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Pasture management strategies for Iowa dairymen

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for Iowa dairymen

by

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CHAPTER I: INTRODUCTION

The dairy industry in Iowa is overshadowed by the beef and pork industries; nevertheless, the dairy industry is big business. In 1977, gross receipts from farm dairy product sales totaled $372,485,000 (Table 1) (45). Iowa is a leading state in dairy cow numbers--seventh in the nation (43). Receipts from dairying is a major source of income for many Iowa farmers.

Dairy cow numbers have been decreasing in Iowa (Table 2) and the nation, but value of milk production has not shown these declines. In fact receipts from milk sales have tended upwards. A dairy cow unit in 1970 produced $516.85 in gross revenue and in 1977 accounted for $967.49 in gross revenue which represents an increase in excess of 87 percent. Rising costs of dairy replacement, feed grains, labor and other production items have largely offset the increase in gross revenue/cow.

Farm profitability is a concern of every dairyman. Increasing production costs have caused difficulties for most dairymen. Even though milk prices have increased these increases have not always been sufficient to cover production costs. While the individual dairyman has little control over the prices received for his products, he can improve the profitability of his operation by improving his production efficiency. These improvements may include improved genetics or herd quality, size economics, least-cost rations, more efficient facilities, etc. The main emphasis of this study will deal with feed efficiencies.

Table 1. Gross farm income from sale of dairy products, 1970-1977[a] (45)

Year	Dollars[b]
1970	225,994
1971	229,203
1972	229,689
1973	267,799
1974	285,467
1975	304,224
1976	344,953
1977	372,485

[a]Wholesale milk sales represent in excess of 98 percent of total dairy product sales.

[b]Expressed in thousands of dollars.

Table 2. Iowa dairy cow numbers 1950-1975 (43)

Year	Number of cows
1950	1,038,800
1955	911,300
1960	783,821
1965	694,376
1970	437,247
1975	405,000
1977	385,000

Replacement animals, labor and feed costs account for over 70 percent of the cost of producing milk (24). While the former two costs are generally fixed in the short run the latter, representing over 40 percent of the cost of milk production, is not. Almost all replacements on Iowa dairy farms are grown within the herd. Labor requirements for the dairy herd are determined by the size of milking herd, type of housing, milking parlor, milking equipment and feeding system used.

Feed costs can be delineated into three categories; concentrates, supplements and roughages. While the prices of concentrates and supplements are readily available on the market, the value of roughages cannot be as easily determined. Roughages are either harvested grain silage, hay and haylage or grazed pasture. Collectively these are referred to as forages. The main thrust of this study will be aimed at forage management with particular attention paid to pasture management. The major objectives of this study are to economically evaluate different varieties of pastures and pasture management techniques. These objectives are:

1. Develop milk production costs with emphasis upon feed requirements for varying stages of milk production throughout the annual production cycle. Least cost feed sources will be tabulated.
2. Specify forage productivity levels for common grasses and silages.
3. Develop and evaluate forage management strategies.
4. Develop a set of conclusions and recommendation that will be useful to Iowa dairymen for improving the economic efficiency of their herds.

CHAPTER II: METHODS AND PROCEDURES

Farming activities were simulated using an annual multi-period linear programming model. The model maximized profits while using least-cost feed specification on an annual basis.[1] To accurately represent the monthly differences in labor needs and supply, and nutrient yields of forage varieties over the summer months the annual model was divided into eight time periods (Table 3). Labor requirements for each of the farm activities was allocated to the respective time period in which it occurred.

Period I consisted of the months December through April. In these months no feed production activities took place. All roughage fed was from storage. Labor requirements for the dairy herd were considered to be uniform throughout the year. Since there were no crop labor requirements for December through April, it was not necessary to treat this period as individual months.

Periods II-VIII represented the months May through November, respectively. Farm labor requirements during these periods were higher and had the possibility of large variations depending on the cropping enterprise and forage management strategy selected. Also, forage yields varied greatly in Periods II-VIII and were determined by the forage variety and grazing plan used on that variety.

Linear programming was selected as the research tool to specify

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[1] For linear programming optimization conditions and applications see Heady and Chandler (18) or Beneke and Winterboer (5).

Table 3. Time periods to be used in the annual linear programming models

	Month[a]
Period I	December-April
Period II	May
Period III	June
Period IV	July
Period V	August
Period VI	September
Period VII	October
Period VIII	November

[a]Each month was considered to be 30.5 days in length.

optimal crop production activities which would maximize income from dairy production. Application is made to a specific situation considered to be typical of many other dairy farms in Iowa. Specific procedures and sequences of this study were:

1. Select a model farm typical of the area in Iowa where most of the dairy farms are located. This model farm was similar in soil type and topography of many other dairy farms.
2. Identify the dairy enterprise and its characteristics. The dairy enterprise was selected on the basis of such characteristics as herd size, level of milk production, housing, milking equipment and replacement activities. These were selected to represent a typical Iowa farm situation. Dairy characteristics were determined from government publications and work done by Linkeman and Boehlje (31).
3. Select cash crops and identify their respective production costs and yields. Crops were limited to the basic cash crops found in the model farm area.
4. Select forage varieties and identify their respective production costs and yields. Selection was based on productivity and adaptability to the chosen model farm area.
5. Develop grazing management strategies to be evaluated. The model was designed flexible enough to select from combinations of strategies on a least-cost basis.

6. Analyze initial solution and all additional solutions. Solutions allow economic evaluation of such variables as herd size, level of milk production and pasture management.

CHAPTER III: THE MODEL FARM

The model farm was constructed to be a family oriented type of operation, the chief sources of income being derived from the sale of dairy products and cash grain crops. Equipment was restricted to the basic equipment necessary to perform the dairying and farming activities. If additional capital and labor were needed it was assumed that they could be obtained freely at an opportunity cost reflected in market prices, interest rates and wage rates.

Selection of Model Farm Location

In 1975 the twelve leading counties in dairy cow numbers contained 53.6 percent of all dairy cows in Iowa (Table 4). Ten of the twelve counties are located in northeast Iowa bordered by the Mississippi River on the east and the Minnesota border on the north (Figure 1). This ten county area accounts for 47.6 percent of Iowa's dairy cow population and was selected as the area to locate the model farm.

