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Specialization and Pork Production Methods In Relation to Over-All Farm Resource Use and Integration

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Specialization and Pork Production Methods In Relation to Over-All Farm Resource Use and Integration[1]

BY EARL O. HEADY, JAMES R. GIBBONS AND GEORGE IRWIN

Rapid changes have been taking place in the technology of agriculture. These technical changes have important implications for the structure of farming. They affect the size and degree of specialization of enterprises and farms. Some also alter the comparative advantage of different producing regions and the concentration of output in particular areas. An outstanding example in this respect has been broiler production. In contrast to the prewar pattern, broiler output is now concentrated particularly on farms with highly specialized enterprises. Also, the center of production has shifted from the Corn Belt states to the Southeast.

Are similar trends likely to occur in pork production? The technology of producing pork has changed greatly in the last decade. One of the more recent innovations has been the development of more specialized hog systems built on multiple litters throughout the year. Historically, the common Corn Belt systems have included either spring litters alone or spring and fall litters in combination. The newer systems, however, include farrowing as frequently as four and six times per year. If the latter systems come to predominate on Corn Belt farms, the nation's pork output could be produced on many fewer farms. In general, these farms would specialize more in pork production than has held true in the past, although they wouldn't necessarily produce only hogs.

This study was initiated to examine the profitability of the more specialized pork production methods within the framework of maximum returns to the farm as a whole. The purpose of the analysis is to determine whether 4-litter and 6-litter systems have more or less advantage than the systems conventionally used on Iowa farms. Answers to questions such as this, however, cannot be obtained simply by comparing different hog systems. It is necessary to examine pork production methods relative to the over-all organization of the farm, because enterprises compete for the use of scarce supplies of labor, land and capital.

Analysis is made of optimum, or profit-maximizing, organization of farms on two soil types and with different amounts of capital and managerial skill. This procedure is followed because the most profitable pork production method may well differ, depending on the quantity and quality of resources available to the farmer. The method of analysis allows the more specialized 4-litter and 6-litter hog systems to be considered as investment alternatives, along with the more conventional pork production methods and crop and livestock enterprises. Since the study is one of over-all farm organization or resource use, plans which maximize profits at different capital levels are computed. These plans indicate the various crop and livestock enterprises and investment alternatives which give greatest returns for particular resource situations. Hence, they indicate the conditions under which the specialized hog systems do or do not have advantage under specified Iowa farming conditions.

OBJECTIVES

The purpose of this study is to examine the relative advantage of various hog systems, including methods under contract farming, on 160- and 240-acre farms in two soil areas. Specific objectives are: (1) to determine whether, and by how much, income might be increased by use of the more intensive multiple-farrowing hog production systems as compared with conventional systems; (2) to determine which hog production systems are best adapted to farms with different types of soils, various amounts of capital and alternative managerial practices; (3) to estimate the effect of different pork production systems on optimum farm resource use and income; and (4) to estimate the possible effect on farming methods if increased capital is made available through vertical integration or contract farming.

FARM SITUATIONS STUDIED

This study considers farms typical of Iowa with respect to general crop and livestock production. It does not refer to units which produce hogs only as a specialized activity. Other studies have shown that there is not a "standard plan" which is equally adapted to all farms. The best plan or production method has been found to vary with type and amount of capital, type of land, labor availability and employment, level of management and size of farm. Hence, the analysis which follows considers farms in two somewhat contrasting soil areas which represent

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[1] Project 1328 of the Iowa Agricultural and Home Economics Experiment Station.

different sizes, amounts of labor, capital resources and levels of management.

RESOURCE CHARACTERISTICS AND SUPPLIES

LAND RESTRICTIONS

The analysis was made for 160-acre and 240-acre owner-operated farms in two contrasting soil areas: Clarion-Webster, the level soils of north-central Iowa, and Shelby-Grundy-Haig, the rolling and hilly soils of southern Iowa where a relatively large proportion of the land is in permanent pasture.[2] For purposes of this study, it is assumed that the same cropping systems can be used on the Clarion and Webster soils. The two types of soils, therefore, are not differentiated for the analysis which follows. Because of the differences in productivity and erosion hazards of soils in the Shelby-Grundy-Haig series, however, three groups which are considered to be different from the standpoint of cropping opportunities are distinguished: class I, which includes mainly Haig soil with slope of 0-1 percent; class II, which includes mostly Grundy silt loam of more than 1 percent but less than 5 percent slope; and class III, which includes all land of more than 5 percent slope and is mostly Shelby. The stratification of the two soil situations is shown in table 1.

TABLE 1. CLASSIFICATION OF SOILS FOR PROGRAMMING ANALYSIS AND SPECIFICATIONS OF CROPPING SYSTEMS.

Use	Clarion-Webster (percent)	Shelby-Grundy-Haig (percent)
Cultivated	93.9	69.6
Class I	......	10.1
Class II	......	42.9
Class III	......	16.6
Permanent pasture	3.3	27.2
Woodland and farmstead	2.8	3.2

MANAGEMENT RESTRICTIONS

Not only does land differ among geographic locations, but also management differs among farms of the same soil type. Hence, to determine how management skill might affect the best pork production system, three levels of management have been examined for each of the soil situations studied. These three levels, specified as A, B and C, are represented by the different technical coefficients or input-output ratios used for crops and livestock. Hence, they denote different production practices.

The coefficients selected to represent A, B and C management levels were not intended to typify any particular level of management skill among the population of farmers. Production techniques represented by A- level management conditions, however, approach those used under experimental conditions. Those represented by B conditions approach management found on the better commercial farms with large hog enterprises while those represented by C conditions approach management found on typical or average farms with commercial hog enterprises.

BUILDING RESTRICTIONS

Farms in the Clarion-Webster area are assumed to have 15 units of specialized hog buildings and 18 units of space that can be used for cattle or hogs. Farms in the Shelby-Grundy-Haig area are assumed to have 18 units which can be used for either class of livestock. A unit is the space (about 50 square feet) which is required for one sow and litter or for one beef cow and calf. Building space may be purchased in either case for $85 per unit. Size of enterprise is initially limited to buildings available on the farm. A building purchase-alternative allows livestock systems to expand beyond this limitation, but the capital requirement is increased by the cost of new buildings.

Enterprise size for beef cows with calves fed out, steer calves drylot-fed and steer calves pasture-fed was limited by the buildings available for the farm situations specified. Thus, maximum size is: 30 head of beef cows, calves both sold out and fed out, and 45 head of steer calves pasture-fed (see table 8). Size of the hog enterprise is *initially* limited to buildings available on the farm as follows: for the 1- and 2-litter systems, only the available building space may be used; for the 4-litter system, shelter for the nursing-growing-finishing period can be converted from available buildings, and the space previously mentioned may be used; for the 6-litter system, shelter needed for the growing-fattening period can be converted from available buildings, and the space previously mentioned can be used. Capital initially is provided for other buildings needed by the 4- and 6-litter systems. The building-purchase alternative allows expansion beyond the space or building limitations already mentioned.

CAPITAL RESTRICTIONS

Since availability of funds may affect the enterprise and resource combination for the optimum farm organization, plans have been computed assuming several different supplies of operating capital. Operating capital includes funds which can be used on any of the enterprises described later. The lower capital level may be representative of conditions facing young farmers. The higher capital levels more nearly represent those of established and experienced operators. Aside from harvesting machinery for corn and soybeans, sufficient farm machinery to crop each farm is assumed. It is assumed that specialized livestock equipment used must be purchased.

LABOR RESTRICTIONS

Separate labor restrictions for farm organizations are used for the following groupings: December-January-February, March-April, May-June, July-August and September-October-November. Labor supplies on 160-acre farms for these groupings are summarized in table 2. In addition to family and operator labor, hourly labor can be hired for $1.10 per hour during May and June for all enterprises.

It was assumed that a full-time hired man was available on 240-acre farms. Accordingly, the labor

[2] For soil type descriptions, see: Simonson, R. W., Riecken, F. F. and Smith, C. D. Understanding Iowa soils. William C. Brown Co., Dubuque, Iowa. 1952. pp. 38-43, 82-89.

TABLE 2. HOURS OF FAMILY PLUS OPERATOR LABOR AVAILABLE IN SPECIFIC PERIODS AS DIRECT LABOR INPUTS ON 160-ACRE FARMS.

Period	Working days	Hours/day	Total hours
Dec.-Jan.-Feb.	78	8	624
March-April	52	8.5	552
May-June	52	10	520
July-Aug.	52	13	676
Sept.-Oct.-Nov.	78	8.5	663

available would be twice that shown in table 2. The hourly labor-hiring activity is not included for 240-acre farms.

MISCELLANEOUS RESTRICTIONS AND COEFFICIENTS

Labor requirements are those demanded directly for the enterprise or rotation. Labor and other costs of harvesting hay are charged to the cattle which consume it. Meadow is considered to be harvested for hay only if it is to be fed in drylot. Other rotation forage and unused permanent pasture is grazed or left idle. Hay cannot be bought or sold. Oats and corn can be purchased, sold or fed to livestock. While specialized livestock equipment necessary for a particular plan or farming system must be purchased, it is assumed that hay and grain storage facilities are adequate for the size of crop enterprises allowed by the various resource restrictions outlined in this section.

Capital coefficients for 2-litter systems under A management and B management include the cost of 15 and 10 square feet, respectively, of concrete floor per fall pig weaned. Similarly, for A and B management, the 4-litter system, capital coefficients include permanent farrowing facilities, sow shelters and concrete feeding floors, while the 6-litter system includes new permanent farrowing facilities, sow shelters, nursing shed and feeding floors. These inputs are not entered as discrete restrictions because purchase at cost is allowed.

Capital inputs or requirements for cattle feeding enterprises include the cost of 32 and 20 square feet, respectively, of concrete flooring per head fattened by type A and C managers.

PRICES USED

Prices used in this study are summarized in table 3. They represent long-run price ratios between commodities, with adjustment to a price level relative to corn at \$1.20 per bushel. The method used in adjusting these prices to obtain their long-run relationship to each other is as follows: The average product price over a complete "price cycle"[8] is divided by the average corn price over the same period; this quotient is then multiplied by \$1.20. The first step guarantees that the historic price relationships between commodities are maintained. The second step adjusts all prices to the \$1.20-per-bushel corn price level. As long as these relationships continue, the farm plan which maximizes profit will be the same, regardless of the absolute price level. Of course, the amount of profit will vary with the price level.

Cattle and hogs prices used for farms with A and C management differ equally from prices used for B

[8] The price cycle periods used were 1927-57 for cattle, 1951-57 for hogs and 1953-57 for grains.

TABLE 3. AVERAGE ADJUSTED INPUT-OUTPUT PRICES ASSUMED FOR THIS STUDY.[a]

Item	Unit	Date bought or sold		Price	
Seed (Iowa prices):					
Alfalfa	lb.	Buy March 15		\$ 0.50	
Smooth bromegrass	lb.	Buy March 15		0.51	
Oats	bu.	Buy March 15		1.60	
Corn	bu.	Buy March 15		11.50	
Soybeans	bu.	Buy April 15		3.10	
Feed (Iowa prices):					
Cattle supplement	cwt.	Buy July 1		4.75	
Hog supplement[b]	cwt.	Buy July 1		6.50	
Fertilizer (U.S. prices):					
Nitrogen	lb.	Buy April 15		0.13	
Phosphorus	lb.	Buy April 15		0.09	
Potassium	lb.	Buy April 15		0.05	
Crops (Iowa prices):					
Corn equivalent	bu.	Sell yearly average		1.20	
Soybeans	bu.	Sell yearly average		2.29	
				Barrows gilts	Sows
Hogs (interior Iowa prices)[c]	cwt.	Sell Jan.		\$15.74	\$13.66
		Sell Feb.		16.16	14.05
		Sell March		16.17	14.20
		Sell April		16.87	14.93
		Sell May		17.58	15.17
		Sell June		17.93	14.91
		Sell July		17.84	14.62
		Sell Aug.		17.84	15.01
		Sell Sept.		16.70	14.58
		Sell Oct.		15.22	13.60
		Sell Nov.		14.25	12.81
		Sell Dec.		14.86	12.98
Cattle (Omaha prices):[d]		Buy	Sell	Buy	Sell
Drylot calves		Oct.	Sept.	\$20.52	\$22.28
Pasture calves		Oct.	Oct.	20.52	22.13
Long-fed yearlings		Oct.	July	18.89	21.73
Short-fed yearlings		Oct.	March	18.89	20.52
Short-fed yearlings		April	Sept.	19.31	22.28
Beef cow		--	Year	--	14.85
Beef calf		--	Oct.	--	20.52

[a] Additional detail on method of deriving prices may be obtained from: Irwin, G. D. Effects of pork production techniques on optimum farm resource use. Unpublished M.S. thesis. Iowa State University Library, Ames, Iowa. 1959.
[b] Composite price of 10 percent sow supplement, 3 percent prestarter, 12 percent starter, 30 percent grower, 45 percent hog supplement.
[c] Listed hog prices are for farms with B management. Add \$0.40 per hundredweight for farms with A management; subtract \$0.40 per hundredweight for farms with C management.
[d] Listed cattle prices are for farms with B management. Add \$0.99 per hundredweight for farms with A management; subtract \$0.99 per hundredweight for farms with C management.

management. For example, the average adjusted price for choice 900- to 1,100-pound slaughter cattle in September is \$22.28 per hundred pounds, and the price range assumed was \$21.29 to \$23.27. Hence, the prices used for choice 900- to 1,100- pound slaughter cattle in September are \$23.27 for type A management, \$22.28 for B management and \$21.29 for C management. This same relative margin differential among management levels was used for all cattle prices. A similar procedure was used in computing hog price differentials, with the difference being \$0.40 per hundredweight between management levels. The \$0.40 variation reflects variation in the ability of A, B and C managers to market effectively.

ENTERPRISES

The basic enterprises considered in this study include eight rotations with two levels of fertilization for each two beef-cow systems, four feeder cattle systems and eight hog systems. All enterprises considered compete with each other for use of the limited resources.

CROP ENTERPRISES

The crop rotations which can be used vary with the land class. Rotations considered for farms on Clarion-Webster soils include corn-corn-oats-meadow (CCOM), corn-soybeans-corn-oats-meadow (CSbCOM) and corn-

corn-soybeans (CCSb). These rotations are also allowed for class I soil in the Shelby-Grundy-Haig area. For class II soils of the Shelby-Grundy-Haig complex, rotations allowed are corn-corn-oats-meadow (CCOM), corn-soybeans-corn-oats-meadow (CSbCOM), corn-corn-oats-meadow-meadow (CCOMM), and corn-oats-meadow (COM); for class III soils, the rotations allowed are corn-oats-meadow (COM), corn-oats-meadow-meadow (COMM) and corn-corn-oats-meadow-meadow (CCOMM).

Two levels of commercial fertilization are considered for each rotation: an intermediate and a high level for A management denoted by the subscripts 1 and 2, respectively, and a high level and no fertilizer for B and C management, denoted by the subscripts 2 and 0, respectively. The intermediate level for A management (1) is the same as the high level (2) for B and C management. A combination of a rotation and fertilization level is called a crop activity. Resource requirements for the various cropping systems are shown in tables 4, 5, 6 and 7.[4]

Market value minus variable cost is the net revenue shown in these tables for each of the activities. To determine net income from the revenue figure, fixed costs which have been estimated for the 160-acre and 240-acre owner-operated farms must be deducted.[5] However, fixed costs do not affect the selection of the maximum profit plan. Fixed costs for the 240-acre farm are increased over the fixed costs on the 160-acre farm by the cost of one year-around hired man and the fixed cost of larger equipment needed for the 240-acre farm.

LIVESTOCK ENTERPRISES

Resource requirements for livestock units are specified in table 8. As mentioned earlier, the three levels of management or technical skill[6] are represented by variations in feeding efficiency, selling dates and prices, practices used and amount invested in equipment and facilities. Thus, the effect of the three management levels is reflected in the basic input-output data used. In the main part of the analysis, the 6-litter hog system is not considered for farms with B management, and neither the 4- nor 6-litter hog systems are considered for C-managed farms. The more specialized enterprises are assumed to be inconsistent with the management levels used in these two situations. As a special examination of the possibility of the management being provided by contractual service, however, a brief analysis is made later of the

[4] Crop yields and fertilization rates are obtained from: Shrader, W. D., Schaller, F. W., Pesek, J. T., Slusher, D. F. and Riecken, F. F. Estimated crop yields on Iowa soils. Iowa Agr. and Home Econ. Exp. Sta. and Iowa Coop. Ext. Serv. Spec. Rpt. 25. April 1960.

[5] Details of fixed cost estimation are explained in: Irwin, G. D. Effects of pork production techniques on optimum farm resource use. Unpublished M.S. thesis. Iowa State University Library, Ames, Iowa. 1959.

[6] These levels are represented by management levels A, B and C

TABLE 4. RESOURCE REQUIREMENTS, NET REVENUE AND PHYSICAL OUTPUT PER ACRE OF SELECTED CROPPING ACTIVITIES FOR THREE MANAGEMENT LEVELS ON CLARION-WEBSTER ASSOCIATION SOILS.

