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HIGHEST RETURN FARMING SYSTEMS for Drummer-Flanagan soils

An application of linear programming to farm planning

By Earl R. Swanson

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For highest-return farming systems developed by linear programming for Tama and Muscatine soils, see Bulletin 602 of this Station.

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HIGHEST-RETURN FARMING SYSTEMS for Drummer-Flanagan Soils

EARL R. SWANSON, Associate Professor of Agricultural Economics

THE PURPOSE OF THIS BULLETIN IS TO PRESENT THE HIGHEST-RETURN farming systems (combinations of crop and livestock enterprises) for various situations on Drummer-Flanagan soils. These soils are highly productive, dark-colored prairie soils found primarily in east-central Illinois. The highest-return farming systems presented in this report were developed by the method of linear programming.[1]

Farming systems that maximize labor income (returns to labor and management) *per acre of land* farmed are presented in Part I. In Part II systems that maximize labor income *per hour of labor* are given. The systems presented in Parts I and II are long-term plans; that is, they should be viewed as goals or ideals that might be achieved over a period of years. In contrast, Part III contains systems to be followed for maximizing return *per dollar of money spent* during the first year of reorganization, when capital is most likely to be limited. Finally, in Part IV the effects of changes in corn, hog, and cattle prices on optimum farming systems are shown.

Assumptions

Crop enterprises. The farm plans in Parts I, II, and IV assume a sufficiently long period of years to show the effect of rotation on yields. The crop yields for the rotations considered as alternatives in the development of optimum plans in these three parts of the report are presented in Table 1. Also shown in Table 1 are labor, capital, and fertilizer requirements for each crop rotation. In this analysis, the labor and cost data are divided into two groups — for farms of less than 200 acres and for farms of 200 acres and more. Since labor and cost requirements per acre probably decrease continuously from small acreages to those beyond 200 acres, the requirements given are likely to be too high for farms slightly under 200 acres and too low for farms slightly larger than 200 acres. The data are based on record-

[1] This is a mathematical procedure which insures that, given a set of assumptions concerning resource supplies, input-output ratios, and prices, the highest-return farming system is derived. For an explanation of this method, see *Linear Programming and Economic Analysis* by Robert Dorfman, Paul A. Samuelson, and Robert M. Solow (New York: McGraw-Hill Book Company, Inc., 1958).

Table 1. — Crop Yields, Labor, Capital, and Maintenance Fertilizer Requirements for Long-Term Planning, Drummer-Flanagan Soils

Rotation	C-C-O-(Cl)	C-C-S-W(Cl)	C-S-W(Cl)	C-C-O-Cl	C-C-O-Cl-Cl
Crop yield per acre[a]					
Corn, bu.	80	80	83	85	88
Soybeans, bu.	..	35	35	..	..
Oats, bu.	51	..	..	57	57
Wheat, bu.	..	36	36	..	..
Clover, tons	..	..	..	3.1	3.6
Direct labor,[b] hours per rotation acre, excluding hay harvesting					
Farms under 200 acres	4.55	4.50	4.33	3.40	2.72
Farms 200 acres and over	4.04	3.99	3.84	3.02	2.41
Capital costs (all charges except land and labor; assumes no hay harvested), dollars per rotation acre					
Farms under 200 acres	38.97	38.05	35.18	28.29	22.91
Farms 200 acres and over	32.84	33.46	31.06	23.51	19.09
Fertilizer (based on crop removals, except hay), pounds per rotation acre					
N	35	29	15	10	4
P_2O_5	24	28	27	19	16
K_2O	16	23	24	10	8

[a] Yield estimates furnished by Department of Agronomy, University of Illinois.
[b] *Detailed Cost Report for Northern Illinois, 1955,* by A. G. Mueller, Department of Agricultural Economics, University of Illinois, 1957. Labor distributed among months according to Table 8, p. 24, *Illinois Farm and Home Development Reference Book,* College of Agriculture, University of Illinois, 1955. Capital costs are on an annual basis. Cost data in this table are used in determining farming systems in Parts I, II, and IV.

keeping farms; the farms of less than 200 acres averaged 160 acres, while those of 200 acres or more averaged 277 acres.

The yields, labor requirements, and direct cash costs for planning the first year of reorganization (Part III) are presented in Table 2.

Table 2. — Crop Yields, Labor Requirements, and Direct Cash Costs for Planning First Year of Reorganization, Drummer-Flanagan Soils

	Corn		Soybeans	Oats	Wheat	Clover
	Medium management	Moderately high management	Medium management			
Yield per acre[a]	70 bu.	79 bu.	28 bu.	56 bu.	25 bu.	3 ton
Direct labor,[b] hours per acre						
Farms under 200 acres	5	5	3.8	3.6	4.2	10.6
Farms 200 acres and over	4.4	4.4	3.4	3.2	3.7	9.4
Direct cash costs,[c] dollars per acre	18.12	28.82	10.85	12.64	14.46	24.00[d]

[a] *The Productivity of Dark, Till-Derived Soils in Northeastern Illinois,* Agronomy Fact Sheet SP-11, Department of Agronomy, University of Illinois, 1956; and *Illinois Soil Type Descriptions,* by H. L. Wascher, J. B. Fehrenbacher, R. T. Odell, and P. T. Veale, Ill. Agr. Exp. Sta. AG-1443, pp. 173 and 175, 1950.
[b] *Detailed Cost Report for Northern Illinois, 1955,* by A. G. Mueller, Department of Agricultural Economics, University of Illinois, 1957. Labor distributed among months according to Table 8, p. 24, *Illinois Farm and Home Development Reference Book,* College of Agriculture, University of Illinois, 1955.
[c] Includes fuel, grease, oil, repairs, seed, and fertilizer to achieve indicated yield levels for grain crops.
[d] Includes harvesting cost only.

Since this is the first year, crop yields are unaffected by the combination of crops grown during that year. The direct cash costs include only fuel, grease, oil, repairs, seed, and fertilizer costs. No charge is made for depreciation or interest on investment.

Livestock enterprises. Alternative enterprises and their feed, labor, and capital requirements are presented in Table 3. These requirements assume better-than-average care and management. If necessary to increase returns, all feeds except forage may be purchased.

Prices. Commodity prices used in developing the highest-return systems in Parts I, II, and III are the 1946-1955 average Illinois farm prices (Table 4). In the systems in which corn is purchased for feeding livestock, the purchase price is considered to be 8 cents per bushel above the selling price of $1.53 per bushel presented in Table 4. The hog-corn price ratio is therefore 13.3 for corn produced on the farm and 12.6 for purchased corn.

The effect on optimum farm organization of price variations from the 1946-1955 average levels is analyzed in Part IV. In this analysis corn, hog, and cattle prices are varied through wide ranges above and below the ten-year average prices presented in Table 4.

Table 3. — Feed, Labor, and Capital Requirements for Hogs and Cattle

	Hogs (two-litter system, 60 percent spring farrowing and 40 percent fall farrowing, hogs sold at 225 pounds)	Good-to-choice calves purchased in October at 450 pounds, 500-pound gain	
		Fed in drylot	Fed on pasture
		(per animal)	
Feed[a]			
Corn	14.3 bu.	55 bu.	50 bu.
Soybean meal	122 lb.	200 lb.	150 lb.
Hay	....	.75 ton	.75 ton
Pasture	5.4 days	....	50 days
Direct labor[b]	1.87 hours	7.33 hours	7.33 hours
Capital costs[c]	$6.86	$19.10	$19.10
Direct cash costs[d]	$42.00	$234.00	$224.00
Additional investment expense for buildings and equipment if enterprise is expanded beyond present facilities	$7.00	$72.00	$72.00

[a] For hogs: *Detailed Cost Report for Northern Illinois, 1955,* by A. G. Mueller, Department of Agricultural Economics, University of Illinois, 1957. For cattle: *Illinois Farm and Home Development Reference Book,* College of Agriculture, University of Illinois, pp. 39-40, 1955.