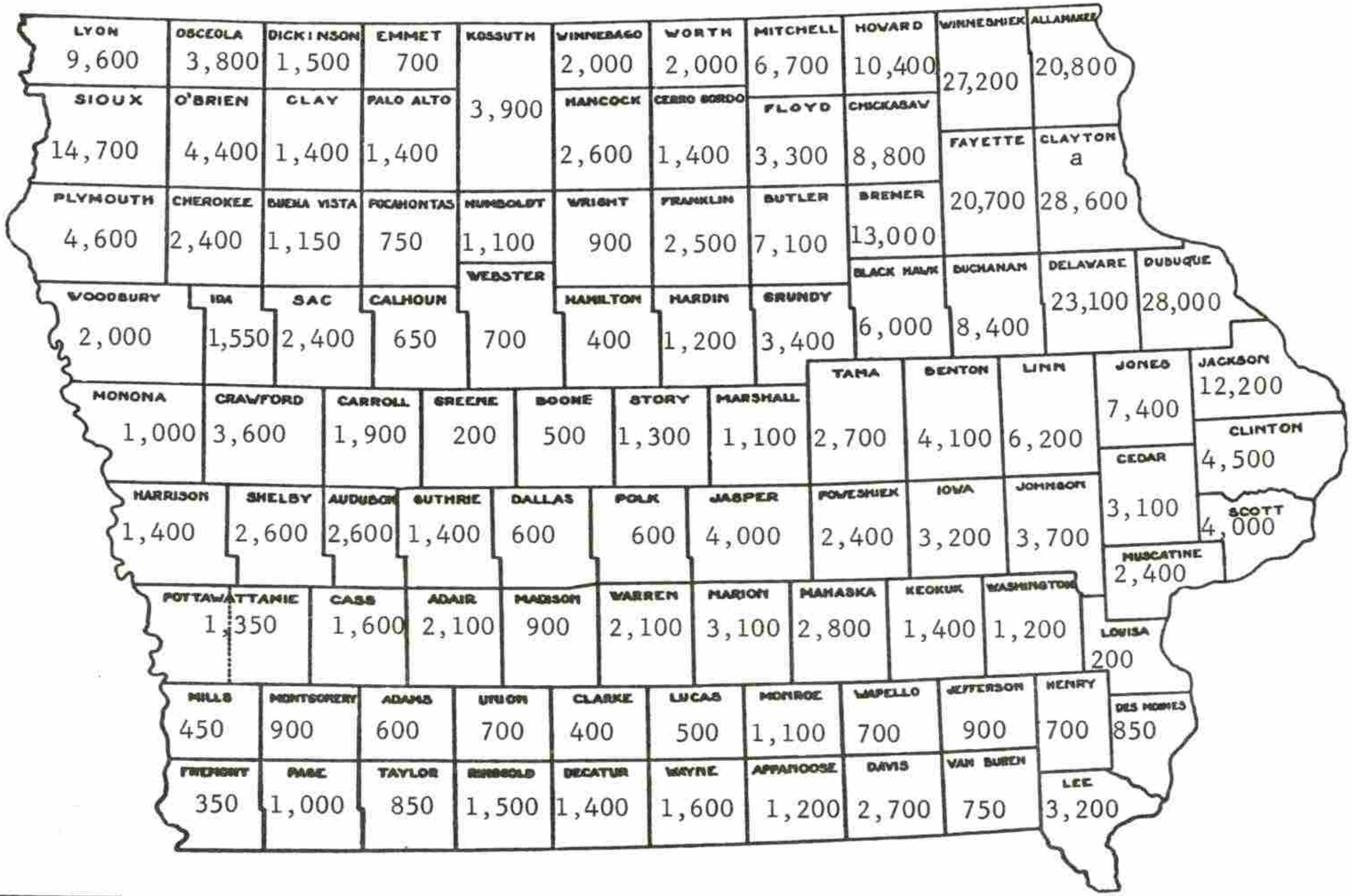
Rainfall in the ten county model farm area averages between 32-34 inches a year with the soil being a loess over bedrock or a clay-loam till. The prominent soil associations in the area are Fayette and Fayette-Dubuque-Stonyland (15). The slope of the land in these soil associations varies between 0 and 30 percent with a majority of the flatter lands being located in the western portion of the model farm area.

Clayton county which contains land in both soil associations and is the leading county in dairy cow numbers was selected as the site of

Table 4. Leading Iowa counties in dairy cow numbers in 1975 (23)

Rank	County	Number of cows
1	Clayton[a]	28,600
2	Dubuque[a]	28,000
3	Winneshiek[a]	27,200
4	Delaware[a]	23,100
5	Allamakee[a]	20,800
6	Fayette[a]	20,700
7	Sioux	14,700
8	Bremer[a]	13,000
9	Jackson[a]	12,200
10	Howard[a]	10,400
11	Lyon	9,600
12	Chickasaw[a]	8,800

[a]Counties located in model farm area.



[a]Location of model farm.

Figure 1. Dairy cow numbers in Iowa by county, 1975 (23; 29)

the model farm. Clayton county's combination of characteristics made it the best representative site of the ten county area.

Model Farm Size and Land Classification

Land in the farming enterprize was divided into four classes depending on the slope and allowable cropping intensity based on Environmental Protection Agency (EPA) regulations, Table 5 shows the land classes on the model farm. New EPA standards call for a maximum of four tons of soil loss per acre during a year (2; 44). Under EPA standards Class I land is able to sustain 100 percent continuous row crops production. Class II land is limited to 40 percent row crops rotated with cover crops such as oats and hay. No corn production was allowed on Class III and IV lands. Class III land was assumed to be restricted in use to pasture varieties to limit soil loss. Class IV land was too steep (14 percent slope or greater) for tilling practices and was left in a permanent pasture of native Kentucky bluegrass with fertilization as the only improvement that could occur.

The distribution of soils by classification in the soil associations named above approximates that of the farm in the model farm area. The model farm had a total of 260 acres with 140, 50, 35, and 35 acres in the respective land classes.

Farm Labor Supply

Operator labor was considered to be above average quality and was assumed to provide an average of 50 hours per week over 50 weeks. This

Table 5. Land classifications and acreage of model farm

Land classification	Slope	Acres	Cropping intensity[a]
Class I	2-4%	140	100% corn
Class II	5-8%	50	40% corn
Class III	9-13%	35	
Class IV	14+	35	
Total acres		260	

[a]Cropping intensity for contour management practices that will allow for a maximum of four tons per acre of soil loss to meet the minimum EPA regulations (2; 44).

represented a total of 2,500 working hours which was assumed to be spread equally over the twelve months, Table 6. Due to the high labor requirements of the dairy enterprise which exceeded that which could be provided by the operator's family an unlimited supply of hired labor was assumed to be available. The importance of hired labor was assessed in some models.

Capital Accounting

Capital accounting was administered on an individual enterprise basis. Charges on operating capital and fixed assets were assessed at a nine percent interest rate. Each crop was run through a simulation model (27) which specified the equipment required, amount of equipment used, depreciation, taxes, repair costs, labor requirements, fixed capital and total operating capital for the given set of characteristics of the model farm area. Labor charges were subtracted from this amount with the hours of labor used for the cropping enterprise being allocated to the time periods in which they occurred. The remainder, including capital charges, was represented in the c_j row in the linear programming model as the net cost to produce that activity.

Farm Product Price Assumptions

Prices used for all livestock and grain selling and/or buying activities were formulated from prices received by Iowa farmers in 1976 (Table 7). To insure that prices were not influenced by an unusual market activity, the 1976 prices were compared with the average price of

Table 6. Availability of operator labor

Period	Hours available
Period I	1040
Period II	208
Period III	208
Period IV	208
Period V	208
Period VI	208
Period VII	208
Period VIII	208

Table 7. 1976 farm product price averages (46)

Item	Price	Unit
Corn	2.45	bu.
Oats	1.48	bu.
Soybeans	5.55	bu.
Hay	57.67	ton
Soybean meal (44%)	10.23	cwt.
Milk	9.15	cwt.
Cull cows	24.97	cwt.
Yearling heifers	36.28	cwt.
Bull calves	29.00	hd.
Straw	40.00	ton

the products over a three year period 1974-1976. The price of baled hay demonstrated the only large price difference. When the price of baled hay was converted from a per ton to a per pound basis, the difference in price amounted to two-tenths of a cent per pound and was not considered enough to warrant using the three year average.

Class I and II Cropping Activities

To limit the size of the model Class I and II land production activities were restricted to the primary crops produced in the study area. Corn, oats and soybeans competed for Class I land, while Class II land was restricted to a rotation of 40 percent corn, 20 percent oats and 40 percent alfalfa-bromegrass. Production costs were simulated for each cropping enterprise (Table 8). These costs were reflected in the c_j row of the linear programming model representing an opportunity cost for producing that activity.

Harvesting and disposal methods varied from crop to crop. Soybeans could only be harvested and sold. Corn could be harvested for grain to be fed on the farm or sold, or harvested as silage for livestock fed on the farm. Oats could be harvested in the form of grain only for farm use or sale. Oatlage was not evaluated.

The hay produced from alfalfa-brome acreage had four possible harvest activities. The hay could be cut for haylage and fed to the dairy herd or the hay could be baled with the choices of baling 1-cut and grazing the remainder, baling 2-cuts and grazing, or baling all three cuts. All hay could be fed to the dairy herd and/or sold.

Table 8. Production costs of class I and class II crop activities (32)

	Alfalfa brome hay	Alfalfa brome haylage	Corn grain	Corn silage	Oats & straw	Soybean
Variable cost:						
Preharvest						
Seed	$ 8.40	$16.80	$ 12.60	$ 12.60	$ 9.00	$ 7.48
Nitrogen			19.20	19.20	4.80	
Phosphate	9.62	9.62	7.87	11.37	5.25	5.25
Potash	14.40	14.40	4.80	12.00	7.20	3.20
Lime	1.80	1.80	1.80	1.80	1.80	
Insecticide			6.00	6.00		
Herbicide			10.00	10.00		12.00
Twine	6.72				3.60	
NH_3 application			3.00	3.00		
Tractors	0.92	1.83	6.71	3.73	0.78	3.27
Machinery	2.28	3.06	6.71	3.73	0.78	3.27
Interest on opr. capital	2.54	2.77	3.73	2.31	0.09	1.86
Harvest						
Machinery	4.21	3.32	22.63	11.41	12.46	13.64
Tractors	11.19	9.16	1.50	5.33	4.49	0.40
Total variable costs	$62.08	$62.76	$104.28	$ 93.46	$50.84	$48.90
Fixed costs:						
Machinery	11.07	11.16	10.30	13.31	3.90	4.89
Tractors	15.02	13.63	6.49	11.24	6.53	4.55
Total fixed costs	$26.09	$24.79	$ 16.79	$ 24.55	$10.43	$ 9.44
Total cost (c_j values)	$88.17	$87.55	$121.07	$118.01	$61.27	$58.34

Yields for each of the crops, Table 9, were a function of the class of land. As the slope increased yields were reduced and represented yields typical of the study area.

