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by

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Preface and Acknowledgement

This bulletin presents the results of an analysis of dairy adjustment opportunities for farms in selected areas of Northern New England. The analysis was done as a part of the Northeast Dairy Adjustment and Supply Response Study, a cooperative research project between the Farm Production Economics Division, Economic Research Service, U. S. Department of Agriculture and the agricultural experiment stations of 10 States in the Northeast.*

The authors wish to thank George E. Frick, of the Farm Production Economics Division, Economic Research Service, U. S. Department of Agriculture for his counsel as leader of the Northeast Dairy Adjustment and Supply Response Study, as well as for his advice and counsel in this analysis.

* Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, and Maryland Agricultural Experiment Stations participated in this regional project.

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Net Incomes and Resource Valuations of Optimum Organizations for Dairy Farms in Northern New England

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I. The Problem and Approach

Quantities of resources used, quality of cows, and the price of milk greatly influence the organization, level of income, and value of resources used on dairy farms. The proportion in which resources are combined, as well as the total quantity of resources used, strongly modifies the farm's business and income. Differences in quality of cows has long been noted and in this analysis is represented by different milk response to hay and grain feeding functions.

The objective of this study is to assess the influence of quantities of resources, quality of dairy cows, and price of milk on Northern New England dairy farms. The specific objectives are:

(1) To determine the optimum organizations for situations involving different quantities of resources, milk responses of cows, and milk prices.

(2) To determine the potential levels of income for these resource combinations with three different milk prices.

(3) To determine the value of additional amounts of major resources to farms with differing quantities of resources, milk responses, and milk prices.

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A linear programming model was developed to reflect the alternatives open to specialized dairy farms. Multiple solutions were obtained for discrete levels of cropland and cow numbers for each of three milk response functions at three milk prices. One series of solutions was run assuming an opportunity to sell hay and a second series was run without the opportunity to sell hay.

These solutions reflect opportunities associated with differences in resource and price combinations on farms in the study areas. This approach provides more usable results than the alternative of determining typical farm situations for analysis. Most farms in the study area will resemble one of the programmed farm situations in amount of resources, milk response, and milk price. This approach has the added advantage that it compares various combinations of resources to determine the better resource combinations and evaluate farm adjustment alternatives.

This analysis represents "should be" situations rather than "would be" actions. In other words, it is concerned with what a farmer "ought to do" if his objective is maximizing the return to his fixed factors; and his resources, prices, and, constraints are as stated in the linear programming model.

Study Areas

The study areas are comprised of parts of Maine, New Hampshire, and Vermont.* These areas are relatively homogeneous in respect to crop response and available alternatives both within and outside dairy farming. The farms are generally on rolling hills of varied, somewhat acid, soil associations; temperature and rainfall differences within the study areas are minor. Dairy farms in these areas are generally specialized in the production of fluid milk for sale both locally and in the Boston market.

Figure 1 shows the areas to which this study applies. Farms in the river valleys (notably the Connecticut River Valley) have significantly different yields than those assumed in this study. Thus, the results apply to farms in the designated areas excluding farms in the river valleys.

Organization

Section II presents a short description of the production and price data and the alternatives considered in the linear programming model. The results of analysis make up section III, IV, and V. Section III presents optimum dairy farm organizations of resources at three milk prices. Possible adjustments of resources for a specific farm can be assessed by comparing its existing organization under the present resource and price situation with the optimum organization presented

* The study areas used in this analysis were designated for use in the Northeast Dairy Adjustment and Supply Response Study.

in this section. Section IV evaluates the net income potential of different resource packages under the three milk prices. The analysis of net incomes points out longer-run adjustments when the quantity of cropland and dairy cows and the milk response may be changed. Section V covers the valuation of resorces. Methods of finding break-even price differentials between cows of different milk responses are presented as well as a method of determining the optimum ratio of cows to cropland. Section VI presents the summary and conclusions.

Figure 1. Study Areas

II. The Framework and Assumptions of the Study

Crop and livestock alternatives typical of most dairy farms are represented in a generalized linear programming model. The differences between farm situations are reflected in number of cows per acre of cropland, milk response functions, and milk prices. Each solution of the model represents the optimum organization for a given package of resources. The adjustments to the cropping patterns within these solutions may take up to 3 years to complete.

A general explanation of the alternatives and factor relations of the linear programming model follows.*

Forage Crops

Three species of forage may be seeded: an alfalfa-grass mixture, a clover-grass mixture, and corn for silage. Where clover-grass and alfalfa-grass revert to grass over a period of years, four alternative stands of hay or pasture are available to the farmer:

(1) Five-year alfalfa-grass
(2) Two-year clover-grass
(3) Three- to five-year grass following clover-grass
(4) Six- to twelve-year grass following either alfalfa grass or three- to five-year grass

Stands of hay which yielded less than 0.3 tons of hay equivalent per acre on any single cutting were not harvested. Yields at three fertility levels were adjusted for losses of harvesting, storing, and feeding (either hay or pasture). To allow maximum flexibility in the feeding program, each stand (species and fertility level could be harvested as:

(1) Three cuts of hay
(2) Two cuts of hay plus fall aftermath
(3) One cutting of hay plus pasture and fall aftermath
(4) Full season pasture

Reseeded acres involve a nurse crop of oats which was pastured in July and August.

The crop alternatives required 29 forage harvesting processes, three drylot feeding processes, four reseeding processes, and two corn silage processes. The hay produced in these processes could be fed to dairy cows and replacements or, in one series of solutions, it could be sold at $27 per ton.

The Dairy Herd

Forage fed to dairy cows and replacements could be in any proportion of pasture, hay and corn silage above a minimum of 1 ton of hay per cow per year. In addition, forage from pasture was limited to

* See appendix I for the linear programming model.

what the herd could consume during the pasture season. The slope of each milk response reflects only the change in milk output due to changing forage and grain inputs. Six combinations of grain and forage feeding were included as processes for each of the three milk response functions.

One dairy replacement was required for every four cows. This assumes a 4-year herd life for milking cows. The replacements could be either purchased or raised. Replacements could be raised in competition with dairy cows for such resources as stall space and forage or, in each model, a few replacements could be raised in housing not suitable for milking cows and could be pastured in fields not accessible to dairy cows or not suited for hay.

The heifer calf crop was assumed to be 40 calves available to be raised as replacements per 100 cows. The balance of the heifers available for raising as replacements over the replacement requirements could be raised and sold or could be sold at birth.

Other intermediate products and joint products of a dairy farm were considered as saleable. These were hay, cull cows, and bull calves. Hay, heifer calves, and replacements were sold through a sales process. However, the sale of cull cows and bull calves was accomplished by subtracting the net return from these alternatives from the cost of keeping a dairy cow. The reason for the different handling of these products stems from the assumption that hay and replacements could be sold in various quantities as determined in the solution, but cull cows and bull calves had to be sold in a fixed proportion with the number of dairy cows kept. Finally, all milk produced was sold through a milk sale process. Table 1 lists the factors which are considered fixed, the factors which are considered variable, the intermediate products, and the saleable products for each single solution in the linear programming model.

Resource Supplies and Restrictions

In this analysis the cropland resources were held constant at 100 acres of cropland of which 50 acres were suitable for corn or alfalfa, and 25 acres were suitable for production of alfalfa. The silo capacity available was not a restriction and was set to be greater than required if all corn land (50 acres) were planted to corn.

The labor hours supplied by the farm family were taken to be 2,252 hours per year. This figure does not include any allowance for overhead time for such tasks as plowing snow, keeping records, repairing buildings, attending meetings, etc. This net labor time was distributed throughout four labor periods in proportion to the number of days in each period. The labor available in each period is only that proportion of the total labor which may be devoted to performing the specific operations required by each process.

Table 1. Fixed factors, variable factors, intermediate products and saleable products in each solution of the linear programming model

Fixed factors	Variable factors		Intermediate products	Saleable products	
Item	Item	Price	Item	Item	Price
Cropland	Operating Cash	$6/$100	Hay	Milk	$4.00/cwt
Operator labor	Hired labor	$1.15/hr.	Silage		$5.00/cwt.
Stall space	Grain	$80/ton	Pasture	Hay	$0/ton, $27/ton
Silo capacity	Gasoline	$.24/gal.	Replacements raised	Replacements sold	$320/each
Special replacements	Fertilizer:		Reseeded		
Resources	0-15-30	$70/ton		Cull cows	$150/each
	15-15-10	$55/ton			
Dairy cows	10-10-10	$65/ton			
	$NH_4 NO_3$	$95/ton		Bull calves	$16/each
	Seed:				
	Alfalfa	$.70/lb.			
	Clover	$.50/lb.		Heifer calves	$16/each
	Timothy	$.25/lb.			
	Corn	$10.40/bu.			
	Oats	$1.90/bu.			
	Replacements bought	$350/each			

The stall spaces, cows on hand, and replacements were varied within each milk response and milk price combination to allow varying intensity of operation. These restrictions were kept in nearly constant ratio to each other while solving with varying ratios of cows per crop acre. Table 2 shows the values of restrictions for different cow/cropland ratios.

Production and Price Data

Most of the production and price data for this study was developed by the Northeast Dairy Adjustment Research Committee.* The rates of performance and costs of operating machines were developed from engineering data by this committee. Yields and responses to fertilizer were developed in cooperation with agronomists. The level of crop response is intended to reflect the yields and costs associated with the top 25 percent of farmers in 1961.** This level of crop response is also intended to be a projection of the yield and variable cost structure which will be typical of the study area in 1970.

Milk response functions were developed from the milk production and feeding data of the Lake States Dairy Adjustment Study, the Northeast Adjustment Study, and an unpublished master's thesis from the University of New Hampshire (Table 3).

The low milk response function developed for the Northeast Dairy Adjustment Study reflects the milk response of cows of the average ability of 1961. It starts at a milk production of 7,230 pounds at the lowest level of grain feeding and rises quite sharply to 8,550 pounds of milk at the 2,500 pound grain feeding level. Below 2,500 pounds of grain, the response to grain feeding is higher because the animal is not fed to her stomach capacity. From 8,550 pounds of milk to the maximum milk production of 9,440 pounds, this response has the same slope as the medium milk response function. This lesser slope indicates cows are fed to their stomach capacity.

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* Dailey, R. T., Frick, G. E., and McAlexander, R. H., editors, "Agricultural Economic Planning Data for the Northeastern United States," A.E. & R.S. 51, Pennsylvania State Univ., Univ. Park, Pa., July 1965.

** See appendix II for yield and price data used in this study.

Table 2. Resource restrictions in the linear programming model

Item	Unit	Ratio of cows/crop/acre										
		.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60
Cows	No.	10	15	20	25	30	35	40	45	50	55	60
Stalls for cows	No.	12	18	24	30	36	42	48	54	60	66	72
Stalls for replacements	No.	1	2	3	4	5	6	7	8	9	10	11
Total stalls available	No.	13	20	27	34	41	48	55	62	69	76	83
Cropland	Acre	100	100	100	100	100	100	100	100	100	100	100
Operator labor	Hr.	2,254	2,254	2,254	2,254	2,254	2,254	2,254	2,254	2,254	2,254	2,254

Table 3. Milk response functions for high, medium, and low quality cows*

			High**			
Grain (pounds)	1500	2000	2500	3000	3500	4000
Forage (pounds TDN)	6062	6000	5938	5805	5805	5725
Milk (pounds)	10,200	10,500	10,775	11,025	11,225	11,375
			Medium†			
Grain (pounds)	1500	2000	2500	3000	3500	4000
Forage (pounds TDN)	5570	5455	5335	5200	5055	4895
Milk (pounds)	9160	9615	10,000	10,320	10,575	10,780
			Low‡			
Grain (pounds)	1500	2000	2500	3000	3500	4000
Forage (pounds TDN)	5285	5235	5180	5000	4805	4570
Milk (pounds)	7230	7925	8550	8900	9195	9440

* Expressed as annual requirements and production. Forage requirements were seasonally distributed in the linear programming model.

** Source: E. R. Rutter, "Estimates of New Hampshire Pasture Production," unpublished M. S. Thesis, University of New Hampshire, 1961.

† Dairy Adjustment Research Committee, based on Jensen, E. et. al.: *Input-Output Relationships in Milk Production,* USDA Tech. Bul. 815, 1942.

‡ Unpublished data, Northeast Dairy Adjustments Research Committee, based on U. S. Census of Agriculture data.

The medium milk response function, developed by Jensen and others starts at a milk production of 9,160 pounds at the 1,500-pound level of grain feeding and rises with a steadily diminishing slope to 10,780 pounds of milk at the 4,000-pound grain level. This response function reflects the milk production and response associated with cows of average production of 1965 which are fed to their stomach capacity.

The high milk response function adapted from an unpublished master's thesis at the University of New Hampshire starts at 10,200 pounds of milk at the 1,500-pound grain level and rises with a gradual slope to 11,375 pounds of milk at the 4,000-pound grain level. The more gradual slope indicates a lower response to grain feeding in this response function.

The three milk response functions used in this analysis were independently determined. They reflect differences in feeding and management as well as differences in quality of cows. The functions were chosen primarily to reflect differences in their positions, with less attention paid to their slopes. These functions may suggest that higher quality cows exhibit less responsiveness to grain feeding; however, this conclusion cannot validly be drawn because of different sources of response data.

III. Optimum Organizations

The influences of milk response, milk price, and cows per crop acre on farm organization was determined both separately and in combination. Table 4 and Appendix tables III 1 to 17 show summaries of the optimum organization of resources for each milk response, milk price and ratio of cows to cropland. Optimum farm organization — i.e., the manner and proportions in which available factors are combined in the production process — is discussed in three segments: the cropping pattern, the dairy herd, and the replacement program.

The Cropping Pattern

As more cows are added to a fixed acreage of cropland, more forage must be produced per acre. Production of this forage requires a more intensive cropping pattern. Table 5 and figure 2 show the optimum cropping patterns at the various ratios of cows to crop acres. These patterns are stated in percentage utilization of 100 acres of cropland. In table 5 each block is a summary of the cropping patterns of all solutions at that ratio. The median and the limits of the range of percentage utilization are presented for each ratio of cows to cropland.

In figure 2 the optimum cropping pattern for a given cow/cropland ratio can be read by drawing a vertical line connecting the given cow/cropland ratio. The intersection of the lines separating each crop with this vertical line will show the cumulative percentage of cropland used. For example, at the 0.30 ratio, corn silage occupies 16 percent of the cropland, alfalfa-grass at low fertilization occupies 10 percent (26 percent corn silage and alfalfa-grass minus 16 percent corn silage), clover-grass at zero fertilization occupies 24 percent (50 percent minus 26 percent alfalfa-grass and corn silage), 3-4-5-year grass at zero fertilization occupies 36 percent and seedings of alfalfa and clover occupy 2 percent and 12 percent, respectively.

The most extensive cropping patterns occur at the 0.10 and 0.15 ratios where sale of hay is not allowed. At these ratios no alfalfa or corn silage is produced and the meadow series of rotation is 2 years of clover followed by approximately 8 years of grass. No commercial fertilizer is used except in the seeding year and some cropland is left idle. From this extensive base the changes which occur as the ratio of cows to cropland is increased are:

(1) All cropland is utilized at the 0.20 ratio and above.

(2) The meadow series of the rotation is shortened to 5 years at the 0.25 ratio and above.

(3) Corn silage is steadily increased by displacing clover and 3-4-5-year grass as the ratio of cows to cropland is increased.

(4) Alfalfa displaces clover and 3-4-5-year grass on land suited to producing alfalfa at the 0.30 ratio and above.

Table 4. Optimum farm plan with specified ratios of cows to cropland, medium quality of cows, milk price $5.00 per hundred pounds, and hay price $27.00 per ton.

Item	Unit	Ratio of cows to cropland								
		.10	.15	.20	.25	.30	.35	.40	.45	.50
Forage Crops and Level of fertilization:										
5-year alfalfa/low	Acre	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA*	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA
2-year clover/zero	Acre	...	...	...	...	...	...	...	...	...
2-year clover/low	Acre	21.3HHH	22.9HHH	21.3HHH	10.3HHH	...	...	...	...	...
		...	...	0.4PPP	10.0PPP	19.9PPP	19.1PPP	18.9PPP	...	...
2-year clover/med.	Acre	...	...	...	...	...	...	...	18.2PPP	18.9PPP
3-4-5-year grass/zero	Acre	...	...	...	...	...	...	...	...	...
3-4-5-Year grass/low	Acre	36.5HHH	27.1HHH	10.9HHH	10.0HHH	8.0HHH	10.4HPP	27.7HPP	27.2HPP	...
		...	7.4HHA	21.7HHA	21.2HHA	20.7HHA	8.8HHA	...	...	...
						...	9.4PPP	...	...	...
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	...	26.8HPP
6-12-year grass/zero	Acre	...	...	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...	...
Corn silage	Acre	2.0	6.2	9.9	12.5	15.2	17.8	19.7	20.5	21.3
Seed alfalfa-oats	Acre	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	12.1	11.5	10.9	10.4	10.0	9.5	9.2	9.1	8.9
Feeding program:										
Drylot feed May-June, TDN	1000 lb	7.8	11.7	15.3	9.9	4.0	...	13.0	12.0	13.1
Drylot feed July-Aug., TDN	1000 lb	...	...	...	...	...	...	14.0	1.5	1.9
Drylot feed Sept.-Oct., TDN	1000 lb	...	...	...	...	...	2.4	4.2	4.2	4.3
Grain fed per cow	lb	2500	2500	2500	2500	2500	2500	2500	3000	3000
Livestock:										
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	46.5
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.4	10.7	8.3	9.0
Replacements sold	No.	0.1	0.5	1.1	1.6	2.1	2.6	0.7	...	...
Replacements bought	No.	...	...	...	...	...	...	...	2.9	2.6
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.6	5.3	9.7	9.6
Purchased factors:										
Annual cash invested	Dollars	3280	4280	5270	6212	7151	8096	9079	9899	10346
Grain bought	Ton	14.0	21.3	28.7	36.0	43.3	50.6	56.4	72.5	75.2
Hired labor:										
Permanent	Hour	...	...	...	148.4	506.2	863.9	1144.8	1372.7	1484.0
Spring seasonal	Hour	...	...	49	99	106	113	126	128	131
Summer seasonal	Hour	204	245	286	254	176	96	110	103	108
Fall seasonal	Hour	...	43	93	117	96	81	86	89	91
Product sales:										
Hay sold	Ton	138.6	117.0	93.6	65.6	37.4	8.0	...	...	...
Milk sold	Cwt.	1000	1500	2000	2500	3000	3500	4000	4644	4799
Income net of variable costs	$	5200	6436	7583	8617	9560	10464	11145	11591	11778

* The symbols represent forms of forage i.e., H is hay, A is aftermath grazed, and P is pasture. The symbols HHA represent the first and second crops harvested as hay and the third crop as aftermath.

Table 5. Optimum percentage utilization of cropland by species and level of fertilization with specified ratios of cows to cropland and market for hay.

Ratio of cows to cropland	With hay sales at $27 per ton			With hay sales prohibited (hay price = $0.00)		
	Crop/fertilization	Median	Range	Crop/fertilization	Median	Range
		Pct.	Pct.		Pct.	Pct.
.10 Cows/crop acre	Corn Silage	3	1-4	Corn silage	0	0
	Alfalfa/low	21	21	Alfalfa/low	0	0
	Clover/low	24	23-25	Clover/zero	13	13-14
	3-4-5 grass/low	36	36-37	3-4-5 Grass/zero	20	19-21
	Alfalfa seedings	4	4	6-12 grass/zero	12	9-14
	Clover seedings	12	12	Alfalfa seedings	0	0
				Clover seedings	7	6-7
				Idle cropland	48	53-42
	Total	100		Total	100	
.15 Cows/crop acre	Corn silage	6	5-8	Corn soilage	0	0
	Alfalfa/low	21	21	Alfalfa/low	0	0
	Clover/low	23	23-25	Clover/zero	18	17-19
	3-4-5 grass/low	34	33-35	3-4-5 grass/zero	27	25-29
	Alfalfa seedings	4	4	6-12 grass/zero	28	24-32
	Clover seeding	12	11-12	Alfalfa seedings	0	0
				Clover seedings	9	9-10
				Idle cropland	18	25-9
	Total	100		Total	100	
.20 Cows/crop acre	Corn silage	9	8-12	Corn silage	3	1-6
	Alfalfa/low[1]	21	21	Alfalfa/low	0	0-1
	Clover/low	22	21-22	Clover/zero	21	20-22
	3-4-5 grass/low	33	32-33	3-4-5 grass/zero	32	30-33
	Alfalfa seedings	4	4	6-12 grass/zero	33	33-37
	Clover seedings	11	10-11	Alfalfa seedings	0	0
				Clover seedings	11	10-11
	Total	100		Total	100	
.25 Cows/crop acre	Corn silage	12	11-15	Corn silage	8	6-12
	Alfalfa/low	21	21	Alfalfa/low	0	0-1
	Clover/low	21	20-21	Clover/zero	29	27-31
	3-4-5 grass/low	32	30-32	3-4-5 grass/zero	44	41-46
	Alfalfa seedings	4	4	6-12 grass/zero	4	0-12
	Clover seedings	10	10-11	Alfalfa seedings	0	0
				Clover seedings	15	14-16
	Total	100		Total	100	
.30 Cows/crop acre	Corn silage	15	13-18	Corn silage	16	10-18
	Alfalfa/low	21	21	Alfalfa/low	10	5-21
	Clover/low	20	21	Clover/zero	24	19-28
	3-4-5 grass/low	31	28-31	3-4-5 grass	36	34-42
	Alfalfa seedings	4	4	Alfalfa seedings	2	1-4
	Clover seedings	9	9-10	Clover seedings	12	10-14
	Total	100		Total	100	

[1] Maximum and minimum percentages found in solutions at each ratio.