[b] *Detailed Cost Report for Northern Illinois, 1955,* by A. G. Mueller, Department of Agricultural Economics, University of Illinois, 1957. Includes labor for harvesting hay for cattle. Labor distributed among months according to Table 8, p. 24, *Illinois Farm and Home Development Reference Book.*

[c] Includes power, machinery, building, equipment and other nonfeed capital items on an annual cost basis. These cost figures used in determining farming systems in Parts I, II, and IV.

[d] Includes cost of bred sow or feeder calf, feed, fuel, repairs, and veterinary expense. Used in Part III of the report.

Table 4. — Illinois Farm Prices, Average 1946-1955[a]

Commodity	Unit	Price
Corn	Bushel	$ 1.53
Oats	Bushel	.76
Soybeans	Bushel	2.61
Wheat	Bushel	2.03
Hay	Ton	22.21
Slaughter cattle	100 pounds	27.87
Good-to-choice feeder calves	100 pounds	26.10
Hogs	100 pounds	20.33

[a] Source: *Illinois Agricultural Statistics* and *Annual Feeder Cattle Reports* of Farm Bureau Farm Management Service, Department of Agricultural Economics, University of Illinois, 1946-1955.

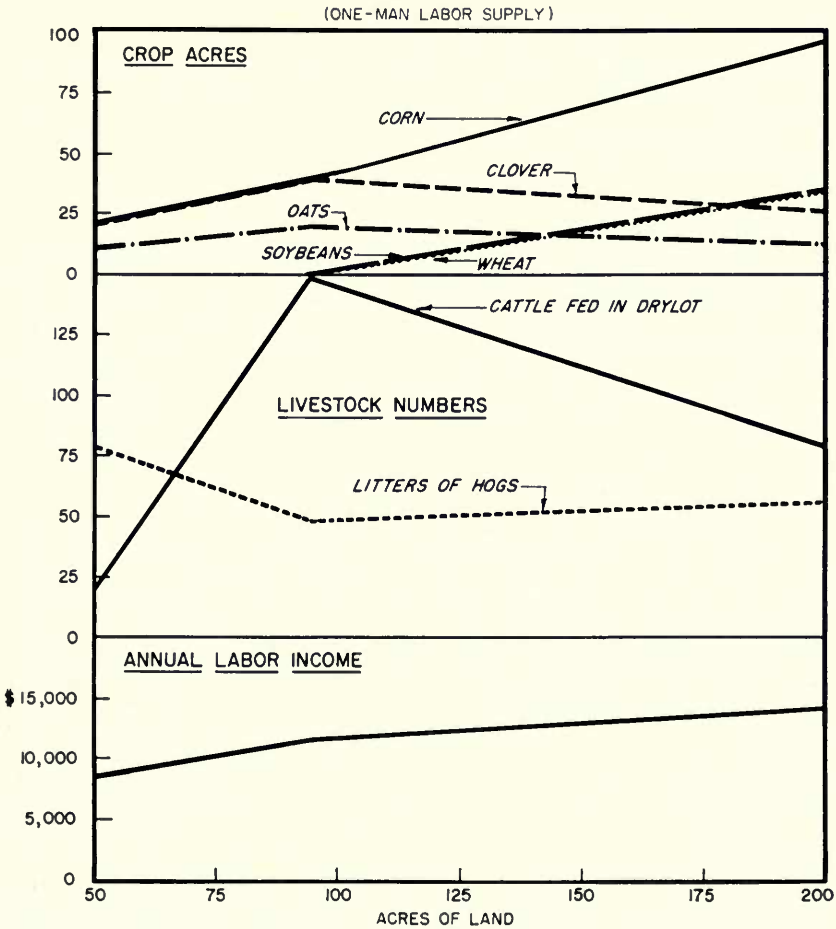
Labor. Two labor-supply situations are assumed in this report: one man — 240 hours available in each month; and one man and a boy — 275 hours available in each month during the school year and 400 hours per month available in June, July, and August. Labor may be hired only to aid in making hay. Labor may be exchanged, but it must be paid back in the same month. Only the direct labor requirements (labor which can clearly be identified with a given enterprise) were considered in arriving at the highest-return systems. It is assumed that all indirect labor may be shifted to months other than the few peak months which usually limit the size of the operation.

Part I — Maximum Labor Income per Acre of Land

The highest-return farming systems presented in this section are based on the assumption that, given the acreage, the labor supply (one man, or one man and boy) is used as intensively as necessary to maximize labor income (returns to labor and management) per acre. Alternatively, to achieve a given level of labor income with the labor supply designated (either one man, or one man and a boy), the results in this part give the *minimum* acreage that yields this level of labor income. In order that the results may be adapted to farms of different sizes and to permit observation of general relationships, the results in this section, as well as in the remainder of the report, are presented graphically.

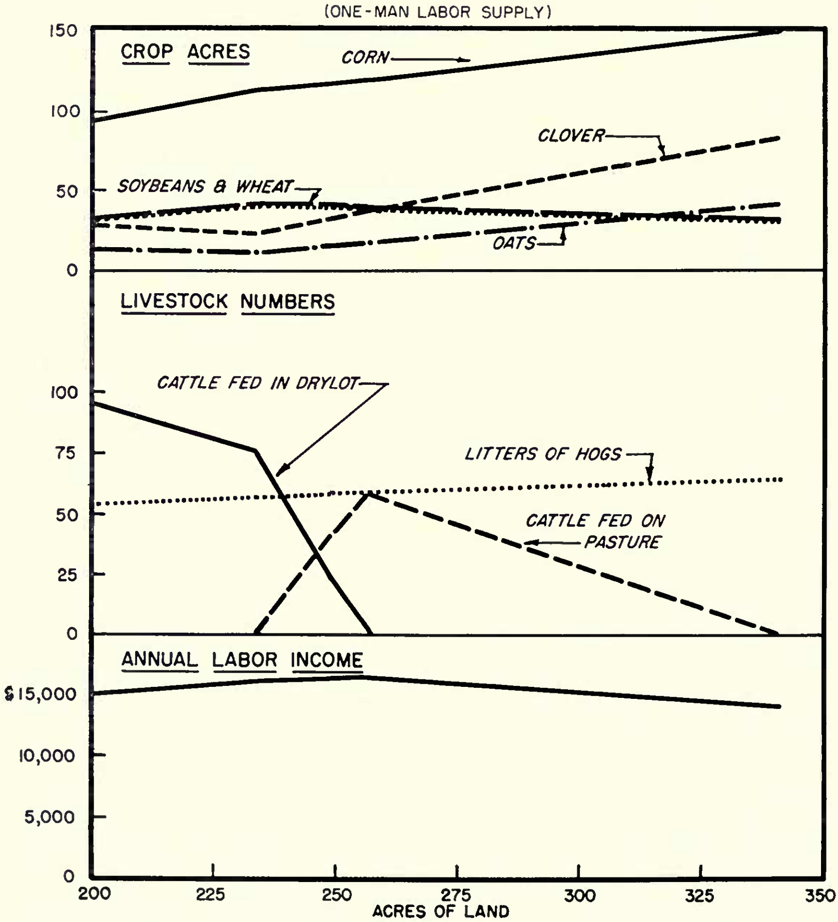
One-man labor supply. Farming systems for maximum labor income per acre for a one-man operation on farms less than 200 acres are presented in Figure 1. For each acreage indicated on the horizontal scale, the corresponding crop and livestock enterprises for maximum labor income are given in the top and center of the figure. The resulting labor income is given in the bottom section. For farms ranging from 50 to 95 acres, the total acreage for each farm size is divided into 40 percent corn, 20 percent oats, and 40 percent clover, or a C-C-O-Cl-Cl rotation (Table 1). The optimum farming systems for farms larger than 95 acres include soybeans and wheat with an accompanying decrease in stand-over clover.

