_1. The return under R_4 is about \$1,000 less than the return under S_4 which does not include the CCOMM rotation. However, as the level of capital increases, the difference in net returns is reduced. The difference is only \$200 when capital is unlimiting. Still, the 40-percent meadow rotation is not as profitable as rotations with less meadow, or no meadow at all. The restriction of "no hay sales" accounts for part of the difference in net return, but a substantial increase in corn yields should be expected when corn follows 2 years of meadow. The analysis indicates that an increase in grain yields through use of fertilizer is more profitable than through use of meadow in the rotation. While soil topography may be a reason for use of a CCOMM rotation, the slope considered for the farm is from 1 percent to 3 percent, and erosion should not be a problem. On farms where slopes are greater but the soil is similar in productivity to that considered here, some of the acres may need to be in meadow even for situations similar to the main situations in table 10.

CCOMM in competition with livestock. The situations discussed above consider a 40-percent meadow rotation as the only alternative of land use (i.e., a rotation of CCOMM "forced into the plan" for conservation purposes). Further analysis of the effect of a CCOMM rotation are made by examining a group of situations where CCOMM is, again, the only rotation. However, it is a "variable" activity as compared to the situations above where it is a "fixed" activity in the sense of being applied to the entire farm before any other enterprise can be considered. Under the current procedure, the CCOMM rotation must compete with the livestock activities for the use of resources in order to become part of the farm plan. The farmer can plant only half of his acreage to CCOMM and use the rest of his capital for livestock. Or he can select livestock first and the optimum quantity of CCOMM second. The resulting plans under these conditions are shown in table 12b, and the following discussion pertains to the situations in this table.

When capital is limited to \$3,000, it is most profitably used by investing in 17 deferred-fed calves and 39 acres of the CCOMM rotation fertilized at the first rate. In other words, it is more profitable to plant only part of the land to the "restricted" rotation and to invest some funds in livestock (in contrast to "forcing" the rotation over the entire farm, as in the previous case). The 39 acres of $CCOMM_1$ are necessary to supply forage for the 17 calves. Deferred-fed calves are the most profitable investment, but a certain amount of rotation is required to supply forage since these situations are restricted to hay produced on the farm. Therefore, the plan must include enough acres of rotation to meet the forage requirements of the livestock in the plan. The result of land use, with \$3,000 of capital, is 114 acres remaining idle and 39 acres used for crops. The net revenue under this plan is about \$500 greater than the net revenue in the plan for the parallel capital situation where CCOMM was a "fixed" activity (i.e., no land was left idle as the CCOMM rotation was "forced" over the entire farm before any other enterprise could be selected).

As capital is increased to \$5,000, \$7,500 and \$10,000, respectively, the number of acres remaining idle is less with each increase in capital. The difference in net return between these situations where CCOMM is a "variable" activity as compared to the parallel capital situations where CCOMM is a "fixed" activity also becomes less with each increase in available capital; capital is the only limiting resource up to and including the situation with \$10,000. Hence, each increase in available capital increases the number of deferred-fed calves and similarly the number of acres in $CCOMM_1$ necessary to supply forage.

The purpose for considering the above situations is to compare the investment opportunities and profit

between the CCOMM rotation and livestock. The significance of these comparisons is: A farmer with limited capital who follows a recommendation of using the CCOMM rotation will realize a higher profit by letting some acres remain idle, instead of seeding all the acres into CCOMM first and using his remaining capital for livestock. The long-run result of having idle acres on the farm is unpredictable. Therefore, a farmer confronted with the situation where CCOMM is the only rotation alternative, would likely adjust his program to a smaller farm or increase his capital by some means so that all of the acres can be efficiently used in crop production.

Further rotation considerations (table 13). To consider the situation where only rotations including meadow are considered, plans have been completed for the collateral situations explained below. The crop opportunities allowed do not require a rotation with as much meadow as CCOMM, but do require that some meadow be included. For these purposes, plans for situations $S_{2\text{-}r}$ and $S_{4\text{-}r}$ of table 13 have been computed with the CCSb rotation omitted as a possibility. The other three meadow rotations are allowed to compete for the use of land.

The rotation with the least meadow, CSbCOM, is most profitable for both the $5,000 and $10,000 capital levels. The third or highest rate of fertilization also is most profitable for this single rotation. Deferred-fed calves are most profitable at the lowest capital level ($5,000) since, in contrast to the parallel capital situation of S_2 in table 10, they are necessary to use the forage from the rotation. While hogs are more profitable in S_2, the "interaction effects" of resource restrictions, fertilizer levels and forage production cause hogs to be less profitable than deferred-fed calves under $S_{2\text{-}r}$. As the amount of available capital is increased to $10,000, the hog enterprise is the next activity to enter the plan because it uses capital more profitably than other enterprises. At low capital levels, hogs is the first livestock activity to come into a plan when CCSb is the major rotation. However, when a CCSb rotation is omitted from crop possibilities and a meadow rotation is forced in to use the land, a beef-feeding activity is always more profitable than hogs, until capital becomes nonlimiting.

The reasons for these results can be explained through analyses of the ratio of land to capital for each activity. When it is allowed in crop possibilities, the CCSb rotation is always included in the farm plan for low levels of capital (unless it has been omitted from the situation). This is because the rate of return to investment, the capital returns ratio, is highest for the CCSb rotation. The next highest capital return ratios are for the CSbCOM rotation, deferred-fed calves and hogs, respectively. Hence, the CSbCOM rotation comes into the farm plan when it does not compete with the CCSb rotation. As the amount of available capital is increased and one investment opportunity is fully exploited, the optimum plans allow those livestock which give highest capital returns, where the available capital restricts the plan. Eventually, however, other resources limit the plan, and activities come into the plan which give the greatest return to the particular limiting resources. The result is a combination of activities, fitted to the scarcities of the various resources. The linear programming technique selects the plan or combination of activities which maximizes profits in consideration of the individual or group of resources which restrict the plan.

UNCERTAINTY CONSIDERATIONS (TABLE 14)

The plans for the collateral situations which consider organization of the farm to meet uncertainty are presented in this section. Under plans to lessen risk, small dairy and poultry enterprises have been forced into the plan since it is known that these enterprises have a relatively low year-to-year variability of income.[6] Enterprises of five dairy cows and 100 hens have been forced into the plan with $5,000; 10 dairy cows and 200 hens have been forced into the plan with $10,000. (As mentioned previously, the poultry enterprise includes replacement chickens.)