Table 5. (Continued)

Ratio of cows to cropland	With hay sales at $27 per ton			With hay sales prohibited (hay price = $0.00)		
	Crop/fertilization	Median	Range	Crop/fertilization	Median	Range
		Pct.	Pct.		Pct.	Pct.
.35 Cows/crop acre	Corn silage	19	16-21	Corn silage	19	16-21
	Alfalfa/low	21	21	Alfalfa/low	21	21
	Clover/low	19	18-20	Clover/low	19	18-20
	3-4-5 grass/low	28	27-30	3-4-5 grass/low	28	27-30
	Alfalfa seedings	4	4	Alfalfa seedings	4	4
	Clover seedings	9	9-10	Clover seedings	9	9-10
	Total	100		Total	100	
.40 Cows/crop acre	No hay was sold at this ratio; thus, the solutions are identical in both series. This ratio was beyond the maximum intensity for all milk response functions at the $4 milk price.			Corn silage	20	17-22
				Alfalfa/med.	21	21
				Clover/med.	18	17-19
				3-4-5 Grass/med.	28	26-28
				Alfalfa seedings	4	4
				Clover seedings	9	9-10
				Total	100	
.45 Cows/crop acre	No hay was sold at this ratio; thus, the solutions are identical in both series. This ratio was beyond the maximum intensity for all milk response functions at the $4 milk price and the high & low milk response functions at the $5 milk price.			Corn silage	21	18-24
				Alfalfa/med.	21	21
				Clover/med.	18	17-19
				3-4-5 grass/med.	27	26-28
				Alfalfa seedings	4	4
				Clover seedings	9	9-10
				Total	100	
.50 Cows/crop acre	No hay was sold at this ratio; thus, the solutions are identical in both series. This ratio way beyond the maximum intensity for all milk response functions at the $4 and $5 milk prices and the high milk response function at the $6 milk price.			Corn silage	21	19-21
				Alfalfa/med.	21	21
				Clover/med.	18	18-19
				3-4-5 Grass/med.	27	27-28
				Alfalfa seedings	4	4
				Clover seedings	9	9-10
				Total	100	
.55 Cows/crop acre	No hay was sold at this ratio; thus, the solutions are identical in both series. Only the medium milk response function at the $6 milk price attained this ratio.			Corn silage	21	....
				Alfalfa/med.	21	....
				Clover/med.	18	....
				3-4-5 grass/med.	27	....
				Alfalfa seedings	4	....
				Clover seedings	9	....
				Total	100	

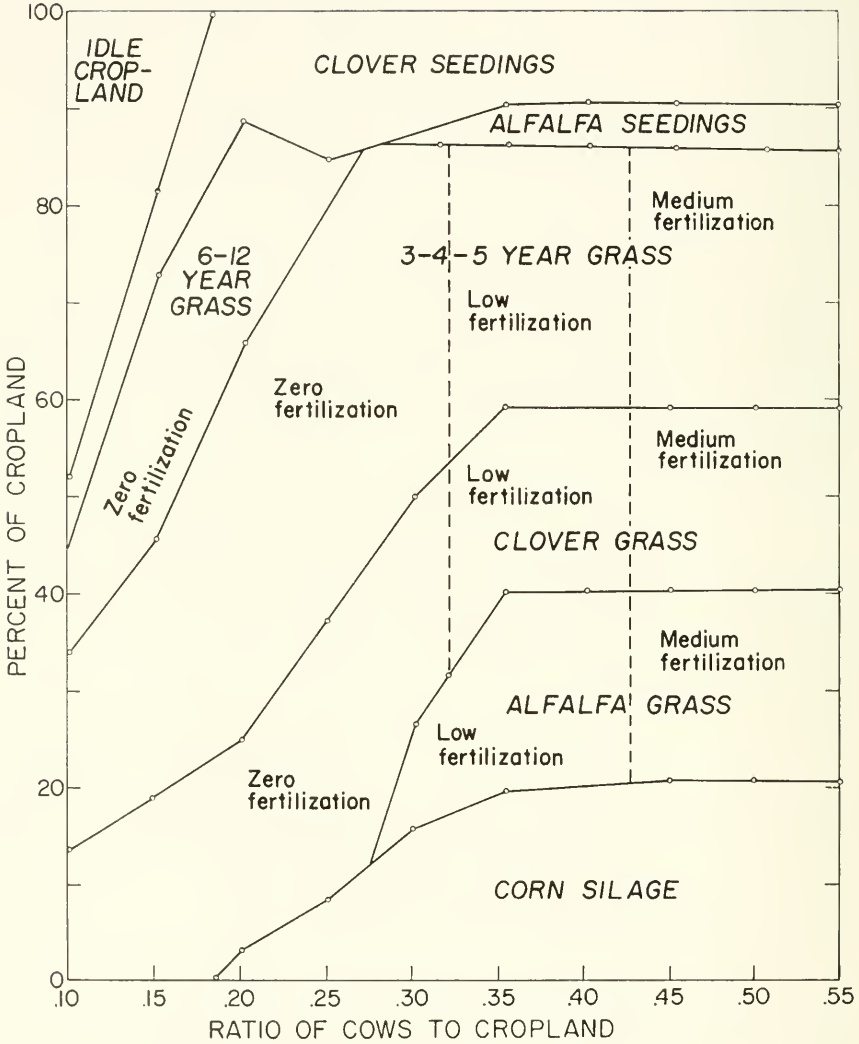

Figure 2. Optimum cropping program with specified ratios of cows to cropland and no market for hay.

(5) Reliance on supplemental hay feeding in the summer is steadily increased and pastured forage is steadily decreased as the ratio of cows to cropland is increased.

(6) The level of fertilization of each meadow species is increased to the low and then to the medium level of fertilization. The increase in level of fertilization occurs at different ratios for each species in each milk response and milk price combination; however, the order in which the levels of fertilization occur are the same.

In the series in which hay is sold, the alternative of harvesting three cuttings of hay is utilized a great deal. At ratios above 0.35, the two series are identical; no hay is sold because the opportunity cost of utilizing it on the farm is too high. Below this ratio the alternative of selling hay at $27 per ton prevents the plan from becoming more extensive.

Some general recommendations on adjusting cropping patterns can be obtained by ranking these adjustments from lowest to highest opportunity cost. In order, these adjustments are:

(1) Utilize all available cropland.

(2) Add a few acres of corn silage. Corn silage should be steadily increased in acreage as more cows are added.

(3) Shorten the meadow series of the rotation to 5 years.

(4) Add alfalfa at the low level of fertilization.

(5) Begin to utilize supplemental hay feeding in July and August. Supplemental hay feeding should be steadily increased as more cows are added.

(6) Increase the level of fertilization from no commerical fertilizer to the low level of fertilization.

(7) Stop selling hay. If the price of hay were higher than $27 per ton, it would pay to intensify further before stopping hay sales.

(8) Plant 2 years of continuous corn on some land. The ratio of the acreage of corn silage to the acreage in new seedings exceeds 1.0 at this level of intensity.

(9) Increase the level of fertilization of alfalfa to the medium level.

(10) Increase the level of fertilization of clover and 3-4-5-year grass to the medium level.

(11) Decrease acreage harvested as pasture while continuing to increase supplemental hay feeding in all pasture periods.

The series of adjustments from (7) to (11) apply whether or not hay can be sold. The first six adjustments apply only when hay sales are not an alternative. When hay can be sold it pays to make the first six adjustments regardless of the ratio of the cows to cropland.

Grain Feeding Levels

The quality of cows is a major determinant of the milk produced per cow and relative profitability of cows. It exerts little influence on the level of grain feeding. The high quality cows have a relatively low response to grain feeding due to the characteristics of the function used in this study.

The slope of the milk response functions for low, medium and high quality cows reflects the additional milk which is estimated to be produced with a given increase in grain fed. In determining optimum levels of grain feeding, the added income from milk sales and the reduced cost of forage are equated with the added cost of grain. The slope of the milk response function and the milk price largely determines the optimum level of grain feeding, because the reduced costs of forage are very small in comparison to the added cost of grain and the added income from milk sales. These reduced costs of forage alter the level of grain feeding only at very high and very low ratios of cows to cropland (see table 6 for all situations considered). The level of grain feeding may be reduced by 500 pounds at very extensive ratios where forage opportunity costs are low, or increased by 500 pounds at very intensive ratios where forage opportunity costs are high.

The Replacement Program

Other alternatives in the dairy herd are production of replacements and disposition of the joint products — replacements and heifer calves. The alternatives available were:

(1) Buy all replacements required for the dairy herd.

(2) Raise replacements which can be raised with resources not accessible to dairy cows and purchase the balance required by the herd.

(3) Raise only the number of replacements required by the herd.

(4) Keep the maximum number of milk cows and raise enough replacements to fully utilize the stall space available.

(5) Raise the maximum number of replacements and keep only enough milk cows to fully utilize the stall space remaining. In this alternative replacements displace cows from available stall spaces.

The first alternative of buying all replacements is used only at the maximum intensity of cropland use with the high and medium milk response functions at the highest milk price. In these two solutions the opportunity costs of using the forage, grain, and labor to produce milk are great enough to exclude the raising of replacements entirely. All heifer calves are sold at birth in these two solutions.

The second alternative, that of raising replacements only with facilities not usable by dairy cows, is employed at high intensity ratios with the high and medium milk response functions at the $6.00 and

Table 6. Optimum levels of grain feeding under specified conditions

Price of milk	Quality of cows	Hay sales	Ratio of cows to cropland									
			.10	.15	.20	.25	.30	.35	.40	.45	.50	.55
			Pounds per cow per year									
	High	Permitted @ $27/ton	1500	1500	1500	1500	1500	1500	1500	2500	2500	.....
		Prohibited	1500	1500	1500	1500	1500	1500	1500	2500	2500	.....
$6.00	Medium	Permitted @ $27/ton	3000	3000	3000	3000	3000	3000	3000	3000	3771	4000
		Prohibited	2500	2500	3000	3000	3000	3000	3000	3000	3771	4000
	Low	Permitted @ $27/ton	3500	3500	3500	3500	3500	3500	3814	4000	4000	.....
		Prohibited	3000	3000	3000	3018	3500	3500	3814	4000	4000	.....
			Pounds per cow per year									
	High	Permitted @ $27/ton	1500	1500	1500	1500	1500	1500	1500	1500	.....	.....
		Prohibited	1500	1500	1500	1500	1500	1500	1500	1500	.....	.....
$5.00	Medium	Permitted @ $27/ton	2500	2500	2500	2500	2500	2500	2500	3000	3000	.....
		Prohibited	2000	2000	2500	2500	2500	2500	2500	3000	3000	.....
	Low	Permitted @ $27/ton	3000	3000	3000	3000	3000	3000	3030	3500	.....	.....
		Prohibited	2500	2500	2500	2500	2500	3000	3030	3500	.....	.....
			Pounds per cow per year									
	High	Permitted @ $27/ton	1500	1500	1500	1500	1500	1500	1500	.....	.....	.....
		Prohibited	1500	1500	1500	1500	1500	1500	1500	.....	.....	.....
$4.00	Medium	Permitted @ $27/ton	1500	2000	2000	2000	2000	2000	.....	.....	.....	.....
		Prohibited	1500	1500	1500	1500	1500	2000	.....	.....	.....	.....
	Low	Permitted @ $27/ton	2500	2500	2500	2500	2500	2500	2500	.....	.....	.....
		Prohibited	2500	2500	2500	2500	2500	2500	2500	.....	.....	.....

$5.00 milk prices. The balance of replacements required are purchased and the excess of heifer calves are sold at birth.

The third alternative, that of raising only as many replacements as are required by the herd and neither buying nor selling replacements is used in a few solutions at high intensity ratios. These solutions are on the high milk response functions at the $4.00 milk price and the low milk response function at the $5.00 milk price.

At all ratios of 0.30 cows per acre of cropland and below, replacements are raised and sold. In all solutions except those with the low milk response function at the $4.00 milk price, replacements are raised only after the maximum number of cows for that situation are kept (alternative 4). In the solutions for the low milk response at the $4.00 milk price the maximum number of heifer calves are raised as replacements and the balance above the replacement requirements are sold. Only enough cows to fully utilize the stall space are kept under this alternative.

Summary of Optimum Organizations

It is important to note the relative importance of the influence of milk response, milk price, intensity ratio, and hay sales in determining farm organization. The ratio of cows to cropland appears to influence the organization most strongly, especially when hay sales is not a feasible alternative. The cow cropland ratio exerts a strong effect on the cropping pattern and the replacement program. As more cows are kept on a fixed acreage, the intensity of use of resources increase markedly.

The milk response function and the milk price are of about the same magnitude in influencing organization. Both exert their primary influence on the level of grain feeding. Each has some influence on the replacement program. Higher milk response functions and higher milk prices favor more intensive production of milk.

Listed in descending order of their influence on the overall organization, these factors are:

(1) The ratio of cows to cropland
(2) The presence or absence of the alternative of selling hay
(3) The slope of the milk response function
(4) The milk price
(5) The level of the milk response function

IV. Net Incomes

Net income as used in this study refers to the income net of variable costs of production. Variable costs are purchased feed, seed, fertilizer, dairy supplies, electricity, gasoline, oil, hired labor, use depreciation of machinery and interest on capital used in production.

Net income thus defined is the residual amount left for covering fixed costs, such as interest on fixed capital, depreciation of buildings and machinery, insurance, taxes, and return to operator's labor and management. By maximizing the net income, one also maximizes residual return to the operators labor and management since the other costs are fixed in the time period under consideration.

Net Income Functions

Figures 3, 4, and 5 compare net income functions for three milk prices; and 6, 7, and 8 compare net income functions for three milk responses. These net income functions show the income effects of adding more cows to a fixed acreage of cropland.

At the point at which hay sales become profitable, each net income function separates into two values. The higher function representing solutions in which hay was sold, is graphed from ten cows to the maximum net income attainable. The lower function, representing solutions in which hay sales were not allowed, is graphed from twenty cows to the maximum. The slopes of each of the net incomes functions decrease as more cows producing at the optimum on their milk response function are added to the fixed acreage. This indicates diminishing returns from adding resources to a fixed acreage.

Observation of figures 3, 4, and 5 shows that milk price has three distinct effects:

(1) A higher milk price raises the position of the net income function by a substantial amount;
(2) A higher milk price substantially increases the number of cows kept at the point of maximum net income;
(3) A higher milk price increases the slope of the net income function slightly.

These three effects are present with the milk response functions for each quality of cows, but are accentuated in the medium and low milk response functions.

Observing figures 6, 7, and 8 shows that the milk response function exerts influences similar to those of milk price, with the income response functions for high quality cows having steeper slopes.

The net income functions illustrate that farms with low quality cows and a low milk price cannot improve their incomes very much by adding cows. Farms with medium or high quality cows fare somewhat better under a low milk price; however, they do not have the

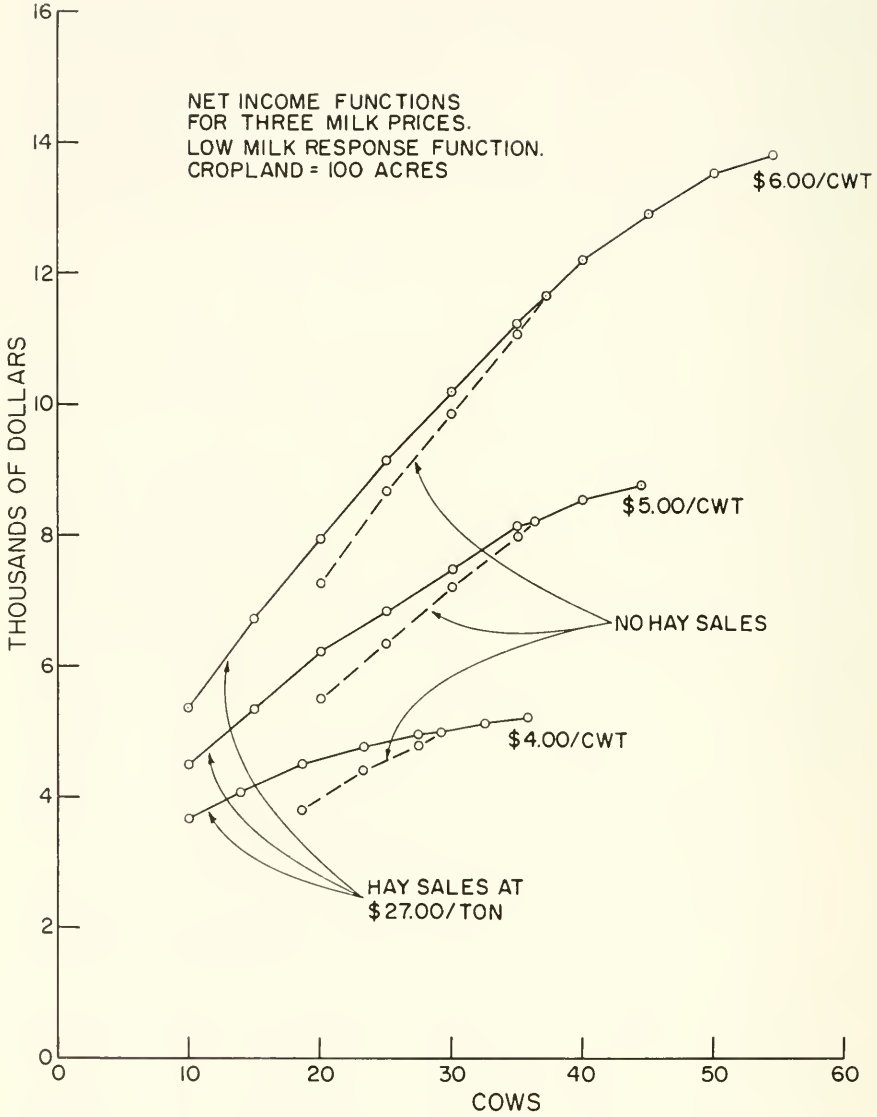

Figure 3. Net income functions for 100 acres of cropland and various numbers of low quality cows with 3 prices for milk and with and without hay sales.

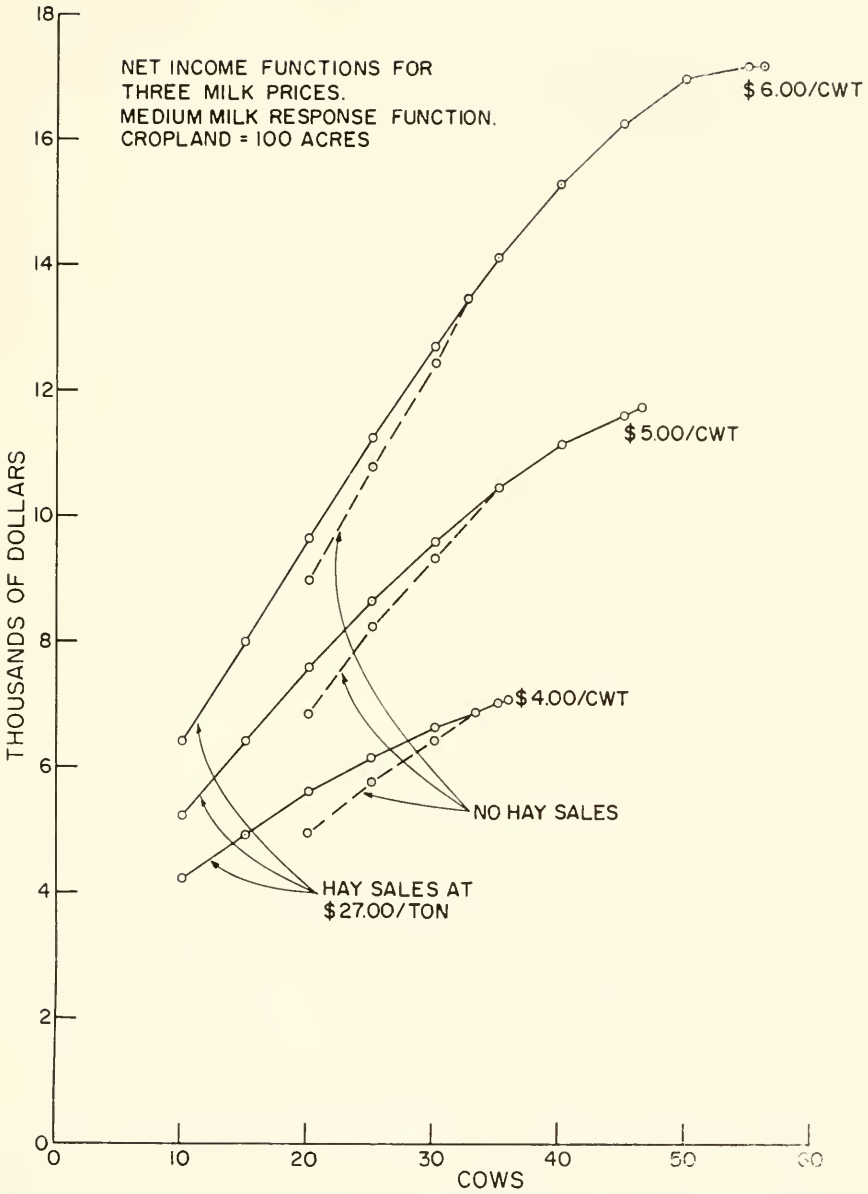

Figure 4. Net income functions for 100 acres of cropland and various numbers of medium quality cows with 3 prices for milk and with and without hay sales.

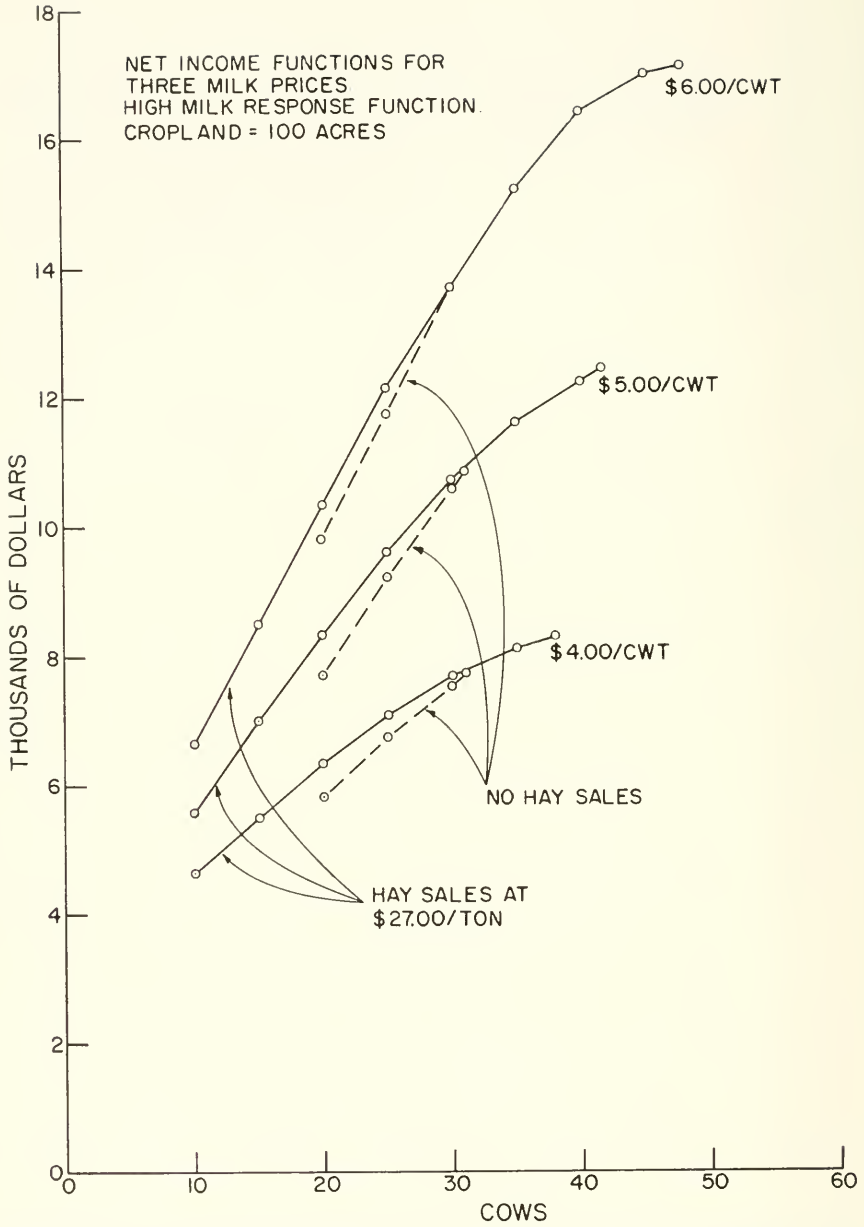

Figure 5. Net income functions for 100 acres of cropland and various numbers of high quality cows with 3 prices of milk and with and without hay sales.