Table 9. Yields per acre of class I and II land activities (32; 38)

Activity	Unit	Class I	Class II[a]
Corn	bu.	113.00	105.0
Corn silage	tons	16.00	14.9
Soybeans	bu.	34.00	-
Oats	bu.	80.00	74.0
Straw	tons	2.15	2.0
Alfalfa brome haylage	tons	-	7.7
Alfalfa brome hay	tons	-	4.2
Alfalfa brome hay (1 cut)	tons[b]	-	2.3
Alfalfa brome hay (2 cuts)	tons[c]	-	3.5

[a]Yields expressed on a wet matter basis.

[b]Grazed after first cut.

[c]Grazed after second cut.

CHAPTER IV: THE DAIRY ENTERPRISE

In the initial matrix the dairy herd consisted of 40 cows with all replacements grown within the herd. The herd produced 12,000 pounds of milk annually per cow with milk being sold at an all-milk price basis which is a composite average of the fluid and manufacturing grade prices.

The number of cows during the simulation was not allowed to vary. In order to keep a consistent number of cows in the milking line, year-around calving was an assumed management practice.

Dairy enterprise costs were divided into three categories. Fixed cost included charges for the building and equipment requirements of the dairy herd. Constant per cow unit costs consisted of salt and mineral veterinary expenses, supplies, equipment repair, etc. Variable costs were defined to be the amounts of concentrates and roughages needed to satisfy the nutritional requirements of the herd. The types and amounts of concentrates and roughages required were determined within the linear programming model on a least-cost basis.

In determining the nutritional requirements of the herd, crude protein and total digestible nutrients were specified as minimum requirements. Stomach capacity was a maximum constraint. Nutrient requirements varied by the stage of milk production and the age of the replacement animal (discussed later).

Labor Requirements

The labor requirements of the milking herd were dependent on the type of milking system used and the number of cows. On the model farm a 40-cow stanchion barn was used with a mechanical portable pipeline milking system and conventional manure handling. Sixty-nine hours of labor/cow was the estimated annual labor requirement to operate the system (24). The sixty-nine hours included all time necessary for gathering the cows for milking, milking and clean-up, feeding, bedding and manure disposal.

With continuous calving as the assumed management practice it was not necessary to differentiate the labor hours with respect to the seasonal lactation cycle, viz high-lactating, low-lactating or dry cow stage. At any point in time it was expected that their would be approximately 17 high lactating cows, 17 low lactating cows and 6 dry cows. Labor requirements were assumed to be homogenous throughout the year, thus the average monthly labor requirement for a cow unit was 69/12 or 5.75 hours (Table 10).

Labor requirements for replacements grown within the herd were handled in a similar manner. The monthly labor requirements of a replacement heifer between 0-12 months and a replacement heifer 12-24 months of age were .50 hours/month and .286 hours/month, or 6.0 hours/year and 3.816 hours/year, respectively (25).

Fixed Costs

Due to the lack of information on purchase costs and present values of existing facilities with their salvage values and depreciation rates it was necessary to estimate the costs of new facilities and equipment. These building and equipment costs were estimated from a survey of

Table 10. Labor requirements for the dairy herd[a] (24)

	Dairy cow	Replacement I (0-12 mo.)	Replacement II (12-24 mo.)
		-Hours-	
I (Dec.-Apr.)	28.75	2.50	1.430
II (May)	5.75	0.50	0.286
III (June)	5.75	0.50	0.286
IV (July)	5.75	0.50	0.286
V (August)	5.75	0.50	0.286
VI (September)	5.75	0.50	0.286
VII (October)	5.75	0.50	0.286
VIII (November)	5.75	0.50	0.500
Total	69.00[a]	6.00	3.432

[a]Hours on a per head basis.

building contractors and equipment dealers. The costs arrived at are shown in Table 11.

The values obtained from the survey were placed in a computer budget generator to determine the relevant annual ownership and operating charges for each piece of equipment, Table 12. Total ownership charges included depreciation, interest on investment, taxes and insurance. Operating charges included costs necessary for proper maintenance. Machinery used for the dairy enterprise which was also used for other enterprises was charged to the dairy enterprise on a percentage of use basis, Table 13. For example, the dairy herd needed only 45 percent of the silo space for haylage, therefore, it was charged 45 percent of the ownership and operating costs. Excess silo capacity was assumed to be absorbed by other livestock activities.

Constant Variable Costs

Costs which were held constant on a per cow unit basis are short run costs that were not allowed to vary in the model planning horizon of one year. These constant variable costs were delineated into two parts; livestock investment and operating inputs. Livestock investment included the milking herd and the replacements saved from each calf crop, Table 14. Operating inputs encompassed salt and mineral needs, artificial insemination (AI), breeding fees, bedding, calf starter, milk replacer, veterinary bills, etc., Table 15.

Total Fixed Cost

Total fixed costs are calculated by summing fixed costs and constant costs, Table 16. A 9 percent charge for capital was used in arriving

Table 11. Salvage value and repair costs of dairy housing and equipment (31)

Item	Purchase price	Years life	Salvage value % of purchase price	Lifetime repair cost % of purchase price
40-cow stanchion barn	$28,207.00	20	10	5
Milk house	9,680.00	20	10	5
Mechanical portable				
Pipe line	2,643.00	10	20	40
Bulk milk cooler	4,762.00	20	11	4.5
Silo, silage (upright)	8,293.00	20	0	30
Silo, haylage (upright)	8,293.00	20	0	30

Table 12. Total annual housing and equipment charges (31)

	Purchase price	Depreciation cost	Interest charge	Insurance costs	Taxes	Repairs	Total ownership charge/yr.	Total operations charge/yr.
				-Dollars-				
40-cow stanchion barn	$28207.00	1269.31	1396.25	77.57	321.14	70.52	1668.02	70.52
Milk house	9680.00	435.60	479.16	26.62	110.21	24.20	572.43	24.20
MR. portable pipeline	2643.00	211.44	142.72	7.93	32.83	105.72	252.20	105.72
Silo, silage	8293.00	414.65	373.18	20.73	85.83	124.39	521.21	124.39
Silo, hay	8293.00	414.65	373.18	20.73	85.83	124.39	521.21	124.39
Bulk milk cooler	4762.00	211.91	237.86	13.21	54.71	10.71	279.83	10.71

Table 13. Annual equipment charges (31)

	Proportion of cost charged	Ownership charges	Operating charges	Interest charges
40-cow stanchion barn	1.00	$1668.02	$ 70.52	$1396.25
Milk house	1.00	572.42	24.20	479.16
Mechanical portable pipeline	1.00	252.20	105.72	142.72
Bulk milk cooler	1.00	279.83	10.71	237.86
Silo, silage	0.55	286.67	68.42	205.25
Silo, haylage	0.45	234.55	55.98	167.93
Total		$3293.70	$335.55	$2629.17

Table 14. Livestock investment (46)

Type	Number	Value/unit	Total value
Heifer calves (6 mo.)	11.00	$110.00	$ 1,210.00
Yearling heifers	10.00	330.00	3,300.00
Dairy cows	30.00	456.50	13,694.00
Total livestock investment			$18,204.99

Table 15. Constant costs per 40-cow dairy herd (24; 31)

Input	Units	Rate units	# of units	Total units	Price unit	Value
Salt & min.	lbs.	130.00	40.00	5,200.00	$ 0.09	$ 468.00
Bedding	tons	0.50	40.00	20.00	30.00	600.00
Milk replacer	lbs.	30.00	16.00	480.00	0.35	168.00
Calf starter	lbs.	99.96	16.00	1,599.36	0.12	191.92
Breeding fee (AI)	dol.	1.00	40.00	40.00	13.00	520.00
Herd records	dol.	1.00	40.00	40.00	10.00	400.00
Vet. & med.	dol.	1.00	40.00	40.00	15.50	620.00
Supplies & misc.	dol.	1.00	40.00	40.00	16.00	640.00
Power-fuel	dol.	1.00	40.00	40.00	20.00	800.00
Total input cost						$4,407.92

Table 16. Total fixed cost per 40-cow dairy herd

	Amount	Charge rate	Total charge
Fixed cost			
Ownership charges (taxes depreciation insurance	$ 3,293.70	1.00	$ 3,293.70
Operating charges (repairs)	335.55	1.09	365.75
Interest charges (equipment)	2,629.17	1.00	2,629.17
Constant variable cost			
Inputs	4,407.92	1.09	4,804.63
Livestock investment	18,204.99	0.09	1,638.45
Total adjusted fixed cost			$12,731.70

at an adjusted total fixed cost. In summary, the total adjusted fixed cost was $12,731.70 for the 40 cow herd for an average fixed cost of $318.29 per cow unit.