The resulting farm plans for situations $S_{2\text{-}u}$ and $S_{4\text{-}u}$ in table 14 can be compared to plans developed for the parallel capital situations S_2 and S_4 in table 10. The difference in net returns between situations S_2 and S_4, and the uncertainty situations of table 14 with the same capital reflects the price of security associated with a "steadier" income. Since dairy and poultry enterprises are predetermined in size under the "uncertainty considerations," the rest of the farm plan is a function of the remaining resources (i.e., five dairy cows and 100 hens require 20 acres of land for feed, $1,074 capital and a certain amount of labor and building space which are subtracted from

[6] 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 13. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS $S_{2\text{-}r}$ AND $S_{4\text{-}r}$ WHEN THE CCSb ROTATION IS OMITTED.

Situation	Capital level*	Net returns†	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit
$S_{2\text{-}r}$	$5,000	$2,941	153 acres $CSbCOM_3$ 14 calves (deferred-fed)	Capital Land	+2,010 bu.
$S_{4\text{-}r}$	$10,000	$5,447	153 acres $CSbCOM_3$ 38 calves (deferred-fed) 12 litters of hogs	Capital Land	−885 bu.

* Capital above machinery investment (see discussion in text).
† Net returns before fixed costs of $1,379 are subtracted.

TABLE 14. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS S_{2-u}, S_{4-u}, F_{2-u} and F_{4-u} WITH DAIRY AND POULTRY AS FIXED ENTERPRISES TO LESSEN UNCERTAINTY.

Situation	Capital level*	Net returns†	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit
S_{2-u}	$5,000	$3,651	6 acres corn 14 acres meadow 5 dairy cows 100 hens 118 acres $CCSb_2$ 15 acres $CCSb_1$	Capital Land	+2,963 bu.
S_{4-u}	$10,000	$4,648	12 acres corn 27 acres meadow 10 dairy cows 200 hens 81 acres $CCSb_2$ 25 acres $CCOM_2$ 8 acres $CSbCOM_3$ 11 calves (pasture-fed) 14 litters of hogs	Capital Land November labor	+205 bu.
F_{2-u}	$5,000	$3,651	6 acres corn 14 acres meadow 5 dairy cows 100 hens 118 acres $CCSb_2$ 15 acres $CCSb_1$	Capital Land	+2,963 bu.
F_{4-u}	$10,000	$4,640	12 acres corn 27 acres meadow 10 dairy cows 200 hens 80 acres $CCSb_2$ 25 acres $CCOM_2$ 9 acres $CSbCOM_2$ 11 calves (pasture-fed) 14 litters of hogs	Capital Land November labor	+237 bu.

* Capital above machinery investment (see discussion in text).
† Net returns before fixed costs of $1,379 are subtracted.

resources before other activities are considered). The activities which make up the remainder of the farm plan are those activities which use the remaining resources most profitably. At $5,000 the "uncertainty plans" are somewhat analogous to the S_1 and F_1 situations because the CCSb rotation is more profitable than all other activities for the use of capital and land, the limiting resources. The capital available for the CCSb rotation is $3,926 ($5,000 minus $1,074) under situations S_{2-u} and F_{2-u}, and therefore, compare more nearly with the $3,000 capital level under S_1 and F_1 in tables 10 and 11, respectively.

The uncertainty plans with $10,000 in capital follow the same general pattern as in the S and F situations, except for the dairy and poultry enterprises and a smaller hog enterprise. The CSbCOM rotation provides forage for the hog enterprise, and the CCOM rotation supplies hay for the pasture-fed calves. Since November labor is limiting, only pasture-fed calves are included; they use November labor more profitably than deferred-fed calves. The 39 acres of land required to support the dairy and poultry enterprises leave only 114 acres for other activities. This amount of remaining land, together with the labor which remains in each of the months, causes the particular combination of activities shown under S_{4-u} and F_{4-u} in table 14 to be most profitable under the uncertainty precautions. The land-capital ratio of the several activities is the dominant factor causing these activities to come into the farm plan. When activities are allowed to compete freely for the use of all resources, the resulting farm plan always contains those activities which have relatively high capital return ratios (i.e., pasture-fed yearlings and any of the activities containing a rotation with no fertilizer have relatively low capital return ratios, and none of these appear in any of the farm plans).

However, the capital return ratio is not the only factor which determines the selection of an activity. If an activity with a high investment ratio does not use labor efficiently, it does not often come into the plan when labor is limiting. With both labor and capital as limiting resources, final selection of an enterprise depends on the relative amounts of labor and capital available.

The main reason for analysis of the uncertainty considerations is to compare the net returns of the farm plans which include dairy and poultry to income under farm plans which do not include these enterprises. Comparisons of S_{2-u} in table 14 with S_2 in table 10 and of F_{2-u} in table 14 with F_2 in table 11 show differences of about $1,600 in income. In other words, a sacrifice of $1,600 is necessary to have a more steady or less risky income. However, plans with dairy and poultry enterprises as uncertainty precautions may be desirable for farmers with low equities and a necessity of averting risks. Only the individual can make this determination; and it must be made to fit his capital situation and risk preferences.

The difference in net return between the uncertainty situations and the S and F situations is less than $1,200 when available capital is at $10,000. Again, selection of a plan to lessen uncertainty would require a sacrifice in level of income for a gain in income stability.

However, dairy and poultry are not always less

TABLE 15. CHANGES IN NET REVENUE FOR MAIN SITUATIONS S_2 THROUGH S_5 WHEN LIVESTOCK PRICES CHANGE AFTER THE FARM PLAN IS ADOPTED.