A relatively intensive hog operation is carried on at low acreages. Cattle fed in drylot reach a maximum of 147 head at 95 acres. Purchase of large quantities of corn for livestock feed is required for all

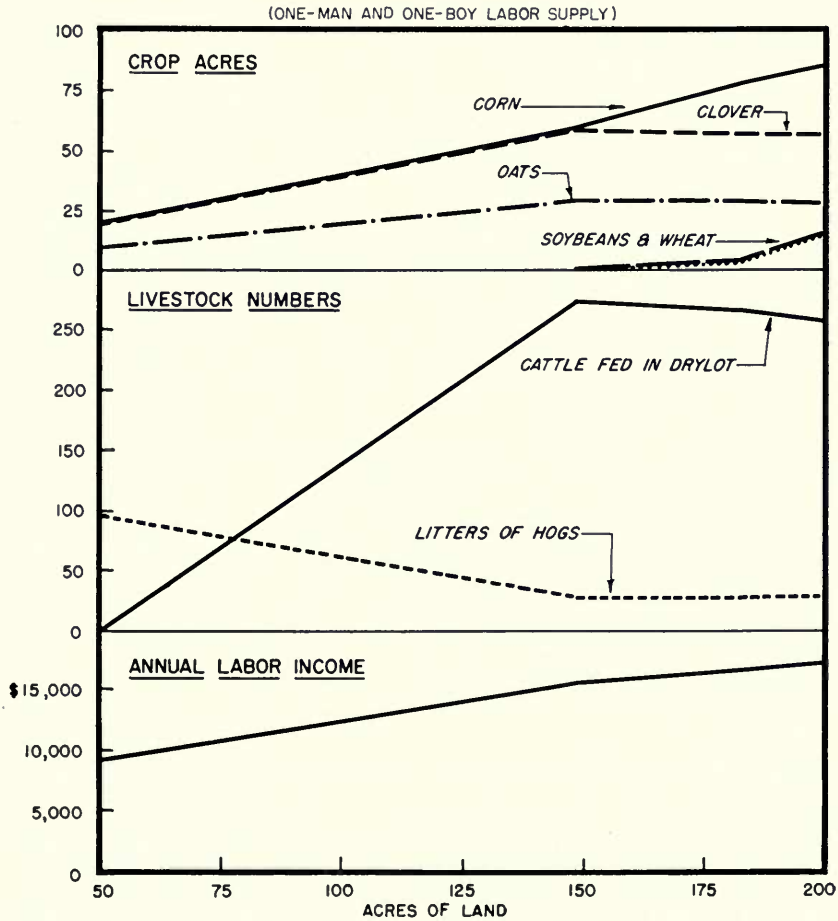


Farming systems giving maximum labor income per acre of land, with one-man labor supply on farms of 50 to 200 acres (annual land charge, $30 per acre). (Fig. 1) sizes of farms up to 200 acres. At 50 acres, 8,560 bushels are purchased; at 95 acres, 11,560 bushels are purchased; and at 200 acres, 2,625 bushels are purchased. Although 12 months of labor are available for all acreages in the range, the crop and livestock enterprises considered as alternatives do not permit complete utilization of the labor supply until approximately 170 acres. Because of their more uniform seasonal labor requirements, poultry or dairy enterprises may permit more profitable operations on the small acreages.

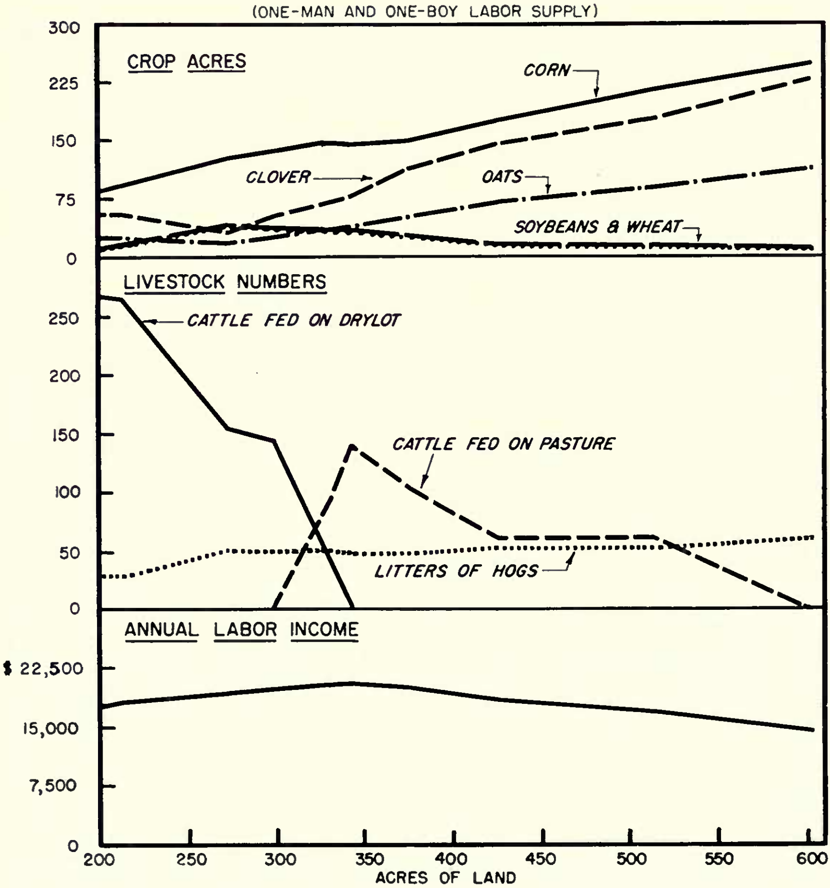
Systems yielding maximum labor income per acre for a one-man



Farming systems giving maximum labor income per acre of land, with one-man labor supply on farms of more than 200 acres (annual land charge, $30 per acre). (Fig. 2) operation for farms over 200 acres are presented in Figure 2. Although labor income *per acre* is at a maximum for each acreage given, total labor income for the labor supply (one man) is at a maximum at 257 acres. Acreage in corn makes up about 45 percent of the total acreage throughout the entire range of acreages considered. Clover acres increase sharply for farms larger than 257 acres, but the additional clover is not completely utilized as hay or pasture by livestock because labor is not available to expand the livestock enterprises. As a consequence, labor income declines after reaching its peak at 257 acres. Less favor-



Farming systems giving maximum labor income per acre of land, with one-man and one-boy labor supply on farms of 50 to 200 acres (annual land charge, $30 per acre). (Fig. 3) able prices for livestock would increase the acreage required to maximize labor income. The hog enterprise increases very slightly over the entire range, remaining at about 60 litters (36 spring and 24 fall). As acreage increases, a shift occurs to feeding cattle on pasture rather than in drylot. At 257 acres, the corn produced almost exactly equals that needed for livestock production — only 610 bushels are sold. On farms smaller than 250 acres, it is necessary to purchase corn for livestock feeding, and on farms larger than 250 acres, some corn is marketed as cash grain.