Nutritional Requirements and Replacement Activities

The large variation in nutritional requirements within the dairy herd made it necessary for the herd to be divided into nutritional categories by level of milk production and age of replacement stock. Minimum nutritional requirements were calculated on a dry matter basis for each category. In addition, a maximum amount of dry matter that could be ingested was formulated to reflect the stomach capacity of the animals in each category (Table 17).

The milking herd nutritionally was divided into three groups on the basis of their milk production, i.e. high lactating, low lactating and dry cows. The high lactating group consisted of cows in their first five months of lactation with an average daily production of 44 lbs. of milk/day. The low lactating group included the cows in the last five months of lactation with an average daily production of 33 lbs. of milk/day. The dry cow group contained cows that were not producing milk but were assumed to be in the last two months of gestation.

In order to divide the milking herd into three groups it was necessary to make the following assumptions:

1. the herd manager used continuous calving as a management practice,

Table 17. Nutrient requirements for dairy herd producing 12,000 lbs. of milk per year[a] (33)

	Unit	Period I	Period II-VIII
High lactating			
CP	lbs.	304.83	60.94
TDN	lbs.	1,515.20	303.04
DM	lbs.	2,337.83	467.57
Low lactating			
CP	lbs.	260.25	52.05
TDN	lbs.	1,330.83	266.16
DM	lbs.	2,220.51	444.10
Dry			
CP	lbs.	54.62	10.92
TDN	lbs.	340.00	68.00
DM	lbs.	711.70	142.30
Replacement I (0-12 months)			
CP	lbs.	150.50	30.10
TDN	lbs.	935.00	187.00
DM	lbs.	2,287.50	457.50
Replacement II (12-24 months)			
CP	lbs.	277.00	55.40
TDN	lbs.	1,800.70	360.10
DM	lbs.	3,431,25	686.25

[a]CP--crude protein, TDN--total digestible nutrients and DM--dry matter.

2. the average calving interval was twelve months,

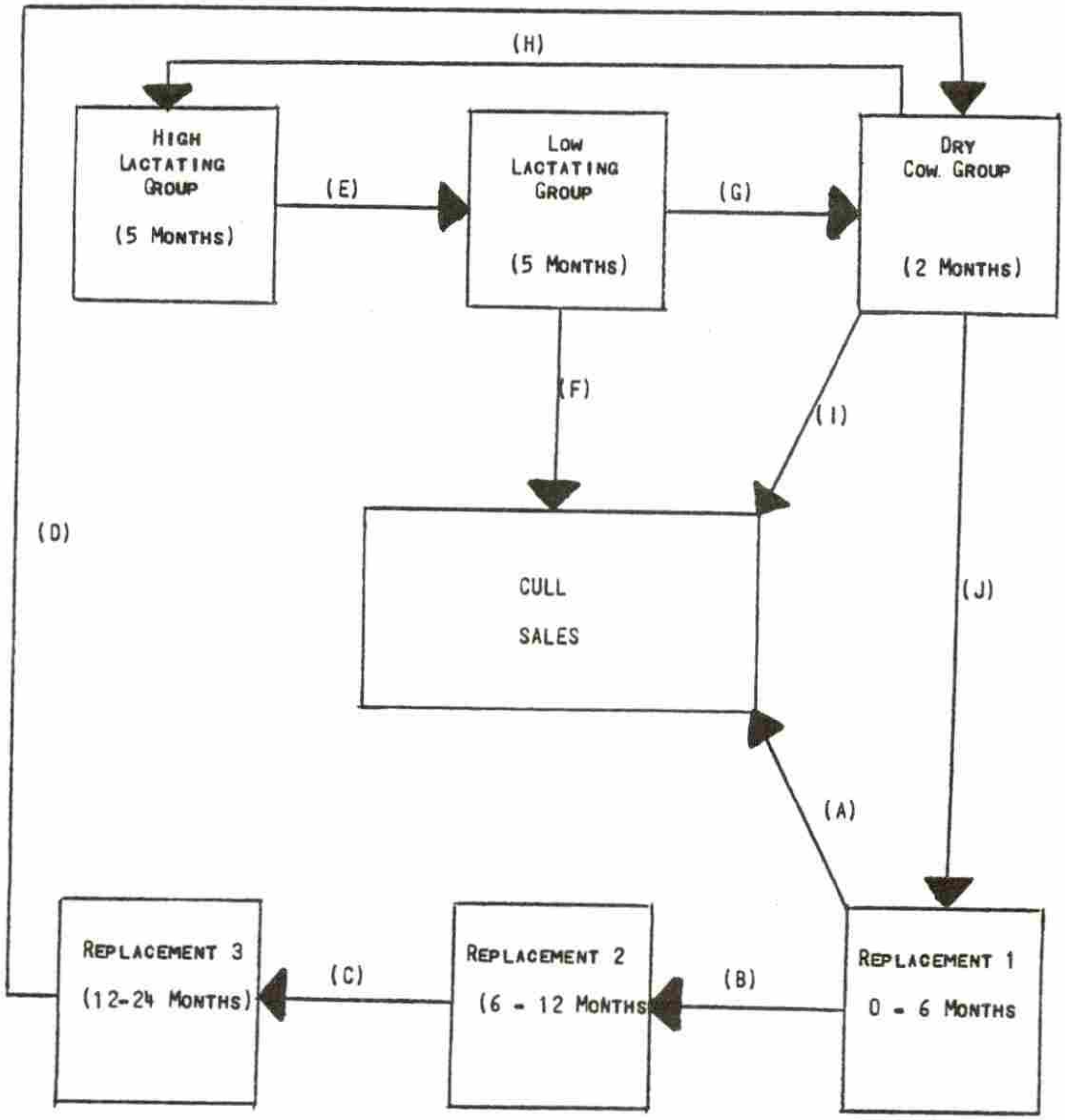
3. the average lactation was 305 days in length (10 months).

The annual replacement rate of the milking herd was assumed at 25 percent with all replacement coming from within the herd. An average calving rate of 85 percent was assumed with 50 percent heifers and 50 percent bull calves being born. All bull calves were immediately sold while heifer calves were kept a minimum of six months. After six months the needed replacement heifers were selected to enter the replacement growing activities while the remainder was sold (Figure 2).

Heifers in the replacement growing activities were nutriently divided into two groups: replacement I and replacement II. Replacement I consisted of heifers that were six to twelve months of age. Replacement II included heifers that were twelve to twenty-four months of age. After twenty-four months the replacements entered the dry cow activity for their last 2 months of gestation. The replacement ration was determined on a least cost basis satisfying minimum requirements for crude protein and total digestible nutrients expressed on a dry matter basis while not exceeding dry matter stomach capacity.

Stored Feeds for Consumption by Dairy Herd

Production of corn, corn silage, hay, haylage and oats on Class I and II land had the option of being sold or stored for feeding to the dairy herd. Storage and feeding losses were to be added to the actual amount of nutrient ingested from each feedstuff to arrive at the amount to be stored, Table 18.