Management level	Item	CCOM 0 or 1[a]	CCOM 2	CSbCOM 0 or 1[a]	CSbCOM 2	CCSb 0 or 1[a]	CCSb 2
A	Labor (man-hours)	4.48	4.48	4.85	4.85	7.06	7.06
	Operating capital[b] ($)	11.53	14.50	11.09	13.73	14.44	19.27
	Net revenue[c] ($)	36.40	39.30	40.55	42.57	53.26	56.57
	Feed grain produced (bu.)	39.55	44.38	31.94	35.10	40.77	46.67
	Hay produced (tons)	0.75	0.85	0.60	0.68	0.00	0.00
B	Labor (man-hours)	4.30	4.32	4.44	4.62	6.81	6.81
	Operating capital[b] ($)	7.48	13.47	7.56	12.91	8.55	17.38
	Net revenue[c] ($)	32.05	36.02	34.81	38.07	43.70	53.94
	Feed grain produced (bu.)	32.62	40.81	26.45	32.05	30.50	44.17
	Hay produced (tons)	0.58	0.68	0.46	0.56	0.00	0.00
C	Labor (man-hours)	4.21	4.23	4.44	4.52	6.91	7.01
	Operating capital[b] ($)	7.12	13.08	7.21	12.54	7.83	16.65
	Net revenue[c] ($)	29.84	32.10	31.97	33.11	41.43	50.14
	Feed grain produced (bu.)	30.50	37.25	24.40	29.00	28.33	41.67
	Hay produced (tons)	0.45	0.50	0.36	0.44	0.00	0.00

[a] Subscript number (0) on rotation symbol means no fertilization; it applies to farm situations with B and C management. Subscript (1) refers to intermediate fertilization rate used by operators at A management level. Subscript (2) refers to high rate of fertilization for all three management situations; however, (2) represents a higher rate of fertilization at A management level than at other management levels.
[b] Operating capital requirements include funds required for production cost, such as spraying, shelling, seed and fertilizer.
[c] Net revenue is market value minus variable costs.

TABLE 5. RESOURCE REQUIREMENTS, NET REVENUE AND PHYSICAL OUTPUT PER ACRE OF SELECTED CROPPING ACTIVITIES FOR THREE MANAGEMENT LEVELS ON SHELBY-GRUNDY-HAIG ASSOCIATION SOILS, CLASS I SOIL.[a]

Management level	Item	CCSb 0 or 1[b]	CCSb 2	CCOM 0 or 1[b]	CCOM 2	CSbCOM 0 or 1[b]	CSbCOM 2
A	Labor (man-hours)	7.06	7.06	4.48	4.48	4.85	4.85
	Operating capital[c] ($)	13.59	17.27	10.81	13.13	10.34	12.30
	Net revenue[d] ($)	45.26	49.77	29.88	31.09	34.57	35.64
	Feed grain produced (bu.)	33.40	39.33	33.59	36.50	26.79	29.00
	Hay produced (tons)	0.00	0.00	0.58	0.65	0.46	0.52
B	Labor (man-hours)	6.81	6.91	4.30	4.37	4.54	4.62
	Operating capital[c] ($)	8.40	15.85	7.38	12.14	7.48	11.49
	Net revenue[d] ($)	35.89	44.90	26.32	28.52	30.24	32.82
	Feed grain produced (bu.)	24.50	36.00	27.81	33.56	22.25	26.75
	Hay produced (tons)	0.00	0.00	0.52	0.61	0.42	0.49
C	Labor (man-hours)	6.91	7.01	4.39	4.46	4.54	4.62
	Operating capital[c] ($)	7.35	14.31	7.03	11.76	7.14	11.13
	Net revenue[d] ($)	43.42	40.15	24.77	25.33	28.37	29.53
	Feed grain produced (bu.)	24.00	32.67	26.25	30.62	21.00	24.50
	Hay produced (tons)	0.00	0.00	0.50	0.58	0.40	0.46

[a] Soil classes are described in the section on land restrictions in the text.
[b] Subscript number (0) on rotation symbol means no fertilization; it applies to farm situations with B and C management. Subscript (1) refers to intermediate fertilization rate used by A operators at A management level. Subscript (2) refers to high rate of fertilization for all three management situations; however, (2) represents a higher rate of fertilization at A management level than at other management levels.
[c] Operating capital requirements include funds required for production cost, such as spraying, shelling, seed and fertilizer.
[d] Net revenue is market value minus variable costs.

TABLE 6. RESOURCE REQUIREMENTS, NET REVENUE AND PHYSICAL OUTPUT PER ACRE OF SELECTED CROPPING ACTIVITIES FOR THREE MANAGEMENT LEVELS ON SHELBY-GRUNDY-HAIG ASSOCIATION SOILS, CLASS II SOIL.[a]

Management level	Item	CCOM 0 or 1[b]	CCOM 2	CSbCOM 0 or 1[b]	CSbCOM 2	CCOMM 0 or 1[b]	CCOMM 2	COM 0 or 1[b]	COM 2
A	Labor (man-hours)	4.48	4.48	4.85	4.85	3.61	3.61	3.50	3.50
	Operating capital[c] ($)	10.79	13.20	12.34	12.34	8.52	10.23	9.34	10.82
	Net revenue[d] ($)	29.93	31.32	34.41	36.10	26.34	26.83	23.60	24.54
	Feed grain produced (bu.)	33.61	36.75	26.89	29.40	28.70	30.60	27.02	29.00
	Hay produced (tons)	0.58	0.65	0.46	0.52	0.96	1.08	0.77	0.87
B	Labor (man-hours)	4.30	4.32	4.44	4.62	3.45	3.51	3.28	3.33
	Operating capital[c] ($)	7.36	12.18	7.46	11.52	5.94	9.39	7.17	10.19
	Net revenue[d] ($)	25.59	28.63	28.51	32.34	23.25	23.96	20.76	22.22
	Feed grain produced (bu.)	27.19	33.69	21.75	26.95	24.10	27.55	22.92	26.58
	Hay produced (tons)	0.52	0.61	0.42	0.49	0.81	0.95	0.70	0.82
C	Labor (man-hours)	4.21	4.23	4.44	4.52	3.53	3.59	3.29	3.35
	Operating capital[c] ($)	7.01	11.80	7.12	11.16	5.65	9.08	6.98	9.98
	Net revenue[d] ($)	23.59	25.30	25.60	28.14	20.99	20.60	18.62	19.49
	Feed grain produced (bu.)	25.25	30.62	20.20	24.50	22.00	24.50	21.00	24.17
	Hay produced (tons)	0.50	0.58	0.40	0.46	0.70	0.82	0.67	0.77

[a] Soil classes are described in the section on land restrictions in the text.
[b] Subscript number (0) on rotation symbol means no fertilization; it applies to farm situations with B and C management.. Subscript (1) refers to intermediate fertilization rate used by operators at A management level. Subscript (2) refers to high rate of fertilization for all three management situations; however, (2) represents a higher rate of fertilization at A management level than at other management levels.
[c] Operating capital requirements include funds required for production costs, such as spraying, shelling, seed and fertilizer.
[d] Net revenue is market value minus variable costs.

TABLE 7. RESOURCE REQUIREMENTS, NET REVENUE AND PHYSICAL OUTPUT PER ACRE OF SELECTED CROPPING ACTIVITIES FOR THREE MANAGEMENT LEVELS ON SHELBY-GRUNDY-HAIG ASSOCIATION SOILS, CLASS III SOIL.[a]

Management level	Item	COM 0 or 1[b]	COM 2	COMM 0 or 1[b]	COMM 2	CCOMM 0 or 1[b]	CCOMM 2
A	Labor (man-hours)	3.50	3.50	2.63	2.63	3.61	3.61
	Operating capital[c] ($)	10.92	14.40	8.45	11.29	10.34	14.04
	Net revenue[d] ($)	10.40	10.57	7.65	7.60	11.47	10.78
	Feed grain produced (bu.)	17.46	20.47	13.69	15.69	19.72	20.47
	Hay produced (tons)	0.43	0.60	0.80	0.95	0.64	0.76
B	Labor (man-hours)	3.27	3.33	2.53	2.47	3.45	3.51
	Operating capital[c] ($)	6.77	13.83	5.11	10.68	5.83	13.32
	Net revenue[d] ($)	8.33	8.82	7.52	6.20	10.50	8.70
	Feed grain produced (bu.)	12.37	18.54	10.35	13.96	13.48	18.16
	Hay produced (tons)	0.30	0.55	0.53	0.85	0.32	0.68
C	Labor (man-hours)	3.29	3.35	2.48	2.52	3.53	3.59
	Operating capital[c] ($)	6.58	13.65	4.93	10.67	5.46	12.93
	Net revenue[d] ($)	7.46	6.66	6.79	4.55	9.98	6.63
	Feed grain produced (bu.)	10.64	16.60	9.60	12.45	12.74	15.84
	Hay produced (tons)	0.27	0.50	0.35	0.75	0.28	0.60

[a] Soil classes are described in the section on land restrictions in the text.
[b] Subscript number (0) on rotation symbol means no fertilization; it applies to farm situations with B and C management. Subscript (1) refers to intermediate fertilization rate used by operators at A management level. Subscript (2) refers to high rate of fertilization for all three management situations; however, (2) represents a higher rate of fertilization at A management level than at other management levels.
[c] Operating capital requirements include funds required for production cost, such as spraying, shelling, seed and fertilizer.
[d] Net revenue is market value minus variable costs.

possibility of using these systems on farms with less advanced management skills.

Beef enterprises.[7] Eight beef enterprises are allowed to compete for scarce resources. Good-to-choice 400-pound calves purchased in October may be pasture-fed or drylot-fed. Good-to-choice yearlings may be long-fed or short-fed. If short-fed, two groups are fed out a year. The operator may have beef cows with the choice of selling calves as feeders or feeding them for sale as fat cattle.

Hog systems. For the 1-litter system, gilts are selected and bred to farrow in late May and are moved to pasture 2 weeks later. Pigs are weaned at 6 to 8 weeks, and all sows are sold after they dry up. Pigs are fed on pasture, allowed to glean cornstalk fields and finished in drylot to be sold in December or later depending on outlook information. Death loss after weaning is 1.5 percent.

Sows farrow twice yearly, February through April and August thrugh October, for the 2-litter system. Spring pigs are moved to pasture for growing and finishing. Fall pigs are finished on cornstalks and in drylot. Pigs are weaned at 6 to 8 weeks of age. Replacement gilts are kept as needed.

The 4-litter hog system, allowed only for farmers with A and B management, includes two groups of sows farrowing twice yearly. Each group farrows in winter and summer, with 1 month between groups during each farrowing season.[8] This farrowing system avoids heavy labor requirements for hogs during the busy spring and fall crop season. The litters and sows are moved from the farrowing house to the nursing-growing-finishing shed when the pigs are 2 weeks old. At 4 to 5 weeks, the pigs are weaned by moving the sows to the sow colony. The pigs remain in the sheds and are kept in confinement on concrete until sold.

The 6-litter system, allowed only for farms with A management, includes three groups of sows farrowing twice a year so that pigs are produced in 6 months of the year. Litters are moved from the farrowing house to nursing sheds at 2 weeks of age. After weaning at 4 to 5 weeks, the pigs are moved to growing-fattening sheds and finished on concrete. Sows are transferred to the colony after pigs are weaned.

OTHER ACTIVITIES

A shortage of labor in May and June often limits

[7] Input-output data on cattle enterprise may be found in: Irwin. *ibid.*; and Heady, Earl O. and Loftsgard, Laurel. Farm planning for maximum profits on the Cresco-Clyde soils in northeast Iowa. Iowa Agr. Exp. Sta. Res. Bul. 450. April 1957.

[8] Farrowing dates and input-output data on swine may be found in Appendix A and also in Irwin, *op. cit.*

TABLE 8. RESOURCE REQUIREMENTS AND RECEIPTS OF SELECTED LIVESTOCK ACTIVITIES FOR THREE MANAGEMENT LEVELS.

Activity and management level	Labor Dec.-Jan.-Feb.	March-April	May-June	July-Aug.	Sept.-Oct.-Nov.	Feed Corn equiv. (bushels)	Hay[a] (tons)	Pasture (days)	Building space (units)[b]	Capital ($)	Net receipts[c] ($)
Beef cows, sell calf											
A	4.39	2.97	3.46	3.11	3.98	0.00	1.20	267.0	0.0	225.72	66.68
B	4.39	2.97	3.46	3.11	3.98	0.00	1.20	267.0	0.0	214.63	57.95
C	4.39	2.97	3.46	3.11	3.98	0.00	1.20	267.0	0.0	204.22	49.61
Beef cows, fed-out calf											
A	7.59	4.51	6.76	8.33	7.56	51.10	2.07	301.2	0.6	356.41	162.85
B	7.59	4.51	6.76	8.33	7.56	45.44	1.97	297.4	0.6	339.32	129.55
C	7.59	4.51	6.76	8.33	7.56	39.76	1.88	283.6	0.6	319.42	98.77
Steer calves, drylot-fed											
A	3.01	2.38	3.60	5.33	2.29	66.30	0.71	0.0	0.6	126.96	130.33
B	3.01	2.38	3.60	5.33	2.29	66.30	0.71	0.0	0.6	126.96	112.49
C	3.01	2.38	3.60	5.33	2.29	66.30	0.71	0.0	0.6	119.56	95.43
Steer calves, pasture-fed											
A	3.20	1.55	3.60	5.27	2.41	50.80	0.96	38.0	0.4	126.71	130.41
B	3.20	1.55	3.60	5.27	2.41	50.80	0.96	38.0	0.4	123.75	111.96
C	3.20	1.55	3.60	5.27	2.41	50.80	0.96	38.0	0.4	118.58	94.42
Yearlings, long-fed											
A	6.30	4.20	4.87	1.72	3.82	54.20	1.26	0.0	0.0	165.07	106.04
B	6.30	4.20	4.87	1.72	3.82	54.20	1.26	0.0	0.0	162.07	89.00
C	6.30	4.20	4.87	1.72	3.82	54.20	1.26	0.0	0.0	157.67	72.51
Yearlings, short-fed											
A	6.30	4.20	4.23	5.06	7.16	80.20	1.94	0.0	0.0	182.35	156.24
Hogs, 1-litter											
A	4.35	3.02	3.72	3.32	4.68	113.14	0.03	37.44	0.75	144.96	254.68
B	4.35	3.02	3.72	3.32	4.68	105.45	0.02	29.38	0.75	123.18	202.83
C	4.35	3.02	3.72	3.32	4.68	107.49	0.00	25.50	0.75	104.12	161.08
Hogs, 1-litter bldg. purchase											
A	4.35	3.02	3.72	3.32	4.68	113.14	0.03	37.44	0.00	208.71	254.68
B	4.35	3.02	3.72	3.32	4.68	105.45	0.02	29.38	0.00	186.93	202.83
C	4.35	3.02	3.72	3.32	4.68	107.48	0.00	25.50	0.00	167.87	161.08
Hogs, 2-litter											
A	10.26	7.79	5.64	6.70	8.77	213.89	0.05	36.48	1.00	290.00	520.52
B	8.81	8.65	6.27	5.72	9.71	202.82	0.03	31.30	1.00	222.11	418.14
C	8.50	7.25	7.79	5.64	9.99	206.92	0.00	23.38	1.00	169.16	332.31
Hogs, 2-litter, bldg. purchase											
A	10.26	7.79	5.64	6.70	8.77	213.89	0.05	36.48	0.00	375.00	520.52
B	8.81	8.65	6.27	5.72	9.71	202.82	0.03	31.30	0.00	307.11	418.14
C	8.50	7.25	7.79	5.64	9.99	206.92	0.00	28.38	0.00	254.16	332.31
Hogs, 4-litter, partial bldg. purchase											
A	22.19	11.87	12.64	12.33	18.54	423.70	0.10	0.00	2.40	318.06	966.54
B	22.03	13.26	12.26	12.64	17.38	401.05	0.10	0.00	1.88	296.59	841.00
Hogs, 4-litter, complete bldg. purchase											
A	22.19	11.87	12.64	12.33	18.54	423.70	0.10	0.00	0.00	468.06	966.54
B	22.03	13.26	12.26	12.64	17.38	401.05	0.10	0.00	0.00	414.09	841.00
Hogs, 6-litter, partial bldg. purchase											
A	29.06	20.89	20.42	18.90	27.42	637.20	0.15	0.00	2.40	1,107.00	1,400.02
Hogs, 6-litter, complete bldg. purchase											
A	29.06	20.89	20.42	18.90	27.42	637.20	0.15	0.00	0.00	1,257.00	1,400.02

[a] Hay fed to hogs is purchased. Expense is included in variable costs.
[b] One unit = 50 square feet, or enough space for 1 sow and 2 litters per year or for 1 beef cow and calf.
[c] Net receipts is the market value minus variable costs.

livestock production on Iowa farms. Therefore, for the purpose of this study, labor may be hired in May and June on 160-acre farms if it returns more than the wage rate of $1.10 per hour. A labor-purchase activity is included for this period to allow expansion of the livestock program through hired help. As a result, labor during other periods can be more fully utilized, and a larger income is allowed. The hourly labor-buying activity is not included for 240-acre farms.