Farming systems giving maximum labor income per acre of land, with one-man and one-boy labor supply on farms of more than 200 acres (annual land charge, $30 per acre). (Fig. 4)

One-man and one-boy labor supply. Farming systems yielding maximum labor income per acre with a labor supply of one man and a boy are presented in Figures 3 and 4. For farms of less than 200 acres (Figure 3), the acreages in each crop follow a pattern similar to that of the one-man operation (Figure 1). A C-C-O-Cl-Cl rotation is selected until farm size is 148 acres. From 148 acres to 200 acres, corn continues to comprise about 40 percent of the total acreage while the number of acres in clover remains about constant. An intensive hog program is found on the very small acreages (for example, 96 litters on 50 acres). The number of cattle fed in drylot reaches a maximum at a farm size of 148 acres and, along with hog litters, remains about the same up to the 200-acre limit. The added labor of the boy, together with the change in the seasonal distribution of available labor, causes the optimum livestock program to have more cattle relative to hogs than with the one-man labor supply (Figure 1). Corn is purchased for feed in large quantities; for example, slightly over 13,000 bushels are purchased when farm size is 148 acres, and approximately 10,000 bushels are purchased at the 200-acre farm size.

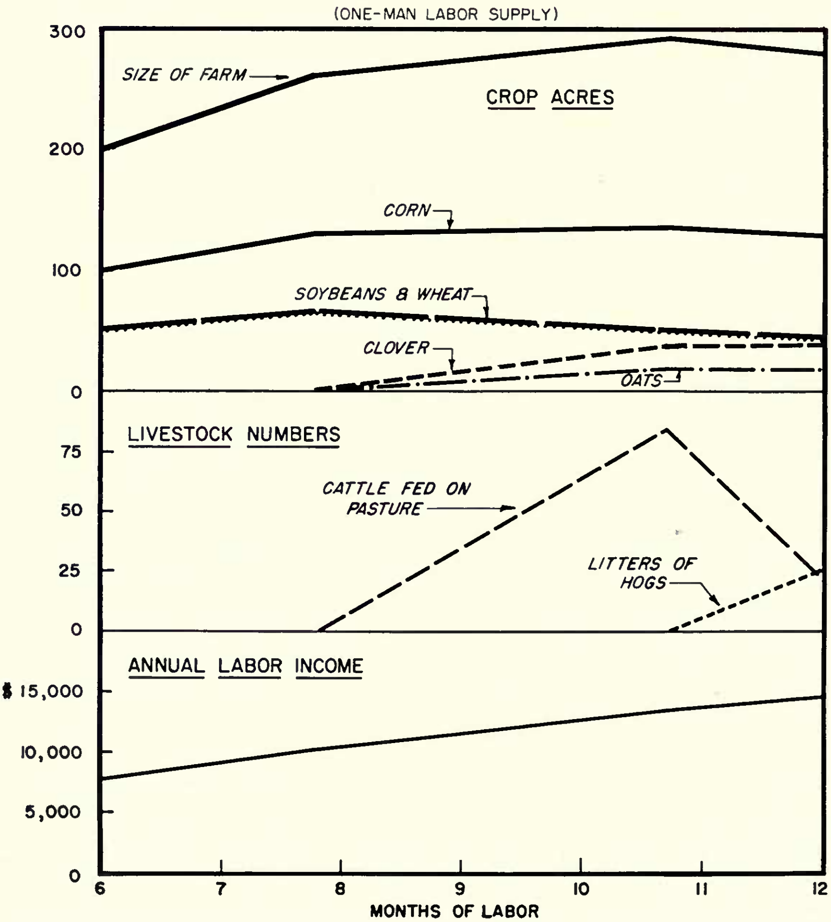
For farms greater than 200 acres (Figure 4), labor income reaches a maximum at 343 acres. Up to this point, corn acreage remains at about 45 percent of the total acreage. Livestock requirements for clover increase between 300 and 343 acres, thus causing an increase in clover acreage. Sufficient labor is not available for livestock expansion to completely use clover produced beyond the point of maximum labor income (343 acres). Litters of hogs increase to a level of about 50 litters annually through the range of farm size from 273 acres to 514 acres. A shift from feeding cattle in drylot to feeding cattle on pasture starts to occur at 300 acres and is complete at 343 acres. At 200 acres, the livestock require purchase of about 10,000 bushels of corn. This amount gradually decreases until the range of 330 to 350 acres is reached. In this range the corn produced is exactly the amount required for livestock production. At acreages greater than 350, corn is sold as grain.

Part II — Maximum Labor Income per Hour of Labor

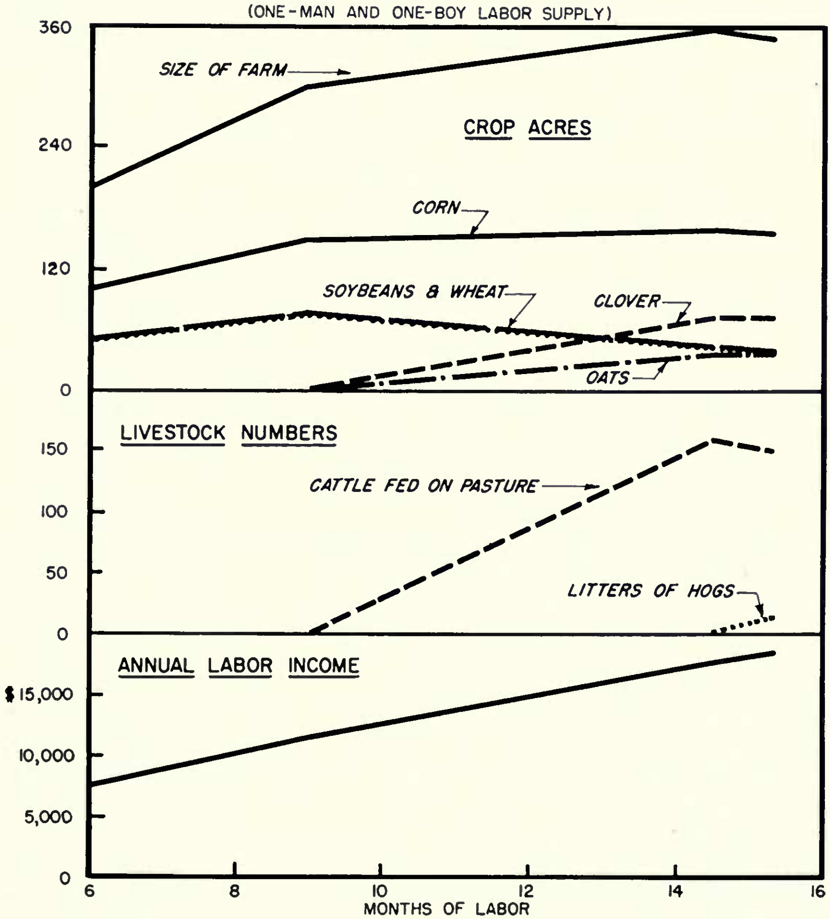
The highest-return farming systems presented in this section are based on the assumption that the objective of the farmer is to maximize the labor income per hour for the time spent working. Stated in another way, interest lies in the farming system which minimizes labor to attain a given level of labor income. Minimum-labor farming systems are presented for all levels of labor input from 6 months to

12 months (2,880 hours) for the one-man labor supply, and from 6 months to 15.3 months (3,675 hours) for the one-man and one-boy labor supply. In this analysis, farm size is permitted to vary to meet the demands of minimum labor per dollar of labor income.

One-man labor supply. Using one-half (6 months) of the labor supply to maximize labor income per hour results in an optimum farm size of 200 acres with a C-C-Sb-W(Cl) rotation and no livestock (Figure 5). Labor income at this level is estimated at $7,790. As the labor use increases from 6 months up to the limit of 12 months, the



Farming systems giving maximum labor income per hour of labor, with one-man labor supply at various levels of labor utilization (annual land charge, $30 per acre). (Fig. 5) intensive cash-grain system is followed up to 7.8 months of labor used. Farm size increases proportionately with increased labor use up to 261 acres. Increasing labor use beyond 7.8 months results in an optimum plan requiring pasture-fed cattle. Increasing labor utilization between 10.7 months and its maximum supply, 12 months, requires the hog enterprise in order to maximize labor income per hour. All plans in Figure 5 involve sale of corn. About 8,000 bushels are sold at the six-months level of labor use; 10,500 bushels at the 7.8 months level; and only 600 bushels at the 12-month limit.