Where

A - Cull Replacement (6 Months)

B - Replacement Heifers (6 Months)

C - Replacement Heifers (12 Months)

D - Replacement Heifers (24 Months) (Entering Last 2 Months of Gestation)

E - Lactating Cows (After 5 Months Lactating)

F - Cull Cows (End of 10 Month Lactation)

G - Lactating Cows (End of 10 Month Lactation)

H - Freshened Cows (After Calving)

I - Bull Calves (0 Months)

J - Heifers Calves (0 Months)

Figure 2. Dairy replacement flow chart.

Table 18. Feeding and storage losses (25)

Feedstuff	Storage loss %	Feeding loss %	Total loss %
Corn silage	7	12	19
Haylage	8	12	20
Hay	3.6	8	11.6
Corn	0.5	3	3.5
Oats	0.5	3	3.5
Soybean meal-44%	0.0	3	3

Storage loss is attributed mainly to spoilage and handling. Feeding loss is the waste that occurs at feeding time due primarily to transport and trampling. Total losses due to storage and feeding were estimated at 19-20 percent for silages and 3.5 percent for the concentrates.

After adjusting for feeding and storage losses it was necessary to transform the stored feeds into their respective nutritional components used to balance the dairy herd ration (Table 19).

Table 19. Nutrients supplied per pound of feedstuff on a dry matter base[a] (33)

Feedstuff	Unit	DM	TDN	CP
Alfalfa-bromegrass Haylage	lb.	.550	.297	.0792
Alfalfa-bromegrass Hay	lb.	.825	.45375	.13365
Corn silage		.400	.280	.0324
Corn grain	lb.	.89	.8099	.089
Oat grain	lb.	.90	.6840	.1197
Soybean meal (44%)	lb.	.89	.7209	.45835

[a]Feeding and storage losses not included.

CHAPTER V: PASTURE VARIETIES AND PASTURE MANAGEMENT SYSTEMS

Due to the slope of Classes III and IV, land production activities were limited to the growing of grasses for use in suppling the summer roughage needs of the dairy herd. The importance of roughage production for the dairy herd must not be understated. Feed costs have been estimated at between 40 and 42 percent of the total yearly cost of operating a dairy herd (24). While the cost of the concentrate portions of the ration is more clearly defined on a year to year basis, the cost of roughages, and in particular pasture, is not.

In this chapter an attempt is made to outline some of the top producing pasture varieties in northeast Iowa is outlined. Representative pasture varieties will be discussed that reach maximum production at different times of the season (spring, summer, fall, all season) including native Kentucky bluegrass. Management strategies that can lengthen the grazing season, including deferred grazing and methods to reduce grazing loss, will be discussed.

Selected Pasture Varieties, Yields and Production Costs

On Class III land selected pasture varieties were: bromegrass, orchard grass-birdsfoot trefoil, reed canary grass, sudan grass and improved Kentucky bluegrass. On Class IV land production was limited to native Kentucky bluegrass due to the slope.

Reed canary grass and bromegrass were considered early spring-late fall grasses with approximately 45 percent of their total production coming in April-May and 35 percent in October-November. With yields of 823 lbs./acre and 778.4 lbs./acre, respectively (Table 20) they were the highest producing varieties.

Orchard grass-birdsfoot trefoil was selected to represent the all season grasses. Production of orchard grass-birdsfoot trefoil peaks in mid to late summer with over 65 percent of its total production coming in June, July and August. Total production from orchard grass-birdsfoot trefoil was 7568 lbs./acre.

Kentucky bluegrass was also selected to represent the all season grasses. Kentucky bluegrass production peaks in May and June and drops off through the summer months and increases in the fall. The yield from unimproved Kentucky bluegrass is extremely low at 2518 lbs./acre but with a nitrogen sidedressing of 80 lbs./acre the yield can be more than doubled to 5135 lbs./acre. Although the yield from unimproved Kentucky bluegrass is nearly 3000 lbs./acre less than the top variety considered (reed canary), it has an advantage in being the native grass of the area and is hardy.

This advantage is illustrated in the differences in production cost of $42.35/acre while improved Kentucky bluegrass is $24.58/acre representing a difference of $17.77/acre. This difference can be accounted for through the additional cost of seed and increased fertilizer requirements of reed canary grass in order to adapt it to the soil conditions of the area.

Sudan grass was used to represent the warm season grasses. Due to nature of sudan grass it can only be grazed four months a year. In

Table 20. Total pasture yields in pounds by land class[a] (38; 48)

Pasture variety	Class II	Class III	Class IV
	Continuous grazing		
Kentucky bluegrass			2518
Kentucky bluegrass (improved)		5405	5135
Reed canary		8023	
Orchard grass-birdsfoot trefoil		7568	
Bromegrass		7784	
Alfalfa-brome (after 1-cut)	4597		
Alfalfa-brome (after 2-cuts)	2364		
	Deferred grazing		
Sudan		7351	
Orchard grass-birdsfoot trefoil		7114	
Reed canary		7577	
Bromegrass		7352	

[a]Yields expressed in pounds on a wet matter basis.

July, August and September nearly 95 percent of its 7351 lbs./acre yield is produced. With the first freeze, sundangrass reaches a toxic state that is poisonous to animals and it must be rested until the toxic condition has diminished. After resting it a month (October) or until after the first freeze it can be grazed for the remainder of November.

On the other classes of land, production of grasses was limited. One Class II land alfalfa-brome could be grazed after one or two cuttings of hay were taken, yielding 4597 lbs./acre and 2364 lbs./acre for grazing respectively. The severity in slope of the Class IV land limited grass production to the native Kentucky bluegrass with the option of being fertilized with 80 lbs./acre of nitrogen to improve its yield.

The labor requirements and production costs for each grass variety are given in Table 21. Production costs include all relevant equipment, seed, fertilizer and interest charges. Production costs were taken from extension budgets run for that area using the Oklahoma State budget generator (27).

To illustrate how production costs were arrived at for each individual crop, the budget for birdsfoot trefoil-orchard grass is given in Table 22. The variable costs include all seed, fertilizer, herbicide charges, operating charges for machinery, and tractors used and interest on operating capital.

The fixed cost includes charges for machinery and equipment. The fixed cost for machinery and equipment includes depreciation, insurance and taxes on those items used in production and are allocated to the activity on a cost/acre charge.

Table 21. Production costs of grasses on class III and class IV land (32; 39)

Variety	Production cost/acre[a] (dollars)	Hours of labor required/acre (hours)
	Class III land	
Bromegrass	45.95	0.69
Kentucky bluegrass (improved)	24.58	0.69
Birdsfoot-trefoil orchardgrass	37.39	
Sudan grass	43.85	0.69
Reed canary grass	42.35	0.69
	Class IV land	
Kentucky bluegrass (unimproved)	2.92	0.00
Kentucky bluegrass (improved)	24.58	0.69

[a]Production costs include all relevant equipment, seed, fertilizer and interest charges.

Table 22. Production costs for birdsfoot-trefoil-orchardgrass pasture per acre (32; 39)

	Unit	Cost/ unit	Quantity	Cost/ unit
Variable costs				
Trefoil	lbs.	$ 1.75	0.80	$ 1.40
Orchardgrass	lbs.	0.60	0.40	0.24
Phosphate	lbs.	0.17	45.00	7.87
Potash	lbs.	0.08	30.00	2.40
Lime	tons	3.60	0.50	1.80
Herbicide	dollar	14.50	1.00	14.50
Machinery	acre	3.06	1.00	3.06
Tractors	acre	1.72	1.00	1.72
Interest on opr. cap.	dollar	0.09	16.45	1.48
Total variable costs				$34.47
Fixed costs				
Machinery	acre	0.78	1.00	0.78
Tractors	acre	2.14	1.00	2.14
Total fixed costs				$ 2.92
Total cost/acre				$37.39

Pasture Management Systems

Increasing pasture production, length of grazing season and minimizing grazing loss depends on proper pasture management. To maximize pasture utilization four pasture management strategies were considered:

1. Continuous grazing--turning the cows out to pasture and leaving them on the total pasture throughout the pasture season.
2. Rotation grazing--dividing the pasture into two or more areas and rotating the dairy herd from one pasture to another on a planned schedule.
3. Deferred grazing--allowing a pasture one or two months rest between grazing seasons at a recommended time for that pasture variety.
4. Deferred rotational grazing--rotational grazing practices used on deferred pastures.