The model employed allows the operator to sell corn (feed grains) for $1.20 a bushel or to feed it, depending upon which adds more to net returns. If net return is increased by more than $1.30 a bushel by feeding corn, grain can be purchased. Cattle buildings can be used for either cattle or hogs. Hence, an activity is included to allow such use. Costs included in hog production activities for repair of specialized buildings are assumed to cover conversion expense.

METHOD OF ANALYSIS

Linear programming techniques have been used in this study to determine optimum farm programs including alternative hog production systems. A modification of the ordinary simplex method of linear programming was used to allow continuous variation of the capital restrictions from zero to an unlimited level. This method allows specifications of maximum profit plans for each level of capital and shows the changing pattern of optimum resource use associated with capital supply. The following specific steps were taken in the analysis:

1. Profit-maximizing, variable capital plans were computed and are presented for 160-acre farms in each soil area at each management level and for 240-acre farms in each soil area at the A-management level.
2. Plans on 160-acre farms with similar capital levels are compared at the three management levels.
3. Effects on income of grain, hog building and May-June labor purchases are analyzed.
4. Plans for basic C-managed 160-acre farm situations are then recomputed and analyzed, assuming 4- and 6-litter hog systems using A management as a production alternative. Thus, the A-managed 4- and 6-litter systems are allowed to compete with C-managed alternative activities for farm resources. As mentioned previously, this step is taken to determine the profitability of commercial or contractual systems which might provide superior management to farms which lack capital and more efficient managerial skills.
5. Plans for A-level management are recomputed and analyzed at a discrete capital level, with a capital-lending provision for the 4- and 6-litter systems. This step is taken to determine whether contractual schemes providing for these systems are profitable on farms which have sufficient managerial skills present but are short on capital. Additional "outside" capital is assumed to be available for breeding stock and cash expenses for the multiple-farrowing hog systems. This capital is assumed to be repaid at 6 percent interest from sales receipts at the end of the year. The purchase of any necessary additional buildings and equipment also is made with operating capital.

These comparisons were made to help answer questions such as: "What are the effects of capital availability on the farm as a whole and on the optimum hog production system?" "Do highly specialized hog farms producing pork on a large-scale basis have advantages over the more typical general farm in Iowa?" "Are the more specialized systems likely to bring concentration of hog production on a few farms?" "How does the level of management alter selection among conventional pork production methods and the more specialized multiple-farrowing systems?"

OPTIMUM PLANS FOR 160-ACRE FARMS ON CLARION-WEBSTER SOILS

Maximum profit plans for 160-acre owner-operated farms in the Clarion-Webster soil area are presented in this section. First, plans are presented for the three levels of management to determine whether the management skill of the operator might be important in determining the best hog system. Second, plans are presented for several capital levels to illustrate how the best pork production method varies with the funds available. Third, plans are presented where added resources are allowed. The last step is used to determine whether elimination of competition for capital and labor among enterprises might give more advantage to the highly specialized multiple-farrowing system.

C-LEVEL MANAGEMENT

Table 9 and fig. 1 present the plans at six capital levels for farms with C management or production practices used on all enterprises. The second column indicates the amount of operating capital[9] required by each plan; the third column indicates the net income,[10] while the fourth column indicates the rotation and livestock enterprises which are optimum for the particular capital level. Column 7 indicates which resources, besides capital, are limiting, while the last two columns indicate the amount of grain and labor to be purchased.

When capital is very limited, other fixed resources are not fully used. They are essentially "free goods," and their use represents no cost to the firm in this particular case. Capital, however, is scarce, and therefore, the enterprise which gives the highest return per dollar invested is chosen first. Accordingly, at the lowest capital level (plan 1), a cash-crop rotation without fertilization provides the optimum plan. No livestock are produced because crops give the highest return on the limited funds. First, the entire 150 acres are planted to the $CCSb_0$ rotation. Land becomes limiting, and additional capital is then used to add fertilizer to the rotation (plan 2). Once crops are planted, crop fertilization provides the highest returns on scarce capital. With $2,503 of operating capital, fertilization is more profitable than investment in any type of hog system. As still more capital is added, additional resources become limiting and affect the combination of enterprises which maximizes profit at a

[9] Operating capital does not include fixed capital.
[10] Fixed expenses of $1,429 were subtracted from net revenue to obtain net income.

TABLE 9. CLARION-WEBSTER SOILS: OPTIMUM FARM PLANS FOR C MANAGEMENT ON 160-ACRE FARMS WITH DIFFERENT QUANTITIES OF OPERATING CAPITAL AVAILABLE.

Plan	Capital level ($)	Net income[a] ($)	Enterprise	Level: Acres	Level: Litters	Additional resources limiting[b]	Corn surplus or deficit[c] (bushels)	May-June labor hired (hours)
1.	1,177	4,798	$CCSb_0$	150		Land	+4,258	0
2.	2,503	6,107	$CCSb_2$	150		Land	+6,263	0
3.	2,735	6,222	$CCSb_2$	150		Pasture	+5,978	0
			Hogs, 2-litter		4			
4.	3,656	6,574	$CCSb_2$	144		May-June labor	+4,796	0
			$CCOM_2$	6				
			Hogs, 2-litter		14			
5.	5,040	7,025	$CCSb_2$	144		Hog building	+3,090	0
			$CCOM_2$	6				
			Hogs, 2-litter		30			
6.	6,927	7,640	$CCSb_2$	122		March-April labor	+765	119
			$CCOM_2$	28				
			Hogs, 2-litter		54			

[a] Net income with all variable costs plus fixed costs deducted from gross returns.
[b] Shows additional resource limiting. Hence, for each row, all resources mentioned previously also are limiting.
[c] A plus (+) indicates a grain sale, while a minus (-) indicates a corn purchase.

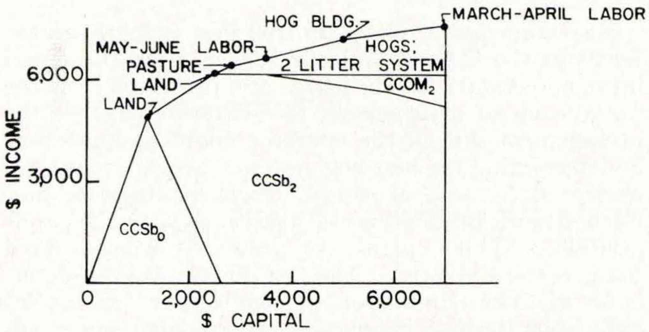

Fig. 1. Clarion-Webster Soils: Optimum farm plans for C management on 160-acre farms with different quantities of operating capital available.

given level of funds. Therefore, to maximize profit, farmers with large capital supplies must choose quite different plans than do farmers who have similar resources but more limited capital supplies.

When capital is increased to $2,735, the 2-litter system is included in the optimum plan. It, rather than the 1-litter system, comes into the plan first because of higher return on capital, lower May-June labor requirements and lower pasture requirements. Capital input is low because the pasture-raising plan requires fewer buildings than the more specialized plans or multiple-farrowing systems. Labor is purchased in the plans at higher capital levels because its imputed marginal return in hog production is greater than its cost per hour. The largest amount of operating capital shown in table 9 is $6,927. The specialized multiple-farrowing systems are not allowed to compete for resources under the C-level management coefficients because it is assumed that the specialized systems require a higher level of management than found here. If enough capital were added and labor were hired, resources would eventually be allocated to cattle feeding rather than to specialized hog systems.

At capital levels of $3,656 and greater, the hog enterprise has used all noncropland or native pasture. More forage and pasture land for sanitation is needed if more hogs or other livestock are added. Consequently, $CCOM_2$ is substituted for some of the $CCSb_2$ at higher capital levels to provide the forage needs of the livestock. When crops alone are produced, the $CCSb_2$ rotation is most profitable. However, the shift of some land to $CCOM_2$ adds more to profit when livestock are included in the plan. The substitution of a rotation with a lower cash return when livestock are added demonstrates that maximum farm return is not synonymous with maximum crop return.

The data of plans 5 and 6 indicate that it is profitable to produce pork with the techniques used for C management as long as buildings are available on the farm and only May-June labor has to be hired. When March-April labor is not available and forage must be obtained by substituting forage crops for corn and soybeans, a 5- percent return cannot be earned on capital used in increasing hog production further under the price and production techniques used for C management. The marginal return on capital is about 20 percent for capital added in plan 5 and about 5 percent for that added in plan 6.

A diagrammatic presentation of the plans and data in table 9 is shown in fig. 1. The corners on the broken curve indicate the points where the optimum plan changes. The relationship between the cropping plans and size of hog enterprise, as variable capital is increased, is clearly shown in this diagram.

B-LEVEL MANAGEMENT

Maximum profit plans for B management, 160-acre farms on Clarion-Webster soils are shown in table 10 and fig. 2.

The $CCSb_0$ rotation gives the highest return when capital is extremely limiting. The capital quantities used are those which represent "corners" in the production possibility relationship under variable resource programming. A "corner" represents each magnitude of capital where the enterprises included in the optimum plan change. Hence, the first amount of capital is smaller for B management than for A management (table 11). It should be remembered that only operating capital, and not investment in real estate and machinery, is included in the funds indicated.

As capital is increased to $4,224 or more, hogs are included in the optimum plan. The 2-litter system enters the plan because it produces maximum total returns to building space, pasture and capital—the bundle of resources which become scarce in use. The rotation does not change between plans 1 and 3 (table 10).

With larger amounts of capital, further expansion of the hog enterprise is profitable, but the increase

TABLE 10. CLARION-WEBSTER SOILS: OPTIMUM FARM PLANS FOR B MANAGEMENT ON 160-ACRE FARMS WITH DIFFERENT QUANTITIES OF OPERATING CAPITAL AVAILABLE.

Plan	Capital level ($)	Net income[a] ($)	Enterprise	Level: Acres	Level: Litters	Additional resources limiting[b]	Corn surplus or deficit[c] (bushels)	May-June labor hired (hours)
1.	1,284	5,139	$CCSb_0$	150		Land	+4,584	0
2.	2,612	6,678	$CCSb_2$	150		--	+6,638	0
3.	4,224	7,947	$CCSb_2$	150		May-June labor	+5,165	0
			Hogs, 2-litter		14			
4.	5,983	9,213	$CCSb_2$	148		Hog buildings	+3,568	45
			$CSbCOM_2$	2				
			Hogs, 2-litter		30			
5.	7,313	10,131	$CCSb_2$	142		March-April labor	+2,298	76
			$CSbCOM_2$	8				
			Hogs, 2-litter		42			
6.	11,522	11,316	$CCSb_2$	150		--	+1,039	132
			Hogs, 1-litter		13			
			Hogs, 4-litter		40			
7.	11,929	11,404	$CCSb_2$	150		--	+1,228	119
			Hogs, 2-litter		8			
			Hogs, 4-litter		26			

[a] Net income with all variable costs plus fixed costs deducted from gross returns.
[b] Shows additional resource limiting. Hence, for each row, all resources mentioned previously also are limiting.
[c] A plus (+) indicates a grain sale, while a minus (-) indicates a corn purchase.

requires a slight shift in rotation to meet the forage requirements of the hogs. When capital is at $5,983 and $7,313, 2 and 8 acres, respectively, are shifted to the $CSbCOM_2$ rotation. (In actual practice, a small acreage might be diverted to permanent-type hog pasture, with the remainder staying in the $CCSb_2$ rotation.) When capital is increased to $11,522, the hog enterprise in the optimum plan changes to a combination of 1- and 4-litter systems because of a shortage of labor in the March-April period as well as in the May-June period when it can be hired. The 4-litter system is combined with the 1-litter system to make the most profitable use of winter labor. Although building space is not as fully used under this plan, hog output per hour of labor in the limiting months is higher than with a 2-litter system. The added capital results in a net addition to income. Marginal return, however, is only 5 percent at a capital level of $11,522. If the model allowed hiring of March-April labor, a higher return on capital could be obtained by adding other enterprises.

Net income as a function of operating capital is shown in fig. 2. The effect of limited March-April labor is indicated after an operating capital level of $11,522 is reached. The 4-litter system replaces the 2-litter system, partly because the farmer uses less meadow. Thus, the optimum cropping plan reverts to the $CCSb_2$ cropping plan.

A-LEVEL MANAGEMENT

Optimum plans for A management, 160-acre farms on Clarion-Webster soils are presented in table 11 and fig. 3.

Only fertilized crop rotations are included for A management techniques. (The crop choice is only among various rotations at intermediate and high rates of fertilization.) For C and B management, alternatives included rotations without fertilizer. A CCSb rotation without fertilizer was the first capital investment made for any of the optimum plans under C management. Fertilization of this same rotation ranked second in profitability of investment, at higher capital levels.

A CCSb rotation fertilized at the first or lowest level is the first or most profitable investment under A management. Under the A level of management, 21 units (42 litters) of the 2-litter hog system and up to $8,626 of capital are used before the high rate of

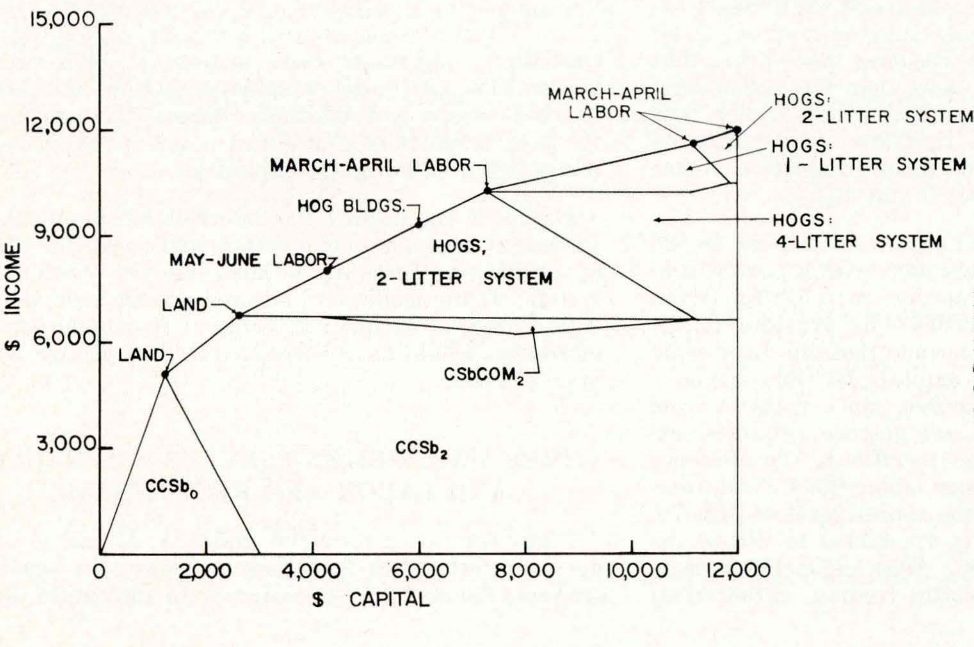

Fig. 2. Clarion-Webster Soils: Optimum farm plans for B management on 160-acre farms with different quantities of operating capital available.

TABLE 11. CLARION-WEBSTER SOILS: OPTIMUM FARM PLANS FOR A MANAGEMENT ON 160-ACRE FARMS WITH DIFFERENT QUANTITIES OF OPERATING CAPITAL AVAILABLE.

Plan	Capital level ($)	Net income[a] ($)	Enterprise	Level: Acres	Level: Litters	Level: Nos.	Additional resources limiting[b]	Corn-surplus or deficit[c] (bushels)	May-June labor hired (hours)
1	2,170	6,577	$CCSb_1$	150			Land	+6,128	0
2	3,945	8,192	$CCSb_1$	150			May-June labor	+4,818	0
			Hogs, 2-litter		12				
3	6,569	10,450	$CCSb_1$	150			Pasture	+2,901	46
			Hogs, 2-litter		30		Hog buildings		
4	8,626	12,199	$CCSb_1$	142			March-April labor	+1,380	79
			$CSbCOM_2$	8					
			Hogs, 2-litter		42				
5	10,524	13,191	$CCSb_2$	133			Cattle buildings	+1,210	113
			$CCOM_2$	17					
			Hogs, 1-litter		27				
			Hogs, 2-litter		24				
6	14,570	13,430	$CCSb_2$	66			Corn	0	121
			$CCOM_2$	84					
			Hogs, 1-litter		4				
			Hogs, 2-litter		24				
			Hogs, 2-litter bldg. purchase		12				
			Steer calves, past.-fed			45			
7	16,600	14,643	$CCSb_2$	60			Forage	—620	140
			$CCOM_2$	90					
			Hogs, 1-litter		20				
			Hogs, 2-litter bldg. purchase		24				
			Steer calves, past.-fed			45			

[a] Net income with all variable costs plus fixed costs deducted from gross returns.
[b] Shows additional resource limiting. Hence, for each row, all resources mentioned previously also are limiting.
[c] A plus (+) indicates a grain sale, while a minus (—) indicates a corn purchase.