Farming systems giving maximum labor income per hour of labor with one-man and one-boy labor supply at various levels of labor utilization (annual land charge, $30 per acre). (Fig. 6)

One-man and one-boy labor supply. At low levels of labor utilization, the farming systems yielding highest labor income per hour worked are cash-grain systems (Figure 6). Since the percent of total labor available that is actually used is so small, these results are the same as those with low rate of use with a one-man labor supply (Figure 5). Labor use beyond 9 months requires introduction of cattle fed on pasture in order to maximize labor income per hour spent working. Hogs are necessary to attain this objective when labor use goes beyond 14.5 months. Size of farm reaches a maximum (358 acres) at this level of labor use. Corn is sold as grain in all systems. The quantity reaches a maximum of about 12,000 bushels when labor use is 9 months. With complete labor use (15.3 months), nearly all corn produced is fed to livestock (only 1,975 bushels are sold).

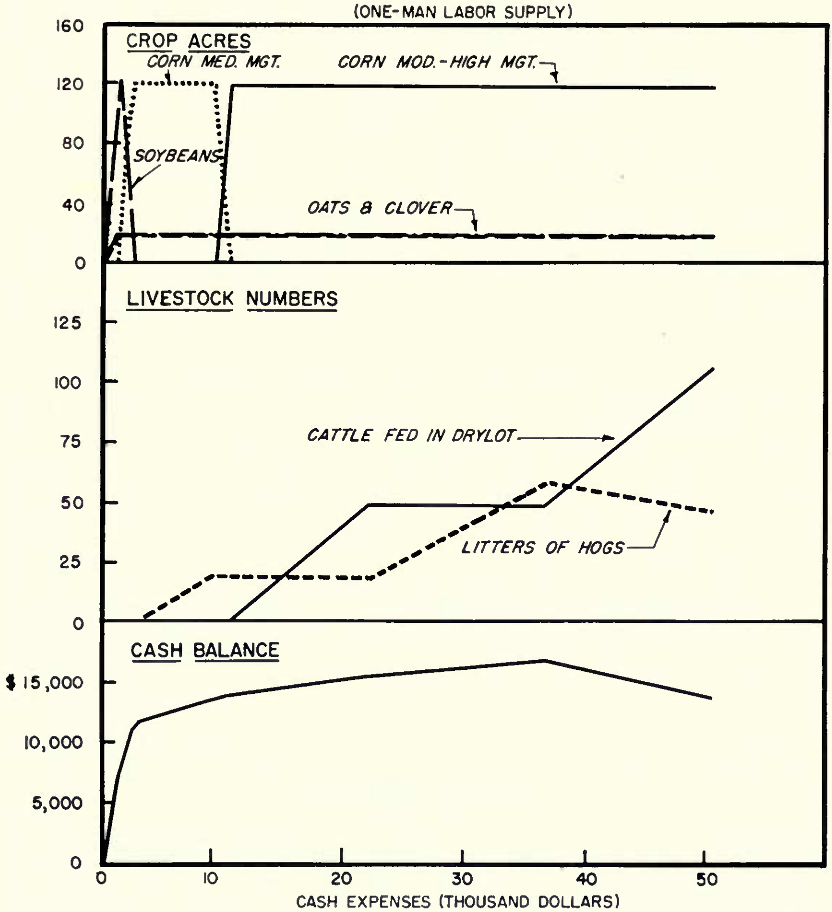
Part III — Maximum Cash Balance per Dollar of Cash Expenses

The farming systems presented in this section are those which yield the greatest cash balance (cash receipts minus cash expenses) per dollar of cash expenses. Two situations are considered — one-man labor supply on 160 acres and one-man and one-boy labor supply on 320 acres. The planning period is considered to be one year, so the effect of crop rotations on yields is not considered (Table 2). The cash expenses for crop production include only those for fuel, grease, oil, repair, seed, and fertilizer. An adequate set of crop equipment and machinery is assumed.

Livestock production expenses include cost of bred sow or feeder calf, feed, fuel, repairs, and veterinary expenses (Table 3). In both the one-man 160-acre situation and the one-man and one-boy 320-acre situation, adequate equipment for 20 litters of hogs per year and 50 head of feeder cattle is assumed. Funds may be used to expand these facilities at the costs presented in Table 3. However, the cash balance does not reflect the value of this purchased equipment at the end of the year. Interest lies in a high rate of turnover on invested funds.

One-hundred-and-sixty-acre farm with one-man labor supply. The farming systems required to maximize cash balance per dollar of cash expenses for this situation are presented in Figure 7. It is assumed that 20 acres of clover were seeded in the previous year and are available for either pasture or hay. It is also assumed that at least 20 acres of clover will be needed in the following year and that accordingly a minimum of 20 acres of oats is seeded.

At a relatively low level of cash expenses ($1,600), soybeans are



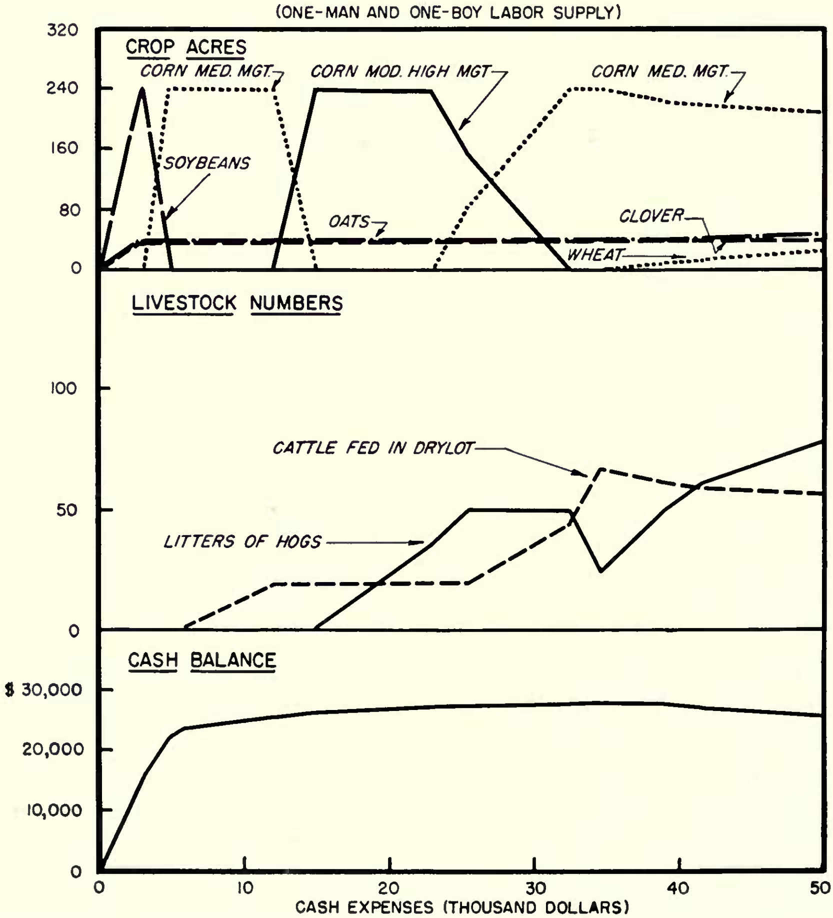
Farming systems giving maximum cash balance per dollar of cash expenses, with one-man labor supply on 160-acre farm. (Fig. 7)

grown on the remaining 120 acres. As cash expenses increase, corn gradually replaces soybeans. Between $2,500 and $9,100, the maximum amount of corn (120 acres) is required to maximize cash balance per dollar of cash expenses. However, this corn is at the "medium level of management" (Table 2). Fertilizer expenses per acre at this level of management are $10.70 per acre.[1] As capital becomes available beyond the $9,100 level, additional fertilizer is gradually added to the corn

[1] Figuring N at 15 cents per pound, P_2O_5 at 10 cents per pound, and K_2O at 6 cents per pound. See Agronomy Fact Sheet SP-11, Department of Agronomy, University of Illinois, for the quantities of plant food required for the yields indicated in Table 2.

to shift it to the "moderately high level of management" (Table 2), which requires a fertilizer outlay of $21.40 per acre. The cropping system remains stable after the $10,400 level of cash expenses.

