A LINEAR PROGRAMMING MODEL FOR THE OPTIMIZATION OF MANAGEMENT DECISIONS ON THE DAIRY FARM

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ABSTRACT

Smith, John L., M.S., Purdue University, May 1974. A Linear Programming Model for the Optimization of Management Decisions on the Dairy Farm. Major Professor: Robert J. Rades.

The purpose of this study was to develop a linear programming model to aid dairy farmers in making management decisions. The model containes activities for crop production, including both forage and grain crops, for the feeding of livestock, for the production of milk, for the production of dairy beef, and activities for both raising and buying herd replacements. The model also includes activities for the hiring of seasonal labor, renting of additional land, hiring of custom hay harvesting and custom combining, and activities for the purchase and sale of hay and grain crops and the purchase of protein supplements.

The model considers the effect of early and late harvesting on the yield and quality of the crops produced. These effects are taken into consideration in the optimization of the forage and concentrate ration for the livestock and ultimately in the optimization of the crop production program.

The model provides the dairyman with a crop production schedule, a profit or loss statement, a land preparation schedule, a least-cost ration, including both forages and concentrates and a schedule of when to feed each crop, and a schedule of the value of additional units of the resources which limit the total dairy farm operation.

Although the model was not developed explicitly as an investment model, it can be used as such by making a number of revised runs to

analyze the effects of various investments.

The model was developed to be used as an extension oriented model which can be used with a remotely located computer terminal. For this reason the input considerations were kept to a minimum along with the size of the model matrix.

Tests were conducted to determine if the model was useful in solving problems of selected dairy farmers. These tests were conducted using six case farms located in Northern and Eastern Indiana. Farmers were asked to provide input data from their own farms, and this data was supplied to the model via remote terminal. The farmers then studied the output from their initial run and were allowed to make revised runs to consider the effects of market changes, or changes on their farms, such as new investment decisions.

Of the six case farms used in the tests only one farmer, who was following the practice of feeding his livestock free-choice, indicated that the results did not represent his present operation and could not be considered reliable as a basis for revised runs or as a planning tool for his operation.

The other five farmers indicated that the model gave good plans, and they could or would use the results from the model in considering possible changes in their operation.

CHAPTER I

INTRODUCTION

The model reported in this thesis is a linear programming model developed to assist the dairy farmer in the planning of his crop and livestock enterprises. Presented in this section are: (1) identification of the problem which this model strives to reconcile, (2) objectives of the model, and (3) a review of published concern in this area of model building.

Problem Statement

With the cost-price squeeze forcing the modern dairy farmer to become more conscious of profit-maximizing planning, there is a definite need for a general dairy farm planning and budgeting model which can incorporate information from existing dairy farm extension models along with existing dairy science technology and provide dairyment with a comprehensive planning model.

A total-farm planning model for the dairy farm should provide a useful complement to the library of computerized planning models of the Purdue University Cooperative Extension Service. The Extension Service has in use at this time a financial management model, a cash grain planning model, a general budgeting and planning model for swine. A decision model for beef cattle is presently being developed. Therefore, an effective planning model for dairymen should make a useful addition to this collection of planning models.

At the present time there are a few limited planning models available to Indiana dairy farmers through the Purdue University Cooperative Extension Service. These incluue a least-cost dairy ration formulation model developed primarily by the Animal Science Department and an alfalfa pesticide information system being developed. The Agricultural Economics Department has at the disposal of dairy farmers the afore mentioned financial management decision model and a loan analysis model which serves some of the needs of the dairy farmers in making management decisions.

To be successful and practical a dairy enterprise planning model should have the ability to correctly represent a plan for a dairy enterprise, and should be simple enough to use so that it can be made available to the dairymen as his farm planning needs arise.

Several challenging difficulties must be encountered and solved before the correct representation can be attained in such a model as this. Some of these difficulties include providing for the interaction of timeliness of harvest on the quality and quantity of forages, the interaction of quality of forage on the consumption habits of the dairy animals, the competing labor requirements for forage production and for livestock skills.

The model developed is a linear programming decision model which includes activities for all the major forages used by the dairy farmer, including corn silage, hay, pasture, and provides flexibility for other crops such as corn, which the individual farmer may wish to produce.