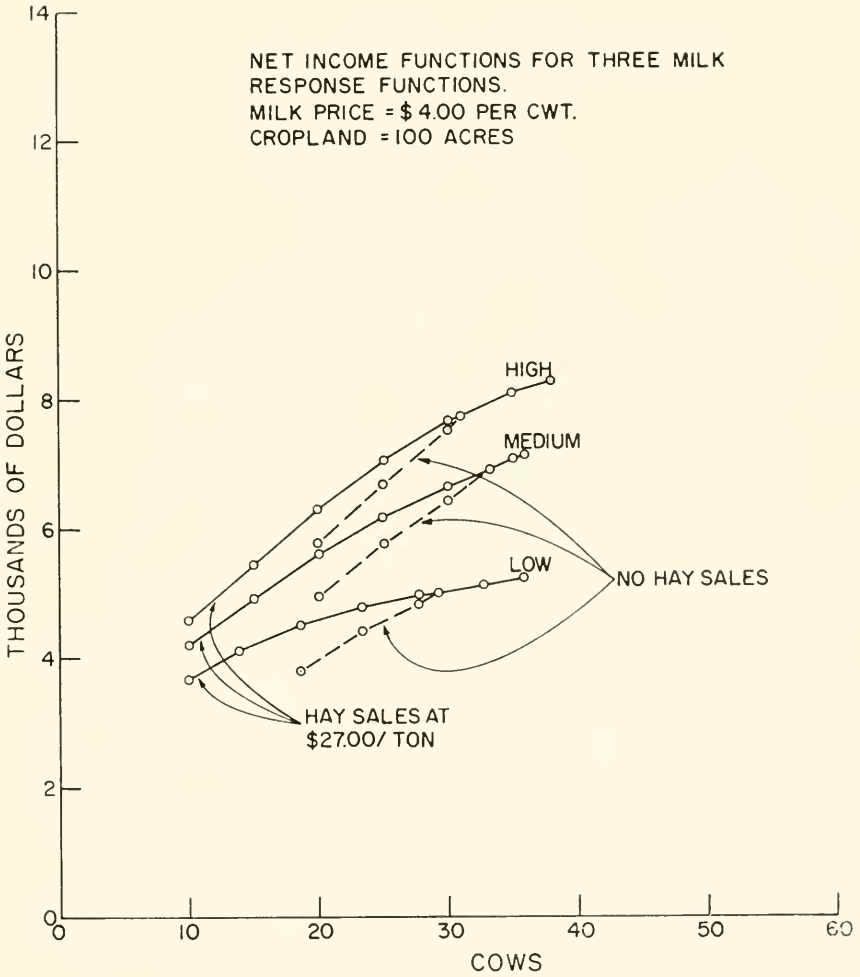

Figure 6. Net income functions for 100 acres of cropland and various numbers of low, medium or high quality cows with a milk price of $4.00 per cwt. and with and without hay sales.

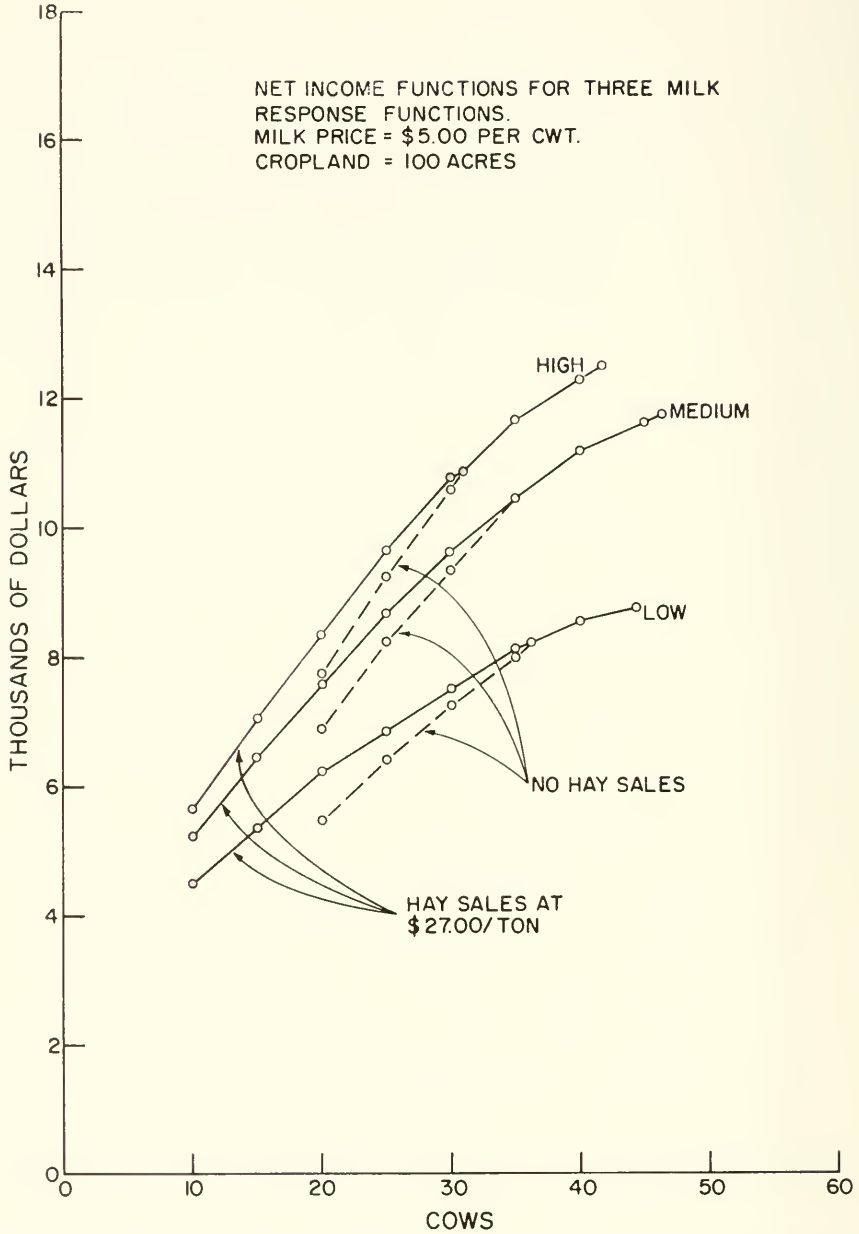

Figure 7. Net income functions for 100 acres of cropland and various numbers of low, medium or high quality cows with a milk price of $5.00 per cwt. and with and without hay sales.

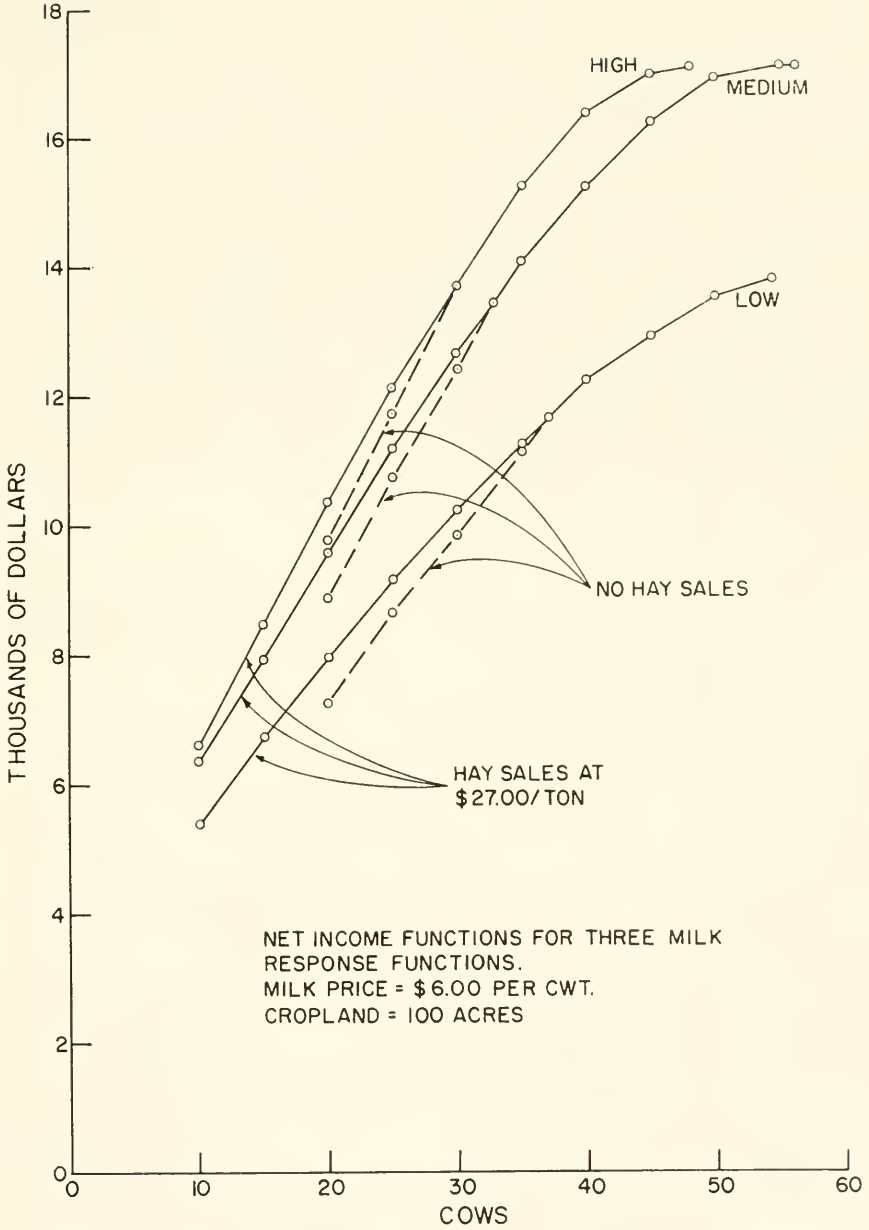

Figure 8. Net income functions for 100 acres of cropland and various numbers of low, medium or high quality cows with a milk price of $6.00 per cwt. and with and without hay sales.

income potential of farms with low quality cows and a $5.00 or $6.00 milk price. Hence, it takes a great increase in quality of cow to offset an unfavorable milk price. Since an individual farmer can't control the milk price, improving the quality of his cows is his best alternative at low milk prices. At higher milk prices adding more cows becomes more favorable.

Net Income Isoquants

The income surfaces developed in this study are shown in Figures 9 and 10. The milk response functions for three qualities of cows are compared in each figure. Figure 9 compares the $6.00 and $4.00 milk prices and figure 10 illustrates the three responses at the $5.00 milk price. Each net income isoquant describes combinations of cropland and cows that yield the specified income level. They also indicate the effects of substituting cows for cropland.

In each figure the slope of the isoquant represents an arc estimate of the marginal rate of substitution of cows for crop-

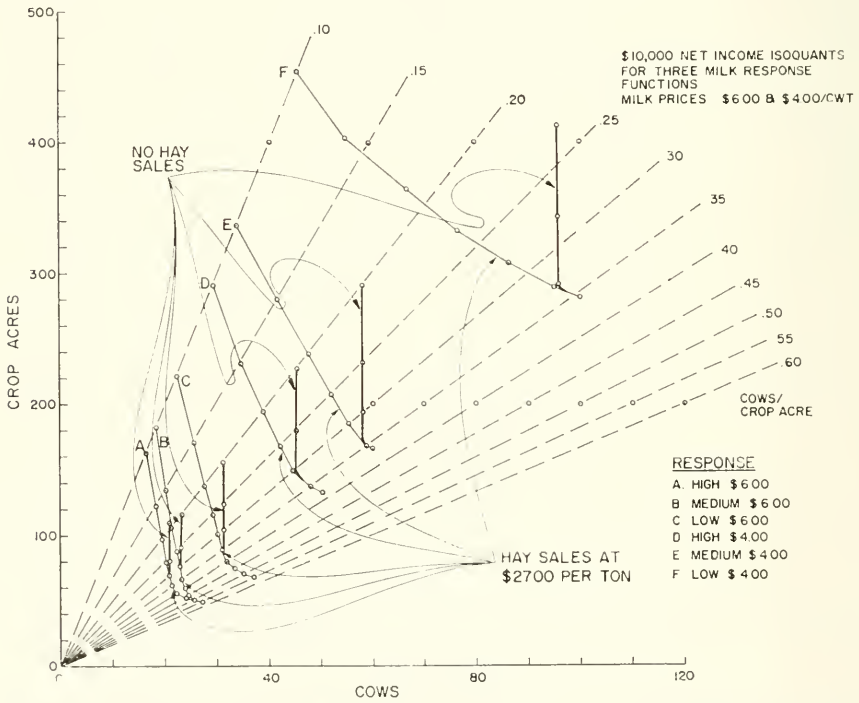

Figure 9. Isoquants for a $10,000 net income with low, medium and high quality cows, two prices for milk, various ratios of cows to cropland and with and without hay sales.

$$\text{land} \frac{(\triangle \text{ cropland})}{(\triangle \text{ cows})}.$$

Each segment of the net income isoquant is a linear approximation of the actual shape of the function. The slope, therefore, is an estimate of the **average** marginal rate of substitution of cows for cropland over the range of the segment.

As the ratio of cows to cropland increases, the slope of the net income isoquants decrease. For the isoquants where hay sales were prohibited the slope becomes infinite at the point at which hay would normally be sold. This indicates that additional land would contribute nothing to net income. Beyond the highest analyzed ratios of cows to cropland the isoquants, if drawn, would bend away from the axis — indicating that additional cows would contribute nothing to net income.

The slope of the net income isoquants show that a cow will substitute for many acres at low ratios of cows to cropland. This relation

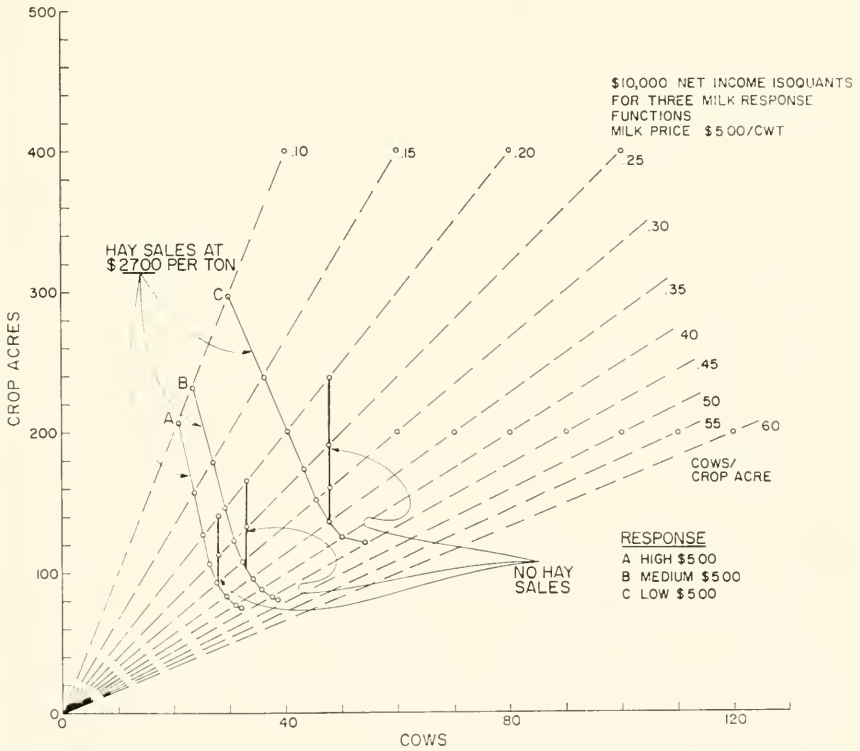

Figure 10. Isoquants for a $10,000 net income with low, medium and high quality cows, one price for milk, various ratios of cows to cropland and with and without hay sales.

is greatly accentuated in the situations where hay sales are not allowed. As higher cow/cropland ratios are obtained a cow will substitute for fewer and fewer acres of cropland.

Profitable adjustments in numbers of cows and acres of cropland can be found by the following procedure:

(1) Multiply the acres for which a cow will substitute, i.e., the slope of the isoquant by the price of land.
(2) Subtract the price of the cow from the above.
(3) The result will be the net gain for making the substitution. A positive net gain indicates it will pay to substitute cows for cropland. A negative figure indicates it will pay to make an opposite substitution — i.e., substitute cropland for cows.

The milk price and the milk response function exert little influence on the shape of the net income isoquants. The substitutability of cows for cropland — i.e., the slope of the net income isoquants — depends mostly on the ratio of these resources.

Two conclusions result from the comparison of net income isoquants for milk responses for different quality cows and milk prices. First, they support the same conclusions as the net income functions. Namely, that it takes a great increase in quality of cow to offset the effects of an unfavorable milk price. Second, the quantities of resources required to produce a $10,000 net income increase rapidly with less favorable prices and lower quality cows.

Both the net income functions and the net income isoquants show that considerably greater incomes may be obtained by intensive farms than by extensive farms. The addition of a few cows will greatly increase the net income of extensive farms. Similarly, the net income isoquants show that a single cow will substitute for several acres of cropland at low ratios of cows to cropland and leave income unchanged.

The milk response of different quality cows exerts a considerable influence on both the net income potential and on the resource requirements to obtain a specified net income. It is shown by the net income functions that net incomes may be up to twice as great with high quality cows than with low quality cows. The greater differences occur on intensive farms with high milk prices. From the net income isoquants it can be seen that to produce a $10,000 net income, the cropland and cows required are one and one-half to two times as great with the low quality cows than with the high quality cows. The greater resource requirements occur with low milk prices.

Viewed a third way, the anaylsis shows that the income potential of identical resource packages are up to four times as great with the $6.00 milk price than with the $4.00 milk price. The greater differences occur at high ratios of cows to cropland at the higher milk response function. Similarly, the resource requirements to produce a $10,000 net income are up to four times as great with the $4.00 milk price than with the $6.00 milk price.

V. Resource Valuation

Marginal Value Products

In linear programming solutions each limiting resource is assigned "opportunity cost" or "shadow price" equal to its value in its most profitable use. These shadow prices of limited resources are the marginal-value products of the resources, i.e., the change in net income attributable to the last unit of the resource employed. An increase in the supply of one resource relative to a resource for which it can substitute decreases the marginal value of the first resource and increases marginal value of the second resource. In table 7 it can be seen that increasing the cows kept on a fixed acreage rapidly decreases the marginal-value product of cows and rapidly increases the marginal-value product of cropland. The marginal-value product

Table 7. Marginal value products for selected resources with medium quality cows, $5.00 price of milk, various ratios of cows to cropland and with and without sales of hay.

Item	Ratio of cows to cropland								
	.10	.15	.20	.25	.30	.35	.40	.45	.50
	Hay sales at $27.00 per ton								
Cropland ($/acre)	22	20	20	20	20	24	47	59	89
Dairy cow ($/head)	139	131	122	110	110	106	96	62	0
Replacement ($/each)	320	320	320	320	320	320	320	350	350
Buy hay ($/ton)	13	13	14	14	14	15	20	22	29
Sell hay ($/ton)	27	27	27	27	27	27	37	44	59
Marginal return over feed costs ($/cow)	307	303	300	300	300	289	238	211	150
Marginal rate of substitution of cows for cropland	—6.3	—6.5	—6.2	—5.6	—5.6	—4.5	—2.1	—1.1	0
	Hay sales prohibited								
Cropland ($/acre)	0	0	5	6	7	17	47	59	90
Dairy cow ($/cow)	152	152	143	112	112	109	96	62	0
Replacement ($/each)	320	320	320	320	320	320	320	350	350
Buy hay ($/ton)	5	5	10	11	12	14	20	22	29
Sell hay ($/ton)	8	8	16	16	16	24	37	44	59
Marginal return over feed costs ($/cow)	371	371	343	332	330	303	238	211	150
Marginal rate of substitution of cows for cropland	...	...	—29.7	—17.2	—15.7	—6.3	—2.1	—1.1	0

of cows assumes that there is a stall available to receive the cow, thus, it represents the annual net return to both the cow and the stall.

The marginal-value product of replacements increases as more cows are added to a fixed acreage, but the range in values products is narrow. Its lower limit is the price for which a replacement may be sold and its upper limit is the purchase price of a replacement.

The marginal-value product of forage is the opportunity cost of producing a ton of hay equivalent. It increases as the ratio of cows to cropland increases. In other words, a more intensive use of land increases the opportunity costs of producing forage.

The marginal return over feed cost is the shadow price of the cow-feeding process. This quantity is the residual income left above all cash and opportunity costs of producing and feeding forage and grain to the marginal dairy cow. The marginal return over feed costs decreases as more cows are added and results from increased grain feeding as well as increased forage costs. It is important to note that one does not maximize net farm income by maximizing return over feed costs.

Break-even Prices of Cropland and Cows

The marginal-value products are estimates of the **annual net return** associated with the marginal unit of each of the resources and intermediate products. In the case of forage and replacements this is their break-even price since they are expended in the 1-year production period. Cropland and cows, on the other hand, provide a flow of services over several production periods. Since this is true, the break-even prices must be calculated by applying proper discounting procedures to the expected return over the life of the resource.

The nature of the resources suggests similar methods of discounting for cropland and cows. Cropland can be considered to yield a perpetual return. Likewise, dairy cows provide a perpetual return because they provide for their own replacements in this analysis.

Both cropland and cows may have an annual tax associated with them. These annual taxes must be subtracted from the marginal-value products before discounting their future returns.

The break-even prices of land and cows are given by the following formulae.

$$\text{Break-even price of land} = \frac{\text{Marginal-value product of land (minus) annual tax on land}}{\text{Desired rate of return}}$$

$$\text{Break-even price of cows} = \frac{\text{Marginal-value of product of cows (minus) annual tax on cows}}{\text{Desired rate of return}}$$

The break-even prices of cows and cropland for the marginal-value products shown in Table 7 are shown below for the following situation:

Hay sales	Prohibited
Milk price	$5.00 cwt.
Milk response	Medium
Annual property tax on land	$4.50 acre
Annual tax on dairy cows	$11.00 head
Desired rate of return	15%

Breakeven price for:	Ratio of cows to cropland								
	.10	.15	.20	.25	.30	.35	.40	.45	.50
Land	0	0	3	10	17	83	283	363	570
Cows	940	940	880	673	673	653	567	340	0

Because the marginal-value product includes both the cow and the stall, very high break-even prices for cows may be obtained. This also indicates the foregone income of maintaining excess barn capacity. If no stall space is available, the break-even price of cows must cover the cost of providing the stall space as well as the animal.

The desired rate of return is the individual's own preference. A rate of 10 to 20 percent is not excessive, considering the risk involved in dairy farming as opposed to alternative investments.