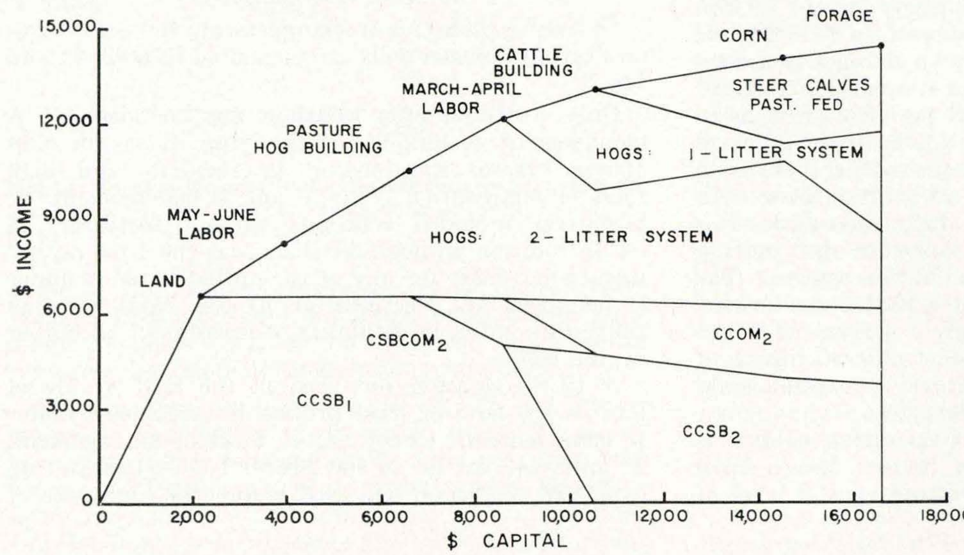

Fig. 3. Clarion-Webster Soils: Optimum farm plans for A management on 160-acre farms with different quantities of operating capital available.

fertilization for the CCSb becomes most profitable. The hog enterprise returns more than the higher level of fertilization up to this capital level. Under both B and C management, the first level of fertilization was more profitable than livestock production at low capital levels (plan 2, tables 9 and 10).

Forage requirements for hogs are met at the $8,626 capital level under A management with a partial substitution of a $CSbCOM_2$ rotation for $CCSb_2$. Given limited capital resources, $CSbCOM_2$ provides forage with less sacrifice in crop income than do other rotations. With $10,524 of capital, $CCOM_2$ replaces $CSbCOM_2$ as the forage source, since returns from the added livestock, corn and pasture produced exceed the value of soybeans sacrificed. To conserve March, April, May and June labor, the CCOM rotation is used on 84 acres at the capital level of $14,570, and pasture-fed steer calves are added to utilize the increased forage production. With efficient management for all enterprises, cattle feeding, rather than specialized hog enterprises, is used at high capital levels. This pattern allows a better utilization of labor, for both crops and livestock, during the months of the year when it is scarce and is not hired. Corn is purchased at the highest capital level.

Figure 3 emphasizes the interrelationship between the hog system and cattle system and again the effect of restricted March-April labor on the 2-litter hog system. If the model had allowed purchase of March-April labor, or earlier farrowing of the spring litters, more hogs would have been produced at capital levels over $14,570.

THREE MANAGEMENT LEVELS WHEN GRAIN AND LABOR ARE RESTRICTING

Plans for farms operated under A, B and C management techniques have been reviewed in previous sections. The plans presented were developed by a variable resource model of linear programming. Accordingly, particular plans are not strictly comparable between management types because they entail use of different quantities of capital. The lowest or highest level of capital is not the same for one management level as for another. This difference arises because variable resource programming provides a plan at each point where a different resource becomes limiting. The point at which various resources become limiting differs among the three management levels because the input-output coefficients or resource requirements are not the same.

To compare plans under the three management systems, we now present programming results when certain resource restraints are made the same for the three management levels. While capital is still allowed to differ, plans are completed when farms can use only the labor available from the farm family and when no grain can be purchased. (Actually, the plans are for a situation where all grain produced is fed to livestock.) The results are presented in table 12.

LIMITED LABOR

We first present plans which are optimum when labor must be restricted to the amount provided by the family supply. The results are provided in the upper part of table 12. Plans for 160-acre farms on Clarion-Webster soil limited to family labor in May and June are quite similar for all three management levels. Each uses the CCSb rotation, has a 2-litter system and sells most of the grain raised.

Differences in income because of the variations in technology for the different management types are relatively great for hogs, intermediate for cattle and small for crop enterprises. Hence, since crops provide the major part of income in this situation, net income does not differ extremely among the plans of the three management levels. The difference, shown in the top of table 12, is largely due to differences in returns from the small hog enterprise. Because the same number of hogs is marketed (although fewer units are raised) and because crops are produced somewhat more efficiently, the return under A management is $1,618 greater than for C management.

Specialized hog production with 4- or 6-litter systems does not enter any of the plans when labor is limited to the family supply in the May-June period. The pattern of the optimum plans emerges so that scarce labor can be most effectively and profitably allocated among crops and livestock. Since crops, including a relatively large amount of corn, provide highest hourly returns to scarce labor, the hogs are produced in 1-litter and 2-litter systems.

LIMITED GRAIN

Plans which involve feeding of all grain raised, without sale or purchase, are presented in the lower part of table 12. Labor in the May-June period can be purchased for these plans.

Corn and corn equivalent produced for C, B and A management situations are, respectively, 6,128, 6,628 and 6,808 bushels. Under C management, less corn is produced because yields are lower, and more hay is grown to release March-April labor and furnish forage for hogs. The specialized hog system allowed under B management, in effect, substitutes capital for labor and forage. Thus, all land is row-cropped, and no forage is produced. (As in previous plans, 4- and 6-litter systems are allowed for A management, while 4-litter systems are allowed for B management. Neither of these systems are allowed for C management.) The optimum cropping plan for A management includes a higher production of forage, but the higher fertilization rates and better management practices result in the largest corn production, as compared with C and B management. To allow the best use of labor under A management, the plan includes hogs produced in the 1- and 2-litter systems and cattle feeding. The specialized 4- and 6-litter systems do not come into the plan, even though labor can be hired.

In the optimum plan for A management, 345 market hogs and 45 pasture-fed steer calves are produced. For B and C management, the number of market hogs sold is 353 and 260, respectively, from the same number of crop acres. Because of variation in litter size, fewer sows are needed to produce the same number of hogs under the higher management levels. Better crop production techniques also allow more grain for

TABLE 12. CLARION-WEBSTER SOILS: COMPARISON OF OPTIMUM PLANS ON 160-ACRE FARMS UNDER THREE MANAGEMENT LEVELS WHEN GRAIN AND LABOR ARE RESTRICTING.

Management level	Optimum plans when labor is restricted to the May-June family supply			
	Net income ($)	Operating capital used ($)	Grain sold (bu.)	Enterprises
A	8,192	3,945	4,818	150 $CCSb_1$ 12 Hogs, 2-litter
B[a]	7,947	4,224	5,165	150 $CCSb_2$ 14 Hogs, 2-litter
C[a]	6,574	3,656	4,796	144 $CCSb_2$ 6 $CCOM_2$ 14 Hogs, 2-litter
	Optimum plans when all grain is fed and none is purchased but labor can be hired			
	Net income ($)	Operating capital used ($)	Labor hired (hours)	Enterprises
A	13,430	14,570	121	66 $CCSb_2$ 84 $CCOM_2$ 4 Hogs, 1-litter 36 Hogs, 2-litter 45 Steer calves, pasture fed
B[a]	11,316	11,522	132	150 $CCSb_2$ 13 Hogs, 1-litter 40 Hogs, 4-litter
C[a]	7,640	6,927	119	122 $CCSb_2$ 28 $CCOM_2$ 52 Hogs, 2-litter

[a] On type B and C farms, feed grain was not all fed at any capital level having a marginal return of more than 5 percent. The two plans showing the largest use of feed grain produced are listed in the table.

feeding. In addition, each bushel of grain converts to a larger poundage of pork. Consequently, at capital levels which permit labor-hiring and a larger livestock program, differences in income among the three management levels are greater. For example, the difference in income for A and C plans is $5,790 in the lower part of table 12, but only $1,618 for plans in the upper part. A greater proportion of income is obtained from livestock in the plans at the bottom of table 12. As mentioned previously, the premium for improved management practice is greater for livestock than for crops.

EFFECT OF RESOURCE HIRING

When labor can be hired but livestock are restricted to feed raised on the farm, the plans for the B-management situation include a 4-litter hog system. This hog production method, aided by hired labor in the May-June period, allows a more efficient utilization of the family labor during other months when it would be in surplus supply and a heavier cropping program than under C management. In contrast, however, the optimum plan for A management includes cattle feeding and the 1- and 2-litter hog systems. This combination of livestock allows the most profitable utilization of feed grown in the CCOM rotation and the most efficient utilization of operator and family labor over the entire year. The optimum plan for C-management techniques includes only a 2-litter hog system.

OPTIMUM PLANS FOR 160-ACRE FARMS ON SHELBY-GRUNDY-HAIG SOILS

Plans which maximize profit for 160-acre farms on Shelby-Grundy-Haig soils are presented in tables 13, 14, 15 and 16 and figs. 4, 5 and 6. A smaller proportion of land in this soil complex can be devoted to grain. Hence, with lower labor requirements for crops and more labor available for livestock, programs were computed to determine whether the more specialized hog systems might now be included in the optimum plans even where they were not specified for a 160-acre farm on Clarion-Webster soils.

Each of the three land classes has different crop rotations in the optimum plans. Roman numerals after the rotation symbols identify the land class to which each rotation applies. Comparisons are made, as in the case of Clarion-Webster soils, among plans for different capital levels and for different management techniques of levels.

C-LEVEL MANAGEMENT

Optimum plans for 160-acre farms operated with C management for all enterprises on the Shelby-Grundy-Haig soils are included in table 13 and fig. 4.

The use of land and funds for the most grain-intensive rotations permitted by soil conservation restrictions maximizes profit when capital is very limited (plan 1). Only 49 acres of corn are grown, and no fertilizer is used. Thus, a very small amount of capital is needed for cropping.

When capital is increased to $5,454 (plan 2), fertilizer is added to class I and II land. Hogs become a more profitable investment alternative than fertilizer applied to class III land. The 2-litter system enters the optimum plan because it gives the highest return to scarce capital. A beef cow enterprise with a calf-selling alternative also enters the optimum plan at this capital level. The hog enterprise could be expanded here only by purchasing corn. Hay and forage are essentially "free goods" to cattle because they must be produced in the rotation, and they are not otherwise fully used. Too, under the coefficients or practices representing C management for Shelby-Grundy-Haig soils, beef cows allow a more profitable

TABLE 13. SHELBY-GRUNDY-HAIG SOILS: OPTIMUM FARM PLANS FOR C MANAGEMENT ON 160-ACRE FARMS WITH DIFFERENT QUANTITIES OF OPERATING CAPITAL AVAILABLE.

Plan	Capital level ($)	Net income[a] ($)	Enterprise	Level: Acres	Level: Litters	Level: Nos.	Additional resource limiting[b]	Corn surplus or deficit[c] (bushels)	May-June labor hired (hours)
1	753	1,291	$CCSb_0$ I	16					
			$CSbCOM_0$ II	69			Land	+2,113	0
			$CCOMM_0$ III	27					
2	5,454	3,131	$CCSb_2$ I	16			Pasture	0	0
			$CSbCOM_2$ II	69					
			$CCOMM_0$ III	27					
			Hogs, 2-litter		24				
			Beef cows, sell calves			10			
3	6,264	3,327	Same cropping plan				Corn	0	0
			Hogs, 2-litter		24				
			Beef cows, sell calves			14			
4	8,652	3,652	Same cropping plan				Building space	—1,170	0
			Hogs, 2-litter		36				
			Beef cows, sell calves			14			
5	14,749	4,518	Same cropping plan				May-June labor	—4,176	0
			Hogs, 2-litter		36				
			Hogs, 2-litter, bldg. purchase		28				
			Beef cows, sell calves			13			
6	15,794	4,642	Same cropping plan				May-June labor	—4,176	0
			Hogs, 2-litter		36				
			Hogs, 2-litter, bldg. purchase		34				
			Beef cows, sell calves			12			

[a] Net income with variable costs plus fixed costs deducted from gross returns.
[b] Shows additional resource limiting. Hence, for each row, all resources mentioned previously also are limiting.
[c] A plus (+) indicates a grain sale, while a minus (—) indicates a corn purchase.

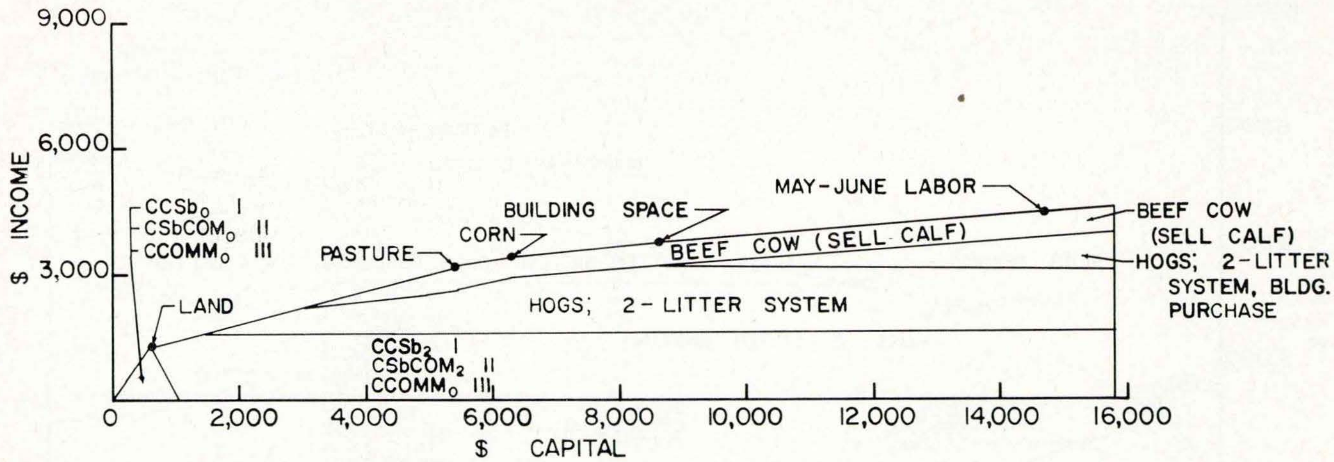

Fig. 4. Shelby-Grundy-Haig Soils: Optimum farm plans for C management on 160-acre farms with different quantities of operating capital available.

use of forage than do feeder steers. (There is a harvesting cost for hay should it be used for steers in drylot.) Pasture limits the beef-cow herd in this plan because the hay-transfer activity has not yet entered the optimum plan. With the next increment of capital (plan 3), the hay-transfer activity becomes a part of the optimum plan, and meadowland becomes available for pasture.

Plan 4 includes a capital level of $8,652. Enough hogs are produced under the 2-litter system to use all available buildings. Hence, volume increase is temporarily halted by the building restriction. The corn-purchase activity is used in plan 4, and 1,170 bushels are purchased at $1.30 a bushel.

When capital is increased to $14,749 (plan 5), a building-purchase activity is included in the optimum plan. The cost of additional hog production must be increased to cover building purchase. (The hog enterprise is expanded by increasing the size of the 2-litter system. The more specialized multiple-farrowing systems which require a heavy outlay of new capital and more labor in May and June were not allowed as alternatives at this management level.)

A graphic indication of the relative importance of various enterprises for different capital levels is provided in fig. 4. The returns line is low, as compared with fig. 1 which shows returns for the same level of management and variable capital on Clarion-Webster soils. The main reason for the difference in returns involves soil productivity. Although there is no essential difference in the hog enterprise, the fixed investment for land is much higher in the Clarion-Webster area.

B-LEVEL MANAGEMENT

Maximum profit plans for southern Iowa soils under B management are shown in table 14 and fig. 5. The $CCSb_2$ rotation on class I land gives the highest return when capital is extremely limiting. High fertilization on class I land gives a higher return to

TABLE 14. SHELBY-GRUNDY-HAIG SOILS: OPTIMUM FARM PLANS FOR B MANAGEMENT ON 160-ACRE FARMS WITH DIFFERENT QUANTITIES OF OPERATING CAPITAL AVAILABLE.

Plan	Capital level ($)	Net income[a] ($)	Enterprise	Level: Acres	Level: Litters	Level: Nos.	Additional resource limiting[b]	Corn surplus or deficit[c] (bushels)	May-June labor hired (hours)
1	924	1,682	$CCSb_2$ I	16			Land	+2,790	0
			$CSbCOM_0$ II	69					
			$CCOMM_0$ III	27					
2	4,258	4,336	$CCSb_2$ I	16			Corn	0	0
			$CSbCOM_2$ II	69					
			$CCOMM_0$ III	27					
			Hogs, 2-litter		26				
3	6,319	4,992	Same cropping plan				Building space	—860	0
			Hogs, 2-litter		36				
4	15,258	7,411	Same cropping plan				March-April labor	—4,036	0
			Hogs, 2-litter		36				
			Hogs, 2-litter, bldg. purchase		30				
5	15,537	7,485	Same cropping plan				Pasture Hay	—3,021	0
			Hogs, 2-litter		36				
			Hogs, 2-litter, bldg. purchase		20				
			Beef cows, sell calves			14			
6	33,106	10,961	$CCSb_2$ I	16			May-June labor	—8,669	0
			$CCOM_0$ II	69					
			$CCOMM_0$ III	27					
			Hogs, 2-litter		8				
			Hogs, 4-litter		28				
			Hogs, 4-litter, bldg. purchase		76				
			Beef cows, sell calves			8			

[a] Net income with variable costs plus fixed costs deducted from gross returns.
[b] Shows additional resource limiting. Hence, for each row, all resources mentioned previously also are limiting.
[c] A plus (+) indicates a grain sale, while a minus (—) indicates a corn purchase.