Hogs become a part of the optimum system beginning at the $3,000 level of cash expenses. The favorable hog-corn price ratio (12.6), together with the already rather high level of fertilizer applications on "medium level of management" corn, causes hogs to have a higher priority for investment than the additional fertilizer as cash expenses increase beyond the $3,000 point. Feeding cattle in drylot becomes necessary to maximize cash balance per dollar of cash expenses at the



Farming systems giving maximum cash balance per dollar of cash expenses, with one-man and one-boy labor supply on 320-acre farm (Fig. 8)

$10,400 level of cash expenses. Additional housing for 41 more litters (a total of 61 litters) is required at the point of maximum cash balance. Adding cash expenses beyond this point tends to expand the cattle enterprise by investment in buildings and equipment. Since the value of this investment at the end of the year is not cash income, cash balance declines.

Three-hundred-and-twenty-acre farm with one-man and one-boy labor supply. In Figure 8 are presented the optimum farming systems for maximization of cash balance per dollar of cash expenses. Forty acres of clover seeded in the previous year are assumed to be available for pasture or hay. A minimum of 40 acres of a new clover seeding with oats as a companion crop is also assumed to be required.

The pattern of optimum systems related to level of cash expenses is quite similar to that on the 160-acre farm. Hogs begin to enter the program when cash expenses are about $6,000. Since the available hog housing and equipment have a capacity of 20 litters annually, additional investment is not required until cash expenses reach $25,500. At this same level, cattle fed in drylot are at the maximum permitted by available equipment. The high capital requirements of livestock required to use the surplus labor cause a return to the "medium level of management" for corn at the high levels of cash expense. Cash balance reaches a maximum of $28,280 with cash expenses at $34,600.

Part IV — Effects of Price Changes on Highest-Return Farming Systems

An important factor determining the usefulness of the highest-return farming systems developed in the previous parts of this report is the effect of change in assumed prices (1946-1955 average prices in Table 4) on the selection of the system. In this part of the report, prices of corn, hogs, feeder cattle, and slaughter cattle are varied from their 1946-1955 averages to permit observation of the changes necessary in the farming systems to maintain maximum possible labor income. Two situations are considered — a 160-acre farm with a one-man labor supply and a 320-acre farm with a one-man and one-boy labor supply. The capital costs used in developing the following optimum farming systems include all charges on an annual basis (see Tables 1 and 3). Thus shifts from one system to another as a result of price changes are likely to be different from those shifts that consider only short-run variable costs. If specialized facilities and equipment for competitive enterprises are involved, optimum plans would be less sensitive to price changes than those considering all capital costs as variable.

One-hundred-and-sixty-acre farm with one-man labor supply. The farming systems yielding the highest labor income for various combinations of corn and hog prices are presented in Figure 9 and Table 5. Prices other than corn and hogs are assumed to remain at their 1946-1955 levels. If all price movements were proportional, there would be no change in the maximum income system as a result of price change. However, price movements are, in general, not proportional.[1]

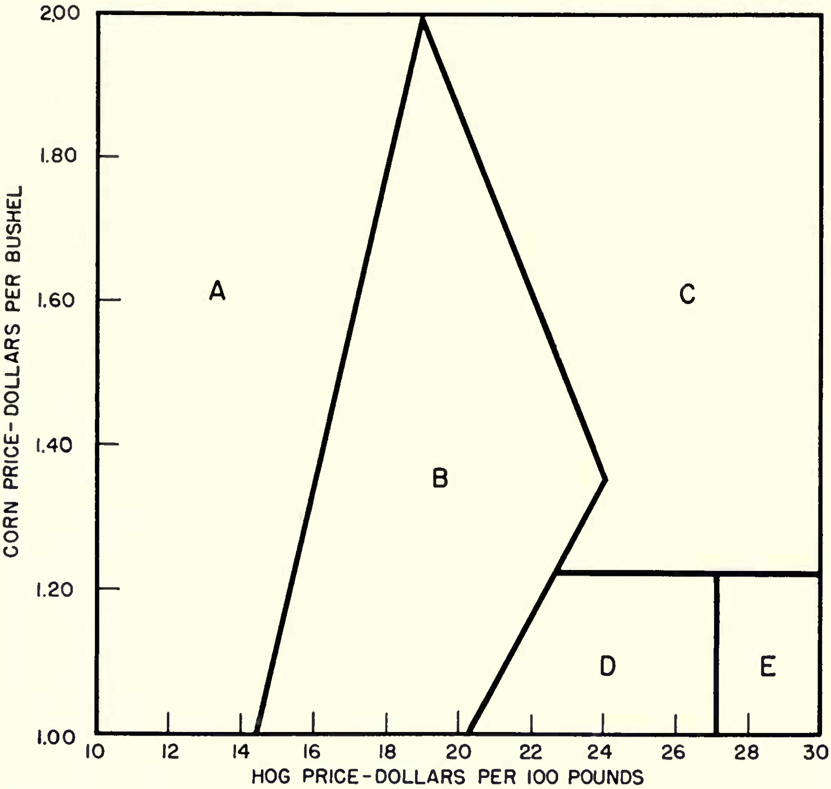
To determine the maximum labor income system for, say, a hog price of $20 per hundred and a corn price of $1.20 we find the point on the map which corresponds to the intersection of a vertical line from 20 on the horizontal scale and a horizontal line from 1.20 on the vertical scale. In Figure 9, this area is marked "B." The crops and livestock for system B are given in Table 5.

Boundary lines between areas indicate corn and hog price combinations for which the two systems designated for the two adjoining areas are *equally* profitable. In Figure 9, system A yields the highest labor income for all corn and hog price combinations in the area marked "A." This system includes 144 head of cattle fed in drylot, but no hogs. On the other hand, B includes both hogs and cattle. The boundary line separating A from B indicates price combinations for which systems A and B would yield identical incomes. Note that the hog-corn price ratios which make systems A and B equally profitable are not independent of the level of hog and corn prices. For example, at $1.80 corn the hog-corn price ratio for equal profitability of systems A and B is 10:1. With corn at $1.00, the hog-corn ratio for equal profitability is 14.4:1. The competitive position of cattle improves at lower price levels for corn and hogs, thus causing a higher hog-corn ratio to be necessary to shift from a system with no hogs (A) to one with both hogs and cattle (B). In areas C and E, hogs are sufficiently profitable to completely replace feeding cattle.