Type of price change	Capital situation (S_2) $5,000	(S_3) $7,500	(S_4) $10,000	(S_5) Unlimiting capital
(1) Original price*	$4,257	$5,138	$5,820	$6,513
(2) High beef price†	4,257	5,138	6,171	7,453
(3) Low beef price†	4,257	5,138	5,423	5,323
(4) High hog price†	4,910	6,730	7,663	7,585
(5) Low hog price†	3,659	3,683	4,137	5,538
(6) High beef and low hog price†	3,659	3,683	4,487	6,478
(7) High beef and high hog price†	4,910	6,730	8,013	8,525
(8) Low beef and low hog price†	3,659	3,683	3,739	4,348
(9) Low beef and high hog price†	4,910	6,730	7,266	6,395

* Average adjusted prices as listed in table 6.
† See previous section on price considerations, under "Situations Studied," for change in prices.

profitable than other farm enterprises. They are less profitable under the average management levels used in this study because the farm and soil situation results in feeds and resource limitations which are best fitted to hogs and cattle feeding. Even on the same soil type, some farmers may have special likes or managerial abilities for handling a dairy enterprise or poultry enterprise, while their managerial capabilities for other types of livestock may be less. Under these circumstances the profit-maximization plan would very likely include dairy and, or, poultry enterprises. The fluctuation of farm prices also affects the profitability of an enterprise. This study is concerned with profit maximization under average prices. Price fluctuations in individual years may, of course, cause poultry or dairy enterprises to be more profitable than hogs or cattle feeding.

PRICE CONSIDERATIONS (TABLES 15 AND 16)

Plans under collateral situations which include changes in price ratios are presented in this section. They are compared with the main plans of table 10 where prices are for average (1) levels and (2) ratios between products for a period of years. Under these collateral situations prices are varied, as explained earlier, to consider fluctuations in cattle and hog prices such as those realized in the last few years.

The level of net income under various price situations (for a single plan under each capital level) is shown in table 15. In calculating the incomes of table 15, the same farm plans shown in table 10 for each capital level have been used. In other words, the question posed is: What level of income would have resulted if plans had been made out for the prices of situations S_2 through S_5 in table 10 but prices had changed, after adoption of the specific plan, as indicated in table 15?

In situations S_2 and S_3, a change in beef prices has no effect on net revenue because hogs are the only livestock in the farm plan. Low hog prices depress income from as little as $600 in S_2 to as much as $1,500 in S_3. High hog prices increase the income by approximately these same amounts for situations S_2 and S_3.

The situations with high levels of capital have farm plans which include both beef and hog enterprises. Accordingly, a combination of high beef prices and high hog prices results in a sizeable increase in return for these situations; contrariwise, income is reduced considerably when prices of both products are low. (The reduction in income at low capital levels is less where only one of the livestock enterprises is included in the plan.)

Incomes in table 15 are for a single plan under each capital situation; the optimum plan of table 10 for

TABLE 16. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS $S_{4\text{-LH}}$, $S_{4\text{-HB}}$, $S_{4\text{-HH}}$ AND $S_{4\text{-LB}}$ WHERE LIVESTOCK PRICES VARY AND CAPITAL IS RESTRICTED TO $10,000.

Situation	Capital level*	Net returns†	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit
$S_{4\text{-LH}}$	$10,000	$5,215	141 acres $CCOM_3$ 12 acres $CSbCOM_3$ 49 calves (deferred-fed)	Capital Land	+690 bu.
$S_{4\text{-HB}}$	$10,000	$6,560	127 acres $CCOM_3$ 26 acres $CCOM_2$ 49 calves (deferred-fed)	Capital Land	+718 bu.
$S_{4\text{-HH}}$	$10,000	$7,699	73 acres $CCSb_2$ 50 acres $CSbCOM_3$ 30 acres $CSbCOM_1$ 13 calves (deferred-fed) 40 litters of hogs	Capital Land All building space April labor	−2,822 bu.
$S_{4\text{-LB}}$	$10,000	$5,437	91 acres $CCSb_2$ 42 acres $CSbCOM_3$ 20 acres $CCOM_3$ 11 calves (deferred-fed) 40 litters of hogs	Capital Land April labor	−2,486 bu.

* Capital above machinery investment (see discussion in text).
† Net returns before fixed costs of $1,379 are subtracted.

average prices. They are not the incomes for the optimum plans when prices change to those suggested in table 15. We now examine the optimum plans for a $10,000 capital level when the organization of the farm is geared to the price change situations presented in table 15. The resulting plans are shown in table 16. Income under these plans can be compared to the plan under S_4 in table 10 where farm organization is geared to prices as an average over a period of years. The new plans in table 16 show how farm organization and income are changed when prices are predicted accurately. That is, they are the optimum plans under the price changes shown in table 15. (The figures in table 15 show how incomes are affected if prices are predicted wrongly to be those of situations S_1 through S_5 in table 10, and a single plan for each capital level—that for "average-period prices"—had been used.)

The situations with low hog prices and high beef prices ($S_{4\text{-LH}}$ and $S_{4\text{-HB}}$) have no hogs. Both have the same amount and kind of beef since the hog enterprise cannot compete with beef for the use of capital. Returns on capital is the deciding factor for livestock when no other resources are limiting. The rotations and fertilization rates differ somewhat, however, between situations $S_{4\text{-LH}}$ and $S_{4\text{-HB}}$ because the prices for beef differ under the two situations. In other words, a change in livestock prices can also change the level of fertilization and the most profitable rotation for a particular capital situation. If the capital level were a few dollars higher under Situation $S_{4\text{-LH}}$, the 12 acres of CSbCOM could be replaced by CCOM. Also, a little additional capital under $S_{4\text{-LH}}$ would allow use of the CCOM rotation fertilized at the third rate for the whole farm. Situation $S_{4\text{-HB}}$ has only one rotation in the optimum farm plan but it has two levels of fertilization. However, since most of the acres are fertilized at the highest rate, a little additional capital ordinarily would be used to fertilize all the acres at the same level.

Situations $S_{4\text{-HH}}$ and $S_{4\text{-LB}}$ with high hog prices and low beef prices, respectively, have both hogs and beef in the resulting plans. Hogs are expanded under these situations to the extent of the limiting resources: land, capital, April labor and building space. Since April labor is limiting in both situations (because of the large amount of hogs), the high-profit plan includes deferred-fed calves. In Situation $S_{4\text{-HH}}$, building space also is limiting. However, the same enterprises are in the optimum plan, with only a slight increase in calves up to the limits of building space. Two more calves are added in this situation because of the manner in which hog prices affect the kind of rotations entering into the farm plan. When hog prices are high, the optimum rotation to provide forage for 40 litters is 30 acres of CSbCOM fertilized at the lowest rate. This leaves 123 acres for other activities, and the optimum combination under these circumstances is: 73 acres of $CCSb_3$, and 50 acres of $CSbCOM_3$ which provides forage for calves (50 acres of $CSbCOM_3$ supplies enough forage for 13 calves, deferred-fed). In Situation $S_{4\text{-LB}}$, which has low beef prices and average hog prices, the forage requirements for 40 litters of hogs are supplied most profitably by 20 acres of $CCOM_3$[7]; leaving 133 acres for other activities. The optimum plan then is 91 acres of $CCSb_2$ with 42 acres remaining to supply the forage for calves. Hence, this situation has only 11 deferred-fed calves. In both situations $S_{4\text{-HH}}$ and $S_{4\text{-LB}}$, the size of the hog enterprise is limited to 40 litters by labor during farrowing time.