To meet the availability requirement, the planning model should be incorporated into a remote terminal computer access system.

The principal reason that the dairy farmer needs a model adapted to remote computer terminal use is a result of the confining nature of his enterprise. Dairy farming is not well adapted to workshop type planning models because a dairy enterprise will not normally allow the farmer to be absent from his operation for time periods necessary for intensive workshop sessions. This suggests that a short-input and short-output remote terminal model would be much better suited to the needs of dairy farmers. Therefore, this model will be developed on the same general basis as found in the Purdue Automatic Crop Budget (Model CC). (33) As in the case of Model CC the intent of this model is to allow the dairy farmer to use the adaptive approach in his farm planning. The model will not automatically make any structural changes in the farm plan, but instead provides the dairy farmer with the means to make any desired structural changes himself and then to analyze the results of these changes through a revised plan.

Development of this model requires cooperation with the animal science, agronomy, and agricultural engineering departments at Purdue University and other midwester universities. The production technology represented in this model was derived from research and data gathered by these departments along with the agricultural economics departments.

Testing of this model was done by actual farm planning with the recording, observation and analysis of the results. This farm planning was necessarily conducted on individual farm basis due to the confining nature of the dairy farm.

This model, together with others which are already available, gives Cooperative Extension Agents in dairy a complete kit of tools to assist dairymen in analyzing management problems. It provides extension agents with additional information for advising dairy farmers about possible solutions to management problems.

Objectives

The objective of this study was to apply existing dairy science, agronomy, farm management, and computer modeling technology in the development of an effective adaptive type dairy farm planning model suitable for on-the-farm planning assistance.

The model must be simple enough for the typical farmer to understand the input and output implications and yet complete and accurate enough to gain the farmer's confidence in using the results of the model.

Important considerations in developing the model were the efficiency of data handling and minimizing the cost to the farmer of using the model. This objective could only be accomplished by keeping computer time and input requirements to a minimum. Therefore, in the development of the model, considerable effort was made to keep activities and constraints to a minimum, and yet to make the model a workable representation of the actual farm operations.

The model should be flexible enough to fit the needs of various degrees of managerial ability of the dairy farm manager. A manager with information on the nutrient contents of his crops, and with information on the labor requirements of his milking and manure disposal systems should have the opportunity to better describe his operation by using this information, but dairymen lacking this information should not be excluded from using the planning model with the information that he has.

Research Procedure

The general procedure involved in developing the model involved gathering and developing technical coefficients necessary for dairy farm planning and developing a model suitable for complete enterprise planning for a dairy farm.

The specific procedure to be followed in accomplishing the purpose is:

1. Identify the considerations into a complete enterprise planning decisions.
2. Build these considerations into a complete enterprise planning model.
3. Develop the technical coefficients necessary to use the model.
4. Develop a computer program to aid in the continued use of the model.
5. Test the planning ability of the model by actual farm enterprise planning on established farms.

A Review of Published Concern for the Dairy Farm Planning Problem

In a review of past attempts by dairy researchers, there has been considerable concern over the type of planning which is needed on the dairy farm. In the words of University of Wisconsin researchers, "Additional planning efforts are needed to focus on the transitory period". (45) The concern is focused on the short-run versus the long-run planning model along with the total farm versus the individual enterprise planning model. Dean, et. al. said, ". . .such a model would need to encompass both the cropping and livestock system to be realistic, and therefore, is less amenable to a more-or-less standard format". (14)

In recognition of the need for a realistic dairy farm planning model, researchers from various universities across the nation have developed or are in the process of developing linear programming models for dairy farm planning.

Researchers at the University of California, Davis, have developed a linear programming model "for income maximization above feed costs for dairy cattle". This model includes: (1) milk response to feed function, (2) a least-cost ration section, (3) specification of maximum voluntary intake of roughage for alternative levels of concentrate feeding, and (4) constraints on the concentrate-roughage ratios. (13)

Researchers at the University of Connecticut have developed a generalized linear programming model for dairy farm planning which allows the user to formulate his specific situation according to the generalized format. Kottke said, "It (the model) is built on the premise that there are certain cropping, feeding, and milking structural relations that are common to most dairy farms. Of course, we recognize that no two farms are exactly alike, but we contend that variation among farms is mainly in the quantities of available resources, rates of input application, technology used, and managerial capabity." (23)

Barker and Heady (16) recognized the possibilities which linear programming offered for dairy farm planning in the statement, "Linear programming is particularly well suited to an over-all farm analysis because it simultaneously considers both the opportunities open to the farmer and the limited resources which he possesses."