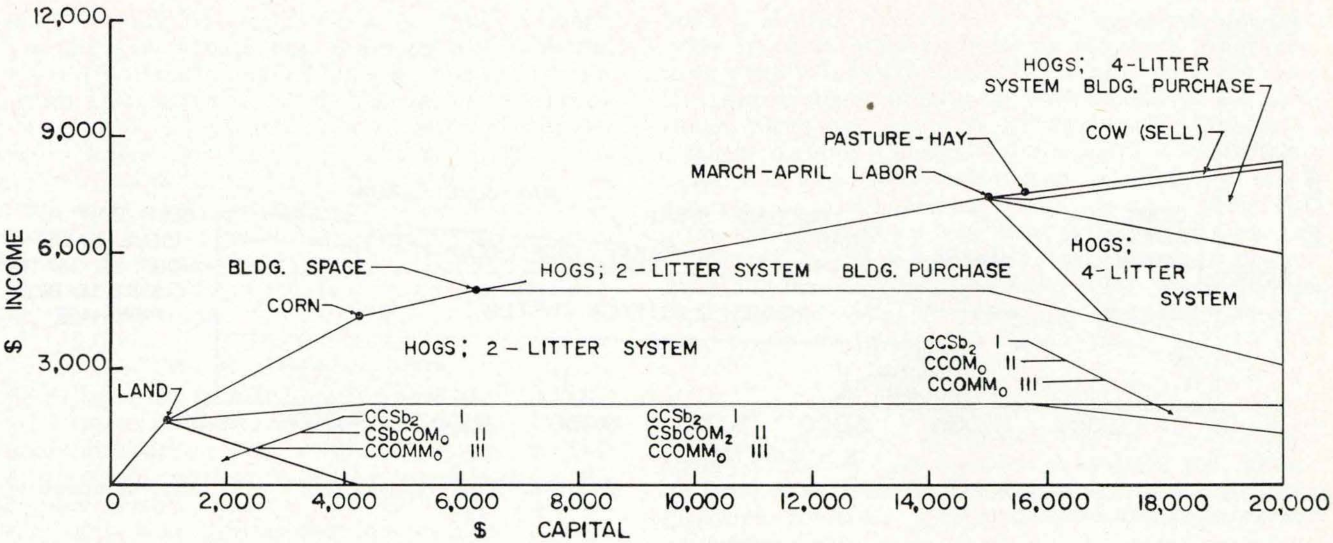

Fig. 5. Shelby-Grundy-Haig Soils: Optimum farm plans for B management on 160-acre farms with different quantities of operating capital available.

resources than on class II and III under the coefficients assumed for B management. With the exception of high fertilization in plan I, the cropping plan is the same under both B and C management until operating capital is expanded to $33,106 under B management.

In plans 2, 3 and 4, the 2-litter hog enterprise is the most profitable livestock enterprise. Thus, even though all forage is not utilized, investment in hogs is more profitable than beef cattle. When March-April labor becomes limiting with operating capital at the $15,258 level, however, the beef cow (calf-selling) activity comes into the optimum plan.

The optimum plan, when all May-June labor is used and the operating capital is expanded to $33,106, includes 26 units (104 litters) of the 4-litter hog system. The conditions which make the 4-litter system profitable are: (1) the marginal revenue of capital is greater than 5 percent for hogs, but no other capital use will return more than this amount; (2) March-April labor and buildings are limiting; (3) labor must be hired in May-June; and (4) corn must be purchased. Under these conditions and with the coefficients assumed for B-level management, a 4-litter hog system maximizes profits.

Again as a result of gains from improved livestock management, incomes are much higher for B management than for C management. Figure 5 is a graphic presentation of the net income as a function of capital quantity for the plans in table 14. The graph shows a 4-litter hog system replacing a 2-litter system in the optimum plan when March-April labor becomes limiting. For each hour of March-April labor used, more pork is produced under a 4-litter system than under a 2-litter system, thus allowing the hog enterprise to expand. Although cost per unit is higher and return on capital lower, the added volume increases net income, assuming the alternatives for capital allowed in the model.

A-LEVEL MANAGEMENT

The plans for A-level management are presented in table 15 and fig. 6. Again at very low capital levels, land is cropped as heavily as soil conditions will allow. [11] Starting from a low capital level, cropland is first fertilized at a high rate, then the 2-litter hog system is introduced and expanded until all corn is utilized. Next, the corn purchase activity is introduced (plan 3), and the 2-litter hog system is expanded until the existing building space is exhausted. At the $18,834 level of operating capital, the 2-litter hog activity with building-purchase is introduced, and pork production is expanded until all March-April labor is utilized.

Pasture-fed steer calves are produced at capital levels above $18,834. The 2-litter hog system cannot be expanded further without taking March-April labor from cropping alternatives. When forage is available and A-level management coefficients are used, adding the steer-feeding enterprise is more profitable than adding beef cows or buying buildings to expand hog production. The better production techniques used for A management cause livestock production to be more competitive with crops for resources. Hence, with A-level management there is more variation in cropping plans as capital is expanded than under B and C management.

In plan 6, with operating capital requirements of $29,408, a 1-litter hog system with building purchase is introduced. The 2-litter system is not expanded because the supply of March-April labor is restricted. (The farm is not allowed to buy March-April labor under this situation.) The 1-litter system requires labor at the times of the year when there is a surplus. It doesn't require much labor in the period when labor demand by other enterprises is high. This plan includes 27 acres of idle class III land. If the model had allowed renting out pasture or a transfer of cropland to pasture, class III land would not be left idle. With labor limited in March and April and with no

[11] Remember all cropping activities for A management assumed at least an intermediate level of fertilization.

TABLE 15. SHELBY-GRUNDY-HAIG SOILS: OPTIMUM FARM PLANS FOR A MANAGEMENT ON 160-ACRE FARMS WITH DIFFERENT QUANTITIES OF OPERATING CAPITAL AVAILABLE.

Plan	Capital level ($)	Net income[a] ($)	Enterprise	Level: Acres	Level: Litters	Level: Nos.	Additional resource limiting[b]	Corn surplus or deficit[c] (bushels)	May-June labor hired (hours)
1	1,155	2,137	CCSb$_1$ I	16			Land	+2,850	0
			CSbCOM$_1$ II	69					
			COM$_1$ III	27					
2	5,763	6,290	CCSb$_2$ I	16			Corn	0	0
			CSbCOM$_2$ II	69					
			COM$_2$ III	27					
			Hogs, 2-litter		30				
3	7,475	7,021	CCSb$_2$ I	16			Buildings	—644	0
			CSbCOM$_2$ II	69					
			COM$_2$ III	27					
			Hogs, 2-litter		36				
4	18,834	11,233	CCSb$_2$ I	16			March-April labor	—4,359	0
			CSbCOM$_2$ II	69					
			COM$_2$ III	27					
			Hogs, 2-litter		36				
			Hogs, 2-litter, bldg. purchase		34				
5	24,090	12,428	CCSb$_2$ I	16			May-June labor	—4,974	0
			CCOM$_2$ II	69					
			CCOMM$_1$ III	27					
			Hogs, 2-litter		8				
			Hogs, 2-litter, bldg. purchase		56				
			Steer calves, past.-fed			35			
6	29,408	13,179	CCSb$_2$ I	16				—6,796	31
			CCOM$_2$ II	69			Pasture		
			Idle class III land	27					
			Hogs, 1-litter bldg. purchase		54		Cattle building		
			Hogs, 1-litter bldg. purchase		16				
			Steer calves, past.-fed			45			

[a] Net income, with all variable costs plus fixed costs deducted from gross returns.
[b] Shows additional resource limiting. Hence, for each row, all resources mentioned previously also are limiting.
[c] A plus (+) indicates a grain sale, while a minus (—) indicates a corn purchase.

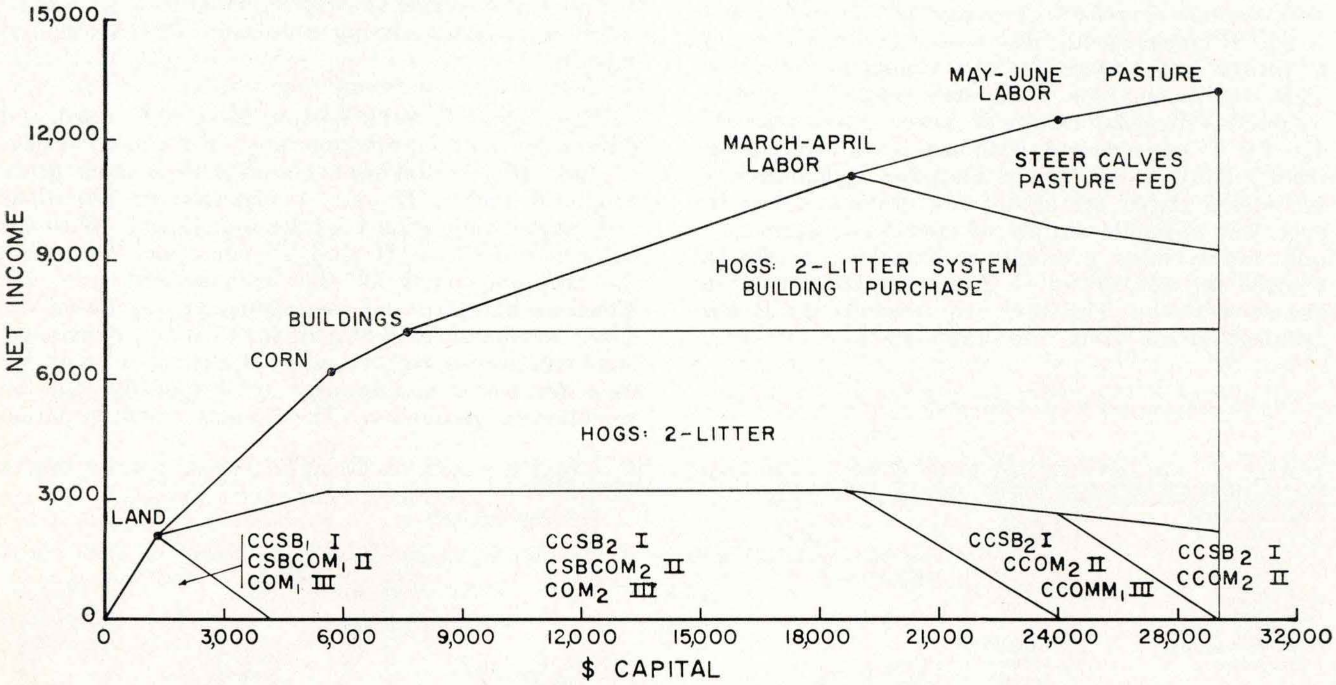

Fig. 6. Shelby-Grundy-Haig Soils: Optimum farm plans for A management on 160-acre farms with different quantities of operating capital available.

labor-buying activity for these months, steer feeding gives a higher return to March-April labor than does cropping class III land under the coefficients used for this management level. The class III land was cropped in previous plans because labor was not completely used and was "internally free" to remaining enterprises.

In fig. 6 are indicated graphically the changes which occur in the optimum farm plan as available capital is increased on the 160-acre farm in the Shelby-Grundy-Haig soil area under A-level management. Plan 6 (table 15) is not included in fig. 6, and the optimum plan when hay becomes limiting is not included in the table.

COMPARISON OF PLANS UNDER THREE MANAGEMENT LEVELS WHEN GRAIN AND LABOR ARE RESTRICTING

Plans are presented in table 16 showing results when certain resource restraints are the same under three levels of management. The plans in table 16 are for farms on Shelby-Grundy-Haig soils. Capital levels are not the same for one management level as for another for the reasons mentioned in the section on Clarion-Webster soils.[12] The plans for farms under three management levels in this section include those where: (1) labor is restricted to the amount provided by the family and (2) grain is restricted to that raised, with none purchased.

The situations in the Shelby-Grundy-Haig soils have optimum plans with low crop-labor requirements because conservation restrictions allow only small crop acreages. Hence, in contrast to the Clarion-Webster area, feed grain is a more restricting resource than the supply of May-June labor.

LIMITED LABOR

Optimum plans when May-June labor is restricted to the family supply are presented in the top of table 16. Class I and class III land is cropped the same under all three management levels. Cropping is more intensive on class II land with C management, however, because returns to roughage are lower than with A and B management. The model used did not allow a 4-litter hog system for the C-management level. This restriction, plus differences assumed in input-output coefficients, results in lower returns for forage for C management than for A and B management. Thus, the optimum plan for C management includes a higher acreage of row crops and less forage. The optimum supply of operating capital with only family labor available in May-June is $14,749, $33,106 and $24,090 for C, B and A management levels, respectively. The large requirements for B management result from the large amount of capital needed for the 4-litter hog system, which becomes optimum because March-April labor restrictions prevent expansion of the 2-litter hog system to the volume allowed by the May-June labor supply.

With capital unlimited, differences in income resulting from the variation in technology for the different management levels are great. Income ranges from $4,518 for C management to $12,428 for A management. The $8,000 difference between net income in C and A management situations is the result of the premium allowed for improved management practice, plus the larger amount of operating capital used in the optimum plan under A management.

In the optimum plan under A management, 734 market hogs are produced, and 35 steer calves are pasture-fed. Under B management, the optimum plan calls for production of 766 market hogs and 8 beef calves, which are sold as feeders. Under C management, the optimum plan calls for production of 343 market hogs and 13 beef calves to be sold as feeders. The coefficients used assume a relatively large effect of management on steer feeding. The 4-litter hog system did not have to compete with highly efficient steer feeding activities under B management. Twenty-two percent of the labor requirement for the 2-litter hog system and 17 percent of that for the 4-litter hog system was in the March-April period. The 4-litter hog system thus is optimum when March-April labor becomes restricting and capital is allowed to expand.

LIMITED GRAIN

Plans which involve feeding all grain raised and purchasing no feed are presented in the bottom part of table 16. Capital inputs needed to feed all grain produced for C, B and A management situations are, respectively, $6,264, $4,258 and $5,763. With the exception of Class III land, A-management situation, the cropping plans at each management level are identical, but corn and corn equivalent produced are 2,807, 3,086 and 3,210 bushels for C, B and A management situations, respectively. Higher yield assumptions for better management are responsible for the variation in production. The B-management situation

[12] Three management levels when grain and labor are restricting.

TABLE 16. SHELBY-GRUNDY-HAIG SOILS: COMPARISON OF OPTIMUM PLANS ON 160-ACRE FARMS UNDER THREE MANAGEMENT LEVELS WHEN GRAIN AND LABOR ARE RESTRICTING.

Characteristic and item	Unit	Management level: C		B		A	
		Optimum plans when labor is restricted to the May-June family supply but grain can be purchased.					
Net income	$		4,518		10,961		12,428
Operating capital used	$		14,749		33,106		24,090
Corn purchased	bushels		4,176		8,669		4,974
Enterprises	acres	$CCSb_2$ I	16	$CCSb_2$ I	16	$CCSb_2$ I	16
	acres	$CSbCOM_2$ II	69	$CCOM_0$ II	69	$CCOMM_2$ II	69
	acres	$CCOMM_0$ III	27	$CCOMM_0$ III	27	$CCOMM_1$ III	27
	litters	Hogs, 2-litter	36	Hogs, 2-litter	8	Hogs, 2-litter	8
	litters	Hogs, 2-litter bldg. purchase	28	Hogs, 4-litter	28	Hogs, 2-litter bldg. purchase	56
	litters			Hogs, 4-litter bldg. purchase	76		
	nos.	Beef cows, sell calves	13	Beef cows, sell calves	8	Steer calves, past.-fed	35
		Optimum plans when all grain is fed and none is purchased but labor can be hired.					
Net income	$		3,327		4,336		6,290
Operating capital used	$		6,264		4,258		5,763
Enterprises	acres	$CCSb_2$ I	16	$CCSb_2$ I	16	$CCSb_2$ I	16
	acres	$CSbCOM_2$ II	69	$CSbCOM_2$ II	69	$CSbCOM_2$ II	69
	acres	$CCOMM_0$ III	27	$CCOMM_0$ III	27	COM_2 III	27
	litters	Hogs, 2-litter	24	Hogs, 2-litter	26	Hogs, 2-litter	30
	nos.	Beef cows, sell calves	14				

takes less operating capital than does the C-management situation because, with the input-output coefficients used for B management, buying grain to expand the 2-litter hog enterprise is more profitable than any other livestock activity allowed to compete for funds. The hog enterprise is most profitable under A management also, but more capital is used for fertilizer, and some capital is substituted for labor in hog production. In the C-management situation, the beef cattle enterprise is just large enough to use forage produced in the crop plan and not used by hogs.