Fluctuations in hog prices, of the magnitude included in this study, have a greater effect on net revenue than fluctuations in beef prices. That is, the average beef prices under $S_{4\text{-LH}}$ do not offset low hog prices to the extent that average hog prices offset low beef prices in $S_{4\text{-LB}}$. For example, Situation $S_{4\text{-LH}}$ has a net return of about $600 less than Situation S_4, but Situation $S_{4\text{-LB}}$ has only $380 less income than Situation S_4. This effect is further demonstrated by examination of net return under high prices. High hog prices under $S_{4\text{-HH}}$ increase the net return by more than $1,800 over S_4; high beef prices increase income by less than half this amount.

The income results in table 16, where the plan is adjusted to new price situations, also need to be compared to the net returns for $10,000 capital in table 15, where the plan for S_4 is used rather than the optimum plan for the changed price situation. The comparisons show, of course, that if a farmer can predict price outlook accurately, he will have a somewhat greater income than if he adopts a plan to meet average prices and uses this plan continuously. However, the difference may be so small as to prevent year-to-year deviation from the "main plan" by a beginning farmer who is not greatly experienced in use of outlook materials. For example, with high beef prices, the income under the plan to fit the price change ($S_{4\text{-HB}}$ in table 16) would return $389 more than the average plan (line 2 for $10,000 in table 15) for the same price situation. The difference would be only $36 under high hog prices ($S_{4\text{-HH}}$ in table 16 as compared to line 4 in table 15). With a decline in hog prices, the difference would be $1,079 ($S_{4\text{-LH}}$ in table 16 as compared to line 5 in table 15). With a decline in beef prices, the difference would be only $14, because of the greater "compensating effect" of hog prices and because under the original price situation for S_4, hogs are only slightly less profitable than beef. The farmer needs to consider carefully his ability to predict price outcomes. If he has little ability and predicts hogs to be low while beef is the product which actually declines in price, his sacrifice in income will be greater than indicated above (where the optimum plan for average prices—S_4 in table 10—is used under price changes).

LEASE CONSIDERATIONS (TABLES 17, 18, 19 AND 20)

The plans presented in this section are those for the collateral situations where different leasing arrangements are used. For the main situations of table 10, a conventional crop-share lease was assumed and

[7] An acre of CCOM will support more livestock, on the basis of hay, than an acre of CSbCOM because the latter rotation is 40 percent meadow while the CCOM rotation is 25 percent meadow.

the optimum plan was determined for a beginning farmer as a tenant who could make all decisions in respect to crops and livestock. However, on many farms, the landlord specifies the cropping plan, or a range of plans from which the tenant can choose, and the livestock plan must be altered accordingly. A fairly common practice on some rented farms in the locality to which this study refers is for the landlord to specify a rotation without meadow (the actual situation on the farm studied). Hence, in the collateral situations below, the rotation is restricted to a CCSb rotation which can be fertilized at various levels. Further, it is supposed that the 10 acres of permanent pasture, for which $10 per acre cash rent is paid, can be used in any manner selected by the tenant. With lease restrictions of this type found on many farms, feeder cattle enterprises are possible only if hay is purchased; hogs must be produced in drylot. How do these leasing restrictions alter the optimum plan and the income for the tenant?

With the lease restrictions mentioned above, plans have been made out for four sets of collateral situations. Plans for the first set, L_{2-a} through L_{5-a}, are presented in table 17; dairy cows are limited to the 10 acres of pasture; hogs are limited to hog building space and corn is not purchased from off the farm. Plans for the second set, L_{2-b} through L_{5-b}, are presented in table 18. They are the same as those in the preceding table, except that hogs can compete with cattle for beef barn space. Plans for the third set, L_{2-c} through L_{5-c}, are presented in table 19 and are the same as for table 17, except that corn can be purchased from off the farm and hay can be purchased for dairy cows. Plans for the fourth set, L_{2-d} through L_{5-d}, are presented in table 20. They are the same as the situations in table 19, except that hogs can compete with beef and dairy for barn space. In all of these situations, the permanent pasture is used only for dairy cattle; hogs are produced in drylot. The pasture forage allows four dairy cows. Feeder cattle are allowed to come into the plans. However, hay for cattle feeding must be purchased since the rotation is restricted to the CCSb of the lease arrangement. In all of the situations for the four tables which follow, the available capital for livestock is each capital level minus the capital required for the rotation. As an example, the $5,000 level has only $1,970 left for livestock after $3,030 has been used for the CCSb rotation fertilized at the second level.

In the situations of table 17, dairy cows come into the plan before beef because of this reason: Cattle feeding is possible only if hay is purchased at the price of $17.40 per ton, whereas the limited dairy enterprise gets its entire forage supply from permament pasture rented at $10 per acre. However, pasture limits the number of dairy cows before capital does and funds remain, at the $5,000 level, for nine litters of hogs. In the situations of table 17, the maximum number of hogs is limited to 11 litters because of the space limitations. Hence, with $7,500 in capital, dairy and hogs are expanded to the respective limits of pasture and building space. Also, there is enough capital for 16 choice calves. The choice calves use capital more profitably than the other beef enterprises on drylot when: capital is scarce; hay must be purchased and the rotation produces only grain. Labor also becomes a limiting resource with capital at $10,000. Medium yearlings then come into the plan to allow the most effective use of labor. Since the capital-labor ratio is higher for medium yearlings than for choice calves or dairy cows, the farm plan must include medium yearlings if labor is limiting and profits are to be maximized. A poultry enterprise also comes into the plan when capital is at $10,000 because it allows a more effective use of funds. It is limited by building space.