CHAPTER II

ECONOMIC THEORY

The dairy farm, for the purposes of this study, is considered a separate, money-making unit which exists for the sole purpose of returning a profit to the owner. The primary and only objective of the dairy farm manager, for the purpose of this study, is to maximize profit incurring from the operation of the dairy farm.

The objective of this study is to develop a model which will allocate the scarce resources of the dairy farm among alternative uses in such a way as to maximize net cash profit received from the use of available resources.

The model developed in this study is based on the assumption that dairy farmers have limitations on certain resources and these resources limit production on the farm. These limitations come in two forms: (1) Fixed resources, such as silos, which cannot be varied within the scope of the planning horizon of this model and (2) semi-fixed resources which can be varied within limitations, such as labor or land.

There are basically two common methods of developing a farm plan; ordinary budgeting, and linear programming. The method chosen for this project was linear programming.

Linear programming has an advantage over budgeting in that it speedily considers among the production combinations and selects the most profitable combination of alternatives. (22) For this reason, linear programming is well suited to the solving of resource allocation problems.

Linear programming was chosen with the realization that there are certain characteristics which must be inherent in the real world situation before a linear programming model can accurately represent the situation.

These characteristics which are assumed by the linear programming model are: (1) additivity, (2) divisibility, (3) finiteness, and (4) single-valued expectations.

The additivity assumption states that given the activity levels of the variables, the total amounts of each input and the associated profit are the sums of the inputs and profit for each process. (43) This is equivalent to saying that there is no interaction among the activities. This is one of the more nearly realistic assumptions used in farm planning. Because of the specialized production practices which are becoming common on the modern farm, there is very little interaction among the various enterprises which make up a complete dairy farm.

The divisibility assumption states that for each activity, the total amounts of each input and the associated profit are strictly proportional to the level of output. (43) This assumption implies constant returns to scale of the activities. Before this assumption can be applied to the modern dairy farm, the relevant size range over which the model should be used must be defined. Taking into consideration that the model is bounded so far as the dairy herd size is concerned, it is possible to limit the size range of the model.

Studies have shown strong evidence that modern dairy farms have achieved nearly all of the economies of size by the time they reach a 30-cow herd size, and that very little diseconomy of size is evidenced until the herd size exceeds 200 cows. (25) With this evidence as to the size range over which very nearly constant returns to scale is evidenced, it is possible to define the relevant range of the planning model to be greater than 30 cow herds and less than 200 cow herds.

With the strong possibility that dairy farm managers of 30 cow herds or less would have very little interest in a sophisticated planning model, and with so few dairy cow herds in the midwest exceeding 200 cows; it becomes realistic to develop a planning model assuming constant returns to scale.

Also implicit in the divisibility assumption is the assumption that factors can be used and commodities can be produced in quantities which are fractional units. (43) This assumption is realistic in a short-run planning model with a defined horizon of one year. Problems occur with this assumption in long-run investment planning models. Although in the long-run it is difficult to justify buying one-half of a tractor, there is no problem in using one-half of the capacity of a fixed resource.

The finiteness assumption states that there is a limit to the number of alternative activities and to the resource restrictions which need to be considered. This is a practical assumption. If the farmer, businessman, or planner had an unlimited number of alternatives, he would never have them programmed because he could never finish describing additional activities, nor could he ever finish the computational task of determining the most profitable program. (7)

Linear programming also assumes that resource supplies, input-output coefficients, and prices are known with certainty. Although this assumption may be unrealistic, the availability of such information will be the same regardless of the planning technique used. Also implicit in this assumption is that the dairy farm exists in a perfectly competitive industry. This assumption may also be slightly unrealistic but also faced regardless of the planning technique.