OPTIMUM PLANS FOR 240-ACRE FARMS

Plans presented in previous sections were for 160-acre farms. It is, of course, possible that the optimum hog production methods may differ from these on farms of other sizes. For example, some larger farms keep a "year-around" hired man. He is used especially for peak labor seasons on crops and the usual types of livestock enterprises. With the larger labor supply is it possible that the more specialized hog systems, such as 4-litter and 6-litter systems, might have greater advantages than on a 160-acre farm operated mainly with the labor of the family? Some 240-acre farms are operated with about the same family labor supply as 160-acre farms, but with some curtailment in livestock programs. Is it possible that the tight labor situation on these farms may place even more of a restraint on highly specialized hog systems? The analysis of this section has been designed to explore these questions for 240-acre farms with A management and various levels of capital.

RESOURCE AND INPUT-OUTPUT COEFFICIENT ADJUSTMENTS

For this analysis, as compared with that for 160-acre farms, land resources have been increased by one-half, and labor resources have been increased to include an additional man-year of labor. Too, crop coefficients have been adjusted to allow for larger power units and field equipment on 240-acre farms, and the May-June labor-hiring activity has been removed. Fixed costs were increased from $1,429 for the 160-acre farm situations in the Clarion-Webster soils to $5,450 for the 240-acre farm situations and from $1,269 for the 160-acre farm situations in the Shelby-Grundy-Haig soils to $4,950 for the 240-acre farm situations. These increases include the cost of one hired man and the additional taxes and equipment needed for a 240-acre farm.

OPTIMUM PLANS FOR 240-ACRE FARMS ON CLARION-WEBSTER SOILS

The optimum plans for 240-acre farms on Clarion-Webster soils as capital varies are shown in table 17. Again, plans are only for A management. The relation between net returns and amounts of operating capital is shown graphically in fig. 7. The limiting factor in planning is indicated at each "corner" in the graph. Comparison of table 17 with table 11 (plans for 160-acre farm with A-level management) show proportionately larger but otherwise similar crop and livestock plans up to plan 5. March-April labor is a limiting factor in plan 2 on the 160-acre farm and on the 240-acre farm in plan 6. In table 11, May-June labor is a variable cost beyond plan 2. In table 17, May-June labor is assumed as a fixed cost but restricted to 1,040 hours. The consistency of the 2-litter system to be included in the optimum plans of the 240-acre farms arises because of the low return in capital for the specialized systems, which prevents 4- and 6-litter systems from coming into the optimum plans when labor is available for the 2-litter system. Plans 6 and 7, table 17, have the 2-litter system expanded to the limit allowed by available labor. With a hired man included as a "fixed cost," a large volume of production is allowed before labor becomes restricting. The plans emerge not because the specialized systems are themselves unprofitable, but because they must compete with other practices and enter-

TABLE 17. CLARION-WEBSTER SOILS: OPTIMUM FARM PLANS FOR A MANAGEMENT ON 240-ACRE FARMS WITH DIFFERENT QUANTITIES OF OPERATING CAPITAL AVAILABLE.[a]

Plan	Capital level ($)	Net income[b] ($)	Enterprise	Level: Acres	Level: Litters	Additional resource limiting[c]	Corn-surplus or deficit[d] (bushels)
1	3,357	6,460	$CCSb_1$	225		Land	+9,194
2	7,707	10,418	$CCSb_1$	225			
			Hogs, 2-litter		30	Hog building	+5,985
3	8,068	10,747	$CCSb_1$	225		Pasture	+5,719
			Hogs, 2-litter		32		
4	12,918	15,035	$CCSb_1$	213		Cattle building	+2,067
			$CSbCOM_2$	12			
			Hogs, 2-litter		66		
5	19,406	19,642	$CCSb_2$	203		Corn	0
			$CSbCOM_2$	22			
			Hogs, 2-litter		66		
			Hogs, 2-litter, bldg. purchase		30		
6	31,892	24,012	$CCSb_2$	189		March-April labor	—4,202
			$CSbCOM_2$	36			
			Hogs, 2-litter		66		
			Hogs, 2-litter, bldg. purchase		68		
7	32,401	24,158	$CCSb_2$	191		Forage	—4,285
			$CCOM_1$	34			
			Hogs, 2-litter		66		
			Hogs, 2-litter, bldg. purchase		68		

[a] A May-June labor hiring activity was not allowed, but cost of one full-time hired man was included in fixed cost.
[b] Net income with all variable costs plus fixed costs deducted from gross returns.
[c] Shows additional resource limiting. Hence, for each row, all resources mentioned previously also are limiting.
[d] A plus (+) indicates a grain sale, while a minus (—) indicates a corn purchase.

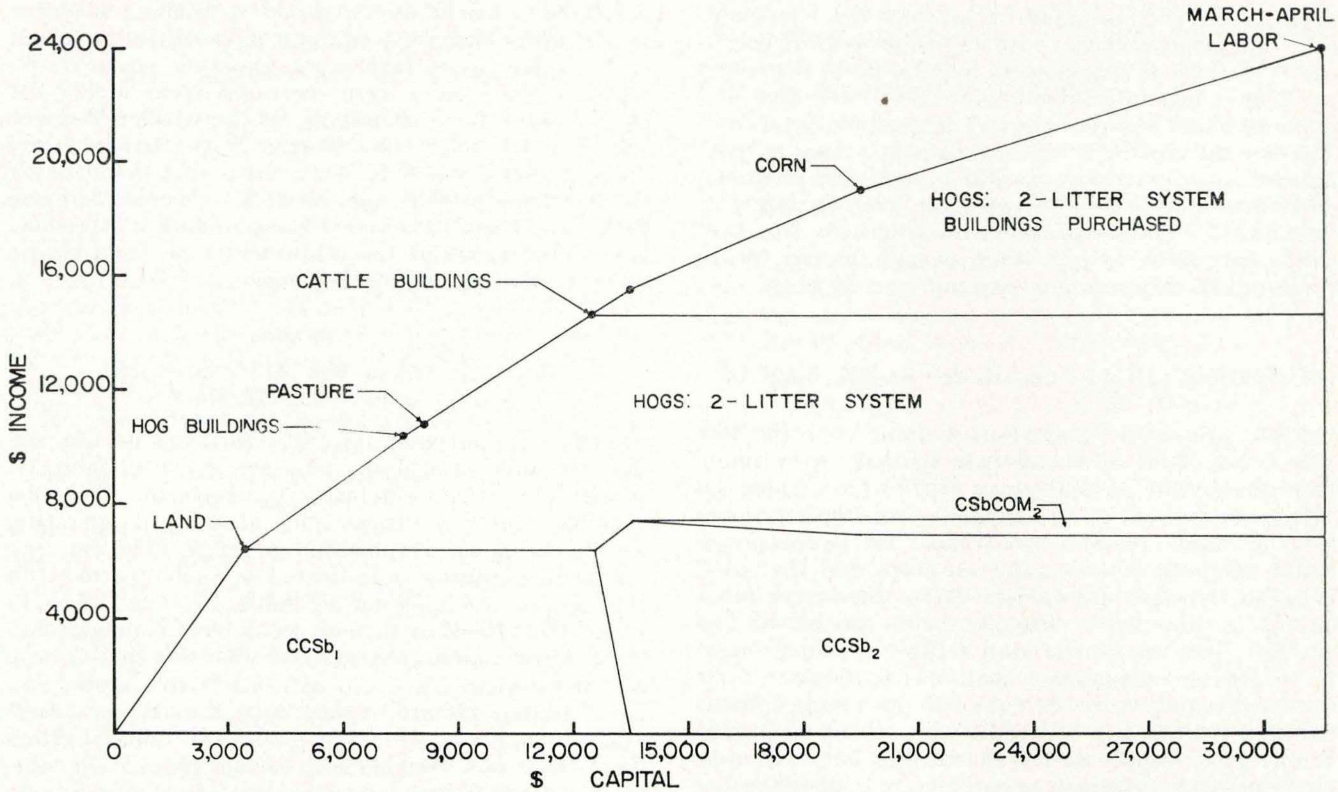

Fig. 7. Clarion-Webster Soils: Optimum farm plans for A management on 240-acre farms with different quantities of operating capital available.

prises in level of capital return. As mentioned in previous sections, for both types of soil analyzed, returns on capital are highest in this order; planting land to crops, fertilizing corn and raising hogs. Hence, 1- and 2-litter hog systems which allow use of more capital for crops and fertilizer investment are more profitable than diversion of part of this capital to a more costly hog system. Too, even with the labor supply of a hired man, the problem of availability of labor for crops during periods of peak labor requirements also has some effect on the livestock system which best fits into the optimum plan. In plan 6 (table 17), labor during the March-April period is restricting and, if the full corn acreage is to be planted, the hog system must be geared accordingly.

Farrowing combinations other than those used in the study might make better use of December-January-February labor. Within the framework of the model used, a 4-litter system might prove profitable at very large operating capital levels because it could make use of winter labor. It would, however, have to be modified so that crop labor requirements in other periods would not conflict. With the production coefficients and prices assumed in this study, however, the marginal return to capital, used in the necessary large quantities to bring a 4-litter system into the plan without curtailment of other profitable investments, would have a return of less than 5 percent. The specialized systems would not become optimum as long as labor has high returns for alternative enterprises in the March-April period.

The decreasing slope of successive segments of the net return line in fig. 7 indicates the decreasing marginal return on capital as funds are increased.

OPTIMUM PLANS FOR 240-ACRE FARMS ON SHELBY-GRUNDY-HAIG SOILS

The plans at five capital levels for 240-acre farms with A management used on all enterprises are presented in table 18 and fig. 8 for Shelby-Grundy-Haig soils. The cost of a hired man for the full 12 months is included in the fixed cost and deducted from the returns in computing net income. Net income at the lower capital levels is very low because of the relatively high fixed costs. Following the pattern found in the analysis of other farm situations, the 2-litter system enters the optimum plans at the lower capital levels. In contrast to the optimum plans at various capital levels on 240-acre farms on Clarion-Webster soils, steer feeding proves to be more profitable than expanding hog production when March-April labor becomes limiting. This difference results because hay is available with only a marginal cost for harvesting. Plan 3 is the optimum plan when capital is increased to $54,003 to allow expansion of the 2-litter hog system until March-April labor is entirely used. The large amount of labor available for livestock allows the 2-litter system to expand to 182 litters. With a full-time hired man available, the size of each enterprise becomes relatively large before labor becomes limiting and before more hired help would need to be obtained. Hence, even though a 240-acre farm on Shelby-Grundy-Haig requires less labor for crops, with more labor available for other enterprises throughout the year, the specialized 4- and 6-litter systems still remain out of the profit-maximizing plans. The conventional 2-litter system now found on farms still fits in best with the over-all organization of the farm if profit maximization is the goal.

Increasing farm size to 240 acres and allowing a full-time hired man has the effect of increasing the amount of internal "free labor" during the peak labor periods. In the 160-acre situations, the high opportunity cost of the limited March-April labor restricted the expansion of the 2-litter hog system in most plans. With the large amount of off-season labor available for livestock production, opportunity costs of March-April labor allow large expansion of the 2-litter hog systems. Hence, the 4- and 6-litter specialized systems are unable to compete with the 2-litter systems at the capital levels considered.

EFFECT OF MANAGEMENT SUPERVISION AND ADDED CAPITAL ON ORGANIZATION OF HOG ENTERPRISE

In certain localities, feed, processing and marketing firms furnish management and capital to farmers in return for a contract to process the farmer's products, or under an arrangement to furnish sows, feed, capital and other resources to the hog producer. Previous plans did not indicate any advantage for highly specialized hog production systems under the farm and soil situations studied. Evidently the farmer who

TABLE 18. SHELBY-GRUNDY-HAIG SOILS: OPTIMUM FARM PLANS FOR A MANAGEMENT ON 240-ACRE FARMS WITH DIFFERENT QUANTITIES OF OPERATING CAPITAL AVAILABLE.[a]

Plan	Capital level ($)	Net income[b] ($)	Enterprise	Level: Acres	Level: Litters	Level: Nos.	Additional resource limiting[c]	Corn surplus or deficit[d] (bushels)
1	6,298	4,023	CCSb$_1$ I	24			Class I and II land	0
			CSbCOM$_1$ II	103				
			Idle class III land	40				
			Hogs, 2-litter		32			
2	8,337	5,801	CCSb$_1$ I	24			Class III land Buildings Corn	
			CSbCOM$_1$ II	103				
			CCOMM$_1$ III	40				
			Hogs, 2-litter		36			
			Hogs, 2-litter, bldg. purchase		6			
3	54,003	22,214	CCSb$_2$ I	24			March-April labor	—14,744
			CCOMM$_2$ II	103				
			CCOMM$_1$ III	40				
			Hogs, 2-litter		36			
			Hogs, 2-litter, bldg. purchase		146			
4	58,361	22,941	CCSb$_2$ I	24			Cattle buildings	—15,115
			CCOMM$_2$ II	103				
			CCOMM$_1$ III	40				
			Hogs, 2-litter, bldg. purchase		164			
			Steer calves, past.-fed			45		
5	61,694	23,420	CCSb$_2$ I	24			Forage	—16,752
			CCOMM$_2$ II	103				
			CCOMM$_1$ III	3				
			Idle III	37				
			Hogs, 2-litter, bldg. purchase		174			
			Steer calves, past.-fed			45		

[a] A May-June labor hiring activity was not allowed, but cost of one full-time hired man was included in fixed cost.
[b] Net income with all variable costs plus fixed costs deducted from gross returns.
[c] Shows additional resource limiting. Hence, for each row, all resources mentioned previously also are limiting.
[d] A plus (+) indicates a grain sale, while a minus (—) indicates a corn purchase.

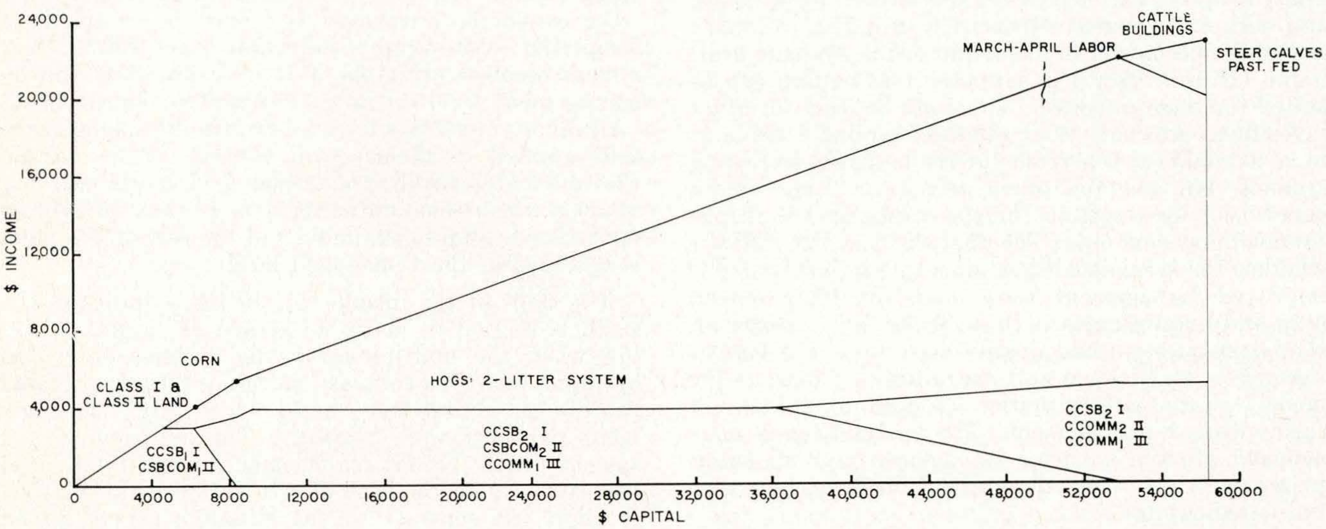

Fig. 8. Shelby-Grundy-Haig Soils: Optimum farm plans for A management on 240-acre farms with different quantities of operating capital available.

has ample managerial ability (such as the A and B levels discussed previously) and capital can develop a profit-maximizing plan which includes the more conventional 1- and 2-litter systems, rather than the 4- and 6-litter methods. As indicated earlier, the marginal return to capital is very low for the three plans which did include a 4-litter system. The problem of allocating scarce labor, capital and feed resources among crop and livestock alternatives causes nonspecialized systems to be most profitable under the Iowa farming conditions. Now, however, we examine whether a specialized hog system might be included in the optimum farm plan if contracts providing the necessary "management rules" and providing capital for feed, hogs and equipment were available to an operator with managerial skills of the C level. Firms furnishing such contracts have usually specified a multiple-farrowing or specialized system.

To accomplish this end, plans were recomputed and analyzed for the basic C-managed 160-acre farm situations, adding 4- and 6-litter hog activities, with coefficients corresponding to A-level management. These are then allowed to compete with other activities for resources. The 1- and 2-litter activities were dropped from the model, supposing that added capital under a contract would be used only for specialized systems. Thus, the arrangement of the model is that of a farm operated by a manager of low-level skills who can obtain capital and management supervision providing that he adopts the specialized multiple-farrowing system.