In the situations of table 18, hogs are not restricted to hog building space. Hogs then outcompete choice calves for the use of corn and capital at the $7,500 level. (In table 17, hogs were limited to 11 litters, and 16 choice calves were included in the plan.) Addition of capital to $10,000, however, brings beef feeding enterprises into the farm plan in table 18. With beef all the labor in May and November is used. When labor is limiting, profit is greater with more medium yearlings and fewer choice calves (i.e., L_{4-b} has greater profits than L_{4-a}). Since poultry competes only for the use of capital, this enterprise enters the farm plan when other enterprises are limited by resources other than capital. Poultry again enters the plan up to the limits of feed and building space. In all situations of this study, poultry is unable to compete with other activities for the use of capital, except where relatively large amounts of capital are available and other enterprises are limited by feed supplies, labor or buildings.

In tables 19 and 20 where hay is purchased for dairy cows and pasture is used for grazing only, dairy does not come into the optimum plans. Regardless of the capital level, dairying cannot compete with feeder cattle in the use of limited capital for purchasing hay. Dairy came into the plan previously under the assumption that some of the pasture could be harvested as hay and used for winter forage.

In tables 19 and 20, off-farm purchases of corn are allowed with the purchase price arbitrarily set at 10 cents per bushel more than the market price to cover hauling and handling. In table 19, however, hogs are limited to 11 litters by building space. In Situation L_{2-c}, the remainder of the $5,000 is used most profitably by choice calves, which replace dairying, as compared to the same capital levels in tables 17 and 18. As capital is increased in table 19, the number of choice calves is increased until labor becomes a limiting resource. Again, medium yearlings then enter the farm plan to allow the most effective use of labor (choice calves come in first to allow the most profitable use of capital). Medium yearlings are added to the limits of building space. Poultry then comes into the plan up to the space limitations of the poultry house.

Under the set of situations in table 20 where the hog enterprise can compete with the beef enterprises for barn space, hogs use all the capital in the situations including $5,000 and $7,500 of capital. When $10,000 of capital is available, labor is more limiting than capital. The emphasis then becomes one of select-

TABLE 17. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS $L_{2\text{-}a}$ THROUGH $L_{5\text{-}a}$ WITH EXISTING LEASE RESTRICTIONS;* DAIRY LIMITED TO PASTURE, HOGS LIMITED TO HOG BUILDING SPACE, NO CORN PURCHASED FROM OFF THE FARM.

Situation	Capital level†	Net returns‡	Activities or enterprises in the farm plan	Limiting resources	Corn surplus
$L_{2\text{-}a}$	$5,000	$4,149	143 acres $CCSb_2$ 10 acres pasture 9 litters of hogs 4 dairy cows	Capital Land Pasture	1,897 bu.
$L_{3\text{-}a}$	$7,500	$4,703	143 acres $CCSb_2$ 10 acres pasture 11 litters of hogs 16 choice calves 4 dairy cows	Capital Land Pasture Hog building space	630 bu.
$L_{4\text{-}a}$	$10,000	$4,957	143 acres $CCSb_2$ 10 acres pasture 11 litters of hogs 23 choice calves 2 dairy cows 9 medium yearlings 100 hens	Capital Land May labor Hog building space Poultry building space Corn	none
$L_{5\text{-}a}$	Unlimiting ($11,074)§	$4,968	143 acres $CCSb_2$ 10 acres pasture 11 litters of hogs 15 choice calves 22 medium yearlings 3 dairy cows 100 hens	Land Corn May labor November labor Hog building space Poultry building space	none

* The lease restrictions specify 143 acres of CCSb and 10 acres of permanent pasture. The capital required for these crops is $3,030 in each situation; hence the capital available to livestock in each situation is the capital level minus $3,030. The net return in each situation is $3,400 net return from crops plus the net return from livestock.
† Capital above machinery investment (see discussion in text).
‡ Net returns before fixed costs of $1,379 are subtracted.
§ Amount of capital used for maximum profits with limiting resources indicated in column 5.

TABLE 18. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS $L_{2\text{-}b}$ THROUGH $L_{5\text{-}b}$ WITH EXISTING LEASE RESTRICTIONS;* DAIRY LIMITED TO PASTURE, HOGS NOT LIMITED TO HOG BUILDING, NO CORN PURCHASED FROM OFF THE FARM.

Situation	Capital level†	Net returns‡	Activities or enterprises in the farm plan	Limiting resources	Corn surplus
$L_{2\text{-}b}$	$5,000	$4,149	143 acres $CCSb_2$ 10 acres pasture 9 litters of hogs 4 dairy cows	Capital Land Pasture	1,897 bu.
$L_{3\text{-}b}$	$7,500	$4,873	143 acres $CCSb_2$ 10 acres pasture 24 litters of hogs 4 dairy cows 100 hens	Capital Land Pasture Corn	none
$L_{4\text{-}b}$	$10,000	$4,975	143 acres $CCSb_2$ 10 acres pasture 16 litters of hogs 9 choice calves 15 medium yearlings 4 dairy cows 100 hens	Land Pasture Corn May labor November labor Poultry building space	none
$L_{5\text{-}b}$	Unlimiting ($9,983)§	$4,975	143 acres $CCSb_2$ 10 acres pasture 16 litters of hogs 9 choice calves 15 medium yearlings 4 dairy cows 100 hens	Land Pasture Corn May labor November labor Poultry building space	none

* The lease restrictions specify 143 acres of CCSb and 10 acres of permanent pasture. The capital required for these crops is $3,030 in each situation; hence the capital available to livestock in each situation is the capital level minus $3,030. The net return in each situation is $3,400 net return from crops plus the net return from livestock.
† Capital above machinery investment (see discussion in text).
‡ Net returns before fixed costs of $1,379 are subtracted.
§ Amount of capital used for maximum profits with limiting resources indicated in column 5.

ing enterprises which give the greatest net return to labor. Since the ratio of returns per hour of labor is greater for medium yearlings than for hogs, the plan for $10,000 in capital includes fewer hogs than the plan for $7,500. When capital is not limiting, a small shift is made between choice and medium yearlings. However, the difference in profit is small.

The important comparison between tables 17 through 20 with table 10 is the effect of leasing restrictions on income to the tenant. With complete

TABLE 19. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS $L_{2\text{-}c}$ THROUGH $L_{5\text{-}c}$ WITH EXISTING LEASE RESTRICTIONS;* DAIRY USE PASTURE FOR GRAZING ONLY, HOGS LIMITED TO HOG BUILDING, CORN MAY BE PURCHASED FROM OFF THE FARM.