So long as the planning model stays within the domain defined by the assumptions of linear programming, it is logical to believe that the model can be a relatively good representation of the real world situation. It is also logical to believe that the farther outside the defined domain, the farther from reality the model representation will be from the real world situation.

CHAPTER III

THE MODEL

The development of a dairy farm planning model encompasses three considerations: (1) output considerations; (2) input considerations; and (3) model structure.

Output Considerations

The first item of information that a dairy farm manager would prefer to have is the profit-loss statement for his plan. This information should include:

(1) The total profit or loss which the plan should provide to the farm. This comes in the form of total revenue - total variable cost-total fixed cost= total return to the farm above costs.

(2) If the model is used as a short-run planning model, the manager would like to know if total revenue exceeds variable costs. If the variable costs exceeds the revenue generated from operations the manager will know that in order to minimize losses on his farm, he should suspend operations or at least look for the problem areas in his enterprise.

(3) To assist the manager in analyzing the profit-making abilities of his farm, the output information should include a report on where the revenue generated came from and where the variable costs came from. This portion of the output form serves a dual purpose. Besides providing information to the manager,

it also helps to gain the confidence of the manager in the planning ability of the model.

(4) To assist the manager in planning the operations on his farm, the model should report what and in what quantities crops are produced, when the crops are harvested as the planning model ascertained the preceeding information to be according to the optimal plan. This information provides the manager a basis with which to plan the planting and harvesting activities on his farm.

(5) The model should provide the manager information on the buying and selling of such items as grains, hay, and feed supplements. This information can assist the manager in contracting practices.

(6) The model should provide the manager with information on the optimal replacement program, given the current set of prices and input-output coefficients, realizing that these coefficients are quite subject to change, but at least the manager will have an indication of whether he should be raising or buying his replacements. With this information, the manager will be better able to plan his replacement raising or buying activities.

(7) The model should provide labor use information to allow the manager to schedule his labor needs and to provide him with the information necessary to improve his hiring practices to avoid shortages and surplus periods in his labor supply. The model should also provide break-even wage levels to inform the manager as to the wages that he can profitably offer to secure additional labor.

(8) The model should provide information to indicate what time periods suffered machinery shortages; what type of machinery was in short supply, and the value of additional units of this machinery. This information can provide the manager a basis to plan machinery use and machinery purchases.

(9) In order for the manager to schedule his tillage operations, the model should provide an optimal schedule of tillage activities.

(10) The model should also provide feed storage information to inform the manager of any additional storage needs and the value of additional storage capacity, or in the case where the manager is using the model to plan his investments, the model should indicate if he has planned excessive investment in feed storage structures.

(11) Probably the most important set of information that the model can provide the dairyman is a feeding schedule. A feeding schedule should inform the dairyman of what to feed his herd for each season of the year to assure that the animals are receiving a balanced ration and that there is a sufficient supply of forages to meet the ration requirements.

The preceeding information base should provide the dairy farm manager with sufficient information to plan his major operations, recognizing of course, that actual operations will deviate from the optimal plan as is true of all plans.

Input Considerations

Before any model can develop an optimal plan for a dairy farm, it must be provided a description of the farm resources and limitations. This description comes in the form of a data set which tells the model how the particular farm deviates from the typical dairy farm. The more accurate this information is the more nearly optimal the calculated plan will be for the particular farm. The input considerations for the model reported in this thesis strives to present the dairy farm manager every possible opportunity to describe his operation to the best of his ability with the information that he has available to him.

The input consideration for this model include:

(1) Information on the size of farm and availability of land that may be rented which includes productive ability and cropping limitations.

(2) Price data for farm inputs, and outputs. This data includes selling prices for milk, animals produced on the farm, and salable crops and buying prices for such inputs as feedgrains, herd replacements, crop production inputs, labor, machinery and power costs.

(3) Resources available to be used in the farming operations. Labor resources are reported both for permanent and seasonal hired labor. Machinery resources may be reported as machinery presently available in the case where the manager is concerned with optimizing operations with present machinery resources, or machinery resources may be reported in terms of possible machinery purchases along with present machinery in the case

where the manager is interested in the possible effects of additional investment in machinery.