The Optimum Ratio of Cows to Cropland

The marginal rates of substitution of cows for cropland recorded in Table 7 and appendix IV were derived from the inverse ratio of the marginal-value products of cropland and cows.*

From these estimates of the marginal rate of substitution of cows for cropland, the optimum ratio of combination of cows and cropland can be determined. Optimum combination of two inputs occurs when their marginal rate of substitution equals the inverse ratio of their

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* Marginal rate of substitution of cows for cropland

$$\frac{\frac{P_{milk}\,\Delta\,milk}{\Delta\,cows}}{\frac{P_{milk}\,\Delta\,milk}{-\,\Delta\,cropland}} = \frac{-\,\Delta\,cropland}{\Delta\,cows}$$

The last expression on the right of the equality is the defining formula for the marginal rate of substitution of cows for cropland. The customary notation for this formula involves partial derivatives. However, in linear programming, derivative notation and the delta notation are equivalent.

prices. In this analysis, however, it is necessary to correct the prices of land and cows for annual taxes. This is done in the following procedure. The first step corrects the prices for direct taxes; the second step determines the inverse ration of their prices; and the third step finds their marginal rates of substitution.*

(1) Add the capitalized value of annual taxes on cropland (at the desired rate of return) to the price of cropland. Add the capitalized value annual taxes on cows to the price of cows.
(2) Form a ratio of the corrected price of cows to the corrected price of land.
(3) Compare this ratio with the marginal rates of substitution of cows for cropland in appendix IV. The optimum combination of cows and cropland will be at the place where these quantities are equal.

As an example of the calculation of the optimum ratio of cows to cropland the situation illustrated in table 7 follows:

Assume: Hay sales not allowed
Milk price = $5.00/cwt.
Milk response = Medium
Price of land = $100/acre
Annual taxes on land = $4.50/acre
Desired rate of return = 15%
Price of cows = $450
Annual taxes on cows = $11.00/head

Step 1 (a) $\$100 + \frac{\$4.50}{.15} = \$130$ corrected price of land

(b) $\$450 + \frac{\$11.00}{.15} = \$523$ corrected price of cows

Step 2 Inverse Ratio of Prices $= \frac{\$523}{\$130} = -4.2$

Step 3 Marginal rates of substitution of cows for cropland at the assumed milk price and milk response: (Table 7)

.40 ratio = −2.1
.35 ratio = −4.5
.30 ratio = −5.6

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* The problem is to find R, the gross annual return necessary to pay the direct taxes and provide the desired rate of return on the purchase price of the asset.

$$iP = R - T$$

where: R = gross annual return
T = annual direct tax
P = purchase price
i = desired rate of return

this formula transposes to $R = iP + T$

For simplicity in exposition this analysis is presented in terms of the present value of R in perpetuity $V = R/i$

where V = present value of an asset which returns R annually in perpetuity.

$$V = P + T/i$$

Therefore, the optimum ratio of cows to cropland under the assumed conditions and prices is between 0.35 cows per acre, and 0.40 cows per crop acre.

Figures 11, 12, and 13 describe the optimum ratios of cows to cropland and different ratios.

To use these figures:

1. Locate present ratio of cows to cropland on vertical axis.
2. Locate price ratio on horizontal axis.
3. Plot a point having the coordinates (price ratio, cow to cropland ratio) found above.
4. Find the line corresponding to the milk price. This line connects all the ratios which would be optimum at this milk price.
5. If the point located in Step 3 is above or to the right of the milk price line it will pay better to add cropland. If below or to the left, it will pay better to add cows.

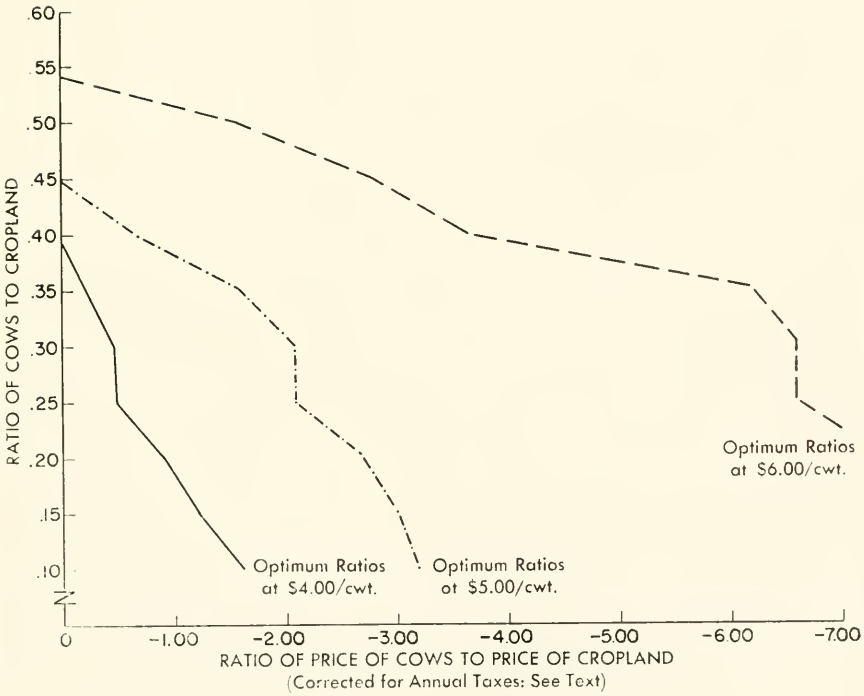

Figure 11. Optimum ratios of cows to cropland with low quality cows; hay sales at $27 per ton and three prices for milk.

These figures indicate:

1. The optimum ratio of cows to cropland is more sensitive to changes in the prices of milk than to differences in milk response of cows.
2. The optimum ratio of cows to cropland is not very sensitive to changes in the cow-cropland ratios at high and medium levels of milk price. It takes a large change in the relative prices of cropland to cows to change the optimum ratio of cows to cropland by 0.05.
3. Lower milk prices and lower milk response make the optimum ratio of cows to cropland more sensitive to changes in the price ratios.
4. Intensive farms, above 0.30 cows per acre, are optimal under most probable cow and cropland prices when milk prices are $5.00 per hundredweight or above. Extensive farms, below 0.30 cows per acre, are optimal only at the $4.00 milk price and when land is low priced relative to the price of cows.

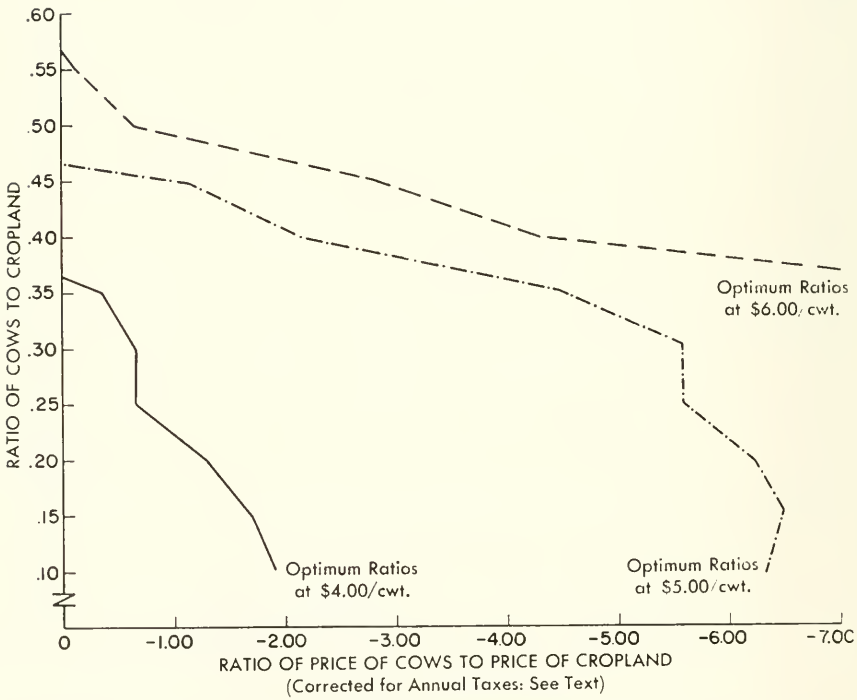

Figure 12. Optimum ratios of cows to cropland with medium quality cows; hay sales at $27 per ton and three prices for milk.

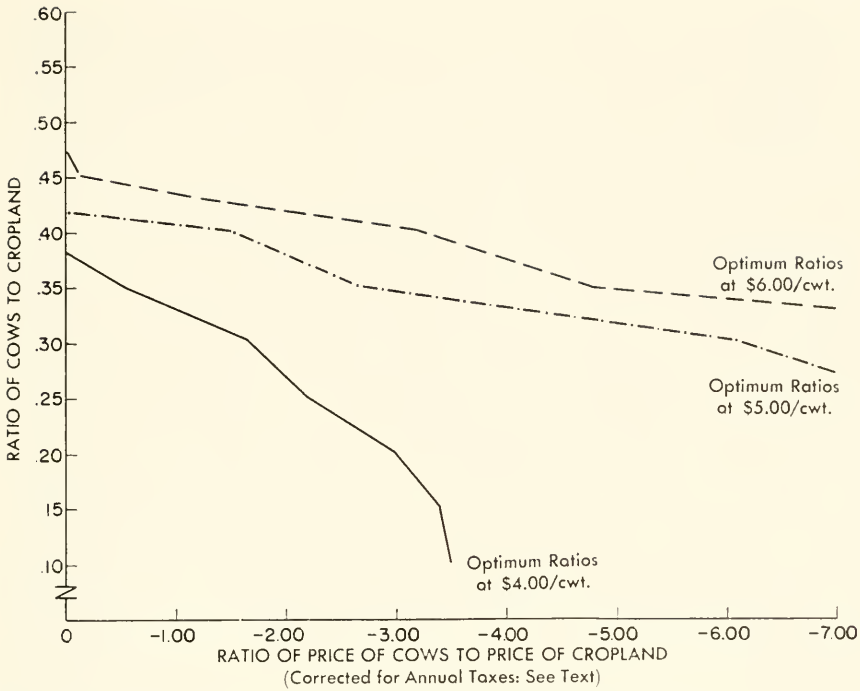

Figure 13. Optimum ratios of cows to cropland with high quality cows; hay sales at $27 per ton and three prices for milk.

Appraisal of Non-Optimal Milk Production Alternatives

Comparing the shadow prices of non-optimal production alternatives, provides a direct method of comparing alternative qualities of cows as well as levels of grain feeding. Six levels of grain feeding based on three milk response functions as alternatives.

Table 8 compares shadow prices of non-optimal milk production alternatives at the 0.35 ratio of cows to cropland. The basis for comparison is a cow of low milk response. At the $6. milk price, this cow would be fed grain at the optimal 3,500 pound level. If this cow were fed 3,000 pounds of grain instead of the optimal level, the result would be a foregone income of $1; if 2,500 pounds, the loss would be $5. Replacing this low-quality cow with a cow of medium quality fed the optimal grain level would result in a gain in net income of $81. Replacing the low-quality cow with a cow of high quality and feeding grain at the optimal level would raise net income by $119.

Within both the medium and the high response functions the net change in income associated with changes in level of grain feed-

Table 8. Comparison of optimal and non-optimal milk production alternatives with 35 cows per 100 crop acres, three milk response functions, and three prices of milk.

Alternative milk response functions	Grain fed per cow	Shadow prices* $6.00 milk	Change in net income per cow per 500 lb. increase in grain fed	Shadow prices* $5.00 milk	Change in net income per cow per 500 lb. increase in grain fed	Shadow prices* $4.00 milk	Change in net income per cow per 500 lb. increase in grain fed
	4000	+ 95		+ 70		+43	
High quality cow	3500	+105	−10	+ 81	−11	+55	−12
	3000	+111	− 6	+ 90	− 9	+66	−11
	2500	+115	− 4	+ 96	− 6	+75	− 9
	2000	+118	− 3	+101	− 5	+83	− 8
	1500	+119†	− 1	+105†	− 4	+90†	− 7
Change in net income per cow associated with a change from low to high milk response function at optimum grain level**		+119		+105		+90	
	4000	+ 78		+ 56		+34	
Medium quality cow	3500	+ 78	− 5	+ 63	− 7	+43	− 9
	3000	+ 81†	− 3	+ 67	− 4	+50	− 7
	2500	+ 79	+ 2	+ 69†	− 2	+55	− 5
	2000	+ 74	+ 5	+ 67	+ 2	+59†	− 4
	1500	+ 65	+ 9	+ 62	+ 5	+57	+ 2
Change in net income per cow associated with a change from low to medium response function at optimum grain level**		+ 81		+ 69		+59	
	4000	− 1		− 5		−13	
Low quality cow	3500	.....†	− 1	− 2	− 3	− 7	− 6
	3000	− 1	+ 1	.....†	− 2	− 3	− 4
	2500	− 5	+ 4	− 1	+ 1	.....†	− 3
	2000	− 24	+19	− 13	+12	− 6	+ 6
	1500	− 46	+22	− 29	+16	−15	+ 9

* The sign of each shadow price has been changed. In this table the shadow price indicates the increase in net income generated by the marginal cow if its milk response function and level of grain feeding were as indicated at the left of the table.

** The difference in net income associated with a change of response function is interpreted as an addition to or subtraction from the annual net return of the cow of the response function in the plan.

† Optimal level of grain feeding.

ing is interpreted the same as with the low response function. A positive value of the change in net income resulting from a 500 pound increase in grain feeding per cow indicates that such an increase will increase net income. A negative value indicates that the change in grain feeding would reduce net income. The optimum level of grain feeding for each milk function is at the point where these signs change from positive to negative.

Comparison of the three milk response functions shows that a cow of high milk production ability can be expected to return annually between $31 and $38 more than a cow of the medium production ability, and between $90 and $119 more than a cow of the low production ability if each is fed its optimal level of grain feeding. A cow of medium productive ability will return between $59 and $81 more than a cow of low productive ability.

Break-Even Price Differentials Between Cows of Different Production Abilities

The difference in net income resulting from a difference in production per cow can be interpreted as an addition to or subtraction from the annual net return of the dairy cow.

If the quality of the offspring from cows of different milk response functions is not considered, then the excess of the price of a high response cow over a low response cow must be accumulated over the expected herd life of the animal. For a herd life of 4 years the break-even price between cows of different milk responses must be computed by discounting the increased net return over 4 years. The following formula gives the break-even price differential between two cows of different milk response:

$$V = \frac{R}{i}\left(1 - \frac{1}{(1+i)^n}\right)$$

Where V = the break-even price differential between cows
R = change in annual net income associated with a change in milk response
i = desired rate of return
n = herd life of cow

An example of this computation is as follows:

Assume: Milk price = $5.00/cwt.
Desired rate of return = 15%
Change in net income with cow of high milk response = $36
Change in net income with cow of low milk response = –$69

Break-even price differentials:

For high milk response cows

$$V = \frac{.36}{.15}\left(1 - \frac{1}{(1 + .15)^4}\right)$$

$$V = 240\left(1 - \frac{1}{1.749}\right)$$

$$V = 240 \quad (0.4283)$$

$$V = \$103$$

For low response cows

$$V = \frac{-69}{15}\left(1 - \frac{1}{(1 + .15)^4}\right)$$

$$V = -460 \quad (0.4283)$$

$$V = -\$197$$

The results of these computations can be interpreted as follows: it pays to buy a cow of the high milk response only if its price is less than $103 more than a cow of medium response. Similarly, it pays to buy a cow of medium milk response only if its price is less than $197 higher than a cow of low milk response.

Summary of Resource Valuation

The ratio of cows to cropland strongly influences the value of added units of all resources and intermediate products. This influence is increased by the absence of the alternative to sell hay. The ratio of cows to cropland has a similar influence on the marginal rate of substitution of cropland for cows.

The price of milk has been shown to exert a considerable influence on the marginal return of cows and the marginal return over feed costs. However, it has an almost negligible effect on the marginal return of cropland, forage, and replacements in this model.

The amount of cropland per cow has little effect on the differences in net income due to changes in quality of cows or grain feeding levels. The price of milk has a somewhat greater effect on the differences in net income due to changing quality of cows than to changing grain feeding levels.

VI. Summary and Conclusions

This study examines the influence of several variables upon farm organization, income, and resources valuation. These variables are:

(1) The ratio of cows to cropland.

(2) The quality of dairy cows.

(3) The presence or absence of the alternative of selling hay.

(4) Price of milk.

Multiple linear programming solutions were used to analyze production and price data typical of New Hampshire dairy farms.

Marginal value products were used to determine break-even prices which may be paid for cropland and cows of varying qualities. Discounting methods were applied to the marginal value products to determine break-even prices of durable assets.

The cropping pattern, the feeding program, and the replacement programs are all highly responsive to changes in the ratio of cows to cropland. The presence or absence of the alternative of selling hay modifies the cropping pattern. Optimum cropping patterns range from **very extensive plans to very intensive plans,** as the ratio of cows to cropland increases. The profitableness of adjustments in forage and grain feeding depends primarily on the quality of cows and the price of milk. Changes in the ratio of cows to cropland have little effect on the level of grain feeding. The replacement program depends on the intensity of use of resources. In very intensive plans (high ratios of cows to cropland), it pays to buy replacements, thus freeing resources for milk production. In extensive plans or when resources are under utilized, it pays to raise and sell replacements.

The analysis indicates that the income potential of a farm increases greatly as higher milk prices, higher milk responses, and optimal ratios of cropland to cows are attained. Differences in the milk price causes greater differences in income potential than differences in resource combinations. Resource requirements to produce a specified net income increase greatly when farmers receive lower milk prices or have low quality cows. The optimal ratios of cows to cropland appear to occur on fairly intensive farms.

The effect of the quality of the cow is less marked than the effect of milk price. Cows of low quality at a high milk price yield somewhat higher incomes than cows of a high quality at a low milk price. In contrast, the net income potential with high quality cows and a high milk price is more than four times the net income potential with low quality cows and a low milk price.

Within each milk price and milk response combination, the more intensive farms have higher net incomes. Extensive farms are disadvantaged in all price and response combinations, but are more disadvantaged by low milk prices and low milk response.

Changes in the ratio of the price of cows to the price of cropland alter the optimum ratio of cows to cropland; however, at high milk prices, considerable changes in the price ratio would be required to make extensive farms optimal.

The results of this analysis provide guidelines in planning short- and long-run farm adjustments. In the short run the farmer is not able to make large changes in the resources he controls; but he can change the way his present resources are organized. Therefore, in the short run, the optimum organizations and break-even prices are most relevant to his problem. An optimal, short-run plan for a farm can be found by selecting the appropriate ratio of cows to cropland, milk response, and milk price for the farm. The break-even prices for this plan can be calculated by applying the methods developed in this study.

In a longer planning period the farmer has the opportunity to alter the resources he controls quite substantially as well as seek the most advantageous resource combination. Using optimum ratio of cows to cropland can help the farmer develop a long-run plan. The organization and resource valuation information of a long-term plan can suggest the better alternatives and his probable income position after reaching his optimum resource combination.

APPENDIX I

THE LINEAR PROGRAMMING MODEL

Description	Unit	Row ID	Ci	Level	Alfalfa grass — 5 yr. HHA low fert.	Alfalfa grass — 5 yr. HHA med. fert.	Clover grass – zero fert. HHA	Clover grass – zero fert. HPP	Clover grass – zero fert. PPP	
Cj					-13.11	20.72	5.34	—3.66	0.86	
Activity number				P_0	P_1	P_2	P_3	P_4	P_5	
Milk sales	10 cwt.	73	50.00	0.0	....	....	....	....	....	1
Total cropland	acre	74	.....	b 2	1.0	1.0	1.0	1.0	1.0	2
Maximum alfalfa-corn acres	acre	75	.....	b 3	1.0	1.0	....	....	....	3
Maximum alfalfa acres	acre	76	.....	b 4	1.0	1.0	....	....	....	4
Max. non cropland pasture	acre	77	.....	b 5	....	....	....	....	....	5
Min. non-alfalfa reseeding	acre	78	—999.00	b 6	....	....	....	....	....	6
Cows on hand	no	79	.....	b 7	....	....	....	....	....	7
Overhead cows	no	80	999.00	10.0	....	....	....	....	....	8
Stall space	no	81	.....	b 9	....	....	....	....	....	9
Max. spl. repl. res.	no	82	.....	b10	....	....	....	....	....	10
Replacement required	no	83	.....	0.0	....	....	....	....	....	11
Heifer calf control	no	84	16.00	0.0	....	....	....	....	....	12
Silo capacity	10 ton	85	.....	b13	....	....	....	....	....	13
Alfalfa seeding	art.	86	.....	0.0	0.2	0.2	....	....	....	14
Clover seeding	art.	87	.....	0.0	....	....	0.5	0.5	0.5	15
Clover to 3-4-5 yr. grass	art.	88	.....	0.0	....	....	3.0	—3.0	—3.0	16
Reseed clover from 6-12 yr.	art.	89	—999.00	0.0	....	....	....	....	....	17
Reseed alfalfa from 6-12 yr.	art.	90	—999.00	0.0	....	....	....	....	....	18
Reseed alfalfa from 6-12 yr.	art.	91	—999.00	0.0	....	....	....	....	....	19
5 yr. alfalfa to 6-12/reseed	art.	92	.....	0.0	1.4	—1.4	....	....	....	20
Total forage (excl. aftermath)	1000 TDN	93	.....	0.0	1.970	—2.180	1.360	1.590	1.480	21
Max. May-June pasture	1000 TDN	94	.....	0.0	....	....	....	....	-0.730	22
Max. July-August pasture	1000 TDN	95	.....	0.0	....	....	....	0.450	—0.450	23
Max. Sept.-Oct. pasture	1000 TDN	96	.....	0.0	....	....	....	0.300	—0.300	24
Aftermath collect	1000 TDN	97	.....	0.0	—0.450	—0.495	0.300	....	....	25
Hay control	ton	98	.....	0.0	—1.93	—2.14	1.28	—0.80	....	26
Cow feeding control	art.	99	.....	0.0	....	....	....	....	....	27
Buy grain	ton	100	.....	0.0	....	....	....	....	....	28
Cash reservation	$100.00	101	6.00	0.0	—0.066	—0.104	0.027	0.018	0.002	29
Labor — spring	10 hrs.	102	2.50	b30	0.037	0.038	....	....	0.050	30
Labor — summer	10 hrs.	103	2.50	b31	0.536	0.601	0.536	0.368	0.047	31
Labor — fall	10 hrs.	104	2.50	b32	....	....	....	....	....	32
Labor — winter	10 hrs.	105	2.50	b34	....	....	....	....	....	33
Max. hired winter labor	10 hrs.	106	.....	b34	....	....	....	....	....	34
Max. corn/new seeding ratio	art.	107	.....	0.0	....	....	....	....	....	35