Situation	Capital level†	Net returns‡	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit
$L_{2\text{-}c}$	$5,000	$4,003	143 acres $CCSb_2$ 10 acres pasture 11 litters of hogs 4 choice calves	Capital Land Hog building space	+1,508 bu.
$L_{3\text{-}c}$	$7,500	$4,518	143 acres $CCSb_2$ 10 acres pasture 11 litters of hogs 22 choice calves	Capital Land Hog building space	+411 bu.
$L_{4\text{-}c}$	$10,000	$4,929	143 acres $CCSb_2$ 10 acres pasture 11 litters of hogs 34 choice calves 2 medium yearlings 100 hens	Capital Land Hog building space Poultry building space May labor	−370 bu.
$L_{5\text{-}c}$	Unlimiting ($11,700)§	$4,936	143 acres $CCSb_2$ 10 acres pasture 11 litters of hogs 27 choice calves 20 medium yearlings 100 hens	Land Hog building space Beef building space Poultry building space May labor	−510 bu.

* The lease restrictions specify 143 acres of CCSb and 10 acres of permanent pasture. The capital required for these crops is $3,030 in each situation; hence the capital available to livestock in each situation is the capital level minus $3,030. The net return in each situation is $3,400 net return from crops plus the net return from livestock.
† Capital above machinery investment (see discussion in text).
‡ Net returns before fixed costs of $1,379 are subtracted.
§ Amount of capital used for maximum profits with limiting resources indicated in column 5.

TABLE 20. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS $L_{2\text{-}d}$ THROUGH $L_{5\text{-}d}$ WITH EXISTING LEASE RESTRICTIONS;* DAIRY USE PASTURE FOR GRAZING ONLY, HOGS NOT LIMITED TO HOG BUILDING, CORN MAY BE PURCHASED FROM OFF THE FARM.

Situation	Capital level†	Net returns‡	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit
$L_{2\text{-}d}$	$5,000	$4,091	143 acres $CCSb_2$ 10 acres pasture 17 litters of hogs	Capital Land	+1,137 bu.
$L_{3\text{-}d}$	$7,500	$4,778	143 acres $CCSb_2$ 10 acres pasture 37 litters of hogs	Capital Land	−1,503 bu.
$L_{4\text{-}d}$	$10,000	$4,933	143 acres $CCSb_2$ 10 acres pasture 25 litters of hogs 12 choice calves 11 medium yearlings 100 hens	Capital Land Poultry building space May labor	−1,098 bu.
$L_{5\text{-}d}$	Unlimiting ($10,963)§	$4,937	143 acres $CCSb_2$ 10 acres pasture 25 litters of hogs 8 choice calves 21 medium yearlings 100 hens	Land Beef building space Poultry building space May labor	−1,177 bu.

* The lease restrictions specify 143 acres of CCSb and 10 acres of permanent pasture. The capital required for these crops is $3,030 in each situation; hence the capital available to livestock in each situation is the capital level minus $3,030. The net return in each situation is $3,400 net return from crops plus the net return from livestock.
† Capital above machinery investment (see discussion in text).
‡ Net returns before fixed costs of $1,379 are subtracted.
§ Amount of capital used for maximum profits with limiting resources indicated in column 5.

freedom to choose the cropping plan, and hence to adopt the livestock program to it, profits are highest in table 10 for parallel capital levels. The restriction of the lease which allows only a CCSb rotation in tables 17 through 20 lowers profit by the smallest amount when capital is most limited. For example, when capital is at $5,000, returns in table 17 through 20 are never more than $253 less than in table 10. This similarity holds true because a CCSb rotation is most profitable for a tenant with very limited capital, regardless of the lease conditions (i.e., under S_2 in table 10, 144 acres are devoted to a CCSb rotation and only 9 acres are devoted to a meadow rotation which furnishes pasture for hogs). However, as the tenant's capital increases, the lease restriction causes a much greater sacrifice in profits. The larger sacrifice holds true since, at higher capital levels, rotations cannot be used for the forage-consuming livestock enterprises which make the best use of limited labor and building space. With unlimiting capital,

the income in tables 17 through 20 averages about $1,500 less than the income in table 10. The optimum plans at higher capital levels in table 10, without restrictions on the lease, all include rotations with meadow.

Hence, to increase income to beginning farmers on rented farms, important progress can be made by educating the landlord to allow optimum rotations. Landlords under crop-share lease commonly limit forage acreage to maximize their own returns. However, it may be possible for the tenant to pay an increase in cash rent to make up for the loss in landlord income as lease restrictions are removed. Thus a more favorable over-all plan results for the tenant. This aspect of leasing is being presented in a separate report.

LABOR CONSIDERATIONS (TABLES 21 AND 22)

Plans for collateral situations where labor is not a limiting resource are presented in table 21. Only one capital level, $10,000, is considered for these situations. Hence, profits of Situation $S_{4\text{-}w}$ can be compared with those of Situation S_4 in table 10 where labor is limited; profits of $F_{4\text{-}w}$ can be compared with those of F_4 in table 11; profits from $L_{4\text{-}a\text{-}w}$ can be compared with those of $L_{4\text{-}a}$ in table 17 and those for $L_{4\text{-}c\text{-}w}$ can be compared with those of $L_{4\text{-}c}$ in table 19. Most beginning farmers limit their farm plan to enterprises and sizes which can be handled with their own labor, plus some supplemental labor by the housewife. Hence, the collateral plans shown below indicate how profits might be increased by use of hired labor. It is true, of course, that not all of these plans would provide enough work for a year-round hired man. Too, many young renters do not have housing for a hired man. Finally, it should be remembered that this analysis of the productivity of labor is made with capital fixed at $10,000. With a greater amount of capital, added labor might have a productivity greater than that shown later.

With labor restrictions removed, land and capital become the first limiting resources. However, as more capital is added, building space becomes limitational. Situation $S_{4\text{-}w}$ serves as an example where the plan is limited mainly by capital. Since the CCSb rotation and the hog enterprise use capital more profitably under $10,000 in capital, they are included in the most profitable farm plan. The CSbCOM rotation also is included to provide pasture for the spring hogs; it provides pasture more economically than any other rotation at this capital level. In comparison to Situation S_4 in table 10, hogs replace deferred-fed calves under $S_{4\text{-}w}$ because of the large amount of labor available for the latter situation. With unlimiting labor, hogs give greater returns on capital than cattle.