(4) Weather is considered a resource consideration which affects the days available for field work. Weather data is reported as a ratio of working days in the particular area in question as related to state averages. The availability of field work days is a function not only of variations in weather patterns but also in the time that it takes the soil to get ready for working which is a function of soil type and drainage characteristics of the soil.

(5) The technology used, or under consideration to be used, on the particular farm is an important input consideration, because the technology used in the model determines the ratio in which resources are used in production. Technology is reported in terms of the milking system, the manure disposal system, crop production technology and feeding systems.

(6) Management ability is handled as a resource in terms of the maximum size of herd the manager would consider, and production and feeding practices that the manager feels capable of handling.

(7) For those managers who take advantage of forage testing, nutrient information on produced crops may be supplied. For those managers who do not undertake forage testing, assumptions implicit in the model based on national averages (2, 28, 29, 11) provide the nutrient information necessary to the model. In either case the manager must select those crops which he would consider producing on his particular farm.

The input information reported is not intended to be accurate beyond a reasonable extent.

Information accurate to the point of being specious has little virtue in a planning model which is intended to be a basis for planning under such variable conditions as a dairy farm manager must operate. Oskar Morgenstern (1963) summarized this theory when he said, "Whether the data are satisfactory depends on their use. . ." (26) But on the other hand Morgenstern was credited with originating the cliche, "Garbage in garbage out", which summarizes the fact that the results which the model produces will be only as good as the input information which the model uses in the calculations. If the model is to arrive at the optimal plan for the particular farm, then those characteristics peculiar to that farm must be accurately reported.

Model Structure

The linear programming problem can be stated as:

$$\text{Minimize costs} = \text{Minimize} \sum_{j=1}^{M} C_j X_j$$

s.t.

$$\sum_j a_{ij} X_j \leq b_i$$

$$X_j \geq 0$$

Where: C_j = cost incurred per unit of activity "j" brought into the solution

X_j = the number of units of activity "j" in solution

a_{ij} = the amount of resource "i" consumed per unit of activity "j" in solution

b_i = the total amount of resource "i" available

M = the total number of activities in the problem

Table 3.1 - Matrix of General Relationships Between Activities and Constraints.

X_j			Slack Act.	Heifer Calf Sales	Slack Act.	Bull Calf Sales	Slack Act.	Land Rental	Hire Labor	Hire Custom Comb.	Hire Hay Harvest	Buying & Selling Feeds	Feeding Act. (Period 1)	Feeding Act. (Period 2)	Feeding Act. (Period 3)	Cow Act.	Raise Repl.	Buy Repl.	Raise Dairy Beef	Feed High Moisture Corn	Prepare Land for Planting	Crop Production Act.
C (Objective Function)	1			-C		-C		C	C	C	C	*	C	C	C	-C	C	C	-C	C		C
Row B:			1-11	12	13-54	55	56-96	97	98-108	109-111	112-115	116-130	131-151	152-172	173-193	194	195	196	197	198-200	201-208	209-242
Land Constraints	2-4	b	1					-a														a
Prepared Land Control	5-9	o	1																		-a	a
Unprepared Land Control	10-11	o	1																		a	-a
Heifer Transfer	12	o		1												-a	a					
Replacement Transfer	13	o			1											a	-a	-a				
Labor Constraints	14-24	b			1				-a	-a	-a		a	a	a	a			a	a	a	a
Field Hour Constraints	25-52	b			1					-a	-a										a	a
Silage Storage Constraints	53	b			1																	a
High Moisture Corn Storage	54	b			1															a		
Male Calf Transfer	55	o				1										-a			a			
Nutrient Req. (Period 1)	56-58	o					1						-a			a	a		a	-a		-a
Nutrient Req. (Period 2)	59-61	o					1							-a		a	a		a	-a		-a
Nutrient Req. (Period 3)	62-64	o					1								-a	a	a		a	-a		-a
Hay Transfers	65-71	o					1					*	a	a	a							-a
Silage Transfers	72-77	o					1						a	a	a							-a
Grain Transfers	78-82						1					*	a	a	a					a		-a
Protein Supp. Transfers	83-85	0					1					-a	a	a	a							-a
Tractor Constraints	86-96	b					1			-a	-a										a	a
Urea Constraints	97-99	o					1						*	*	*							
Forage (Min) Constraints	100-102	o											*	*	*							*

The model reported in this thesis contains one hundred and two constraints and one hundred and forty-six possible real activities. Slack activities are numbered 1-102 and real activities are numbered 103-248.