Description	Clover grass — low fert.				Clover grass — med. fert.				3-4-5 yr. grass — zero fert.			
C_j	HHA 12.98	HHH 15.01	HPP 11.21	PPP 8.25	HHA 20.50	HHH 22.56	HPP 18.69	PPP 15.64	HHA 5.35	HPP 3.81	PPP —0.86	
Activity number	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	
Milk sales	....	....	....	....	....	....	....	....	....	....	....	1
Total cropland	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2
Maximum alfalfa-corn acres	....	....	....	....	....	....	....	....	....	....	....	3
Maximum alfalfa acres	....	....	....	....	....	....	....	....	....	....	....	4
Max. non-cropland pasture	....	....	....	....	....	....	....	....	....	....	....	5
Min. non-alfalfa reseeding	....	....	....	....	....	....	....	....	....	....	....	6
Cows on hand	....	....	....	....	....	....	....	....	....	....	....	7
Overhead cows	....	....	....	....	....	....	....	....	....	....	....	8
Stall space	....	....	....	....	....	....	....	....	....	....	....	9
Max. spl. repl. res.	....	....	....	....	....	....	....	....	....	....	....	10
Replacement required	....	....	....	....	....	....	....	....	....	....	....	11
Heifer calf control	....	....	....	....	....	....	....	....	....	....	....	12
Silo capacity	....	....	....	....	....	....	....	....	....	....	....	13
Alfalfa seeding	....	....	....	....	....	....	....	....	....	....	....	14
Clover seeding	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	....	....	....	15
Clover to 3-4-5 yr. grass	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	2.0	16
Reseed clover from 6-12 yr.	....	....	....	....	....	....	....	....	....	....	....	17
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	....	....	....	....	....	18
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	....	....	....	....	....	19
5 yr. alfalfa to 6-12/reseed	....	....	....	....	....	....	....	....	2.333	2.333	2.333	20
Total forage (excl. aftermath)	1.715	2.155	2.010	1.865	1.890	2.370	2.215	2.060	1.350	1.480	1.265	21
Max. May-June pasture	....	....	....	0.915	....	....	....	1.010	....	....	0.810	22
Max. July-August pasture	....	....	0.570	0.570	....	....	0.630	0.630	....	0.260	0.260	23
Max. Sept. Oct. pasture	....	....	0.380	0.380	....	....	0.420	0.420	....	0.195	0.195	24
Aftermath collect	0.380	....	....	....	0.420	....	....	....	0.195	....	....	25
Hay control	1.62	2.03	1.01	....	1.79	2.24	1.12	....	1.29	0.99	....	26
Cow feeding control	....	....	....	....	....	....	....	....	....	....	....	27
Buy grain	....	....	....	....	....	....	....	....	....	....	....	28
Cash reservation	0.065	0.075	0.056	0.021	0.102	0.113	0.094	0.039	0.027	0.019	0.002	29
Labor — spring	0.038	0.038	.038	0.087	0.038	0.038	0.038	0.088	....	....	0.050	30
Labor — summer	0.536	0.536	0.368	0.047	0.574	0.574	0.406	0.085	0.536	0.368	0.047	31
Labor — fall	....	0.218	....	....	....	0.218	....	....	....	....	....	32
Labor — winter	....	....	....	....	....	....	....	....	....	....	....	33
Max. hired winter labor	....	....	....	....	....	....	....	....	....	....	....	34
Max. corn new seeding ratio	....	....	....	....	....	....	....	....	....	....	....	35

Description	3-4-5 yr. grass — low fert.				3-4-5 yr. grass — med. fert.				
	HHA	HHH	HPP	PPP	HHA	HHH	HPP	PPP	
Cj	—12.60	—14.54	—10.99	—7.82	—23.44	25.40	- 21.54	- 18.23	
Activity number	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}	
Milk sales	....	....	....	....	....	....	....	....	1
Total cropland	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2
Maximum alfalfa-corn acres	....	....	....	....	....	....	....	....	3
Maximum alfalfa acres	....	....	....	....	....	....	....	....	4
Max. non-cropland pasture	....	....	....	....	....	....	....	....	5
Min. non-alfalfa reseeding	....	....	....	....	....	....	....	....	6
Cows on hand	....	....	....	....	....	....	....	....	7
Overhead cows	....	....	....	....	....	....	....	....	8
Stall space	....	....	....	....	....	....	....	....	9
Max. spl. repl. res.	....	....	....	....	....	....	....	....	10
Replacement required	....	....	....	....	....	....	....	....	11
Heifer calf control	....	....	....	....	....	....	....	....	12
Silo capacity	....	....	....	....	....	....	....	....	13
Alfalfa seeding	....	....	....	....	....	....	....	....	14
Clover seeding	....	....	....	....	....	....	....	....	15
Clover to 3-4-5 yr. grass	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	16
Reseed clover from 6-12 yr.	....	....	....	....	....	....	....	....	17
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	....	....	18
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	....	....	19
5 yr. alfalfa to 6-12/reseed	—2.333	—2.333	—2.333	—2.333	—2.333	—2.333	—2.333	—2.333	20
Total forage (excl. aftermath)	—1.750	—2.065	—1.910	—1.635	—1.985	—2.345	—2.170	1.860	21
Max. May-June pasture	....	....	....	—1.050	....	....	....	—1.195	22
Max. July-August pasture	....	....	0.335	0.335	....	....	—0.380	—0.380	23
Max. Sept.-Oct. pasture	....	....	0.250	0.250	....	....	0.285	0.285	24
Aftermath collect	—0.250	....	....	....	—0.285	....	....	....	25
Hay control	1.67	1.97	—1.28	....	—1.91	—2.25	—1.46	....	26
Cow feeding control	....	....	....	....	....	....	....	....	27
Buy grain	....	....	....	....	....	....	....	....	28
Cash reservatiou	0.063	—0.073	—0.055	—0.020	—0.117	—0.127	—0.108	—0.046	29
Labor — spring	0.038	0.038	0.038	0.087	0.038	0.038	0.038	0.088	30
Labor — summer	0.536	0.536	0.368	0.047	0.601	0.601	0.406	0.085	31
Labor — fall	....	0.218	....	....	....	0.218	....	....	32
Labor — winter	....	....	....	....	....	....	....	....	33
Max. hired winter labor	....	....	....	....	....	....	....	....	34
Max. corn/new seeding ratio	....	....	....	....	....	....	....	....	35

Description	6-12 yr. grass — zero fert.					New seeding				
	HPP	PPP	HHA	HPP	PPP	Alfalfa from 5 yr.	Alfalfa from 6-12	Clover from 6-12	Clover Unrest.	
Cj	—4.70	—2.01	—13.36	—11.84	8.97	—49.90	88.22	—42.35	—42.35	
Activity number	P_{25}	P_{26}	P_{27}	P_{28}	P_{29}	P_{30}	P_{31}	P_{32}	P_{33}	
Milk sales	....	....	....	....	....	....	....	....	....	1
Total cropland	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	2
Maximum alfalfa-corn acres	....	....	....	....	....	1.0	2.0	....	....	3
Maximum alfalfa acres	....	....	....	....	....	1.0	2.0	....		4
Max. non-cropland pasture	....	....	....	....	....	....	....	....	....	5
Min. non-alfalfa reseeding	....	....	....	....	....	....	....	....	1.0	6
Cows on hand	....	....	....	....	....	....	....	....	....	7
Overhead cows	....	....	....	....	....	....	....	....	....	8
Stall space	....	....	....	....	....	....	....	....	....	9
Max. spl. repl. res.	....	....	....	....	....	....	....	....	....	10
Replacement required	....	....	....	....	....	....	....	....	....	11
Heifer calf control	....	....	....	....	....	....	....	....	....	12
Silo capacity	....	....	....	....	....	....	1.3	....	....	13
Alfalfa seeding	....	....	....	....	....	1.0	1.0	....	....	14
Clover seeding	....	....	....	....	....	....	....	1.0	1.0	15
Clover to 3-4-5 yr. grass	....	....	....	....	....	....	....	....	....	16
Reseed clover from 6-12 yr.	....	....	....	....	....	....	....	7.0	....	17
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	7.0	....	....	18
Reseed alfalfa from 6-12 yr.	—1.0	—1.0	—1.0	—1.0	—1.0	....	....	....	....	19
5 yr. alfalfa to 6-12/reseed	1.0	1.0	1.0	1.0	1.0	7.0	....	....	....	20
Total forage (excl. aftermath)	—0.920	0.790	1.170	1.280	—1.095	—1.360	6.140	—1.360	1.360	21
Max. May-June pasture	....	—0.505	....	....	0.700	....	....	....	....	22
Max. July-August pasture	0.640	0.165	....	—0.225	—0.225	1.360	1.360	1.360	1.360	23
Max. Sept.-Oct. pasture	0.160	0.120	....	0.170	—0.170	....	....	....	....	24
Aftermath collect	....	....	—0.170	....	....	....	....	....	....	25
Hay control	—0.64	....	—1.16	....	....	....	....	....	....	26
Cow feeding control	....	....	....	....	....	....	....	....	....	27
Buy grain	....	....	....	....	....	....	....	....	....	28
Cash reservation	—0.024	0.005	—0.067	0.059	—0.022	—0.499	0.882	—0.424	—0.424	29
Labor — spring	....	0.050	0.038	0.038	0.087	0.190	0.601	0.190	0.190	30
Labor — summer	0.368	0.047	0.536	0.368	0.047	0.050	0.050	0.050	0.050	31
Labor — fall	....	....	....	....	....	0.200	0.533	0.200	0.200	32
Labor — winter	....	....	....	....	....	....	....	....	....	33
Max. hired winter labor	....	....	....	....	....	....	....	....	....	34
Max. corn/new seeding ratio	....	....	....	....	....	2.0	....	2.0	2.0	35

Description	Slack for eq. 6	Rot. trans. 1	Rot. trans. 2	Corn silage	Non-cropland pasture	Feed aftermath	Overhead cows	Free cows (benchmark)	
Cj	0.0	0.0	0.0	38.32	-0.50	-1.50	+8.00	+8.00	
Activity number	P_{34}	P_{36}	P_{36}	P_{37}	P_{38}	P_{39}	P_{40}	P_{41}	
Milk sales	....	....	....	....	....	....	....	....	1
Total cropland	....	....	....	1.0	....	....	....	....	2
Maximum alfalfa-corn acres	....	....	....	1.0	....	....	....	....	3
Maximum alfalfa acres	....	....	....	....	....	....	....	....	4
Max. non cropland pasture	....	....	....	....	1.0	....	....	....	5
Min. non-alfalfa reseeding	1.0	....	....	....	....	....	....	....	6
Cows on hand	....	....	....	....	....	....	1.0	1.0	7
Overhead cows	....	....	....	....	....	....	1.0	....	8
Stall space	....	....	....	....	....	....	1.0	1.0	9
Max. spl. repl. res.	....	....	....	....	....	....	....	....	10
Replacement required	....	....	....	....	....	....	0.25	0.25	11
Heifer calf control	....	....	....	....	....	....	-0.35	-0.35	12
Silo capacity	....	....	....	1.3	....	....	....	....	13
Alfalfa seeding	....	....	....	....	....	....	....	....	14
Clover seeding	....	....	....	....	....	....	....	....	15
Clover to 3-4-5 yr. grass	....	....	....	....	....	....	....	....	16
Reseed clover from 6-12 yr.	....	....	7.0	....	....	....	....	....	17
Reseed alfalfa from 6-12 yr.	....	7.0	....	....	....	....	....	....	18
Reseed alfalfa from 6-12 yr.	....	7.0	7.0	....	....	....	....	....	19
5 yr. alfalfa to 6-12/reseed	....	....	....	....	....	....	....	....	20
Total forage (excl. aftermath)	....	....	....	-4.780	-0.720	1.00	....	....	21
Max. May-June pasture	....	....	....	....	-0.460	....	....	....	22
Max. July-August pasture	....	....	....	....	-0.150	....	....	....	23
Max. Sept.-Oct. pasture	....	....	....	....	-0.110	-1.0	....	....	24
Aftermath collect	....	....	....	....	....	1.0	....	....	25
Hay control	....	....	....	....	....	....	....	....	26
Cow feeding control	....	....	....	....	....	....	-1.10	1.0	27
Buy grain	....	....	....	....	....	....	....	....	28
Cash reservation	....	....	....	-0.192	-0.005	0.015	1.80	1.80	29
Labor — spring	....	....	....	0.411	0.050	....	2.46	1.23	30
Labor — summer	....	....	....	....	....	....	2.18	0.99	31
Labor — fall	....	....	....	0.339	....	0.150	2.45	1.23	32
Labor — winter	....	....	....	....	....	....	4.61	2.28	33
Max. hired winter labor	....	....	....	....	....	....	....	....	34
Max. corn/new seeding ratio	....	....	....	1.0	....	....	....	....	35

Description	Medium milk response feed grain						Dry lot feeding — summer			
	1500	2000	2500	3000	3500	4000	May-June	July-Aug.	Sept-Oct.	
Cj	0.0	0.0	0.0	0.0	0.0	0.0	—0.47	0.49	—0.49	
Activity number	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	
Milk sales	—9.160	9.615	10.000	10.320	10.575	10.780	....	....	....	1
Total cropland	....	....	....	....	....	....	....	....	....	2
Maximum alfalfa-corn acres	....	....	....	....	....	....	....	....	....	3
Maximum alfalfa acres	....	....	....	....	....	....	....	....	....	4
Max. non-cropland pasture	....	....	....	....	....	....	....	....	....	5
Min. non-alfalfa reseeding	....	....	....	....	....	....	....	....	....	6
Cows on hand	....	....	....	....	....	....	....	....	....	7
Overhead cows	....	....	....	....	....	....	....	....	....	8
Stall space	....	....	....	....	....	....	....	....	....	9
Max. spl. repl. res.	....	....	....	....	....	....	....	....	....	10
Replacement required	....	....	....	....	....	....	....	....	....	11
Heifer calf control	....	....	....	....	....	....	....	....	....	12
Silo capacity	....	....	....	....	....	....	....	....	....	13
Alfalfa seeding	....	....	....	....	....	....	....	....	....	14
Clover seeding	....	....	....	....	....	....	....	....	....	15
Clover to 3-4-5 yr. grass	....	....	....	....	....	....	....	....	....	16
Reseed clover from 6-12 yr.	....	....	....	....	....	....	....	....	....	17
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	....	....	....	18
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	....	....	....	19
5 yr. alfalfa to 6-12/reseed	....	....	....	....	....	....	....	....	....	20
Total forage (excl. aftermath)	5.570	5.455	5.335	5.200	5.055	4.895	....	....	....	21
Max. May-June pasture	0.720	0.705	0.690	0.670	0.650	0.630	1.0	....	....	22
Max. July-August pasture	0.945	0.930	0.910	0.885	0.860	0.830	....	—1.0	....	23
Max. Sept.-Oct. pasture	0.685	0.670	0.655	0.640	0.620	0.600	....	....	—1.0	24
Aftermath collect	....	....	....	....	....	....	....	....	....	25
Hay control	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	26
Cow feeding control	1.0	1.0	1.0	1.0	1.0	1.0	....	....	....	27
Buy grain	0.75	1.00	1.25	1.50	1.75	2.00	....	....	....	28
Cash reservation	....	....	....	....	....	....	....	....	....	29
Labor — spring	....	....	....	....	....	....	0.089	....	....	30
Labor — summer	....	....	....	....	....	....	....	0.093	....	31
Labor — fall	....	....	....	....	....	....	....	....	0.094	32
Labor — winter	....	....	....	....	....	....	....	....	....	33
Max. hired winter labor	....	....	....	....	....	....	....	....	....	34
Max. corn/new seeding ratio	....	....	....	....	....	....	....	....	....	35

	Replacements				Labor						
Description	Buy	Sell	Raise spl. res.	Raise compet. res.	Spring	Summer	Hire Fall	Winter	Buy grain	Sell hay	
C_j	−350.00	+320.00	−43.00	−48.00	−11.50	−11.50	−11.50	−30.48	−80.00	+27.00	
Activity number	P_{51}	P_{52}	P_{53}	P_{54}	P_{55}	P_{56}	P_{57}	P_{58}	P_{59}	P_{60}	
Milk sales	....	....	....	....	....	....	....	....	....	....	1
Total cropland	....	....	....	....	....	....	....	....	....	....	2
Maximum alfalfa-corn acres	....	....	....	....	....	....	....	....	....	....	3
Max. alfalfa acres	....	....	....	....	....	....	....	....	....	....	4
Max. non-cropland pasture	....	....	....	....	....	....	....	....	....	....	5
Min. non-alfalfa reseeding	....	....	....	....	....	....	....	....	....	....	6
Cows on hand	....	....	....	....	....	....	....	....	....	....	7
Overhead cows	....	....	....	....	....	....	....	....	....	....	8
Stall space	....	....	....	1.3	....	....	....	....	....	....	9
Max. spl. repl. res.	....	....	1.0	....	....	....	....	....	....	....	10
Replacement required	1.0	1.0	1.0	−1.0	....	....	....	....	....	....	11
Heifer calf control	....	....	1.0	1.0	....	....	....	....	....	....	12
Silo capacity	....	....	....	....	....	....	....	....	....	....	13
Alfalfa seeding	....	....	....	....	....	....	....	....	....	....	14
Clover seeding	....	....	....	....	....	....	....	....	....	....	15
Clover to 3-4-5 yr. grass	....	....	....	....	....	....	....	....	....	....	16
Reseed clover from 6-12 yr.	....	....	....	....	....	....	....	....	....	....	17
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	....	....	....	....	18
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	....	....	....	....	19
5 yr. alfalfa to 6-12/reseed	....	....	....	....	....	....	....	....	....	....	20
Total forage (excl. aftermath)	....	....	3.200	5.200	....	....	....	....	....	1.050	21
Max. May-June pasture	....	....	....	0.600	....	....	....	....	....	....	22
Max. July-August pasture	....	....	....	0.800	....	....	....	....	....	....	23
Max. Sept.-Oct. pasture	....	....	....	0.600	....	....	....	....	....	....	24
Aftermath collect	....	....	....	....	....	....	....	....	....	....	25
Hay control	....	....	2.0	2.0	....	....	....	....	....	1.0	26
Cow feeding control	....	....	....	....	....	....	....	....	....	....	27
Buy grain	....	....	0.60	0.60	....	....	....	....	1.0	....	28
Cash reservation	....	....	0.43	0.48	....	....	....	....	....	....	29
Labor — spring	....	....	0.60	0.60	−1.0	....	....	−0.55	....	....	30
Labor — summer	....	....	0.60	0.60	....	1.0	....	−0.55	....	....	31
Labor — fall	....	....	0.60	0.60	....	....	−1.0	−0.55	....	....	32
Labor — winter	....	....	1.2	1.2	....	....	....	−1.0	....	....	33
Max. hired winter labor	....	....	....	....	....	....	....	−1.0	....	....	34
Max. corn/new seeding ratio	....	....	....	....	....	....	....	....	....	....	35

	Low milk response Feed Grain						High milk response feed grain						
Description	1500	2000	2500	3000	3500	4000	1500	2000	2500	3000	3500	4000	
Cj	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Activity number	P_{61}	P_{62}	P_{63}	P_{64}	P_{65}	P_{66}	P_{67}	P_{68}	P_{69}	P_{70}	P_{71}	P_{72}	
Milk sales	—7.230	7.925	—8.550	8.900	—9.195	9.440	10.200	10.500	—10.775	11.025	11.225	11.375	1
Total cropland	....	....	....	....	....	....	....	....	....	....	....	....	2
Maximum alfalfa-corn acres	....	....	....	....	....	....	....	....	....	....	....	....	3
Maximum alfalfa acres	....	....	....	....	....	....	....	....	....	....	....	....	4
Max. non-cropland pasture	....	....	....	....	....	....	....	....	....	....	....	....	5
Min. non-alfalfa reseeding	....	....	....	....	....	....	....	....	....	....	....	....	6
Cows on hand	....	....	....	....	....	....	....	....	....	....	....	....	7
Overhead cows	....	....	....	....	....	....	....	....	....	....	....	....	8
Stall space	....	....	....	....	....	....	....	....	....	....	....	....	9
Max. spl. repl. res.	....	....	....	....	....	....	....	....	....	....	....	....	10
Replacement required	....	....	....	....	....	....	....	....	....	....	....	....	11
Heifer calf control	....	....	....	....	....	....	....	....	....	....	....	....	12
Silo capacity	....	....	....	....	....	....	....	....	....	....	....	....	13
Alfalfa seeding	....	....	....	....	....	....	....	....	....	....	....	....	14
Clover seeding	....	....	....	....	....	....	....	....	....	....	....	....	15
Clover to 3-4-5 yr. grass	....	....	....	....	....	....	....	....	....	....	....	....	16
Reseed clover from 6-12 yr.	....	....	....	....	....	....	....	....	....	....	....	....	17
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	....	....	....	....	....	....	18
Reseed alfalfa from 6-12 yr.	....	....	....	....	....	....	....	....	....	....	....	....	19
5 yr. alfalfa to 6-12/reseed	....	....	....	....	....	....	....	....	....	....	....	....	20
Total forage (excl. aftermath)	5.285	5.235	5.180	5.000	4.805	4.570	6.062	6.000	5.938	5.875	5.805	5.725	21
Max. May-June pasture	.666	.659	.653	.630	.605	.575	.763	.756	.748	.740	.731	.721	22
Max. July-August pasture	.898	.889	.881	.850	.817	.777	1.03	1.02	1.009	.999	.987	.973	23
Max. Sept.-Oct. pasture	.650	.644	.637	.615	.591	.562	.746	.738	.730	.723	.714	.704	24
Aftermath collect	....	....	....	....	....	....	....	....	....	....	....	....	25
Hay control	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	26
Cow feeding control	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	26
Buy grain	0.75	1.00	1.25	1.50	1.75	2.00	0.75	1.0	1.25	1.50	1.75	2.00	28
Cash reservation	....	....	....	....	....	....	....	....	....	....	....	....	29
Labor — spring	....	....	....	....	....	....	....	....	....	....	....	....	30
Labor — summer	....	....	....	....	....	....	....	....	....	....	....	....	31
Labor — fall	....	....	....	....	....	....	....	....	....	....	....	....	32
Labor — winter	....	....	....	....	....	....	....	....	....	....	....	....	33
Max. hired winter labor	....	....	....	....	....	....	....	....	....	....	....	....	34
Max. corn/new seeding ratio	....	....	....	....	....	....	....	....	....	....	....	....	35

APPENDIX II

PRODUCTION AND PRICE DATA

Appendix table II-1. Crop yields at three levels of fertilization

Crop	Zero[2] fertilization	Low[2] fertilization	Medium[2] fertilization
	tons[1]	tons[1]	tons[1]
Corn silage fertilization (pounds NPK)	....	13 100-75-75	....
Alfalfa-grass fertilization (pounds NPK)	2.2 0-0-0	2.7 0-30-60	3.0 0-60-120
Clover-grass fertilization (pounds NPK)	1.8 0-0-0	2.3 15-30-30	2.5 30-60-60
3-4-5 year grass fertilization (pounds NPK)	1.7 0-0-0	2.2 30-15-15	2.5 75-37.5-37.5
6-12 year grass fertilization (pounds NPK)	1.1 0-0-0	1.5 30-15-15	1.8 75-37.5-37.5
Clover and alfalfa seedings with oats fertilization (pounds NPK)	....	2.0 30-60-60	....

[1] Expressed as tons of stored forage. Harvesting losses have been deducted.
[2] Manure is assumed to be used with each of these levels of fertilization.

Appendix table II-2. Percentage distribution of forage harvested and percentage total digestible nutrients by species and cut.

Species and cut	Forage cut as percentage total forage harvested	Percentage TDN
Alfalfa-grass	**Percent**	**Percent**
1st cut	50	50
2nd cut	27	52
3rd cut	23	53
Clover-grass		
1st cut	60	52
2nd cut	30	54
3rd cut	10	54
3-4-5 year grass		
1st cut	60	50
2nd cut	30	52
3rd cut	10	52
6-12 year grass		
1st cut	70	48
2nd cut	20	50
3rd cut	10	50
Oats (pastured)	....	55
Corn silage	....	19

Appendix table II-3. Estimated losses of total digestible nutrients

Forage	Storage loss[1]	Feeding loss[2]
	Percent	Percent
Alfalfa-grass hay	5.2	8.0
Clover-grass hay	5.2	8.0
Grass hay	5.4	8.0
Corn silage	6.0	2.0

[1] As percent of into storage yield.
[2] As percent of out of storage yield.