In Situation $F_{4\text{-}w}$, capital is the only limiting resource and hogs again replace the 13 deferred-fed calves which appeared in Situation F_4 (table 11). The CCSb acreage is increased and CCOM acres are decreased under the greater amount of labor because less forage is required to support the additional hogs than was required for the 13 calves which the hogs replaced. As shown previously, a CCOM rotation supplies forage more economically than any other rotation when the third or highest level of fertilization is omitted as is the case in F situations.

In Situation $L_{4\text{-}a\text{-}w}$, where labor restrictions are removed but the leasing restrictions of table 17 remain, dairying comes into the farm plan up to the extent of the available forage. Situation $L_{4\text{-}a\text{-}w}$ in table 21 has four cows, whereas Situation $L_{4\text{-}a}$ in table 17 has only two cows. The factor of unlimiting labor also causes choice calves to replace medium yearlings; choice calves use capital and corn more profitably than medium yearlings when the labor supply is not limited. The number of hogs in $L_{4\text{-}a\text{-}w}$ are decreased by two litters when compared to Situation $L_{4\text{-}a}$. This is due to the manner in which choice calves compete with hogs for capital at the $10,000 level, when there are no labor restrictions.

The restrictions of Situation $L_{4\text{-}c}$ in table 19 allow

TABLE 21. OPTIMUM FARM PLANS FOR COLLATERAL SITUATIONS $S_{4\text{-}w}$, $F_{4\text{-}w}$, $L_{4\text{-}a\text{-}w}$ AND $L_{4\text{-}c\text{-}w}$ WITH UNLIMITED LABOR. ALL OTHER ASSUMPTIONS ARE THE SAME AS IN THE MAIN SITUATIONS S_1 THROUGH S_5.

Situation	Capital level*	Net returns†	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit
$S_{4\text{-}w}$	$10,000	$6,019	120 acres $CCSb_2$ 33 acres $CSbCOM_3$ 54 litters of hogs	Capital Land	−3,491 bu.
$F_{4\text{-}w}$	$10,000	$6,011	123 acres $CCSb_2$ 29 acres $CCOM_2$ 54 litters of hogs	Capital Land	−3,556 bu.
$L_{4\text{-}a\text{-}w}$	$10,000	$5,129	143 acres $CCSb_2$ 10 acres pasture 9 litters of hogs 32 choice calves 4 dairy cows 100 hens	Capital Land Corn Pasture	none
$L_{4\text{-}c\text{-}w}$	$10,000	$4,968	143 acres $CCSb_2$ 10 acres pasture 11 litters of hogs 22 choice calves 11 dairy cows	Capital Land Pasture Hog building space	−63 bu.

* Capital above machinery investment (see discussion in text).
† Net returns before fixed costs of $1,379 are subtracted.

TABLE 22. ANALYSIS OF EXTRA LABOR USED IN COLLATERAL SITUATIONS $S_{4\text{-}w}$, $F_{4\text{-}w}$, $L_{4\text{-}a\text{-}w}$ AND $L_{4\text{-}c\text{-}w}$.

Situation	Months requiring extra labor	Extra man-hours per month	Total of extra man-hours	Returns per hour for extra labor
$S_{4\text{-}w}$	April	86	86	$2.31
$F_{4\text{-}w}$	April May	81 21	102	$2.08
$L_{4\text{-}a\text{-}w}$	May	18	18	$9.52
$L_{4\text{-}c\text{-}w}$	May October November	66 34 42	142	$0.27

hay buying to provide winter forage for cows. Therefore, when labor limitations are removed (Situation $L_{4\text{-}c\text{-}w}$ in table 21), cows come into the plan up to the extent of grazing available from the 10 acres of permanent pasture. The remaining capital is most profitably used by allowing enough hogs to use all of the hog building space, then investing the remainder in 22 choice calves. The significant change in Situation $L_{4\text{-}c\text{-}w}$ in table 21, as compared to Situation $L_{4\text{-}c}$ in table 19, is that unlimiting labor caused the 11 cows in $L_{4\text{-}c\text{-}w}$ to replace two medium yearlings and 12 choice calves from $L_{4\text{-}c}$. Hence, with no limitations on labor, dairy cows use capital more profitably than medium yearlings or choice calves (i.e., with the forage restrictions used in the above situations).

Table 22 shows the added labor required for the situations in table 21, as compared to the parallel situations where labor was limited to the amounts specified at the outset. The added amount of labor to carry the larger livestock programs of table 21, as compared to the same situations with limited labor, is small. It might be obtained either from the use of day or seasonal labor, where it is available in an amount and quantity necessary, or from longer hours by the operator and his wife. The return per hour is as high at $9.52 under Situation $L_{4\text{-}a\text{-}w}$; it is as low as 27 cents for $L_{4\text{-}c\text{-}w}$ where the livestock is limited mainly to feed from a grain rotation specified by the lease. Lifting of leasing restrictions would allow returns from use of added labor to increase from 27 cents to at least the $2.31 or the $2.08 of situations $S_{4\text{-}w}$ and $F_{4\text{-}w}$. The operator would be unlikely to expand livestock to earn as little as the 27 cents under Situation $L_{4\text{-}c\text{-}w}$ of table 21.

ALTERNATIVE CONSIDERATIONS (TABLE 23)

We now present plans which are alternatives for certain of the previous situations when capital is at a $10,000 level. These alternative plans are described to show that, if sufficient capital is available, several plans may give similar returns. However, the same possibility of selecting from several plans with nearly equal profits does not exist for low capital levels.

For the alternative plans, prices and resources are exactly the same as for optimum plans under parallel situations. The only difference is that the alternative plans do not give maximum profits, but are organizations for the given price-resource situations which are nearly "profit-maximum" plans. (In terms of the simplex method of linear programming, they are plans where some figures on the Z_j-C_j row are still negative, but the profit is only slightly less than for the final iteration where all such quantities are zero.)[8] Hence, plan S'_4 in table 23 is an alternative plan for S_4 in table 10; F'_4 in table 23 is an alternative plan for F_4 in table 11, etc. The loss in profits under the alternative plans in table 23 is less than $50 for each plan as compared to the optimum plan for the same situation. For example, the net return for Situation S_4 in table 10 is $5,820, and the net return for its alternative plan, S'_4 in table 23, is $5,801 or a difference of $19.