All pasture varieties with the exception of sudan grass could be continuously grazed, Table 23. The major advantage to conventional (continuous) grazing is the minimum amount of labor and management required. The major disadvantage of the system is the amount of feed loss. An estimated 60 to 70 percent of total grass production is lost under a continuous grazing system (36).

Rotational grazing could occur on any pasture variety. Under a rotational grazing system it was assumed that the herd manager would rotate the herd three times a month. The major advantage to rotational grazing is the reduction in feed loss compared to a continuous grazing system. A reduction from 65 to 43 percent loss in total yield adds

Table 23. Pasture management strategies

Pasture variety	Harvesting method[a]
Alfalfa-brome (after 1-cut hay)	C, R
Alfalfa-brome (after 2-cuts hay)	C, R
Bromegrass	C, R, D, DR
Kentucky bluegrass (unimproved)	C, R
Kentucky bluegrass (improved)	C, D, R, DR
Birdsfoot trefoil-orchard grass	C, D, R, DR
Sudan grass	D, DR
Reed canary grass	C, D, R, DR

[a]C = continuous grazing; R = rotational grazing; D = deferred grazing; RD = rotationally-deferred grazing.

greatly to the nutrient supply harvested from a pasture. The disadvantages to this system are the additional cost and labor requirement needed and; the increased managerial skills necessary to administer the grazing system.

The constant cost associated with rotational grazing was estimated at $4.65/acre/month. This cost included battery charger, posts and insulators amortized over their useful lives. The additional labor requirements for erecting the fence was estimated at .4 hours/acre or 1.2 hours each month the rotational system was used.

The grazing intensity under a rotational grazing system necessitates increased managerial surveillance of pastures. Pastures that are grazed too long will be slow in rejuvenating foilage thus decreasing pasture yields.

Bromegrass, reed canary grass, birdsfoot trefoil-orchard grass and sudan grass had the option of being used as deferred pastures. Deferred grazing in most cases lowers yields (Table 24) of pastures but it allows the herd manager to evenout pasture production and to provide adequate forage supply to the dairy herd over an extended grazing season. Table 24 illustrates the grazing seasons of pasture varieties under a deferred grazing system.

Deferred rotational grazing is simply rotational grazing on deferred pastures. This is another means for increasing harvested grass production and providing an adequate supply of forages to the dairy herd.

Table 24. Deferred grazing periods for pastures (48)

Variety	Months grazed	Months rested
Bromegrass	May 1-June 30 Oct. 1-Nov. 30	July 1-Sept. 30
Reed canary	May 1-July 31 Oct. 1-Nov. 30	Aug. 1-Sept. 30
Birdsfoot trefoil-orchard grass	May 15-June 15 July 16-Sept. 15 Oct. 16-Nov. 30	June 16-July 15 Sept. 16-Oct. 15
Sudan grass	July 5-Sept. 15 Oct. 10-Nov. 10	Sept. 16-Oct. 9

Pasture Nutrients Supplied to the Dairy Herd

The pasture nutrients supplied to the dairy herd are given in Table 25. The nutrients are given in the form of crude protein, total digestible nutrients and dry matter that would be supplied by each pasture to the dairy herd on a month to month basis.

To arrive at the results shown in Table 25, pasture yields in a given month were adjusted downward to reflect the feed loss of the grazing system use. For continuous grazing, the pasture yield adjustment was downward 65 percent and for rotational grazing 43 percent. Adjusted yields were then converted on a dry matter basis into crude protein, total digestible nutrients and dry matter that could be directly used to satisfy the nutrient requirements of the dairy herd.

Table 25. Forage nutrients supplied to the dairy herd under grazing systems by land class[a, b] (39; 48)

	Continuous grazing class II land	
	Alfalfa brome (after 1 cut)	Alfalfa brome (after 2 cuts)
P I (Dec.-April)		
CP		
TDN		
DM		
P II (May)		
CP		
TDN		
DM		
P III (June)		
CP		
TDN		
DM		
P IV (July)		
CP	76.9	
TDN	275.7	
DM	483.8	
P V (August)		
CP	76.9	64.1
TDN	275.7	229.8
DM	483.8	403.1
P VI (September)		
CP	32.0	25.6
TDN	114.9	91.9
DM	201.6	161.2
P VII (October)		
CP	32.0	25.6
TDN	114.9	91.9
DM	201.6	161.2
P VIII (November)		
CP	6.4	
TDN	2.3	
DM	40.3	

[a]CP = crude protein, TDN = total digestible nutrients and DM = dry matter.

[b]Nutrients expressed in pounds on a dry matter basis.

Continuous grazing class III land		
Brome-grass	Reed canary grass	Birdsfoot-trefoil orchard grass
114.0	117.4	35.9
408.6	421.1	128.7
716.8	738.8	225.7
114.0	117.4	97.1
408.6	421.1	348.1
716.8	738.8	610.6
38.0	39.2	92.9
136.2	146.4	332.9
238.9	246.3	584.1
19.0	19.6	73.8
68.1	70.2	264.9
119.5	123.1	464.6
38.0	39.2	35.9
136.2	140.4	128.7
238.9	246.3	225.7
38.0	39.2	16.8
136.2	140.4	60.5
238.9	246.3	106.2
19.0	19.6	16.8
68.1	70.2	60.5
119.5	123.1	106.2

Table 25. (Continued)

	Continuous grazing class III	Continuous grazing class IV	
	Kentucky bluegrass (improved)	Kentucky bluegrass (unimproved)	Kentucky bluegrass (improved)
P I (Dec.-April)			
CP			
TDN			
DM			
P II (May)			
CP	79.1	37.6	75.2
TDN	283.6	134.8	269.5
DM	497.7	236.4	472.9
P III (June)			
CP	79.1	37.6	75.2
TDN	283.6	134.8	269.5
DM	497.7	236.4	472.9
P IV (July)			
CP	39.6	18.8	37.6
TDN	141.8	67.4	134.8
DM	248.9	118.2	236.5
P V (August)			
CP	19.7	12.5	18.8
TDN	70.9	44.9	67.4
DM	124.3	78.8	118.2
P VI (September)			
CP	26.4	12.5	25.1
TDN	94.6	44.9	89.8
DM	166.1	78.8	157.6
P VII (October)			
CP	19.7	6.2	18.8
TDN	70.9	22.5	67.4
DM	124.3	39.4	118.2
P VIII (November)			
CP			
TDN			
DM			

Brome-grass	Reed canary grass	Birdsfoot trefoil orchard grass	Sudan grass
	Deferred grazing class III		
107.6	110.4	36.9	
385.9	395.7	132.4	
677.0	694.3	232.3	
107.6	82.8	36.9	
385.9	296.8	132.4	
677.0	520.7	232.3	
	44.1	88.7	137.2
	158.3	317.8	491.7
	277.7	557.5	862.8
		110.9	137.2
		397.2	491.7
		696.9	862.8
		29.6	62.0
		105.9	222.3
		185.8	390.1
89.4	77.3	44.3	
317.8	277.0	158.9	
557.6	486.0	278.8	
54.9	55.2		25.3
196.7	197.9		90.8
345.1	347.1		159.3

CHAPTER VI: ANALYSIS OF ALL SOLUTIONS

In this chapter, the optimal solution of the multi-period linear programming model will be analyzed with specific attention given to Class III and IV land. This model, based on coefficients developed in earlier chapters, will be used as a benchmark to evaluate alternative scenarios. Scenarios will analyze the effects of alternative levels of milk production and herd size on breakeven milk and labor prices for the dairy herd and optimal selection of pasture varieties and pasture management strategies that will maximize returns to the farm manager.

Base Model Solution

The base model consisted of the characteristics developed in chapters 3, 4 and 5 and are summarized in Table 26. The milking herd was limited to 40 cows and not allowed to vary upwards or downwards in the base model. The cows in the milking herd were assumed to produce 12,000 pounds of milk per cow in a continuous 12 month calving cycle with all replacements being grown within the herd.

The labor used to operate the base farm consisted of two types: management labor and hired labor. The managerial labor was assumed to be provided at zero cost, thus the c-row values of the solutions will represent net income to the farm manager for his land, labor and managerial skills. The availability of hired labor was assumed to be infinite at a cost of $4.50 per hour.