Appendix table II-4. Estimated prices paid and received that were used in the analysis.

Item	Estimated prices	
	Unit	Dollars
Prices paid		
Farm wage	hour	1.15
Milk cows (purchased)	each	350.00
Hay (purchased)	ton	32.00
16% dairy ration	ton	80.00
Milk substitute	cwt.	15.60
Fertilizer:		
0-20-20	ton	66.00
5-10-10	ton	55.00
10-10-10	ton	66.00
0-15-30	ton	70.00
15-10-10	ton	55.00
$NH_4 NO_3$	ton	95.00
Spread lime	ton	11.50
Seed:		
Alfalfa	lb.	.70
Ladino clover	lb.	1.00
Red clover	lb.	.50
Timoth	lb.	.25
Bromegrass	lb.	.34
Orchard grass	lb.	.42
Sudan grass	lb.	.15
Oats	bu.	1.90
Hybrid	bu.	10.40
Prices received		
Hay (sold)	ton	27.00 0.00
Cull cows	cwt.	15.00
Dairy calves	each	16.00
Milk cows (sold)	each	320.00
Milk	cwt.	6.00 5.00 4.00

APPENDIX III

OPTIMUM ORGANIZATIONS

Appendix table III-1. Optimum farm plan with specified ratios of cows to cropland, low quality cows, milk price $4.00 per hundred pounds, and hay price $27.00.

Item	Unit	Ratio of cost to cropland						
		.10	.15	.20	.25	.30	.35	.40
Forage crops and level of fertilization:								
5-year alfalfa/low	Acre	20.8HHHA	20.8HHHA	20.8HHHA	20.8HHHA	20.8HHHA	20.8HHHA	20.8HHHA
5-year alfalfa/med.	Acre	...	...	...	...	...	...	...
2-year clover/zero	Acre	...	...	...	...	...	...	...
2-year clover/low	Acre	24.4HHHH	23.2HHHH	22.0HHHH	13.0HHHH	2.5HHHH	...	...
		...	...	...	8.1PPP	17.8PPP	19.4PPP	19.0PPP
2-year clover/med.	Acre	...	...	...	...	...	...	...
3-4-5-year grass/zero	Acre	...	...	...	...	...	...	...
3-4-5-year grass/low	Acre	...	5.2HHHA	19.7HHHA	21.9HHHA	21.6HHHA	15.4HHHA	6.1HHHA
		36.6HHHH	29.5HHHH	23.3HHHH	9.8HHHH	8.8HHHH	6.2HPP	12.8HPP
		...	...	...	...	...	7.5PPP	9.6PPP
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...
6-12-year grass/zero	Acre	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...
Corn silage	Acre	1.8	5.4	9.0	11.7	14.2	16.7	18.0
Seed alfalfa-oats	Acre	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	12.2	11.6	11.0	10.6	10.1	9.7	9.5
Feeding program:								
Drylot feed May-June, TDN	1000 lb	7.5	10.9	14.6	10.9	5.7	...	...
Drylot feed July-Aug., TDN	1000 lb	...	...	...	...	...	...	...
Drylot feed Sept.-Oct., TDN	1000 lb	...	...	...	...	...	1.1	3.1
Grain fed per cow	lb	2500	2500	2500	2500	2500	2500	2500
Livestock:								
Dairy cows	No.	10.0	13.6	18.4	23.2	28.0	32.0	35.4
Replacements raised	No.	2.6	5.4	7.3	9.3	11.2	13.1	14.2
Replacements sold	No.	0.1	2.0	2.8	3.5	4.2	4.2	5.3
Replacements bought	No.	...	...	...	...	...	...	...
Heifer calves sold at birth	No.	1.5	...	...	...	...	...	...
Purchased factors:								
Annual cash invested	Dollars	3277	4070	5034	5957	6871	7782	8293
Grain bought	Ton	14.0	20.2	27.3	34.5	41.7	48.8	53.7
Hired labor:								
Permanent	Hour	...	...	...	82.2	432.0	784.4	977.9
Spring seasonal	Hour	...	...	32	96	102	108	112
Summer seasonal	Hour	205	241	284	274	201	121	88
Fall seasonal	Hour	.	35	84	119	100	79	80
Product sales:								
Hay sold	Ton	139.4	118.9	96.3	69.8	42.6	13.9	...
Milk sold	Cwt.	854	1159	1569	1980	2391	2801	3026
Income net of variable costs	$	3646	4092	4526	4820	4996	5151	5237

Appendix table III-2. Optimum farm plan with specific ratios of cows to cropland, low quality cows, milk price $5.00 per hundred pounds, and hay price $27.00.

Item	Unit	Ratio of cows to cropland							
		.10	.15	.20	.25	.30	.35	.40	.45
Forage crops and level of fertilization:									
5-year alfalfa/low	Acre	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	...	20.8HHA	20.8HHA
2-year clover/zero	Acre	...	...	...	...	...	...	...	...
2-year clover/low	Acre	24.5HHH	23.2HHH	22.0HHH	13.6HHH	3.3HHH	...	...	...
		...	...	...	7.5PPP	17.0PPP	19.5PPP	18.8PPP	...
2-year clover/med.	Acre	...	...	...	...	...	...	...	18.6PPP
3-4-5-year grass/zero	Acre	...	...	...	...	...	...	...	...
3-4-5-year grass/low	Acre	...	4.9HHA	19.1HHA	21.8HHA	21.5HHA	17.3HHA	...	0.8HHA
		36.8HHH	29.9HHH	14.0HHH	9.9HHH	9.0HHH	4.9HPP	28.2HPP	27.1HPP
		...	...	...	...	...	7.1PPP	...	...
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	...
6-12-year grass/zero	Acre	...	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...
Corn silage	Acre	1.4	5.4	8.9	11.9	14.0	16.5	18.7	19.2
Seed alfalfa-oats	Acre	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	12.3	11.6	11.0	11.6	10.2	9.8	9.4	9.3
Feeding program:									
Drylot feed May-June, TDN	1000 lb	7.2	10.8	14.5	11.2	6.1	...	11.4	10.2
Drylot feed July-Aug., TDN	1000 lb	...	...	...	...	...	...	...	...
Drylot feed Sept.-Oct., TDN	1000 lb	...	...	...	...	...	0.7	3.5	3.3
Grain fed per cow	lb	3000	3000	3000	3000	3000	3000	3030	3500
Livestock:									
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	44.8
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.4	12.8	11.2
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.6	2.8	...
Replacements bought	No.	...	...	...	...	...	...	...	...
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.6	3.2	6.7
Purchased factors:									
Annual cash invested	Dollars	3276	4277	5269	6222	7166	8103	9171	9987
Grain bought	Ton	16.5	25.1	33.7	42.2	50.8	59.3	68.3	85.1
Hired labor:									
Permanent	Hour	...	...	...	148.4	506.2	863.9	1213.7	1449.6
Spring seasonal	Hour	...	...	44	96	102	108	120	120
Summer seasonal	Hour	207	249	293	273	201	121	110	105
Fall seasonal	Hour	...	47	98	121	102	79	81	83
Product sales:									
Hay sold	Ton	140.2	119.9	97.7	71.9	45.2	16.9	...	...
Milk sold	Cwt.	890	1335	1780	2225	2670	3115	3567	4117
Income net of variable costs	$	4502	5392	6197	6886	7482	8065	8523	8738

Appendix table III-3. Optimum farm plan with specified ratios of cows to cropland, low quality cows, milk price $6.00 per hundred pounds, and hay price $27.00.

Item	Unit	Ratio of cows to cropland									
		.10	.15	.20	.25	.30	.35	.40	.45	.50	.55
Forage crops and level of fertilization:											
5-year alfalfa/low	Acre	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA
2-year clover/zero	Acre	...	...	...	...	...	...	...	...	...	...
2-year clover/low	Acre	24.7HHH	23.4HHH	22.2HHH	15.5HHH	5.6HHH	...	...	...	...	...
		...	...	...	5.8PPP	15.0PPP	19.8PPP	19.3PPP	19.0PPP	...	...
2-year clover/med.	Acre	...	...	...	...	...	...	...	...	18.6PPP	18.3HPP
3-4-5-year grass/zero	Acre	...	...	...	...	...	...	...	...	...	...
3-4-5-year grass/low	Acre	...	3.5HHA	17.2HHA	22.0HHA	21.7HHA	20.6HHA	8.5HHA	2.9HHA	1.7HHA	...
		37.0HHH	31.5HHH	16.2HHH	10.0HHH	9.2HHH	1.6HHH	...	...	...	...
		...	...	...	...	...	1.5HPP	11.3HPP	25.6HPP	25.3HPP	...
		...	...	...	...	...	6.0	9.0PPP	...	...	...
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	...	...	27.5HHA
6-12-year grass/zero	Acre	...	...	...	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...	...	...
Corn silage	Acre	1.1	5.0	8.3	11.0	13.3	15.6	17.2	18.1	19.1	20.0
Seed alfalfa-oats	Acre	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	12.3	11.7	11.1	10.7	10.3	9.9	9.6	9.5	9.3	9.2
Feeding program:											
Drylot feed May-June, TDN	1000 lb	7.0	10.5	14.0	12.1	7.2	...	...	10.8	10.0	30.5
Drylot feed July-Aug., TDN	1000 lb	...	...	...	...	...	...	...	...	...	11.6
Drylot feed Sept.-Oct., TDN	1000 lb	...	...	...	...	...	...	2.7	2.9	3.0	11.8
Grain fed per cow	lb	3500	3500	3500	3500	3500	3500	3814	4000	4000	4000
Livestock:											
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	54.1
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.4	13.2	11.7	9.0	10.0
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.6	3.2	0.5	...	...
Replacements bought	No.	...	...	...	...	...	...	...	...	3.5	3.3
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.6	2.9	6.3	11.0	11.2
Purchased factors:											
Annual cash invested	Dollars	3274	4275	5266	6228	7172	8107	9072	10013	10818	11719
Grain bought	Ton	19.0	28.8	38.7	48.5	58.3	68.1	84.2	97.0	105.4	112.2
Hired labor:											
Permanent	Hour	...	...	...	148.4	506.2	863.9	1224.3	1481.4	1696.0	1913.3
Spring seasonal	Hour	...	...	41	94	100	104	109	117	120	131
Summer seasonal	Hour	208	251	296	284	214	134	84	103	94	215
Fall seasonal	Hour	...	49	100	124	105	81	77	79	83	152
Product sales:											
Hay sold	Ton	141.0	121.5	99.8	75.4	49.3	21.9	...	...	...	...
Milk sold	Cwt.	919	1379	1839	2299	2758	3218	3740	4248	4720	5011
Income net of variable costs	$	5398	6737	7995	9133	10179	11223	12192	12940	13524	13770

Appendix table III-4. Optimum farm plan with specified ratios of cows to cropland, medium quality cows, milk price $4.00 per hundred pounds, and hay price $27.00.

Item	Unit	Ratio of cows to cropland						
		.10	.15	.20	.25	.30	.35	.40
Forage crops and level of fertilization:								
5-year alfalfa/low	Acre	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA
5-year alfalfa/med.	Acre	...	...	...	...	...	...	...
2-year clover/zero	Acre	...	...	...	...	...	...	...
2-year clover/low	Acre	24.2HHH	22.9HHH	20.4HHH	9.1HHH	...	...	...
		...	...	1.2PPP	11.6PPP	19.8PPP	18.9PPP	18.7PPP
2-year clover/med.	Acre	...	...	...	...	...	...	...
3-4-5-year grass/zero	Acre	...	...	...	...	...	...	...
3-4-5-year grass/low	Acre	...	8.2HHA	21.6HHA	21.2HHA	20.3HHA	5.8HHA	1.8HHA
		36.3HHH	26.0HHH	10.8HHH	9.9HHH	5.8HHH	12.4HPP	17.9HPP
						3.6PPP	10.1PPP	8.4PPP
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...
6-12-year grass/zero	Acre	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...
Corn silage	Acre	2.5	6.5	10.2	12.9	15.6	18.3	18.8
Seed alfalfa-oats	Acre	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	12.1	11.4	10.8	10.4	9.9	9.5	9.4
Feeding program:								
Drylot feed May-June, TDN	1000 lb	8.1	12.0	14.8	9.4	2.1	...	2.7
Drylot feed July-Aug., TDN	1000 lb	...	...	...	...	...	...	...
Drylot feed Sept.-Oct., TDN	1000 lb	...	...	...	...	...	3.0	3.9
Grain fed per cow	lb	1500	2000	2000	2000	2000	2000	2000
Livestock:								
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	36.0
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.4	11.7
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.6	2.7
Replacements bought	No.	...	...	...	...	...	...	...
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.6	2.6
Purchased factors:								
Annual cash invested	Dollars	3282	4281	5268	6209	7142	8095	8296
Grain bought	Ton	2.0	17.6	23.7	29.7	35.8	41.8	43.0
Hired labor:								
Permanent	Hour	...	...	...	148.4	506.2	863.9	935.5
Spring seasonal	Hour	...	...	49	101	107	115	118
Summer seasonal	Hour	202	244	281	247	163	88	83
Fall seasonal	Hour	...	42	92	115	92	82	83
Product sales:								
Hay sold	Ton	137.5	116.0	91.9	63.5	34.3	5.1	...
Milk sold	Cwt.	916	1442	1923	2404	2884	3365	3460
Income net of variable costs	$	4229	4977	5635	6183	6639	7047	7121

Appendix table III-5. Optimum farm plan with specified ratios of cows to cropland, medium quality cows, milk price $6.00 per hundred pounds, and hay price $27.00.

Item	Unit	Ratio of cows to cropland										
		.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60
Forage crops and level of fertilization:												
5-year alfalfa/low	Acre	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.HHA	...	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA	20.8HHA
2-year clover/zero	Acre	...	...	...	...	...	...	...	...	...	...	...
2-year clover/low	Acre	24.4HHH	23.0HHH	21.8HHH	11.7HHH	1.0HHH	...	...	...	...	...	...
		...	...	...	9.3PPP	19.1PPP	19.3PPP	18.6PPP	...	...	...	...
2 year clover/med.	Acre	...	...	...	...	...	...	...	18.2PPP	18.0HPP	18.1HPP	18.1HPP
3-4-5-year grass/zero	Acre	...	...	...	...	...	...	...	...	...	...	...
3-4-5-year grass/low	Acre	...	6.4HHA	21.1HHA	21.6HHA	21.3HHA	12.4HHA	...	...	...	...	...
		36.6HHH	28.1HHH	11.7HHH	9.8HHH	8.9HHH	8.0HPP	27.9HPP	27.2HPP	...	...	...
		...	...	...	...	...	8.6PPP	...	...	27.0HHH	27.1HHH	27.1HHH
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	...	...	...	...
6-12-year grass/zero	Acre	...	...	...	...	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...	...	...	...
Corn silage	Acre	1.8	5.9	9.5	12.1	14.7	17.2	19.2	20.5	21.0	20.8	20.8
Seed alfalfa-oats	Acre	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	12.2	11.5	10.9	10.5	10.1	9.6	9.3	9.1	9.0	9.0	9.0
Feeding program:												
Drylot feed May-June, TDN	100 lb	7.6	11.4	15.3	10.6	5.1	...	12.5	12.0	32.0	34.7	35.6
Drylot feed July-Aug., TDN	100 lb	...	...	...	...	...	...	0.8	1.5	12.9	16.3	17.6
Drylot feed Sept.-Oct., TDN	100 lb	...	...	...	...	...	1.7	4.0	4.3	12.6	15.1	16.0
Grain fed per cow	lb	3000	3000	3000	3000	3000	3000	3000	3000	3771	4000	4000
Livestock:												
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	56.5
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.4	11.5	8.3	9.0	2.3	...
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.6	1.5	2.9	...	...	...
Replacements bought	No.	...	...	...	...	...	...	...	...	3.5	11.4	14.1
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.1	2.6	4.4	9.7	11.0	19.7	22.6
Purchased factors:												
Annual cash invested	Dollars	3278	4278	5271	6216	7159	8098	9114	9900	11124	11737	11912
Grain bought	Ton	16.5	25.1	33.7	42.2	50.8	59.3	66.9	72.5	99.7	111.4	113.1
Hired labor:												
Permanent	Hour	...	...	...	148.1	506.2	863.9	1171.3	1372.7	1699.6	1783.4	1804.7
Spring seasonal	Hour	...	...	47	98	105	111	123	128	137	141	143
Summer seasonal	Hour	205	247	290	262	188	106	110	103	220	215	213
Fall seasonal	Hour	...	45	95	118	98	80	84	89	156	160	162
Product sales:												
Hay sold	Ton	139.2	118.1	95.3	68.1	40.6	11.5	...	...	...	...	...
Milk sold	Cwt.	1032	1548	2064	2580	3096	3612	4128	4644	5343	5929	6094
Income net of variable costs	$	6213	7956	9612	11153	12604	14025	15262	16238	16951	17078	17107

Appendix table III-6. Optimum farm plan with specified ratios of cows to cropland, medium quality cows, milk price $5.00 per hundred pounds, and hay price $27.00.

Item	Unit	Ratio of cows to cropland								
		.10	.15	.20	.25	.30	.35	.40	.45	.50
Forage crops and level of fertilization:										
5-year alfalfa/low	Acre	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA
2-year clover/zero	Acre	...	...	...	...	...	...	...	...	...
2-year clover/low	Acre	24.3HHH	22.9HHH	21.3HHH	10.3HHH	...	...	...	...	...
		...	...	0.4PPP	10.5PPP	19.9PPP	19.1PPP	18.5PPP	...	...
2-year clover/med.	Acre	...	...	...	...	...	...	...	18.2PPP	18.9PPP
3-4-5-year grass/zero	Acre	...	...	...	...	...	...	...	...	...
3-4-5-year grass/low	Acre	36.5HHH	27.1HHH	10.9HHH	10.0HHH	8.0HHH	10.4HPP	27.7HPP	27.2HPP	...
		...	7.4HHA	21.7HHA	21.2HHA	20.7HHA	8.8HHA	...	...	...
		...	...	...	...	...	9.4PPP	...	...	...
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	...	26.8HPP
6-12-year grass/zero	Acre	...	...	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...	...
Corn silage	Acre	2.0	6.2	9.9	12.5	15.2	17.8	19.7	20.5	21.8
Seed alfalfa-oats	Acre	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	12.1	11.5	10.9	10.4	10.0	9.5	9.2	9.1	8.9
Feeding program:										
Drylot feed May-June, TDN	1000 lb	7.8	11.7	15.3	9.9	4.0	...	13.0	12.0	13.1
Drylot feed July-Aug., TDN	1000 lb	...	...	...	...	...	...	14.0	1.5	1.9
Drylot feed Sept.-Oct., TDN	1000 lb	...	...	...	...	...	2.4	4.2	4.2	4.3
Grain fed per cow	lb	2500	2500	2500	2500	2500	2500	2500	3000	3000
Livestock:										
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	46.6
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.4	10.7	8.3	9.0
Replacements sold	No.	0.1	0.5	1.1	1.6	2.1	2.6	0.7	...	...
Replacements bought	No.	...	...	...	...	...	...	...	2.9	2.6
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.6	5.3	9.7	9.6
Purchased factors:										
Annual cash invested	Dollars	3280	4280	5270	6212	7151	8096	9079	9899	10346
Grain bought	Ton	14.0	21.3	28.7	36.0	43.3	50.6	56.4	72.5	75.2
Hired labor:										
Permanent	Hour	...	...	...	148.4	506.2	863.9	1144.8	1372.7	1484.0
Spring seasonal	Hour	...	...	49	99	106	113	126	128	131
Summer seasonal	Hour	204	245	286	254	76	96	110	103	108
Fall seasonal	Hour	...	43	93	117	96	81	86	89	91
Product sales:										
Hay sold	Ton	138.6	117.0	98.6	65.6	37.4	8.0	...	...	...
Milk sold	Cwt.	1000	1500	2000	2500	3000	3500	4000	4644	4799
Income net of variable costs	$	5200	6436	7583	8617	9560	10464	11145	11594	11778

Appendix table III-7. Optimum farm plan with specified ratios of cows to cropland, high quality cows, milk price $4.00 per hundred pounds, and hay price $27.00.

Item	Unit	Ratio of cows to cropland						
		.10	.15	.20	.25	.30	.35	.40
Forage crops and level of fertilization:								
5-year alfalfa/low	Acre	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	20.8HHA	20.8HHA
2-year clover/zero	Acre	...	...	...	...	...	...	...
2-year clover/low	Acre	23.9HHH	22.3HHH	15.7HHH	3.3HHH	...	...	...
		...	...	5.4PPP	16.7PPP	19.0PPP	18.0PPP	...
2-year clover/med.	Acre	...	...	...	...	...	...	17.7PPP
3-4-5-year grass/zero	Acre	...	...	...	...	...	...	...
3-4-5-year grass/low	Acre	...	12.8HHA	21.4HHA	20.9HHA	13.0HHA	...	...
		35.8HHH	20.7HHH	10.2HHH	9.2HHH	7.6HPP	27.1HPP	26.5HPP
		...	...	...	...	7.9PPP	...	...
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...
6-12-year grass/zero	Acre	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...
Corn silage	Acre	3.5	8.0	11.8	14.9	18.0	20.9	22.0
Seed alfalfa-oats	Acre	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	11.9	11.2	10.5	10.0	9.5	9.0	8.8
Feeding program:								
Drylot feed May-June, TDN	1000 lb	8.6	12.8	12.2	6.1	...	13.4	12.6
Drylot feed July-Aug., TDN	1000 lb	...	...	...	...	...	3.0	3.4
Drylot feed Sept.-Oct., TDN	1000 lb	...	...	...	...	1.4	5.3	5.5
Grain fed per cow	lb	1500	1500	1500	1500	1500	1500	1500
Livestock:								
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	38.0
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.3	9.5
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.5	...
Replacements bought	No.	...	...	...	...	...	...	...
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.7	5.7
Purchased factors:								
Annual cash invested	Dollars	3288	4288	5256	6193	7129	8221	8708
Grain bought	Ton	9.0	13.8	18.7	23.5	28.3	33.0	34.2
Hired labor:								
Permanent	Hour	...	...	...	148.4	506.2	861.3	985.8
Spring seasonal	Hour	...	...	55	107	115	131	135
Summer seasonal	Hour	197	237	235	213	122	122	120
Fall seasonal	Hour	...	36	85	107	85	92	96
Product sales:								
Hay sold	Ton	135.5	111.2	83.5	53.0	21.0	...	...
Milk sold	Cwt.	1020	1530	2040	2550	3060	3570	3874
Income net of variable costs	$	4576	5490	6309	7025	7624	8085	8227

Appendix table III-8. Optimum farm plan with specified ratios of cows to cropland, high quality cows, milk price $5.00 per hundred pounds, and hay price $27.00.