A price map showing the effect on optimum farming systems of variation in the price of feeder and slaughter cattle is presented in Figure 10. Feeder and slaughter cattle price combinations in area C are not as profitable for cattle feeding as for hogs (Table 5). All other price combinations on the map (areas A, B, and F) require at least some cattle (Table 5). If feeder and slaughter cattle prices fall simultaneously on the boundary between B and C, the systems desig-

[1] During the ten-year period, 1946-1955, price correlation coefficients were as follows:

Corn and feeder cattle, — 0.17
Corn and slaughter cattle, 0.26
Hogs and feeder cattle, — 0.12
Hogs and slaughter cattle, 0.46



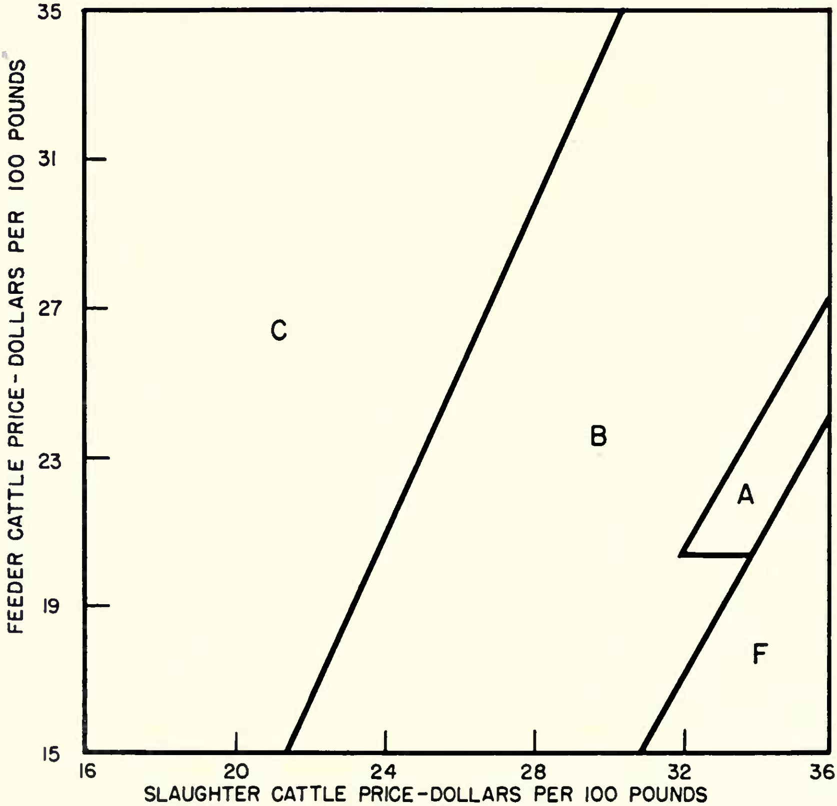
Price map for 160-acre farm with one-man labor supply. The letters indicate the farming systems (see Table 5) that give maximum labor income with corn and hogs at the prices indicated on the vertical and horizontal scales. Prices for commodities other than corn and hogs are assumed to be at their 1946-1955 averages, as shown in Table 4. (Fig. 9)

Table 5. — Farming Systems Giving Maximum Labor Income for 160-Acre Farm With One-Man Labor Supply, Drummer-Flanagan Soils (See Figures 9 and 10)

Area on figures 9 and 10	Land use					Livestock			Corn transactions	
							Cattle			
	Corn	Soy-beans	Oats	Wheat	Clover	Hogs	Drylot	Pasture	Purchased	Sold
	(acres)					(litters)	(head)		(bushels)	
A........	72	23	14	23	28	. .	144	. . .	1,855	. . .
B........	72	21	15	21	31	53	105	. . .	5,363	. . .
C........	76	30	8	30	16	77	. . .	. . .	1,864	. . .
D........	57	29	15	29	30	56	93	. . .	6,109	. . .
E........	56	40	8	40	16	77	. . .	. . .	3,452	. . .
F........	52	10	16	10	32	. .	167	. . .	4,770	. . .

nated in Table 5 for areas B and C would be equally profitable. The price margin necessary to break even is not independent of the level of the prices because of the effect of holding the other prices constant, especially those of corn and hogs. With feeder cattle at $15 per hundred pounds, a spread of about $5.50 is required; with feeder cattle prices at $35 per hundred, a negative margin of about $4.50 would provide equal returns from systems B and C.

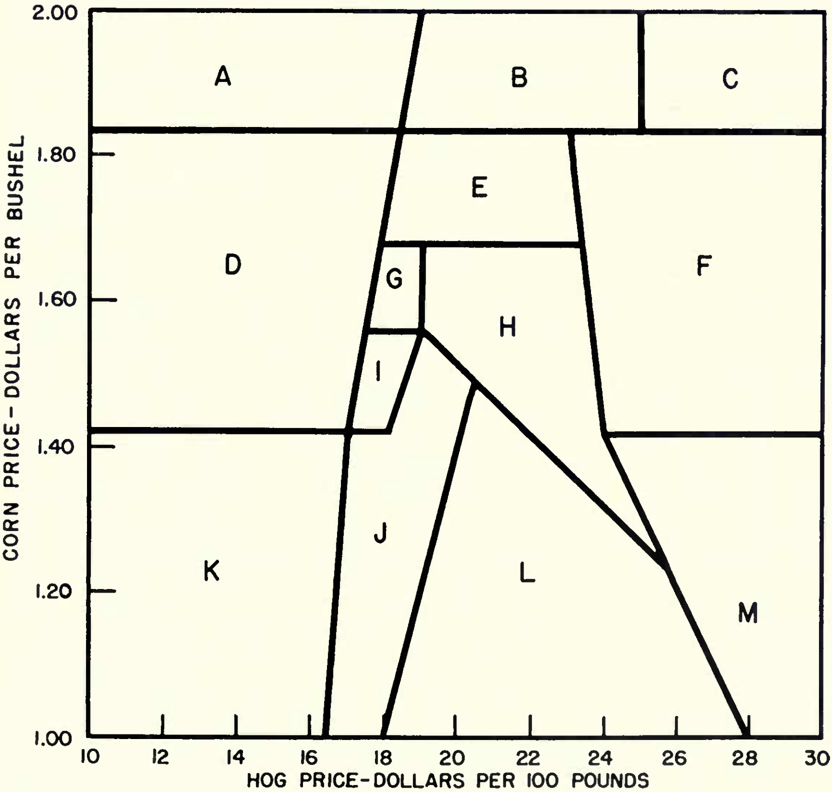
The ten-year average prices for corn, hogs, and cattle (Table 4) assumed for the first three parts of this report result in selection of system B (Table 5).



Price map for 160-acre farm with one-man labor supply. The letters indicate the farming systems (see Table 5) that give maximum labor income with feeder cattle and slaughter cattle at the prices indicated on the vertical and horizontal scales. Prices for commodities other than corn and hogs are assumed to be at their 1946-1955 averages, as shown in Table 4. (Fig. 10)

All systems require purchase of corn. At very favorable hog-corn price ratios (areas D and E in Figure 9), corn acreages are lower than in areas A, B, and C. Corn acreage is also low for the very favorable cattle price margin in area F of Figure 10.

Three-hundred-and-twenty-acre farm with one-man and one-boy labor supply. Figure 11 and Table 6 present the farming systems for maximum labor income for various combinations of corn and hog prices. The price map has an interpretation similar to that of Figure 9. Areas A, D, and K on the left side of the map contain hog and corn price combinations in which hog raising is less profitable than the systems given in Table 6 for areas A, D, and K. None of these three