The solution to the base model yielded the farm manager $30,555.78 in net income, Table 27. The optimal solution used all of the land in

Table 26. General characteristics of base model

Item	Level	Unit
Class I land	140	acres
Class II land	50	acres
Class III land	35	acres
Class IV land	35	acres
Milking herd size	40	head
Milk production level	12,000	lbs./head
Milk price	9.15	dollars/cwt.
Corn grain selling	2.45	dollars/bu.
Oat grain selling	1.48	dollars/bu.
Soybean grain selling	5.55	dollars/bu.
Straw selling	40.00	dollars/ton
Hay selling	57.67	dollars/ton
Hay buying	60.00	dollars/ton
Soybean meal buying	10.23	dollars/cwt.
Labor hiring	4.50	dollars/hour

Table 27. Marginal value products of base solution

Constraint	Level	MVP (dollars)
Value of program	$30,555.78	1.00
Class I land	140.00	150.14
Class II land	50.00	143.17
Class III land	30.03	23.17
Class IV land	35.00	16.29
Milk cows	40.00	-255.58

each land classification. The marginal value products (MVP) which represent the amount of net income added from the last unit of the resource used, for Class I, II, III and IV land was \$150.14, \$143.17, \$23.17 and \$16.29, respectively. The MVP of the dairy cow constraint was -\$255.58. This illustrates that the last dairy cow unit caused the manager's income to be decreased by \$255.58.

Optimal crop production activities by land classifications are given in Table 28. Class I land all went into corn production with 128.81 acres being harvested as grain and 11.19 acres as corn silage. Class II land had 20 acres harvested as alfalfa-brome haylage, 20 acres as corn silage and 10 acres as oat grain and straw.

Class III land used all 35 acres available and exhibited an interesting pasture production and management pattern. Bromegrass was produced on 20.62 acres with 8.88 acres being grazed on a rotational basis and 11.74 acres being grazed on a deferred rotational pattern. Sudan grass was produced on the remaining 14.38 acres and was grazed in a rotational pattern. Class IV land was left as unimproved Kentucky bluegrass and grazed continuously.

The selection of deferred bromegrass and sudan grass as the pasture varieties on Class III land indicates that the optimal pasture planting and harvesting strategy was to maximize the length of the grazing season subject to a relatively even flow of nutrients from those pastures throughout the grazing season. Deferred bromegrass is grazed May through June, rested in July, August and September and then cannot be grazed

Table 28. Production activities by land classification--base model

Activity	Acreage
Class I land	
Corn grain	128.81
Corn silage	11.19
Class II land	
Alfalfa-brome haylage	20.00
Oat grain	10.00
Corn silage	20.00
Class III land	
Bromegrass	
Rotational	8.88
Deferred rotational	11.74
Sudan grass rotational	14.38
Class IV land	
Kentucky bluegrass (unimproved continuous)	35.00

until December, Table 25. While bromegrass does not yield as well as reed canary grass and costs slightly more to plant, it tends to complement sudan grass production more effectively. Sudan grass which is a warm season grass produces high yields in July, August and the first half of September and rested a month and then grazed until the middle of November. In the month that sudan grass is resting the yield from bromegrass is 14.6 percent higher than deferred reed canary grass, Table 25, thus overall giving a more consistent yield per acre per month when combined with sudan grass.

The labor needed to run the farming and dairy operation necessitated the hiring of labor in every period, Table 29, to supplement the labor provided by the manager. The 4346 hours of hired labor illustrates the importance of labor availability and the price of labor to the returns the manager receives. These factors will be addressed in more detail in the breakeven scenarios.

Labor and Milk Price Breakeven Analysis

To give a wide basis for the examination of breakeven milk and labor prices, the base model was extended to include herd production levels of 14,000 and 16,000 pounds of milk per cow per year in addition to the 12,000 pound level. To compensate for the increased production, total cost per cow unit and labor requirements per cow unit were adjusted upwards by 80 percent of the percentage increase in milk production, Table 30. For example, the change from 12,000 to 14,000 pounds per cow represents an increase of 16.67 percent in milk production multiplying

Table 29. Labor hiring in base model

Item	Level	Unit[a]
Labor hiring I (Dec.-April)	1519	hours
Labor hiring II (May)	468	hours
Labor hiring III (June)	401	hours
Labor hiring IV (July)	396	hours
Labor hiring V (August)	317	hours
Labor hiring VI (September)	422	hours
Labor hiring VII (October)	402	hours
Labor hiring VIII (November)	421	hours
Total labor hours hired	4346	hours

[a]Wage rate set at $4.50 per hour.

Table 30. Total fixed cost and labor requirements per cow unit at milk production levels of 12,000, 14,000, and 16,000 pounds of milk per cow per year

	Unit	Milk production level		
		12,000	14,000	16,000
Annual total fixed cost	dollars	344.58	390.52	433.48
Annual labor requirements	hours	69.0	78.2	86.8

this by 80 percent yields an increase of 13.33 percent in total cost per cow and labor requirements per cow. This algorithm was approximated from dairy extension budgets from the state of Iowa.

Increasing the milk production to 14,000 pounds and 16,000 pounds per cow per year necessitated changes in the nutrient requirements of crude protein, total digestible nutrients and stomach capacity expressed in dry matter, Table 31. Since, the only characteristic changed was the level of milk production only the nutrient requirements of the high lactating and low lactating cows needed to be altered.

The MVP of the dairy cow constraint was -$255.58 at 12,000 pounds of milk per cow level with a milk price of $9.15 per hundredweight. Parameterizing the price of milk from $10 to $15 per hundredweight in $1.00 intervals while setting the cow number constraint so that the number of cows could vary from 0 to a maximum of 40 depending on the optimal solution, Table 32, yielded a breakeven price per milk between $11.00 and $12.00 per hundredweight.

To determine the exact breakeven price per hundredweight, another parametric routine was used in prices between $11.00 and $12.00 per hundredweight that caused a basis change. A basis change gives the price at which there has been a change in the number of cows. The breakeven price determined by the basis change for the 40 cow herd was $11.30 per hundredweight of milk and yielded the farm manager $40,898.98 in net income.

At the 14,000 pound and 16,000 pound levels of milk production the marginal value products (MVP) of the dairy cow constraint were

Table 31. Nutrient requirements of lactating cows at 14,000 and 16,000 pounds of milk per cow per year[a] (33)

	Unit	Period I	Period II-VIII
14,000 lbs./cow/yr.			
High lactating			
CP	lbs.	340.44	68.09
TDN	lbs.	1661.26	333.25
DM	lbs.	2430.94	486.19
Low lactating			
CP	lbs.	288.29	57.66
TDN	lbs.	1446.33	289.27
DM	lbs.	2294.06	485.81
16,000 lbs./cow/yr.			
High lactating			
CP	lbs.	375.95	75.19
TDN	lbs.	1807.61	361.52
DM	lbs.	2524.05	504.81
Low lactating			
CP	lbs.	316.30	63.26
TDN	lbs.	1561.78	312.36
DM	lbs.	2367.62	473.52

[a]CP = crude protein, TDN = total digestible nutrients and DM = dry matter.

Table 32. Breakeven milk prices by level of milk production

Level of milk production	Unit	Breakeven milk price	Breakeven price net income	Initial net income[a]
12,000 lbs./cow/yr.	dollars	11.35	40,898.98	30,555.78
14,000 lbs./cow/yr.	dollars	10.58	40,298.73	32,315.00
16,000 lbs./cow/yr.	dollars	10.11	40,304.74	34,130.65

[a]Net income where milk price is $9.15 per hundredweight.

-$199.59 and -$154.35, respectively, and provided the farm manager with $32,315.00 and $34,130.65 in net income. Repeating the parameterization procedure of milk price established breakeven milk prices of $10.58 and $10.11 per hundredweight, respectively.

In summary, regardless of the herd production level examined, a breakeven milk price higher than the prevailing market price was necessary. Increased genetic potential of the milking herd substantially reduces the breakeven price.