Item	Unit	Ratio of cows to cropland							
		.10	.15	.20	.25	.30	.35	.40	.45
Forage crops and level of fertilization:									
5-year alfalfa/low	Acre	20.8HHA	20.8HHA	20.8HHA	20.8HHA	20.8HHA	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA
2-year clover/zero	Acre	...	...	...	...	...	...	...	...
2-year clover/low	Acre	23.7HHH	22.3HHH	15.7HHH	3.3HHH	...	...	...	...
		...	...	5.4PPP	16.7PPP	19.0PPP	18.0PPP	...	...
2-year clover/med.	Acre	...	...	...	...	...	...	17.5PPP	17.2PPP
3-4-5-year grass/zero	Acre	...	...	...	...	...	...	...	...
3-4-5-year grass/low	Acre	...	12.8HHA	21.4HHA	20.9HHA	13.0HHA	...	...	...
		35.1HHH	20.7HHH	10.2HHH	9.2HHH	7.6HPP	27.1HPP	26.2HPP	...
		...	...	...	...	7.9PPP	...	...	...
3 4-5-year grass/med.	Acre	...	...	...	...	...	...	...	25.8HPP
6-12-year grass/zero	Acre	...	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...
Corn silage	Acre	3.5	8.0	11.8	14.9	18.0	20.9	22.6	23.5
Seed alfalfa-oats	Acre	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	11.9	11.2	10.5	10.0	9.5	9.0	8.7	8.6
Feeding program:									
Drylot feed May-June, TDN	1000 lb	8.6	12.8	12.2	6.0	...	13.4	13.1	31.9
Drylot feed July-Aug., TDN	1000 lb	...	...	...	...	...	3.0	4.2	5.2
Drylot feed Sept.-Oct., TDN	1000 lb	...	...	...	...	1.4	5.3	5.9	6.4
Grain fed per cow	lb	1500	1500	1500	1500	1500	1500	1500	1500
Livestock:									
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	41.9
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.3	7.5	8.0
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.5	...	...
Replacements bought	No.	...	...	...	...	...	...	2.6	2.5
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.7	8.6	8.8
Purchased factors:									
Annual cash invested	Dollars	3288	4288	5256	6193	7129	8221	8979	9574
Grain bought	Ton	9.0	13.8	18.7	23.5	28.3	33.0	34.5	36.2
Hired labor:									
Permanent	Hour	...	...	...	148.4	506.2	861.3	1041.5	11171.3
Spring seasonal	Hour	...	...	55	107	115	131	138	148
Summer seasonal	Hour	197	237	253	213	122	122	115	174
Fall seasonal	Hour	...	36	85	107	85	92	99	101
Product sales:									
Hay sold	Ton	135.5	111.2	83.5	53.0	21.0	...	...	...
Milk sold	Cwt.	1020	1530	2040	2550	3069	3570	4080	4270
Income net of variable costs	$	5596	7020	8349	9575	10684	11655	12280	12498

Appendix table III-9. Optimum farm plan with specified ratios of cows to cropland, high quality cows, milk price $6.00 per hundred pounds, and hay price $27.00.

Item	Unit	Ratio of cows to cropland								
		.10	.15	.20	.25	.30	.35	.40	.45	.50
Forage crops and level of fertilization:										
5-year alfalfa/low	Acre	20.8IIIIA	20.8IIIIA	20.8IIIIA	20.8IIIIA	20.8IIIIA	...	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	20.8IIIIA	20.8IIIIA	20.8IIIIA	20.8IIIIA
2-year clover/zero	Acre	...	...	...	...	...	...	...	...	...
2-year clover/low	Acre	23.9IIIII	22.3IIIII	15.7IIIII	3.3IIIII	...	...	...	...	...
		...	...	5.4PPP	16.7PPP	19.0PPP	18.0PPP	...	...	...
2-year clover/med.	Acre	...	...	...	...	...	...	17.5PPP	17.2PPP	17.1PPP
3-4-5-year grass/zero	Acre	...	...	...	...	...	...	...	...	...
3-4-5-year grass/low	Acre	...	12.8IIIIA	21.4IIIIA	20.9IIIIA	13.0IIIIA	...	...	...	...
		35.8IIIIII	20.7IIIIII	10.2IIIIII	9.2IIPPP	7.6IIPPP	27.1IIPPP	26.2IIPPP	...	...
		...	...	...	...	7.9PPPP	...	...	...	...
3-4-5-year grass/med.		...	...	...	...	...	...	...	25.7IIIIII	25.6IIIIII
6-12-year grass/zero	Acre	...	...	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...	...
Corn silage	Acre	3.5	8.0	11.8	14.9	18.0	20.9	22.6	23.5	23.7
Seed alfalfa-oats	Acre	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	11.9	11.2	10.5	10.0	9.5	9.0	8.7	8.6	8.6
Feeding program:										
Drylot feed May-June, TDN	1000 lb	8.6	12.8	12.2	6.1	...	13.4	13.1	33.7	35.8
Drylot feed July-Aug., TDN	1000 lb	...	...	...	...	...	3.0	4.2	17.3	20.3
Drylot feed Sept.-Oct., TDN	1000 lb	...	...	...	...	1.4	5.3	5.9	15.3	17.5
Grain fed per cow	lb	1500	1500	1500	1500	1500	1500	1500	2500	2500
Livestock:										
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	48.0
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.3	7.5	5.2	. .
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.5	...	...	...
Replacements bought	No.	...	...	...	...	...	...	2.6	6.0	12.0
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.7	8.6	12.8	19.2
Purchased factors:										
Annual cash invested	Dollars	3288	4288	5266	6193	7129	8221	8979	10068	10364
Grain bought	Ton	9.0	13.8	18.7	24.5	28.3	33.0	34.5	59.4	59.9
Hired labor:										
Permanent	Hour	...	...	...	148.4	506.2	861.3	1041.5	1272.0	1282.6
Spring seasonal	Hour	...	...	55	107	115	131	138	151	156
Summer seasonal	Hour	197	237	253	213	122	122	115	228	226
Fall seasonal	Hour	...	36	85	107	85	92	99	167	172
Product sales:										
Hay sold	Ton	135.5	111.2	83.5	53.0	21.0	...	...	...	...
Milk sold	Cwt.	1020	1530	2040	2550	3060	3570	4080	4849	5160
Income net of variable costs	$	6616	8443	10389	12125	13744	15225	16360	16949	17007

Appendix table III-10. Optimum farm plan with specified ratios of cows to cropland, low quality cows, milk price $4.00 per hundred pounds.

Item	Unit	Ratio of cows to cropland						
		.10	.15	.20	.25	.30	.35	.40
Forage crops and level of fertilization:								
5-year alfalfa/low	Acre	...	...	1.5HHA	...	9.5HHA	20.8HHA	20.8HHA
5-year alfalfa/med.	Acre	...	...	...	...	...	...	...
2-year clover/zero	Acre	12.8PPP	17.1PPP	20.3PPP	28.5PPP	25.6PPP	19.4PPP	...
2-year clover/low	Acre	...	...	...	...	...	...	19.0PPP
2-year clover/med.	Acre	...	...	...	...	...	...	...
3-4-5-year grass/zero	Acre	15.2HPP	24.6HPP	30.5HPP	42.1HPP	34.4HPP	...	...
		4.0PPP	1.0PPP	...	1.7PPP	4.0PPP	12.0PPP	...
3-4-5-year grass/low	Acre	...	...	...	...	...	5.8HHA	6.1HHA
		...	...	...	...	...	9.7HPP	12.2HPP
		...	...	...	...	...	1.6PPP	9.6PPP
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...
6-12-year grass/zero	Acre	9.8PPP	24.9PPP	36.1PPP	8.4PPP	...	...	..
6-12-year grass/low	Acre	..	...	...	...	...	...	...
Corn silage	Acre	...	...	1.2	6.0	11.7	16.7	18.0
Seed alfalfa-oats	Acre	...	...	0.3	...	1.9	4.2	4.2
Seed clover-oats	Acre	6.4	8.6	10.2	14.3	12.8	9.7	9.5
Feeding program:								
Drylot feed May-June, TDN	100 lb	...	...	...	...	...	...	...
Drylot feed July-Aug., TDN	100 lb	...	...	...	...	...	...	...
Drylot feed Sept.-Oct., TDN	100 lb	...	...	...	...	2.1	3.3	3.1
Grain fed per cow	lb	2500	2500	2500	2500	2500	2500	2500
Livestock:								
Dairy cows	No.	10.0	13.6	18.4	23.2	28.0	32.8	35.4
Replacements raised	No.	2.7	5.4	7.3	9.3	11.2	13.1	14.2
Replacements sold	No.	0.1	2.0	2.8	3.5	4.2	4.9	5.3
Replacements bought	No.	...	...	...	...	...	...	...
Heifer calves sold at birth	No.	1.5	...	...	...	...	...	..
Purchased factors:								
Annual cash invested	Dollars	2224	3115	4201	5403	6548	7690	8293
Grain bought	Ton	14.0	20.0	27.3	34.5	41.7	48.8	52.7
Hired labor:								
Permanent	Hour	...	...	...	82.2	432.0	784.4	977.9
Spring seasonal	Hour	...	...	...	49	70	99	112
Summer seasonal	Hour	...	...	21	91	97	85	88
Fall seasonal	Hour	...	...	...	27	54	77	80
Product sales:								
Milk sales	Cwt.	854	1159	1569	1980	2391	2801	3026
Income net of variable costs	$	1800	2820	3785	4384	4763	5101	5237

Appendix table III-11. Optimum farm plan with specified ratios of cows to cropland, low quality cows, milk price $5.00 per hundred pounds.

Item	Unit	Ratio of cows to cropland								
		.10	.15	.20	.25	.30	.35	.40	.45	.50
Forage crops and level of fertilization:										
5-year alfalfa/low	Acre	...	...	1.0HHA	...	9.8HHA	20.8HHA	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA
2-year clover/zero	Acre	12.8PPP	17.4PPP	20.3PPP	29.9PPP	25.3PPP	19.7PPP	...	...	...
2-year clover/low	Acre	...	...	...	...	...	...	18.8PPP	...	...
2-year clover/med.	Acre	...	...	...	...	...	...	...	18.6PPP	18.6PPP
3-4-5-year grass/zero	Acre	15.3HPP	23.9HPP	30.4HPP	41.1HPP	33.1HPP	0.6HPP	...	...	...
		4.0PPP	2.2PPP	...	3.8PPP	4.8PPP	13.6PPP	...	...	...
3-4-5-year grass/low	Acre	...	...	...	...	...	15.5HPP	28.2HPP	27.1HPP	26.3HPP
		...	...	...	...	...	...	...	0.8HHA	1.6HHA
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	...	...
6-12-year grass/zero	Acre	9.8PPP	25.9PPP	36.0PPP	4.3PPP	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...	...
Corn silage	Acre	...	...	1.9	6.0	12.4	15.9	18.7	19.2	19.3
Seed alfalfa-oats	Acre	...	...	0.2	...	2.0	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	6.4	8.7	10.1	15.0	12.6	9.9	9.4	9.3	9.3
Feeding program:										
Drylot feed May-June, TDN	100 lb	...	...	...	...	...	...	11.4	10.2	10.0
Drylot feed July-Aug., TDN	100 lb	...	...	...	...	...	...	...	...	...
Drylot feed Sept.-Oct., TDN	100 lb	...	...	...	...	2.5	2.7	3.5	3.3	3.0
Grain fed per cow	lb	2500	2500	2500	2500	2500	3000	3030	3500	3500
Livestock:										
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	44.8	45.2
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.4	12.8	11.2	11.3
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.6	2.8	...	...
Replacements bought	No.	...	...	...	...	...	...	...	...	...
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.6	3.2	6.7	6.8
Purchased factors:										
Annual cash invested	Dollars	2226	3328	4441	5693	6849	7992	9171	9987	10066
Grain bought	Ton	14.0	21.3	28.6	36.0	43.3	59.3	68.3	85.1	85.9
Hired labor:										
Permanent	Hour	...	...	...	148.4	606.2	863.9	1213.7	1449.6	1478.7
Spring seasonal	Hour	...	...	...	51	74	96	120	120	120
Summer seasonal	Hour	...	...	28	84	89	73	110	105	105
Fall seasonal	Hour	...	...	...	29	57	73	81	83	83
Product sales:										
Milk sales	Cwt.	855	1283	1710	2137	2565	3115	3567	4117	5156
Income net of variable costs	$	2655	4107	5486	6441	7238	8000	8523	8738	8830

Appendix table III-12. Optimum farm plan with specified ratios of cows to cropland, low quality cows, milk price $6.00 per hundred pounds.

Item	Unit	Ratio of cows to cropland									
		.10	.15	.20	.25	.30	.35	.40	.45	.50	.55
Forage crops and level of fertilization:											
5-year alfalfa/low	Acre	...	...	0.9HHA	...	5.3HHA	20.8HHA	20.8HHA	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA
2-year clover/zero	Acre	12.5PPP	17.0PPP	20.5PPP	27.4PPP	27.9PPP	20.0PPP	...	...	...	...
2-year clover/low	Acre	...	...	...	...	...	...	19.3PPP	19.0PPP	...	...
2-year clover/med.	Acre	...	...	...	...	...	...	...	...	18.6PPP	18.3PPP
3-4-5-year grass/zero	Acre	15.2HPP	23.9HPP	30.7HPP	41.1HPP	41.1HPP	11.0HPP	...	...	...	...
		3.6PPP	1.6PPP	...	...	0.7PPP	12.1PPP	...	...	...	...
3-4-5-year grass/low	Acre	...	...	...	...	...	7.0HPP	11.3HPP	25.6HPP	26.3HPP	...
		...	...	...	...	...	...	8.5HHA	2.9HHA	1.7HHA	...
		...	...	...	...	...	...	9.0PPP	...	...	...
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	...	...	27.5HHH
6-12-year grass/zero	Acre	8.9PPP	24.5PPP	30.6PPP	11.9PPP	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...	...	...
Corn silage	Acre	...	...	10.0	5.9	0.1	14.9	17.2	18.1	19.1	20.0
Seed alfalfa-oats	Acre	...	...	0.2	...	1.1	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	6.3	8.5	10.2	13.7	13.9	10.0	9.6	9.5	9.3	9.2
Feeding program:											
Drylot feed May-June, TDN	100 lb	...	...	...	...	...	...	...	10.8	10.0	30.5
Drylot feed July-Aug., TDN	100 lb	...	...	...	...	...	...	...	...	...	11.6
Drylot feed Sept.-Oct., TDN	100 lb	...	...	...	...	1.6	2.3	2.7	2.9	3.0	11.8
Grain fed per cow	lb	3000	3000	3000	3018	3500	3500	3814	4000	4000	4000
Livestock:											
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	54.1
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.4	13.2	11.7	9.0	10.0
Replacements sold	No.	0.1	0.5	1.1	1.6	2.1	2.6	3.2	0.5	...	...
Replacements bought	No.	...	...	...	...	...	...	...	...	3.5	3.3
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.6	2.9	6.3	11.0	11.2
Purchased factors:											
Annual cash invested	Dollars	2219	3318	4426	5640	6795	7952	9072	10013	10818	11719
Grain bought	Ton	16.5	25.1	33.1	42.4	58.3	68.1	84.2	97.0	105.4	112.2
Hired labor:											
Permanent	Hour	...	...	...	148.4	506.2	863.9	1224.3	1481.4	1696.0	1913.3
Spring seasonal	Hour	...	...	...	49	62	89	109	117	120	131
Summer seasonal	Hour	...	...	28	84	94	79	84	103	94	215
Fall seasonal	Hour	...	...	...	25	46	69	77	79	83	152
Product sales:											
Milk sales	Cwt.	890	1335	1780	2227	2759	3218	3740	4248	4720	5011
Income net of variable costs	$	3528	5417	7249	8658	9903	11130	12192	12940	13524	13770

Appendix table III-13. Optimum farm plan with specified ratios of cows to cropland, medium quality cows, milk price $4.00 per hundred pounds.

Item	Unit	Ratio of cows to cropland						
		.10	.15	.20	.25	.30	.35	.40
Forage crops and level of fertilization:								
5-year alfalfa/low	Acre	...	...	0.6HHA	...	15.1HHA	20.8HHA	20.8HHA
5-year alfalfa/med.	Acre	...	...	...	...	...	...	...
2-year clover/zero	Acre	13.4PPP	18.2PPP	20.8PPP	30.6PPP	22.4PPP	11.4PPP	...
2-year clover/low	Acre	...	...	...	...	...	7.5PPP	18.7PPP
2-year clover/med.	Acre	...	...	...	...	...	...	...
3-4-5-year grass/zero	Acre	15.2HPP	23.9HPP	31.2HPP	4.4HPP	23.7HPP	...	...
		4.8PPP	3.5PPP	...	3.6PPP	9.9PPP	...	...
3-4-5-year grass/low	Acre	...	...	...	...	...	1.8HHA	1.8HHA
		...	...	...	...	...	14.5HPP	17.9HPP
		...	...	...	...	...	12.1PPP	8.4PPP
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...
6-12-year grass/zero	Acre	11.8PPP	28.4PPP	33.0PPP	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...
Corn silage	Acre	...	...	3.8	8.1	14.8	18.3	18.8
Seed alfalfa-oats	Acre	...	...	0.1	...	3.0	4.2	4.2
Seed clover-oats	Acre	6.7	9.1	10.4	15.3	11.2	9.5	9.4
Feeding program:								
Drylot feed May-June, TDN	100 lb	...	...	...	...	...	...	2.7
Drylot feed July-Aug., TDN	100 lb	...	...	...	...	...	...	...
Drylot feed Sept.-Oct., TDN	100 lb	...	...	...	1.3	3.3	3.9	3.9
Grain fed per cow	lb	1500	1500	1500	1500	1500	2000	2000
Livestock:								
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	36.0
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.4	11.7
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.6	2.7
Replacements bought	No.	...	...	...	...	...	...	...
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.6	2.7
Purchased factors:								
Annual cash invested	Dollars	2239	3348	4481	5749	6906	8061	8296
Grain bought	Ton	9.2	13.8	18.7	23.5	28.3	41.8	43.0
Hired labor:								
Permanent	Hour	...	...	...	148.4	506.2	868.9	935.5
Spring seasonal	Hour	...	...	...	58	86	112	118
Summer seasonal	Hour	...	...	27	87	84	75	83
Fall seasonal	Hour	...	...	...	38	68	82	83
Product sales:								
Milk sales	Cwt.	916	1374	1832	2290	2748	3365	3460
Income net of variable costs	$	2426	3763	4991	5796	6461	7030	7121

Appendix table III-14. Optimum farm plan with specified ratios of cows to cropland, medium quality cows, milk price $5.00 per hundred pounds.

Item	Unit	Ratio of cows to cropland									
		.10	.15	.20	.25	.30	.35	.40	.45	.50	.55
Forage crops and level of fertilization:											
5-year alfalfa/low	Acre	...	...	1.2HHA	...	12.2HHA	20.7HHA	...	...	...	
5-year alfalfa/med.	Acre	...	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA	
2-year clover/zero	Acre	13.2PPP	18.0PPP	20.1PPP	31.2PPP	24.0PPP	18.1PPP	...	...	...	
2-year clover/low	Acre	...	...	...	...	...	1.0PPP	18.5PPP	...	...	
2-year clover/med.	Acre	...	...	...	...	...	...	...	18.2PPP	17.9PPP	
3-4-5-year grass/zero	Acre	15.2HPP	23.9HPP	30.2HPP	41.3HPP	28.7HPP	...	...	...	...	
		4.6PPP	3.1PPP	...	5.5PPP	7.3PPP	...	...	...	...	
3-4-5-year grass/low	Acre	...	...	...	...	...	2.3HHA	...	...	...	
	Acre	...	...	...	...	...	13.7HPP	27.7HPP	27.2HPP	...	
		...	...	...	...	...	12.6PPP	...	...	...	
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	...	26.6HPP	
6-12-year grass/zero	Acre	11.2PPP	28.0PPP	35.5PPP	...	...	...	...	...	...	
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...	...	
Corn silage	Acre	...	...	2.7	6.4	13.3	17.8	19.7	20.5	21.3	
Seed alfalfa-oats	Acre	...	...	0.2	...	2.4	4.2	4.2	4.2	4.2	
Seed clover-oats	Acre	5.6	9.0	10.1	15.6	12.0	9.5	9.2	9.1	8.9	
Feeding program:											
Drylot feed May-June, TDN	100 lb	...	...	...	...	...	...	13.0	12.0	13.1	
Drylot feed July-Aug., TDN	100 lb	...	...	...	...	...	...	1.4	1.5	1.9	
Drylot feed Sept.-Oct., TDN	100 lb	...	...	...	0.2	2.7	3.8	4.2	4.3	4.3	
Grain fed per cow	lb	2000	2000	2500	2500	2500	2500	2500	3000	3000	
Livestock:											
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	46.0	
Replacements raised	No.	2.6	4.3	6.1	7.9	9.7	11.4	10.7	8.3	9.0	
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.6	0.7	...	...	
Replacements bought		...	...	...	...	...	...	...	2.9	2.6	
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.6	5.3	9.7	9.6	
Purchased factors:											
Annual cash invested	Dollars	2235	3342	1455	5727	6872	8043	9079	9899	10346	
Grain bought	Ton	11.5	17.6	28.6	36.0	43.3	50.6	56.4	72.5	75.2	
Hired labor:											
Permanent	Hour	...	..	...	148.4	506.2	863.9	1144.8	1372.7	1484.0	
Spring seasonal	Hour	...	...	...	53	79	108	126	128	131	
Summer seasonal	Hour	...	...	27	85	86	75	110	103	108	
Fall seasonal	Hour	...	...	...	32	61	80	86	89	91	
Product sales:											
Milk sales	Cwt.	962	1442	2000	2500	3000	3500	4000	4644	4799	
Income net of variable costs	$	3374	5186	6907	8207	9356	10438	11145	11594	11778	

Appendix table III-15. Optimum farm plan with specified ratios of cows to cropland, medium quality cows, milk price $6.00 per hundred pounds.

Item	Unit	Ratio of cows to cropland										
		.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60
Forage crops and level of fertilization:												
5-year alfalfa/low	Acre	...	...	1.1HHA	...	10.5HHA	20.8HHA	20.8HHA	...	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA	20.8HHA
2-year clover/zero	Acre	13.0PPP	17.1PPP	20.3PPP	30.2PPP	25.0PPP	19.3PPP	...	...	...	...	...
2-year clover/low	Acre	...	...	...	...	...	...	18.6PPP	...	...	...	...
2-year clover/med.	Acre	...	...	...	...	...	...	...	18.2PPP	18.0HPP	18.1HPP	18.1HPP
3-4-5-year grass/zero	Acre	15.2HPP	23.9HPP	30.4HPP	41.1HPP	31.8HPP	...	...	...	...	...	...
		4.3PPP	2.7PPP	...	4.2PPP	5.7PPP	6.8PPP	...	...	...	...	...
3-4-5-year grass/low	Acre	...	...	...	...	...	4.0HHA	27.9HPP	27.3HPP	...	...	...
		...	...	...	...	...	11.4HPP	...	...	...	...	...
		...	...	...	...	...	6.8PPP	...	...	...	...	...
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	...	27.0HHH	27.1HHH	27.1HHH
6-12-year grass/zero	Acre	10.6PPP	27.1PPP	35.9PPP	3.3PPP	...	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...	...	...	...
Corn silage	Acre	...	...	2.0	6.0	12.5	17.2	19.2	20.5	21.0	20.8	20.8
Seed alfalfa-oats	Acre	...	...	0.2	...	2.1	4.2	4.2	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	6.5	8.9	10.1	15.1	12.5	9.6	9.3	9.1	9.0	9.0	9.0
Feeding program:												
Drylot feed May-June, TDN	100 lb	...	...	...	...	...	...	12.5	12.0	32.0	34.7	34.6
Drylot feed July-Aug., TDN	100 lb	...	...	...	...	...	...	0.8	1.5	12.9	16.3	17.6
Drylot feed Sept.-Oct., TDN	100 lb	...	...	...	...	2.5	3.6	4.0	4.3	12.6	15.1	16.0
Grain fed per cow	lb	2500	2500	3000	3000	3000	3000	3000	3000	3771	4000	4000
Livestock:												
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	56.6
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.4	11.5	8.3	9.0	2.3	...
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.6	1.5	2.9	...	...	...
Replacements bought	No.	...	...	...	...	...	...	...	...	3.5	11.4	14.1
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.6	4.5	9.7	11.0	19.7	22.6
Purchased factors:												
Annual cash invested	Dollars	2231	3336	4443	5699	6853	8022	9114	9900	11124	11737	11912
Grain bought	Ton	14.0	21.3	33.6	42.2	50.8	59.3	66.9	72.5	99.7	111.4	113.1
Hired labor:												
Permanent	Hour	...	...	...	148.4	506.2	863.9	1171.3	1372.7	1696.0	1783.5	1804.7
Spring seasonal	Hour	...	...	...	51	65	104	123	128	137	141	143
Summer seasonal	Hour	...	...	28	84	88	76	110	103	220	215	213
Fall seasonal	Hour	...	...	...	29	57	79	84	89	156	160	162
Product sales:												
Milk sales	Cwt.	1000	1500	2064	2580	3096	3612	4128	4644	5343	5929	6094
Income net of variable costs	$	4474	6684	8916	10727	12382	13985	15262	16238	16951	17078	17107

Appendix table III-16. Optimum farm plan with specified ratios of cows to cropland, high quality cows, milk price $4.00 per hundred pounds.