In the A and B situations analyzed previously, the 4- and 6-litter hog systems were not usually as profitable as conventional hog enterprises. This was true, even though they were included as activities for selection, because, with two exceptions, other uses of capital and scarce resources paid a higher return. If the multiple-farrowing hog systems are to be included in optimum plans, return on resources in the multiple systems must be increased above other farming alternatives. The present analysis attempts to determine whether making capital available to an operator with limited capital, earmarked for specialized hog systems, and with management supervision supplied, can make the more specialized multiple-farrowing systems profitable. In this case, it is supposed that capital can be added for these purposes but cannot be used for other investment alternatives. Unlimited capital is assumed to be available at 6 percent for the multiple-farrowing systems, but not for other activities. Management supervision is available for the specialized multiple-farrowing system only. The analysis does not indicate whether the specialized systems would be profitable if improved management were made available for all crop and livestock alternatives on the farm. However, the latter question has already been answered (under the prices, coefficients and restraints employed in the model) in the determination of optimum plans for farms with A management. The analysis for A management allowed superior management for all enterprises, with plans also determined for situations with unlimited capital.

The order of this section is: First, we introduce coefficients for all hog enterprises at the A level of management, with capital variable. The 1- and 2-litter systems are allowed in the model and can compete with 4- and 6-litter systems. Next, we delete the 1- and 2-litter systems as alternatives and suppose that A-level management and borrowed capital are available only for 4- and 6-litter hog systems and that C-level management applies to all other enterprises.

ADDED MANAGEMENT ON CLARION-WEBSTER SOILS

Optimum plans were first programmed for 160-acre farms on Clarion-Webster soils with C management for all alternatives except specialized multiple-farrowing hog systems and with 1- and 2-litter systems limited to present building restrictions. (More buildings could be added for 4- and 6-litter systems.) The optimum plans at four capital levels are presented in table 19 and fig. 9.

Plans 1 and 2 are the same in table 19 as plans 1 and 4 in table 9 for the C-managed farm on Clarion-Webster soils. Introducing the A management coefficients for the specialized hog systems does not make them the most profitable alternative when labor is "internally free," buildings are available for the 2-litter system and capital is very limited. The high returns from growing and fertilizing crops, especially corn, cause this to be the most profitable use of scarce funds.

When capital is expanded past the \$3,656 level, May-June labor must be hired, and expansion of the 2-litter system would necessitate decreasing corn acreage to allow for more pasture area. Under these conditions, the optimum plan includes 48 litters of hogs using the 6-litter hog system. The intensive cropping plan and the 6-litter hog system use the entire supply of March-April labor.

Just as was true in table 10, the 4-litter hog system becomes optimum when March-April labor is limiting. When capital is expanded to \$12,992, 41 acres of cropland previously in a $CCSb_2$ rotation, are cropped in a $CCOM_2$ rotation to free labor in the critical March-April period. Thus, in a situation where March-April labor cannot be purchased and must be obtained by competing with crop production, the 4-litter hog system becomes optimum if it is operated at the A-management level on an otherwise C-managed farm. (All other enterprises have a low level of management skill applied to them.) On 160-acre farms in the Clarion-Webster soil area, A-managed specialized hog systems will become optimum if more than \$11,514 of operating capital is available and the rest of the farm is operated at the C-managed level.

The slope of the income line in fig. 7 indicates the small reduction in marginal return of capital resulting when the multiple-farrowing systems enter the optimum plan. In contrast, marginal returns dropped rapidly as capital was varied when only C-management practices were allowed. The addition of hog systems with better management, as capital level increases, causes the level of return to remain relatively high (in contrast to the situation where added capital could be used only for enterprises with low levels of management).

TABLE 19. CLARION-WEBSTER SOILS: OPTIMUM FARM PLANS WITH C MANAGEMENT FOR ALL ENTERPRISES EXCEPT 4- AND 6-LITTER HOG SYSTEMS WHICH HAVE A-LEVEL MANAGEMENT ON 160-ACRE FARMS WITH DIFFERENT QUANTITIES OF OPERATING CAPITAL AVAILABLE.

Plan	Capital level ($)	Net income[a] ($)	Enterprise	Level		Additional resource limiting[b]	Corn surplus or deficit[c] (bushels)	May-June labor hired (hours)
				Acres	Litters			
1	1,177	4,798	$CCSb_0$	150		Land	+4,258	0
2	3,656	6,574	$CCSb_2$	144		May-June labor	+4,796	0
			$CCOM_2$	6				
			Hogs, 2-litter		14			
3	11,514	11,129	$CCSb_2$	150		March-April labor	+1,093	120
			Hogs, 6-litter		48			
4	12,992	11,563	$CCSb_2$	109		Corn	0	92
			$CCOM_2$	41		Sept.-Oct.-Nov. labor		
			Hogs, 6-litter		54			
			Hogs, 4-litter		4			

[a] Net income with all variable costs plus fixed costs deducted from gross returns.
[b] Shows additional resource limiting. Hence, for each row, all resources mentioned previously also are limiting.
[c] A plus (+) indicates a grain sale, while a minus (—) indicates a corn purchase.

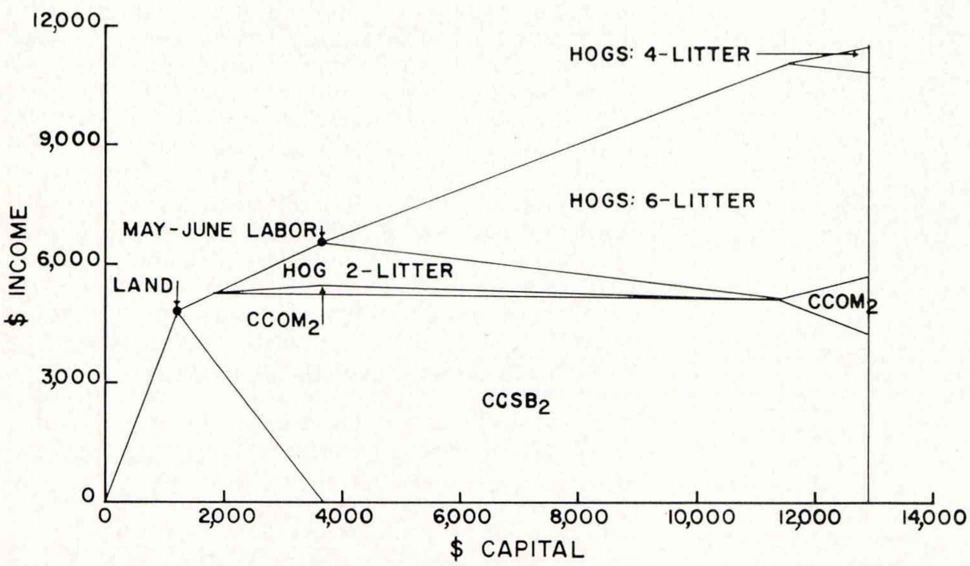

Fig. 9. Clarion-Webster Soils: Optimum farm plans with C management for all enterprises except 4- and 6-litter hog systems which have A-level management on 160-acre farms with different quantities of operating capital available.

EFFECTS OF ADDED MANGEMENT ON SHELBY-GRUNDY-HAIG SOILS

Optimum plans for 160-acre Shelby-Grundy-Haig farms operated with C management for all enterprises, except the 4- and 6-litter hog systems which are operated with A-management techniques, are presented in table 20 and fig. 10.

Comparison of table 20 with table 13 (the latter including plans for farms with C management on all enterprises) shows that the optimum plans are the same for supplies of operating capital of $8,652 or less. When operating capital is increased beyond $8,652, the specialized 4-litter system for pork production becomes the most profitable investment alternative. The 4-litter system continues to be the most profitable system until May-June labor becomes limiting. Thus, over a wide range of capital variation, the 4-litter system is most profitable when A-level management techniques are assumed to be available for the specialized hog system, with other enterprises at the C-management level. In table 15, where A management is assumed for all enterprises, a 4-litter specialized system is not included in the optimum plan. The specialized hog system becomes optimum only when management supervision of this level is added to a C-managed farm.

After the family supply of May-June labor is used (plan 5 in table 20), the cropping plan is changed slightly to free more May-June labor. When March-April labor becomes limiting, class III land is left idle to free labor for the 4-litter hog system. In other words, the 4-litter hog system with superior management becomes more profitable than cropping of class III land with low management practices. Even though forage is left unused and, hence, would be available to a cattle enterprise for only the harvesting costs, cattle produced at C-management levels are not able to compete with a specialized hog system using A management practices. This is true even when the operator has no alternative for the use of forage. (In actual practice class III land would be rented out either as cropland or permanent pasture and other forage would be plowed down or sold. Also, March-April labor may be hired to make possible cropping of class III land.)

Seven units of the 4-litter system use all available building space for nursing-growing-fattening facilities. Farrowing quarters and sow shelters for these units must be purchased. Complete building purchase is required for all units in excess of seven. Thus, capital input increases rapidly when the multiple-farrowing system is used. In order to use all available May-June labor, $32,472 capital is required. The maximum capital plan uses $38,132 capital and all remaining March-April labor.

TABLE 20. SHELBY-GRUNDY-HAIG SOILS: OPTIMUM FARM PLANS WITH C MANAGEMENT FOR ALL ENTERPRISES EXCEPT 4- AND 6-LITTER HOG SYSTEMS WHICH HAVE A-LEVEL MANAGEMENT ON 160-ACRE FARMS WITH DIFFERENT QUANTITIES OF OPERATING CAPITAL AVAILABLE.

Plan	Capital level ($)	Net income[a] ($)	Enterprise	Level: Acres	Litters	Nos.	Additional resource limiting[b]	Corn surplus or deficit[c] (bushels)	May-June labor hired (hours)
1	753	1,291	$CCSb_0$ I	16			Land	+2,113	0
			$CSbCOM_0$ II	69					
			$CCOMM_0$ III	27					
2	5,454	3,131	$CCSb_2$ I	16			Corn	0	0
			$CSbCOM_2$ II	69					
			$CCOMM_0$ III	27					
			Hogs, 2-litter		24				
			Beef cows, sell calves			10			
3	6,264	3,327	Same cropping plan				Pasture	0	0
			Hogs, 2-litter		24				
			Beef cows, sell calves			14			
4	8,652	3,652	Same cropping plan				Building space	—1,170	0
			Hogs, 2-litter		36				
			Beef cows, sell calves			14			
5	32,472	11,627	Same cropping plan				May-June labor	—7,457	0
			Hogs, 4-litter		28				
			Hogs, 4-litter, bldg. purchase		64				
6	33,257	11,806	$CCSb_2$ I	16.2			March-April labor	—7,405	0
			$CCOM_2$ II	68.6					
			$CCOMM_0$ III	22.9					
			$COMM_0$ III	3.7					
			Hogs, 4-litter		28				
			Hogs, 4-litter, bldg. purchase		68				
7	38,132	12,873	$CCSb_2$ I	16.2			March-April labor	—9,653	0
			$CCOMM_0$ II	30.2					
			$CCOM_2$ II	4.4					
			$CSbCOM_2$ II	24.0					
			Idle Land III	26.6					
			Hogs, 4-litter		28				
			Hogs, 4-litter, bldg. purchase		80				

[a] Net income with all variable costs plus fixed costs deducted from gross returns.
[b] Shows additional resource limiting. Hence, for each row, all resources mentioned previously also are limiting.
[c] A plus (+) indicates a grain sale, while a minus (—) indicates a corn purchase.

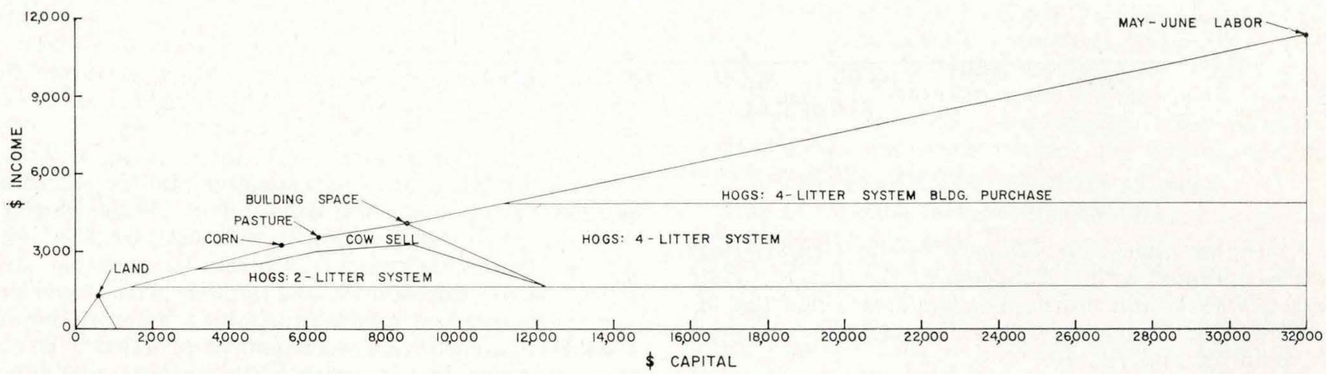

Fig. 10. Shelby-Grundy-Haig Soils: Optimum farm plans with C management for all enterprises except 4- and 6-litter hog systems which have A level management on 160-acre farms with different quantities of operating capital available.

When the level of management of the specialized multiple-farrowing systems is higher than the level of management for all other alternative enterprises allowed to compete for scarce resources, level of management does affect selection among conventional pork production methods and the more specialized multiple-farowing systems. As shown earlier, however, a high level of management for all alternatives does not cause the specialized systems to enter the optimum plans.

Management supervision and capital allowed for the multiple-farrowing system does allow a much greater income on the C-managed farm, compared with the same farm where all practices, including hogs, are at a lower management level and hogs are restricting. Twenty-seven units (108 litters) of the 4-litter system are raised under the maximum capital plan. Net income is $12,873, compared with $4,642 on the C-managed situation (table 13), without the management supervision. Capital requirements are $38,132 as compared with $15,794 in table 13. Income is still lower, however, than in plans where A management practices are allowed for all enterprises and only 1- and 2-litter hog systems come into the plan. (Compare tables 15 and 20.)

EFFECTS OF CAPITAL LENDING FOR A MANAGEMENT

Since levels of capital necessary to make extensive use of the multiple-farowing systems are higher than may be available to many operators and feasible for some firms interested in contract arangements, an analysis was made of the effect of loaned capital earmarked for the hog enterprise. Here our concern is to determine whether farmers with A-level management ability but with extremely limited capital might profitably use specialized systems. It is assumed that added capital can be made available only under a contractual arrangement requiring specialized systems.

Optimum plans for a discrete capital level were computed assuming a 160-acre A-managed farm in each of the two soil areas. Levels chosen were $8,626 for the Clarion-Webster soil area and $7,475 for the Shelby-Grundy-Haig soil area.

The lending provision was included in this manner: Capital requirements for multiple-farrowing hog systems were reduced to the cost of buildings and equipment. It was assumed that an outside source would loan operating capital for breeding stock and cash expenses. The money would be repaid at the end of the year at 6 percent interest. Return remaining at the end of the year was reduced by the amount of the loan plus interest.

The optimum plans for these capital-lending situations were the same as those in the same situations without a lending provision of this type (plan 4, table 11, and plan 3, table 15). Availability of specialized credit did not cause the multiple-farrowing systems to become more profitable than 2-litter systems at these capital levels. A possible explanation for the result is this: Adding a multiple-farrowing system would require some building purchase. This increased capital input and the interest charge would reduce return on capital from the multiple-farrowing systems. The 2-litter system, with no building purchase to reduce return on capital, would provide a greater return to all limiting resources. Hence, where farmers already have sufficient facilities for conventional 1- and 2-litter systems, the 4- and 6-litter systems are not competitive.

With increased capital supplies, the 1- and 2-litter systems would require building purchase. These systems use buildings much less intensively than the multiple-farrowing enterprises. It is possible that at higher capital levels the credit provision would cause the multiple-farrowing systems to be optimum. But it has been shown that these multiple-farrowing systems, even with special credit available, are not profit-maximizing at lower capital levels.

SPECIALIZATION & RESOURCE SITUATIONS

Many farmers, especially those just beginning, have very limited capital. Multiple-farrowing hog systems are not adapted to these limited capital situations because they require a relatively large investment in buildings. Even with management supervision offered, potential income increases are not large when capital is very limited. (Crops and their fertilization provide a higher return to capital than do hogs or other livestock at the price levels used.) If, however, enough capital is made available to allow the manager of a C-managed farm to expand his business beyond plan 4, table 20, and if management supervision also is made available for the specialized systems, the multiple-farrowing hog systems could be optimum in many of these situations. Operating capital for all purposes would need to exceed minimum levels for multiple-farrowing hog systems suggested in tables 19 and 20, however—even on the farm of a beginning operator.

Under the price, coefficients and restricitions used in this study, highly specialized hog systems generally do not outcompete the more conventional hog systems, if the organization of crops and livestock is to maximize income from the farm as a whole. It would appear, then, that highly specialized hog farming would not endanger the more general systems now found on Iowa farms. This is true, because capital, labor and feed must be allocated among numerous crop and livestock enterprises relative to the scarcities of the resources and the marginal returns of the enterprises. Because the production of corn is a profitable use of these resources, it has priority over specialized hog systems in use of capital. Then less specialized hog systems, in conjunction with cattle, apparently provide a more optimum use of resources, considering the need and profitability of crops. Only where specialized systems are given the advantage of high-level management and capital availability, without these resources and facilities allowed for other enterprises, do the specialized systems prevail in profit-maximizing opportunities. Of course, if farming activities other than specialized pork production were not to be considered, a highly specialized pork farm would represent the profitable opportunity.