Normally, the farm manager has no control over the price he receives for his product, but has some degree of control over hired labor price. To establish a breakeven labor price with free labor mobility, labor price was parameterized downward from $4.50 per hour in increments of 50 cents, Table 33. Herd size was left in the model at a level of 40 cows. At the 12,000 pound production level, as labor price decreased from $3.00 an hour to $2.50 an hour, the MVP of the dairy cow constraint turned positive, meaning that the last dairy cow unit added to the farm operator's net income. Linearly extrapolating the breakeven labor price for a 40 cow herd at 12,000 pounds of milk per year was $2.76 per hour. Repeating this procedure at the 14,000 pound production level yielded a breakeven labor price of $3.27 per hour, for the 16,000 pound level, of milk production the breakeven labor price was $3.60 per hour.

Affects of Grazing Intensity on Selection of Pasture Varieties and Grazing Management Strategies

To analyze the affects of increased grazing intensity on pasture variety selection and grazing strategies, herd size was parameterized

Table 33. Labor price breakeven analysis at all levels of milk production

Level of milk production	Unit	Labor price breakeven analysis with labor price/hr. at: $4.50	$4.00	$3.50	$3.00	$2.50
12,000 lbs./cow/yr.						
MVP of dairy cow constraint	dollars	-258.58	-181.04	-103.50	-25.97	51.80
Net income	dollars	30,555.78	32,728.88	37,901.97	27,075.07	39,254.75
14,000 lbs./cow/yr.						
MVP of dairy cow constraint	dollars	-199.59	-118.36	-37.10	44.33	125.82
Net income	dollars	32,315.00	34,680.18	37,046.50	39,417.69	41,790.30
16,000 lbs./cow/yr.						
MVP of dairy cow constraint	dollars	-154.35	-68.58	17.36	105.32	189.32
Net income	dollars	34,130.65	36,676.74	39,224.25	41,777.00	44,330.23

from 40 to 80 cows in increments of 10, Table 34. Total costs per cow except feed costs were considered linear functions, i.e., these costs remained unchanged on a per cow unit basis.

On Class III land, the increase in cow numbers from 40 to 50 caused all Class III land to be utilized. Bromegrass and sudan grass, harvested in a deferred-rotational grazing system which tends to maximize grazing season while producing a relatively even amount of forage, continued to dominate the 50 cow solution. As herd size increased from 50 to 80 cows, reed canary grass grazed in a deferred rotational system replaced the bromegrass and reduced the amount of acreage of sudan grass.

The replacement of bromegrass with reed canary grass as herd size increases suggests that at a certain intensity there is a substitution effect of quantity of pasture production over complementary pasture production. Deferred reed canary grass is a higher yielding variety at a slightly lower production cost than bromegrass but deferred reed canary grass, while being complementary, is not as complementary to the warm season sudan grass as bromegrass (discussed in base solution).

The selection of the warm season sudan grass with either the deferred rotational bromegrass or the deferred rotational reed canary grass at all herd size levels indicates that selection of pasture varieties and management of those pasture varieties should be done on the basis of maximizing production and the length of the grazing season while maintaining relatively even production levels throughout the grazing season. Secondly, rotational grazing appeared on all planned

Table 34. Pasture management systems by grazing intensity[a]

	Herd size[b] 40	50	60	70	80
			-acres-		
Class III land					
Sudan grass					
D-C					
D-R	14.38[c]	17.44	14.75	11.46	6.00
Bromegrass					
C					
R	8.88	1.68			
D-C					
D-R	11.74	15.88	2.51		
Reed canary					
C					
R					
D-C					
D-R			17.74	23.54	29.00
Class IV land					
Kentucky bluegrass					
U-C	35.00	21.83			
I-C		13.17	35.00	35.00	35.00
I-R					

[a] D = deferred pasture, C = continuous grazing, R = rotational grazing, U = unimproved pasture and I = improved pasture.

[b] Herd size expressed in cow units which include replacement stock.

[c] Yields expressed in acres.

pastures at all herd size levels in Class III land. This again seems to indicate that economically efficient use of planned or high producing pastures, rotational grazing may be necessary.

On Class IV land, at a 40 cow herd size Kentucky bluegrass was not improved (not fertilized) and was grazed continuously. As herd size increased to 60 cows, all 35 acres of Kentucky bluegrass were improved and grazed continuously; as herd size increased to 80, there was no change in the grazing pattern. This result leads to another implication about rotational grazing. Rotational grazing may not be economically feasible on low yielding pastures. Improving the native Kentucky bluegrass pasture is economically sound, but increases in the harvest by rotational grazing of improved Kentucky bluegrass did not offset the additional labor and fixed cost associated with rotational grazing.

Increases in herd size did not alter the MVP of Class I and II land, but did have an affect on Class III and IV land, Table 35. Class III land shows the greatest increase in MVP but levels off after a 70 cow herd size has been reached. At this point you are receiving the maximum return for an acre of Class III land given the production activities and constraints of the model.

Evaluating changes in herd size at increased levels of milk production (14,000 and 16,000 pounds per cow per year) yielded no significant changes in pasture production and pasture management. Therefore, presentation of these results are omitted.

Table 35. Marginal value product of class III and IV land by grazing intensity

Herd size	Marginal value product (MVP)	
	Class III land	Class IV land
40	23.18	16.29
50	47.68	21.78
60	71.54	26.43
70	78.97	28.27
80	78.97	28.27

CHAPTER VII: SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

In summary, an area in Eastern Iowa was identified as the location of the model farm based on density of dairy cows. From this area, using state publications and census data, the size of the model farm was determined by land classification. Through the use of extension budgets production costs, yields and labor requirements were determined for cash crops and pasture varieties. Selection of the pasture varieties was based on yields and compatability with the study region.

Herd size and level of production were selected to coincide closely with state averages. Housing, equipment and associated constant variable costs were determined based on herd size and level of production. Minimum nutritional requirements were calculated based on stage of lactation and age of replacement stock. The cost of the dairy rations was minimized within the multi-period linear programming model while maximizing returns to the farm manager for his land, labor and management skills.

The results from the base model indicate that the average dairy farmer is not in an economically advantageous position with respect to his milking operations. Breakeven analysis reveals that milk price would have to be increased from $9.15 per hundredweight to $11.44 per hundredweight when labor cost is $4.50 per hour, or labor price would have to decrease to $2.76 per hour for the 40 cow herd at 12,000 pounds per cow per year to be profitable. Scenarios that increase milk production reduce substantially the breakeven milk or labor price.

In summary, the breakeven analysis yields two primary factors that the dairyman has some control over that are crucial to having a profitable dairy herd: genetic potential and the availability of a relatively cheap labor force.

In analyzing the pasture variety selection and grazing systems on Class III land, two conclusions can be drawn. Regardless of the grazing intensity (40 to 80 cow units), some combination of the warm season deferred sudan grass and with deferred bromegrass or deferred reed canary grass was utilized. Pastures should be planned to maximize the length of grazing season. Secondly, all pastures on Class III land were rotationally grazed regardless of the intensity. This implies that to efficiently graze high producing pastures rotational grazing may be necessary.

Analysis of Class IV land which was limited to the native Kentucky bluegrass pasture showed that as cattle numbers increase, there is positive returns to improving pasture through fertilization. Even when Kentucky bluegrass was improved, it still maintained a continuous grazing system, as cattle numbers continued to increase rather than going to a rotational system. Thus implying that rotational grazing does not increase harvested nutrients sufficiently to offset labor and fixed costs of rotational grazing on relatively low yielding pastures.

In summary, full utilization of pastures can help keep ration costs down and improve herd profitability. Dairymen must consider the number of cow units that are allowed to graze and the amount of available pasture in determining optimal pasture utilization strategies.

The results of this study indicate the following recommendations to Iowa dairymen about pasture management and grazing strategies to help maximize dollar returns.

1. Fertilization of native Kentucky bluegrass greatly increases yield and economic returns from these pastures, but yields are still well below other pasture varieties.
2. Rotational grazing of improved Kentucky bluegrass pastures to increase harvested yield is not economically feasible. The value of the increased harvest is less than the labor and fixed cost of rotational grazing.
3. Deferred grazing of planted pastures, consisting of a warm season grass and early season grasses that tend to maximize the length of the growing season and maintains a relatively constant flow of production, is economically preferred to grazing a pasture continuously. Selection of pasture varieties used in two pasture deferred grazing systems should be made on the basis of adaptability of the variety to the area, yield, complementary grazing relationships between the varieties and production costs.
4. High yielding pastures should be rotationally grazed to increase production from these pastures. Furthermore, rotational grazing may be a necessary condition to justify production costs of these pastures.

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