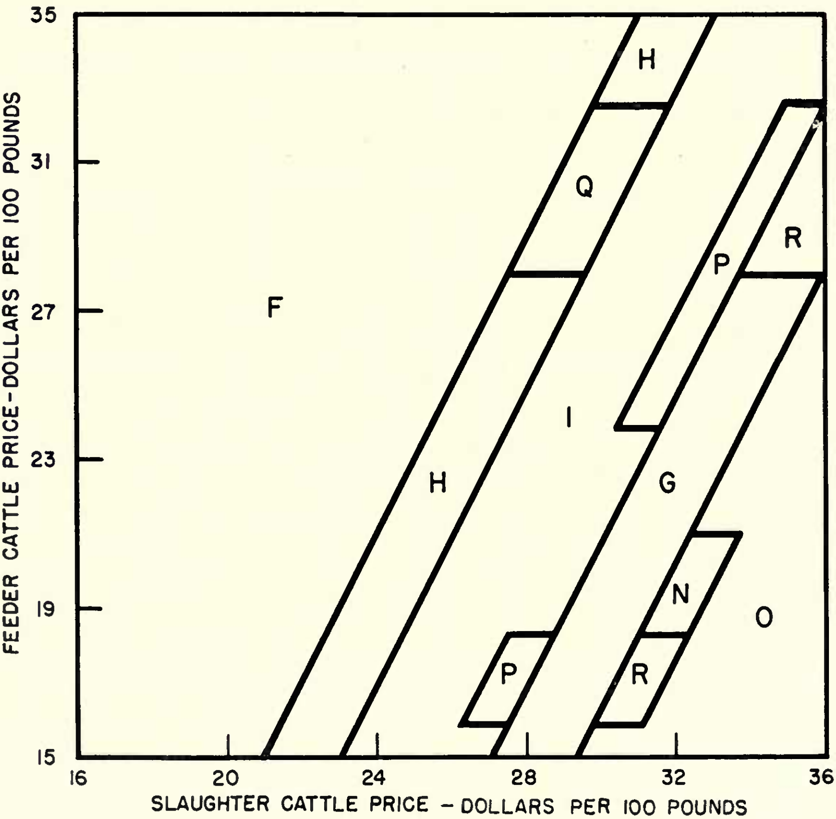


Price map for 320-acre farm with one-man and one-boy labor supply. The letters indicate the farming systems (see Table 6) that give maximum labor income with corn and hogs at the prices indicated on the vertical and horizontal scales. Prices for commodities other than corn and hogs are assumed to be at their 1946-1955 averages, as shown in Table 4.

(Fig. 11)

Table 6. — Farming Systems Giving Maximum Labor Income for 320-Acre Farm with One-Man and One-Boy Labor Supply, Drummer-Flanagan Soils (See Figures 11 and 12)

Area on figures 11 and 12	Land use					Livestock			Corn transactions	
	Corn	Soy-beans	Oats	Wheat	Clover	Hogs	Cattle: Drylot	Cattle: Pasture	Purchased	Sold
	(acres)					(litters)	(head)		(bushels)	
A	165	43	39	43	30	..	156	...	.....	4,785
B	181	34	56	34	15	73	...	...	.....	6,860
C	156	43	35	43	43	72	...	...	.....	4,600
D	147	47	26	47	53	..	43	180	.....	365
E	143	38	34	38	67	50	18	119	292	.....
F	147	47	26	47	53	80	...	...	.....	3,637
G	136	20	48	20	96	24	...	204	1,146	.....
H	143	38	34	38	67	51	77	60	586	.....
I	129	25	47	25	94	39	...	190	2,447	.....
J	120	39	41	39	81	41	37	146	3,304	.....
K	117	57	30	57	59	..	139	72	1,312	.....
L	118	47	36	47	72	44	67	103	3,358	.....
M	116	62	27	62	53	82	...	...	.....	144
N	136	24	44	24	92	..	55	171	.....	.....
O	102	23	28	23	144	..	277	...	6,531	.....
P	132	17	49	17	105	37	...	200	2,545	.....
Q	137	22	46	22	93	40	...	181	1,631	.....
R	137	23	46	23	91	6	33	186	.....	.....



Price map for 320-acre farm with one-man and one-boy labor supply. The letters indicate the farming systems (see Table 6) that give maximum labor income with feeder cattle and slaughter cattle at the prices indicated on the vertical and horizontal scales. Prices for commodities other than corn and hogs are assumed to be at their 1946-1955 averages, as shown in Table 4. (Fig. 12) systems has hogs in the livestock program. Similarly, areas B, C, F, and M include hog and corn price combinations which make the hog enterprise sufficiently profitable to prohibit cattle feeding (Table 6). The remainder of the areas on Figure 11 require combinations of hogs and cattle to maximize labor income.

In Figure 12, the feeder-cattle slaughter-cattle price variation shows a pattern of optimum systems similar to that of Figure 10. Area F requires 80 litters of hogs and no cattle (Table 6). At the other extreme, area O requires 277 head of cattle fed in drylot and no hogs. All other areas require a combination of hogs and cattle to maximize labor income.

The ten-year average prices (Table 4) result in selection of the system for area H in Figures 11 and 12.

Only two of the eighteen systems presented in Table 6 require that the corn produced exactly equal that fed to the livestock (areas N and R). The rest of the systems show a wide variation in the volume of corn transactions. The optimum system for area B requires sale of 6,860 bushels of corn while the optimum system for area O requires purchase of 6,531 bushels of corn.

Summary

By use of the method of linear programming, three types of highest-return farming systems were developed. One type of system maximized labor income per acre of land farmed; another maximized labor income per hour of labor used; and the third maximized cash balance per dollar of money spent.

Two labor supply situations were considered: one man, and one man and one boy. Commodity prices used were the 1946-1955 average Illinois farm prices. The effect of varying corn, hog, and cattle prices on the selection of highest-return systems was analyzed for a 160-acre one-man farm and a 320-acre one-man and one-boy farm.

Maximum labor income per acre of land. In order to meet this objective, one-man farms in the size range of 50 to 95 acres need to feed rather large numbers of hogs and cattle and to have 40 percent of the land in standover legumes. With farm size increasing beyond 95 acres, litters of hogs increase and cattle feeding decreases. Total labor income reaches a maximum at a farm size of 257 acres.

The relation of size of farm to systems giving highest returns per acre for the one-man and one-boy labor situation is similar to that for the one-man labor supply. The added labor of the boy, together with the change in the seasonal distribution of available labor, causes the livestock system to contain more cattle relative to hogs than the one-man labor supply systems. Maximum total labor income occurs at 343 acres.

Maximum labor income per hour of labor. When less than two-thirds of the one-man labor supply (12 months) is used, highest returns per hour of labor are received with a rotation of C-C-Sb-W(Cl) and no livestock. Increasing labor use from this level to the 12 months available requires addition of pasture-fed cattle and a small hog enterprise in order to maintain maximum return per hour.

A cash-grain system gives highest returns per hour for the one-man and one-boy labor supply when actual labor use is less than 9 months of the total 15.3 available months. Labor use beyond 9 months requires introduction of cattle fed on pasture in order to maximize labor income per hour spent working. Hogs are necessary to attain this objective when labor use goes beyond 14.5 months.

Maximum cash balance per dollar of cash expenses. With annual cash expenses at $1,600, a one-man 160-acre farm would obtain highest return per dollar spent by growing soybeans. As cash expenses increase, corn replaces soybeans. Between $2,500 and $9,100 the maximum amount of corn is grown at "medium level of management." Spending beyond $9,100 requires shifting to a "moderately high level of management" for corn which entails heavier fertilizer applications. Hogs are a part of the highest-return system beginning at $3,000 cash expenses; cattle feeding is required beyond the $10,400 level.

The pattern of highest-return systems as related to level of cash expenses is similar for the 320-acre one-man and one-boy operation. The primary difference is that the changes in systems necessary to maintain highest return occur at higher levels of cash expenses.

Effect of price changes on highest-return farming systems. A study of the effect of changes in hog and corn prices on highest-return farming systems indicated the various hog-corn price combinations necessary to make profitable shifts in organization ranging from systems containing no hogs to very intensive hog farms. Similarly, the feeder-cattle and slaughter-cattle price combinations necessary to make profitable livestock organization changes ranging from systems with no cattle to large numbers of cattle are presented. The results show that, in the situations considered, the hog-corn price ratio necessary to break even is not a constant but is higher with lower prices for corn. The price margin between feeder and slaughter cattle necessary to break even is higher for lower prices of feeder cattle.

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