The livestock activities for S'_4 in table 23 are the same as those for S_4 in table 10. However, CCOM supplies forage for the livestock in S'_4, whereas CSbCOM furnishes the forage in S_4. Since the CCOM rotation has a larger percentage of meadow than the CSbCOM rotation, less acres of CCOM are required to support the same amount of livestock in terms of hay. When only 59 acres (Situation S'_4) are needed for forage purposes (instead of 75 acres in Situation S_4), an additional 16 acres are seeded into the CCSb rotation. Thus, the alternative plan includes 94 acres of CCSb rather than 78 acres as in the optimum plan, which also give a difference in the corn deficit for the two plans. The net result is that profits are decreased by $19 for the S'_4 plan when CCOM supplies the forage for livestock instead of CSbCOM.

In Situation F'_4 in table 23, the same livestock activities are shown as in Situation F_4 in table 11. Again, the only change in farm organization is the kind of rotation used to furnish forage for the livestock. Since the F situations do not allow the third level of fertilization to come into the plan, the CCOM rotation furnishes hay for livestock more profitably than does the CSbCOM rotation. Hence, the alternative plan for F_4 substitutes CSbCOM for CCOM. When 55 acres of $CSbCOM_2$ and 21 acres of $CCOM_2$ are used (in Situation F'_4) instead of 65 acres of $CCOM_2$ (in Situation F_4), profits are decreased by $44. The acres in CCSb are changed according to the number of acres used for forage purposes.

The remaining situations in table 23 illustrate variations in farm organization which are similar to those cited above. When beef prices are high (Situation $S_{4\text{-}HB}$ in table 16), the optimum plan includes 49 deferred-fed calves, 127 acres of $CCOM_3$ and 26 acres of $CCOM_2$. An alternative plan (Situation

[8] Heady. Simplified presentation and logical aspects of linear programming technique. op. cit.

TABLE 23. ALTERNATIVE FARM PLANS FOR SITUATIONS S'_4, F'_4, $S'_{4\text{-LH}}$ AND $F'_{4\text{-u}}$.*

Situation	Capital level†	Net returns‡	Activities or enterprises in the farm plan	Limiting resources	Corn surplus or deficit
S'_4	$10,000	$5,801	94 acres $CCSb_2$ 59 acres $CCOM_3$ 40 litters of hogs 13 calves (deferred-fed)	Capital Land April labor	−2,402 bu.
F'_4	$10,000	$5,755	77 acres $CCSb_2$ 55 acres $CSbCOM_2$ 21 acres $CCOM_2$ 40 litters of hogs 13 calves (deferred-fed)	Capital Land April labor	−2,652 bu.
$S'_{4\text{-HB}}$	$10,000	$6,555	141 acres $CCOM_3$ 12 acres $CSbCOM_3$ 49 calves (deferred-fed)	Capital Land	+690 bu.
$S'_{4\text{-LH}}$	$10,000	$5,206	54 acres $CCOM_2$ 99 acres $CSbCOM_3$ 42 calves (deferred-fed)	Capital Land	+668 bu.
$F'_{4\text{-u}}$	$10,000	$4,636	12 acres corn 27 acres meadow 81 acres $CCSb_2$ 33 acres $CCOM_2$ 10 dairy cows 200 hens 13 litters of hogs 11 calves (pasture-fed)	Capital Land November labor	+331 bu.

* These plans are not optimum in respect to profit but net return is not more than $50 less as compared to net return in the optimum plans for these situations.
† Capital above machinery investment (see discussion in text).
‡ Net returns before fixed costs of $1,379 are subtracted.

$S'_{4\text{-HB}}$ in table 23) has the same livestock. However, 12 acres of $CSbCOM_3$ and 141 acres of $CCOM_3$ make up the total acreage. The difference in net return is $5. Situation $S'_{4\text{-LH}}$ in table 23 shows a decrease in profits of $9, as compared to Situation $S_{4\text{-LH}}$ in table 16. The alternative plan ($S'_{4\text{-LH}}$) in this case, has seven calves less than the optimum plan ($S_{4\text{-LH}}$). Also, the alternative plan, as compared to the optimum plan, has more acres in the CSbCOM rotation and less acres in the CCOM rotation. A comparison of $F'_{4\text{-u}}$ with $F_{4\text{-u}}$ illustrates, as before, that CCOM and CSbCOM are nearly substitutable for one another. In other words, 8 acres of $CCOM_2$ are substituted for the 9 acres of $CSbCOM_2$ in the $F_{4\text{-u}}$ plan, and the net return is decreased by only $4 as shown in Situation $F'_{4\text{-u}}$. The livestock activities remain the same in both plans except that hogs are decreased by one litter in the alternative plan.

All of the alternative plans considered in this section have the same limiting resources as their respective optimum plans. The main difference in any of the alternative plans as compared to the optimum plans is the change from a CCOM rotation to a CSbCOM rotation or vice versa. A further analysis can be made for each comparison of plans by totaling the number of acres for each crop. For example, Situation S_4 in table 10 has the same amount of acres in oats and meadow as Situation S'_4 in table 23. The optimum plan (S_4) has 82 acres of corn and 41 acres of soybeans, whereas the alternative plan (S'_4) has about 94 acres of corn and 32 acres of soybeans. Therefore, the difference in net return between the two plans is attributed to the proportion of acres in corn and soybeans. (Similar crop comparisons can be made for all of the situations in this study as well as for the alternative situations above.)

The alternative plans in this section illustrate the degree of flexibility which the farmer may use in organizing his unit if he has a moderate or large amount of capital. He may well have preference for one rotation over another if the difference in net return is less than $50 when the alternative rather than the optimum is used. However, at low capital levels, a similar range of alternatives which give similar profit levels does not exist. The main alternatives relate to varying levels of fertilization, with the rotation restricted to CCSb and no livestock, rather than a shift to meadow rotations and livestock.

TENANT PROFITS

The optimum plans outlined on previous pages indicate that a single standard plan of land use, cropping practices or livestock organization cannot be recommended to all farmers. If profit maximization is the criterion of selection, plans must differ to meet the unique resource situations of the individual farm. Differences in supplies of capital, labor, buildings and machinery and in leasing arrangements are as important as differences in soils in determining the optimum farm plan.

It should be remembered the optimum plans outlined in this study are in terms of profit maximization for a beginning tenant farmer who possesses average managerial abilities. The plans specified are not presented as universal recommendations to all farmers and land owners on the particular soil type. The optimum plan for an owner-operator or a landlord again will differ from those outlined for a beginning farmer. Also, varying levels of management for each enterprise is an important factor in determining the optimum farm plan for the individual farmer.