The analysis of this study suggests that the concentration of hog production on highly specialized farms is not likely on Iowa farms. While only two soil situations were examined, these represent the near extremes upon which farm organization is based. Given the high returns to capital and labor in corn production and its fertilization, resources likely will continue to be allocated to this crop and its complements before they are allocated to other enterprises. While optimum crop enterprises are not independent of the best organization of livestock and vice versa, livestock will still continue to be organized around comparative advantages in crop production and the uneven seasonal requirements for labor and capital used on them. While hog enterprises found on farms may grow in size and specialization, it does not appear that highly specialized hog farms, whether encouraged by contractual developments or integration institutions or by direct structures of prices in relation to resource productivities and farm organization, will come to predominate, or even to prevail widely. This study, however, has not examined economies involved or optimum structures for farms which might consider and produce only hogs, with all other enterprises excluded as possibilities.

SUMMARY

In recent years, farm and nonfarm people have questioned whether "contract farming" might eventually predominate in the Corn Belt. This question has been raised because of the tendency toward more specialization in hog production encouraged by multiple-farrowing and related management systems. Also, contract arrangements — the so-called integration of production — where credit, feed and management guidance are furnished to farmers have caused this question to be raised.

This study includes an analysis, made at the individual farm level, to determine (1) which hog systems, including the more conventional 1- and 2-litter systems as compared with the more specialized 4- and 6-litter systems, contribute most to farm profits, (2) the optimum hog production method in relation to the most profitable over-all organization of farm resources on two soil types and (3) the possible effect of contract arrangements on farm profits where capital for feed, hogs and equipment, plus the management to go with these resources, is lacking but is provided by outside firms. The study was designed to compare the profit potential of the conventional 1- and 2-litter systems with 4- and 6-litter systems on typical 160- and 240-acre farms in northern and southern Iowa where capital and managerial skills might vary among farming situations. The analysis was made for typical farm situations in the Clarion-Webster soil area and the Shelby-Grundy-Haig soil area.

Variable capital linear programming solutions were developed for farms on both soil associations, using three levels of management for each capital and farm-size situation. Several representative crop rotations, each at two alternative fertilization levels, and typical beef producing enterprises were considered as production alternatives. Main emphasis, however, was placed on choice among 1-, 2-, 4- and 6-litter hog systems. The model employed in the empirical analysis allowed each hog system to be expanded through purchase of buildings and equipment. Grain purchases and sales and labor hiring were also allowed.

Effects of "earmarking" capital and management supervision for the multiple-farrowing hog systems were examined by comparison with basic optimum plans in the following manner: First, farms with C-level management (technology near that of typical commercial hog producers) were allowed — with A-level management (technology near laboratory conditions) on 4- and 6-litter hog systems as production alternatives. These plans were compared with those assuming C-level management throughout. Situations on farms with A-level management were recomputed making special capital borrowing provisions available to the multiple-farrowing hog systems. Both comparisons gave management supervision and capital allocated to the specialized hog systems an opportunity to make the maximum contribution to income. These comparisons were more favorable to the 4- and 6-litter hog systems than the basic plans.

The results of this analysis indicate that highly specialized hog enterprises are not likely, in terms of profits to the individual farmer, to supersede the more general management systems now dominant on Iowa farms. There are certain advantages in some degree of specialization which allows use of the same equipment and breeding stock, for as many litters as are consistent with the most profitable over-all combination of livestock and crops. But beyond this point, for the farmer who has the capital and management skills, it is not profitable to increase the number of farrowings to a point of specialization that causes hog operations to draw labor and other resources away from corn or the complex of crops produced with it.

No other crop or enterprise, under the price levels existing now or in recent years, excels corn in terms of return to labor and capital resources. This statement applies generally to the farm sizes, capital levels and management situations studied. For farms of typical size, few situations were isolated where hog systems including 4 or 6 litters per year could be included in the most profitable over-all management plan. Hog production using 2 or 3 litters, fitted into a program allowing allocation of labor and capital to the most profitable crop program and with some feeder cattle included to utilize forage, remained the most profitable. While these optimum plans would allow some added specialization and larger sizes in hog enterprises, they would not entail large sacrifices in corn production or in the more general organization of farms. Too, contracts which provide capital for feed, hogs and equipment — and the necessary "management rules" to go along with these resources — have no profit advantage for farmers who already possess these factors. The study did show, however, that profit might be raised by contractual arrangements based on specialized hog systems where: (1) the farmer possesses low mangement skills and can obtain management supervision for hogs, but not other enterprises, through a contractual arrangement which includes specialized 4- and 6-litter systems or (2) the farmer has sufficient management ability but is short on capital and can obtain more funds for hogs only under such an arrangement. Even in these two management siutations, however, specialized systems would not be most profitable if (a) improved management skills were allowed for all enterprises and (b) borrowed capital could be used for any enterprise on the farm without being restricted to specialized hog systems.

If the farm operator has the managerial ability to produce pork efficiently and can borrow funds at usual market interest rates, a contract arrangement would have advantage only to the extent that a better selling price for hogs could be obtained. On the other hand, if he could produce hogs of the type commanding highest prices and market them at times of price peaks, or could avoid seasonally low prices, his profits would be as great as from the same price premiums and contract production.

Specialization and multiple-farrowing systems have been studied as they fit into typical Iowa farm situations. In these situations hog enterprises which fit especially well with corn production and complementary crop and livestock activities have over-all advantage in farm management. Because of the unique nature of climate and soils giving comparative advantage to capital and labor used for corn production and the general complex of enterprises associated with corn rotations, it appears that the more general organization of farms will continue to be most profitable in the soil areas studied. But for farms which might specialize in or produce only hogs, without corn or other enterprises considered as alternatives, extreme specialization with continuous farrowing throughout the year would be most profitable. Equipment and breeding stock necessary for hog production could then be utilized more effectively.

APPENDIX A

BASIC INPUT-OUTPUT DATA

The following tables include the basic input-output relationships on which production coefficients used in the proceeding analysis were based. A more complete discussion of these will be found in an unpublished thesis.[13]

[13] Irwin, *op. cit.*

TABLE A-1. ONE-LITTER SYSTEM. UNIT = 1 LITTER.

	Levels of Management		
	A	B	C
Farrowing date	May	May	May
Pigs weaned per unit (no.)	9.00	7.30	6.00
Death loss after weaning (no.)	0.12	0.10	0.09
Replacement gilts kept (no.)	1.08	1.08	1.08
Hogs marketed per unit (no.)	7.80	6.12	4.83
Selling weight of pigs (lbs.)	240	240	240
Total cwt. pigs sold	18.72	14.69	11.59
Selling month	Dec.	Dec.	Dec.
Average selling price	$ 15.26	$ 14.86	$ 14.46
Gross revenue from market hogs	$285.36	$218.44	$167.59
Selling weight of sow (lbs.)	350	350	350
Selling month	Aug.	Sept.	July
Selling price	$ 15.01	$ 14.58	$ 14.62
Gross revenue from sow	$ 52.54	$ 51.03	$ 51.17
Gross revenue per unit	$337.90	$269.47	$218.76
Amounts of feed fed:			
Corn equivalent (bu.)	113.139	105.446	107.494
Supplement (cwt.)	9.260	7.192	6.20
Hay (tons)	0.025	0.018	0
Pasture (a.u.d.)[a]	37.440	29.380	25.498
Annual cash expense:			
Supplement	$ 60.28	$ 46.76	$ 40.00
Boar charge	4.00	2.50	1.50
Power and machinery[b]	5.88	5.88	5.88
Equipment use[b]	5.80	5.80	5.80
Hauling[b]	1.27	1.00	0.79
Vet, electricity, misc.[b]	5.99	4.70	3.71
Total annual cash expense	$ 75.27	$ 61.25	$ 51.58
Capital investment:			
Gilt	$ 36.62	$ 35.66	$ 34.70
Equipment[c]	25.12	20.87	11.74
Capital coefficient	$144.96	$123.17	$104.12
Net return per unit	$254.68	$202.83	$161.08
Building space (units)	¾	¾	¾
Cost of purchased building	$ 63.75	$ 63.75	$ 63.75
Capital coefficient with building purchased	$208.71	$186.93	$167.87

[a] Animal unit days.

[b] Hardin, L. S., Weigle, R. N. and Wann, H. S. Hogs — one and two litter systems compared. Ind. Agr. Exp. Sta. Bul. 565. Nov. 1951.

[c] Includes fencing, concrete floor, tanks, feeders and other equipment.

TABLE A-2. TWO-LITTER SYSTEM. UNIT = 2 LITTERS.

	Levels of Management		
	A	B	C
Farrowing dates	Feb.-Aug.	Mar.-Sept.	Apr.-Oct.
Pigs weaned per unit (no.)	18.0	14.6	12.0
Death loss after weaning (no.)	0.23	0.20	0.18
Replacement gilts kept[a] (no.)	0.48	0.83	1.08
Pigs sold per unit (no.)	17.45	13.57	10.74
Selling weight of pigs (lbs.)	220	230	240
Total cwt. pigs sold	38.390	31.211	25.776
Selling months	July-Jan.	Sept.-Mar.	Nov.-May
Average selling price[b]	$ 17.19	$ 16.44	$ 15.52
Gross revenue from market hogs	$677.23	$513.08	$400.06
Selling weight of sow (lbs.)	450	400	350
Selling months	Apr.-Oct.	June-Dec.	July-Jan.
Average price	$ 14.26	$ 13.95	$ 14.12
Pounds of sow sold[a]	180	300	350
Gross revenue from sow	$ 25.67	$ 41.85	$ 49.42
Gross revenue per unit	$702.90	$554.93	$449.48
Amounts of feed fed:			
Corn equivalent (bu.)	213.888	(202.824)	206.916
Supplement (cwt.)	20.237	(14.601)	12.642
Hay (tons)	0.054	0.031	0
Pasture (a.u.d.)	36.480	31.300	28.380
Annual cash expense:			
Supplement	$131.54	$ 94.91	$ 82.17
Boar charge[c]	7.00	4.50	2.50
Power and machinery[d]	9.36	9.36	9.36
Equipment use[e]	16.51	13.42	11.08
Hauling	2.61	2.12	1.75
Vet, electricity, misc.[e]	15.36	12.48	10.31
Total annual cash expense	$182.38	$136.79	$117.17
Capital investment:			
Breeding females	$ 50.62	$ 45.43	$ 38.94
Equipment	57.00	39.89	13.05
Capital coefficient	$290.00	$222.11	$169.16
Net return per unit	$520.52	$418.14	$332.31
Building space (units)	1	1	1
Cost of purchased building	$ 85.00	$ 85.00	$ 85.00
Capital coefficient, with building purchased	$375.00	$307.11	$254.16

[a] 8 percent extra allowed for nonbreeders, etc. Replace sows after 2, 3 and 5 litters, respectively.

[b] Arithmetic average of 2 selling months I $0.40/cwt. for quality.

[c] (*Purch. price-mkt. value*) - 20 units produced (keep boar 2 litters).

[d] Mueller, A. G. and Von Lanken, G. O. Detailed cost report 1955. University of Illinois. AERR15.

[e] Hardin, L. S. et al. Hogs — one-and two-litter systems compared Ind. Agr. Exp. Sta. Bul. 565. Nov. 1951.

[f] Animal unit days.

TABLE A-3. FOUR-LITTER SYSTEM. UNIT = 4 LITTERS, (2 SOWS).

	Levels of Management	
	A	B
Farrowing dates	Jan.-March-July-Sept.	Dec.-Feb.-June-Aug.
Pigs weaned per unit (no.)	36.0	29.30
Death loss after weaning (no.)	0.47	0.40
Replacement gilts kept (no.)	0.96	1.50
Hogs marketed per unit (no.)	34.57	27.40
Selling weight of pigs (lbs.)	220	230
Total cwt. pigs sold	76.05	63.02
Selling months	June-Aug.-Dec.-Feb.	June-Aug.-Dec.-Feb.
Average selling price	$17.10	$16.70
Gross revenue from market hogs	$1,300.52	$1,052.43
Selling weight of sow (lbs.)	450	400
Selling months	March-May-Sept.-Nov.	March-May-Sept.-Nov.
Average price	$14.19	$14.19
Pounds of sow sold[a]	400	573
Gross revenue from sow	$56.76	$81.31
Gross revenue per unit	$1,357.28	$1,133.74
Amounts of feed fed:		
Corn equivalent (bu.)	423.7	408.4
Supplement (cwt.)	43.348	31.540
Hay (tons)	0.103	0.101
Pasture (a.u.d.)[b]	0	0
Annual cash expense:		
Supplement	$281.76	$204.85
Boar charge	10.00	5.00
Power and machinery	30.42	25.21
Equipment use	32.70	27.10
Hauling	5.44	4.67
Vet, electricity, etc.	30.42	25.21
Total annual cash expense	$390.74	$296.10
Capital investment:		
Breeding females	$105.00	$92.24
Equipment and buildings (partial)	318.06	296.59
Capital coefficient, limited building purchase	$813.80	$681.07
Net return per unit	$966.54	$841.40
Building space, grow-fatten (units)	150.00	117.50
Capital coefficient	$963.80	$798.67

[a] Sows and 8 percent nonbreeding gilts.
[b] Animal unit days.

TABLE A-4. SIX-LITTER SYSTEM. UNIT = 6 LITTERS.

Item	A Management level
Farrowing dates	Jan.-Mar.-May-July-Sept.-Nov.
Pigs weaned per unit (no.)	54.00
Death loss after weaning (no.)	0.70
Replacement gilts kept (no.)	1.30
Pigs sold per unit (no.)	52.00
Selling weight of pigs (lbs.)	220
Total cwt. pigs sold	114.40
Selling months	June-Aug.-Oct.-Dec.-Feb.-April
Average selling price	$16.88
Gross revenue from market hogs	$1,931.07
Selling weight of sow (lbs.)	450
Selling months	April-June-Aug.-Oct.-Dec.-Feb.
Average price	$14.25
Pounds sow sold	360
Gross revenue from sow	$51.30
Gross revenue per unit	$1,982.37
Amounts of feed fed:	
Corn equivalent (bu.)	637.2
Supplement (cwt.)	65.21
Hay (tons)	0.154
Pasture (a.u.d.)[b]	0
Annual cash expense[a]	
Protein	$423.86
Boar charge	10.00
Power and machinery	45.76
Equipment use	49.19
Hauling	7.78
Vet, electricity, etc.	45.76
Total annual cash expense	$582.35
Capital investment:	
Breeding females	$157.50
Equipment and buildings	367.15
Capital coefficient, partial building purchase	$1,107.00
Net return per unit	$1,400.02
Building space, grow after purchase	150.00
Capital coefficient, complete building purchase	$1,257.00

[a] Compiled from: Mueller, D. G. Detailed cost reports for northern Illinois, 1955, 1956. University of Illinois.; D. G. Mueller and Hardin, L.S., *op. cit.*
[b] Animal unit days.

TABLE A-5. BEEF COW ENTERPRISES: BASIC DATA FOR TWO SYSTEMS FOR THREE MANAGEMENT LEVELS.

	Sell calves Level of Management			Feed out calves Level of Management		
Item	A	B	C	A	B	C
Marketing month	Oct.	Oct.	Oct.	Oct.	Oct.	Oct.
Market weight of calf or steer (lbs.)	430	415	400	1,078	1,027	976
Calf crop (%)	90	80	70	90	80	70
Weight sold per unit (lbs.):			233.3	808.5	684.7	569.3
Calf or steer	322.5	276.7				
Cow	183	175	167	183	175	167
Annual cash expense						
Protein	$ ----	$ ----	$ ----	$ 10.46	$ 9.20	$ 8.14
Power[a]	1.77	1.77	1.77	4.42	4.42	4.42
Equipment replacement[a]	4.26	4.26	4.26	7.50	7.50	7.50
Hay harvest	5.32	5.32	5.32	9.59	9.59	9.59
Breeding costs[b]	7.00	5.20	3.50	7.00	5.20	3.50
Hauling	1.59	1.53	1.47	3.28	3.12	2.97
Misc., vet.[a]	6.74	6.74	6.74	9.00	9.00	9.00
Total annual cash expense	$ 26.68	$ 24.82	$ 23.06	$ 51.25	$ 48.03	$ 45.12
Capital investment:						
Equipment	$ 8.46	$ 7.91	$ 7.91	$ 26.34	$ 23.33	$ 18.17
Breeding stock	190.58	181.90	173.25	190.58	181.90	173.25
Feed fed:						
Corn equivalent (bu.)	0	0	0	51.10	45.44	39.76
Supplement (lbs.)	0	0	0	220.3	195.8	171.5
Hay	1.2	1.2	1.2	2.068	1.972	1.876
Pasture (a.u.d.)[c]	267	267	267	301.2	297.4	293.6

[a] Mueller, *op. cit.*
[b] Judgment estimate.
[c] Animal unit days.