Item	Unit	Ratio of cows to cropland						
		.10	.15	.20	.25	.30	.35	.40
Forage crops and level of fertilization:								
5-year alfalfa/low	Acre	...	...	...	0.2HHA	20.6HHA	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	20.8HHA	20.8HHA
2-year clover/zero	Acre	14.1PPP	19.3PPP	21.9PPP	29.4PPPI	19.1PPP	...	...
2-year clover/low	Acre	...	...	...	...	...	18.0PPP	...
2-year clover/med.	Acre	...	...	...	...	...	...	17.7PPP
3-4-5-year grass/zero	Acre	15.2HPP 5.9PPP	23.9HPP 5.1PPP	32.9HPP ...	44.1HPP ...	14.2HPP 14.5PPP	... ...	... ...
3-4-5-year grass/low	Acre	...	...	...	...	....	27.1HPP	26.5HPP
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...
6-12-year grass/zero	Acre	14.4PPP	32.6PPP	28.3PPP	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...
Corn silage	Acre	...	...	6.0	11.6	18.0	20.9	22.0
Seed alfalfa-oats	Acre	...	...	...	0.1	4.1	4.2	4.2
Seed clover-oats	Acre	7.1	9.7	10.9	14.7	9.6	9.0	8.8
Feeding program:								
Drylot feed May-June, TDN	100 lb	...	...	...	...	...	13.4	12.6
Drylot feed July-Aug., TDN	100 lb	...	...	...	...	...	3.0	3.4
Drylot feed Sept.-Oct., TDN	100 lb	...	...	0.4	3.4	4.6	5.3	5.5
Grain fed per cow	lb	1500	1500	1500	1500	1500	1500	1500
Livestock:								
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	38.0
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.3	9.5
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.5	...
Replacements bought	No.	...	...	...	...	...	...	...
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.7	5.7
Purchased factors:								
Annual cash invested	Dollars	2256	3373	4537	5794	6975	8221	8708
Grain bought	Ton	9.0	13.8	18.6	23.5	28.3	33.0	34.2
Hired labor:								
Permanent	Hour	...	...	...	148.4	506.2	861.3	985.8
Spring seasonal	Hour	...	...	8	68	100	131	135
Summer seasonal	Hour	...	...	28	92	79	122	120
Fall seasonal	Hour	...	...	...	51	83	92	96
Product sales:								
Milk sales	Cwt.	1020	1530	2040	2550	3060	3570	3874
Income net of variable costs	$	2819	4353	5720	6687	7527	8085	8227

Appendix table III-17. Optimum farm plan with specified ratios of cows to cropland, high quality cows, milk price $5.00 per hundred pounds.

Item	Unit	Ratio of cows to cropland							
		.10	.15	.20	.25	.30	.35	.40	.45
Forage crops and level of fertilization:									
5-year alfalfa/low	Acre	...	...	...	0.2HHA	20.6HHA	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA
2-year clover/zero	Acre	14.1PPP	19.3PPP	21.9PPP	29.4PPP	19.1PPP	...	...	...
2-year clover/low	Acre	...	...	...	...	...	18.0PPP	...	...
2-year clover/med.	Acre	...	...	...	...	...	...	17.5PPP	17.2HPP
3-4-5-year grass/zero	Acre	15.2HPP 5.9PPP	23.9HPP 5.1PPP	32.9HPP ...	44.1HPP ...	14.2HPP 14.5PPP	... ...	... ...	... ...
3-4-5-year grass/low	Acre	...	...	...	...	...	27.1HPP	26.2HPP	
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	25.8HPP
6-12-year grass/zero	Acre	14.4PPP	32.6PPP	28.3PPP	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...
Corn silage	Acre	...	...	6.0	11.5	18.0	20.9	22.6	23.5
Seed alfalfa-oats	Acre	...	...	...	0.1	4.1	4.2	4.2	4.2
Seed clover-oats	Acre	7.1	9.7	10.9	14.7	9.6	9.0	8.7	8.6
Feeding program:									
Drylot feed May-June, TDN	100 lb	...	...	...	...	...	13.1	13.1	31.9
Drylot feed July-Aug., TDN	100 lb	...	...	...	...	...	3.0	4.2	5.2
Drylot feed Sept.-Oct., TDN	100 lb	...	...	0.4	3.4	4.6	5.3	5.9	6.4
Grain fed per cow	lb	1500	1500	1500	1500	1500	1500	1500	1500
Livestock:									
Dairy cows	No.	10.0	15.0	20.0	25.0	30.0	35.0	40.0	41.9
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.3	7.5	8.0
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.5	...	...
Replacements bought	No.	...	...	...	...	...	...	2.6	2.5
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.7	8.6	8.8
Purchased factors:									
Annual cash invested	Dollars	2256	3373	4537	5794	6975	8221	8979	9574
Grain bought	Ton	9.0	13.8	18.6	23.5	28.3	33.0	34.5	36.2
Hired labor:									
Permanent	Hour	...	...	...	148.4	506.2	861.3	1041.0	1171.3
Spring seasonal	Hour	...	...	8	69	101	131	138	148
Summer seasonal	Hour	...	...	28	92	79	122	115	174
Fall seasonal	Hour	...	...	...	51	83	92	99	101
Product sales:									
Milk sales	Cwt.	1620	1530	2040	2550	3060	3570	4080	4270
Income net of variable costs	$	3839	5882	7760	9237	10587	11655	12280	12498

Appendix table III-18. Optimum farm plan with specified ratios of cows to cropland, high quality cows, milk price $6.00 per hundred pounds.

Item	Unit	Ratio of cows to cropland								
		.10	.15	.20	.25	.30	.35	.40	.45	.50
Forage crops and level of fertilization:										
5-year alfalfa/low	Acre	...	...	...	0.2HHA	20.6HHA	...	...	...	...
5-year alfalfa/med.	Acre	...	...	...	...	...	20.8HHA	20.8HHA	20.8HHA	20.8HHA
2-year clover/zero	Acre	14.1PPP	19.3PPP	21.9PPP	29.4PPP	19.1PPP	...	...	...	...
2-year clover/low	Acre	...	...	...	...	...	18.0PPP	...	...	...
2-year clover/med.	Acre	...	...	...	...	...	...	17.5PPP	17.2PPP	17.1PPP
3-4-5-year grass/zero	Acre	15.2HPP 5.9PPP	23.9HPP 5.1PPP	32.9HPP ...	44.1HPP ...	14.2HHP 14.5PPP	... ...	... ...	... ...	... ...
3-4-5-year grass/low	Acre	...	...	...	...	...	27.1HPP	26.2HPP	...	...
3-4-5-year grass/med.	Acre	...	...	...	...	...	...	...	25.7HHH	25.6HHH
6-12-year grass/zero	Acre	14.4PPP	32.6PPP	28.3PPP	...	...	...	...	...	...
6-12-year grass/low	Acre	...	...	...	...	...	...	...	...	...
Corn silage	Acre	...	...	6.0	11.5	18.0	20.9	22.6	23.5	23.7
Seed alfalfa-oats	Acre	...	...	...	0.1	4.1	4.2	4.2	4.2	4.2
Seed clover-oats	Acre	7.1	9.7	10.9	14.7	9.6	9.0	8.2	8.6	8.6
Feeding program:										
Drylot feed May-June, TDN	100 lb	...	...	...	...	...	13.4	13.1	33.7	35.8
Drylot feed July-Aug., TDN	100 lb	...	...	...	...	...	2.0	4.2	17.3	20.3
Drylot feed Sept.-Oct., TDN	100 lb	...	...	0.4	3.4	4.6	5.3	5.9	15.3	17.5
Grain fed per cow	lb	1500	1500	1500	1500	1500	1500	1500	2500	2500
Livestock:										
Dairy cows	No	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	47.9
Replacements raised	No.	2.6	4.3	6.1	7.9	9.6	11.3	7.5	5.2	...
Replacements sold	No.	0.1	0.6	1.1	1.6	2.1	2.5	...	...	...
Replacements bought	No.	...	...	...	...	...	...	2.6	6.0	12.0
Heifer calves sold at birth	No.	1.5	1.7	1.9	2.2	2.4	2.7	8.6	12.8	19.2
Purchased factors:										
Annual cash invested	Dollars	2256	3373	4537	5794	6975	8221	8979	10068	10364
Grain bought	Ton	9.0	13.8	18.6	23.5	28.3	33.0	34.5	59.4	59.9
Hired labor:										
Permanent	Hour	...	...	...	148.4	506.2	861.3	1041.5	1272.0	1282.6
Spring seasonal	Hour	...	...	8	68	101	131	138	151	156
Summer seasonal	Hour	...	...	28	92	79	122	115	228	226
Fall seasonal	Hour	...	...	...	51	83	92	99	167	172
Product sales:										
Milk sales	Cwt.	1020	1530	2040	2550	3060	3570	4080	4849	5160
Income net of variable costs	$	4859	7413	9800	11787	13647	15225	16360	16949	17007

APPENDIX IV

SELECTED MARGINAL VALUE PRODUCTS

Appendix table IV 1. Marginal value products for selected resources with low quality cows, $4.00 price of milk, various ratios of cows to cropland and with and without sales of hay.

Item	Ratio of cows to cropland						
	.10	.15	.20	.25	.30	.35	.40
	Hay sales at $27.00 per ton						
Cropland ($/acre)	22	20	20	20	20	24	28
Dairy cow ($/head)	36	24	18	9	9	4	0
Replacement ($/each)	320	320	320	320	320	320	320
Buy hay ($/ton)	13	13	14	14	14	15	16
Sell hay ($/ton)	27	27	27	27	27	27	30
Marginal return over feed costs ($/cow)	151	148	145	145	145	134	125
Marginal rate of substitution of cows for cropland	—1.6	—1.2	—0.92	—0.47	—0.47	—0.18	0
	Hay sales prohibited						
Cropland ($/acre)	0	0	5	6	7	16	28
Dairy cow ($/head)	67	65	47	25	25	13	0
Replacement ($/each)	320	320	320	320	320	320	320
Buy hay ($/ton)	5	5	10	11	12	13	16
Sell hay ($/ton)	8	8	16	16	16	23	30
Marginal return over feed costs ($/cow)	214	214	186	176	174	152	125
Marginal rate of substitution of cows for cropland	...	...	9.9	—3.9	—3.4	—0.83	0

Appendix table IV 2. Marginal value products for selected resources with low quality cows, $5.00 price of milk, various ratios of cows to cropland and with and without sales of hay.

Item	Ratio of cows to cropland							
	.10	.15	.20	.25	.30	.35	.40	.45
	Ratio sales at $27.00 per ton							
Cropland ($/acre)	22	20	20	20	20	21	46	58
Dairy cow ($/head)	69	61	53	41	41	38	31	0
Replacement ($/each)	320	320	320	320	320	320	320	350
Buy hay ($/ton)	13	13	14	14	14	15	20	22
Sell hay ($/ton)	27	27	27	27	27	27	38	45
Marginal return over feed costs ($/cow)	237	234	231	231	231	220	174	150
Marginal rate of substitution of cows for cropland	—3.2	—3.1	—2.7	—2.1	—2.1	—1.6	—0.68	0
	Hay sales prohibited							
Cropland ($/acre)	0	0	5	6	7	11	50	58
Dairy cow ($/head)	80	80	72	42	42	41	31	0
Replacement ($/each)	320	320	320	320	320	320	320	350
Buy hay ($/ton)	5	5	10	11	12	12	20	22
Sell hay ($1/ton)	8	8	16	16	16	20	38	45
Marginal return over feed costs ($/cow)	299	299	272	261	259	248	174	150
Marginal rate of substitution of cows for cropland	...	...	—15.0	—6.4	—6.8	—3.6	—0.68	0

Appendix table IV 3. Marginal value products for selected resources with low quality cows, $6.00 price of milk, various ratios of cows to cropland and with and without sales of hay.

Item	Ratio of cows to cropland									
	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55
	Hay sales at $27.00 per ton									
Cropland ($/acre)	22	20	20	20	20	21	34	45	58	110
Dairy cow ($/head)	159	151	143	131	131	130	126	125	93	0
Replacement ($/each)	320	320	320	320	320	320	320	320	350	350
Buy hay ($/ton)	13	13	14	14	14	14	17	20	22	33
Sell hay ($/ton)	27	27	27	27	27	27	32	38	45	70
Marginal return over feed costs ($/cow)	327	323	321	321	321	318	289	267	243	150
Marginal rate of substitution of cows for cropland	—7.3	—7.5	—7.3	—6.6	—6.6	—6.2	—3.7	—2.8	—1.6	0
	Hay sales prohibited									
Cropland ($/acre)	0	0	5	6	7	11	34	45	58	110
Dairy cows ($/head)	168	168	160	131	130	130	126	125	93	0
Replacement ($/each)	320	320	320	320	320	320	320	320	350	350
Buy hay ($/ton)	5	5	10	11	12	12	17	20	22	33
Sell hay ($/ton)	8	8	16	16	16	20	32	38	45	70
Marginal return over feed costs ($/cow)	387	387	360	360	348	337	289	267	243	150
Marginal rate of substitution of cows for cropland	...	...	—33.3	—20.9	—18.3	—11.6	—3.7	—2.8	—1.6	0

Appendix table IV 4. Marginal value products for selected resources with medium quality cows. $4.00 price of milk, various ratios of cows to cropland and with and without sales of hay.

Item	Ratio of cows to cropland						
	.10	.15	.20	.25	.30	.35	.40
	Hay sales at $27.00 per ton						
Cropland ($/acre)	22	20	20	20	20	24	35
Dairy cow ($/head)	42	33	25	13	13	9	4
Replacement ($/each)	320	320	320	320	320	320	320
Buy hay ($/ton)	13	13	14	14	14	15	17
Sell hay ($/ton)	27	27	27	27	27	27	33
Marginal return over feed costs ($/cow)	210	206	203	203	203	191	166
Marginal rate of substitution of cows for cropland	—1.9	—1.7	—1.3	—0.65	—0.64	—0.36	—0.11
	Hay sales prohibited						
Cropland ($/acre)	0	0	5	7	7	17	35
Dairy cows ($/head)	57	57	39	16	16	11	4
Replacement ($/each)	320	320	320	320	320	320	320
Buy hay ($/ton)	5	5	10	11	12	14	17
Sell hay ($/ton)	8	8	16	16	16	24	33
Marginal return over feed costs ($/cows)	276	276	243	235	234	206	166
Marginal rates of substitution of cows for cropland	...	...	—7.6	—2.4	—2.2	—0.66	—0.11

Appendix table IV 5. Marginal value products for selected resources with medium quality cows, $5.00 price of milk, various ratios of cows to cropland and with and without sales of hay.

Item	Ratio of cows to cropland								
	.10	.15	.20	.25	.30	.35	.40	.45	.50
	Hay sales at $27.00 per ton								
Cropland ($/acre)	22	20	20	20	20	24	47	59	89
Dairy cow ($/head)	139	131	122	110	110	106	96	62	0
Replacement ($/each)	320	320	320	320	320	320	320	350	350
Buy hay ($/ton)	13	13	14	14	14	15	20	22	29
Sell hay ($/ton)	27	27	27	27	27	27	37	44	59
Marginal return over feed costs ($/cow)	307	303	300	300	300	289	238	211	150
Marginal rate of substitution of cows for cropland	—6.3	—6.5	—6.2	—5.6	—5.6	—4.5	—2.1	—1.1	0
	Hay sales prohibited								
Cropland ($/acre)	0	0	5	6	7	17	47	59	90
Dairy cow ($/head)	152	152	143	112	112	109	96	62	0
Replacement ($/each)	320	320	320	320	320	320	320	350	350
Buy hay ($/ton)	5	5	10	11	12	14	20	22	29
Sell hay ($/ton)	8	8	16	16	16	24	37	44	59
Marginal return over feed costs ($/cow)	371	371	343	332	330	303	238	211	150
Marginal rate of substitution of cows for cropland	...	...	—29.7	—17.2	—15.7	—6.3	—2.1	—1.1	0

Appendix table IV 6. Marginal value products for selected resources with medium quality cows, $6.00 price of milk, various ratios of cows to cropland and with and without sales of hay.

Item	Ratio of cows to cropland										
	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60
	Hay sales at $27.00 per ton										
Cropland ($/acre)	22	20	20	20	20	24	47	49	107	135	145
Dairy cow ($/head)	240	232	224	212	212	208	199	165	70	19	0
Replacement ($/each)	320	320	320	320	320	320	320	350	350	350	350
Buy hay ($/ton)	13	13	14	14	14	15	20	22	32	38	40
Sell hay ($/ton)	27	27	27	27	27	27	37	44	68	82	87
Marginal return over feed costs ($/cow)	408	405	402	402	402	391	341	315	220	169	150
Marginal rate of substitution of cows for cropland	—11.0	—11.6	11.4	—10.7	10.7	—8.8	—4.3	—2.8	—0.65	—0.14	0
	Hay sales prohibited										
Cropland ($/acre)	0	0	5	6	7	16	47	59	107	135	145
Dairy cow ($/head)	252	252	243	213	213	211	199	165	70	10	0
Replacement ($/each)	320	320	320	320	320	320	320	350	350	350	350
Buy hay ($/ton)	5	5	10	11	12	13	20	22	32	38	40
Sell hay ($/ton)	8	8	16	16	16	23	37	44	68	82	87
Marginal return over feed costs ($/cow)	471	471	443	433	431	408	341	315	220	169	150
Marginal rate of substitution of cows for cropland	...	...	—50.7	32.8	29.8	—13.4	—4.3	—2.8	—0.65	—0.14	0

Appendix table IV 7. Marginal value products for selected resources with high quality cows, $4.00 price of milk, various ratios of cows to cropland and with and without sales of hay.

Item	Ratio of cows to cropland						
	.10	.15	.20	.25	.30	.35	.40
Cropland ($/acre)	22	20	20	20	24	47	55
Dairy cow ($/head)	76	67	59	46	41	25	0
Replacement ($/each)	320	320	320	320	320	320	340
Buy hay ($/ton)	13	13	14	14	15	20	21
Sell hay ($/ton)	27	27	27	27	27	37	41
Marginal return over feed costs ($/cow)	244	240	236	236	223	167	147
Marginal rate of substitution of cows for cropland	—3.5	—3.4	—3.0	—2.2	—1.7	—0.53	0
	Hay sales prohibited						
Cropland ($/acre)	0	0	6	7	7	47	55
Dairy cow ($/head)	97	97	73	51	51	25	0
Replacement ($/each)	320	320	320	320	320	320	340
Buy hay ($/ton)	5	5	11	12	12	20	21
Sell hay ($/ton)	0	8	15	16	16	37	41
Marginal return over feed costs ($/cow)	315	315	276	270	269	167	147
Marginal rate of substitution of cows for cropland	. . .	. . .	—12.4	—7.5	—7.2	—0.53	0

Appendix table IV 8. Marginal value products for selected resources with high quality cows, $5.00 price of milk, various ratios of cows to cropland and with and without sales of hay.

Item	Ratio of cows to cropland							
	.10	.15	.20	.25	.30	.35	.40	.45
	Hay sales at $27.00 per ton							
Cropland ($/acre)	22	20	20	20	24	47	59	97
Dairy cow ($/head)	178	169	161	148	143	127	89	0
Replacement ($/each)	320	320	320	320	320	320	350	350
Buy hay ($/ton)	13	13	14	14	15	20	22	30
Sell hay ($/ton)	27	27	27	27	27	37	44	64
Marginal return over feed costs ($/cow)	346	342	338	338	325	269	239	150
Marginal rate of substitution of cows for cropland	—8.1	—8.5	—8.2	—7.5	—6.1	—2.7	—1.5	0
	Hay sales prohibited							
Cropland ($/acre)	0	0	6	7	7	47	59	97
Dairy cow ($/head)	199	199	175	153	153	127	89	0
Replacements ($/each)	320	320	320	320	320	320	350	350
Buy hay ($/ton)	5	5	11	12	12	20	22	30
Sell hay ($/ton)	8	8	15	16	16	37	44	64
Marginal return over feed costs ($/cow)	417	417	378	372	371	269	239	150
Marginal rate of substitution of cows for cropland	...	...	—29.8	—22.3	—21.4	—2.7	—1.5	0

Appendix table IV 9. Marginal value products for selected resources with high quality cows, $6.00 price of milk, various ratios of cows to cropland and with and without sales of hay.

Item	Ratio of cows to cropland								
	.10	.15	.20	.25	.30	.35	.40	.45	.50
	Hay sales at $27.00 per ton								
Cropland ($/acre)	22	20	20	20	24	47	59	134	144
Dairy cow ($/head)	280	271	260	250	245	229	191	20	0
Replacement ($/each)	320	320	320	320	320	320	350	350	350
Buy hay ($/ton)	13	13	14	14	15	20	22	38	40
Sell hay (4/ton)	27	27	27	27	27	37	44	82	86
Marginal return over feed costs ($/cow)	448	444	440	440	427	371	341	170	150
Marginal rate of substitution of cows for cropland	−12.8	−13.6	−13.3	−12.7	−10.4	−4.7	−3.2	−0.15	0
	Hay sales prohibited								
Cropland ($/acre)	0	0	6	7	7	47	59	135	144
Dairy cow ($/head)	300	300	277	255	255	229	191	20	0
Replacement ($/each)	320	320	320	320	320	320	350	350	350
Buy hay ($/ton)	5	5	11	12	12	20	22	38	40
Sell hay ($/ton)	8	8	15	16	16	37	44	82	86
Marginal return over feed costs ($/cow)	519	519	480	474	473	371	341	170	150
Marginal rate of substitution of cows for cropland	...	...	−47.4	−37.1	−35.7	−4.9	−3.2	−0.15	0