Table 3.1 shows the general relation of activities and constraints. For a specific relationship between activities and constraints refer to the model documentation.[1/]

As is shown by the objective function in Table 3.1 the linear programming problem is set up as a cost minimization problem with costs positive and returns negative. Establishing the problem as a cost minimization problem as contrasted to a profit maximization problem makes interfacing with a solution algorithm simpler since most LP algorithms minimize. Minimizing cost arrives at the identical optimal solution as maximizing profit.

The "C" coefficients in the objective function refer to activities which increase cost or reduce profit, while "-C" coefficients refer to activities which increase profit or reduce costs. Coefficients indicated by "*" refer to multiple activities, some of which increase profit and some which reduce profit. The coefficients in the objective function contain variable cost or variable profit. Fixed costs and revenues are added to the right hand side (RHS) of the objective equation at the predetermined level before the solving routine is initiated.

1/ The model documentation is available from the Agricultural Economics Department at Purdue University.

Activities which increase profit are baby calf sales (columns 12 and 55), the cow activity (column 194), which include milk sales, and cull cow sales in combination with the variable costs associated with the production of milk; the dairy beef activity (column 197), which includes profit derived from dairy beef sales minus the variable cost associated with producing dairy beef; and activities for the sale of hay (columns 122-127), and grain (columns 129-131).

Activities which decrease profit include:

1. Hay purchases (column 128).
2. Grain purchases (columns 132-133).
3. Purchases of protein supplements (columns 134-136).
4. Feeding activities (columns 137-199) which decrease profit by the amount of variable costs of feeding the various feedstuffs.
5. Replacement raising activity (column 201) which decreases profit by the variable cost of raising the replacements.
6. Replacement purchasing activity (column 202) which decreases profit by the purchase price of the replacements.
7. High moisture corn feeding activities (columns 204-206) which decrease profit by the variable cost of feeding high moisture corn.
8. Crop production activities (columns 215-248) which decreases profit by the direct cost of production.

The three time periods for the feeding activities were selected with respect to seasonal feeding considerations. The first feeding period extends from October 10 to March 31. This period covers the season when all feeding must be done stored forages and grains.

The second feeding period extends from April 1 to June 11. This period covers the season characterized by rapidly growing pasture crops.

The third feeding extends from June 12 to October 9. This period is characterized by diminishing importance of pasture crops with more significance placed on green-chop crops and recently harvested forage crops.

The feeding activities are grouped first into sets with respect to time periods, then these sets are divided into subsets with respect to the feedstuff which the activities represent. The activities for the first, second and third feeding periods are numbered 137-157, 158-178, and 179-199, respectively. Hay feeding activities make up the first seven activities of each set, followed by six silage feeding activities, five grain feeding activities, and three protein supplement feeding activities.

Pasture crops (activity 215) and green-chop crops (activities 228-231) are considered in a different set of activities because these crops are non-storable and contribute to forage feeding in their harvest periods only. (Feeding periods 1 and 2).

The model allows the farm manager the flexibility of selecting those crops which he would consider producing on his own farm from a rather extensive list of crops which are commonly produced in the midwest.

The purpose of providing this flexibility is to keep the model size as small as possible without reducing the geographic area over which the model is applicable.

The user is allowed to select, at most, three hay crops, three silage crops, two green-chop crop, and three grain crops as possible crops for an optimal farm plan. Since a typical Midwestern dairy farmer will normally not produce even that varied set of crops, the model provides the user some freedom in his crop selection.

In addition, each hay, silage, and green-chop crop is expanded by the computer model to provide an early or late harvest or both with adjustments made in yield, quality, and voluntary intake of the forage according to the period in which the crop is harvested.[2/] Each grain crop is provided with the possibility of an early or late planting and an early or late harvest or any combination of planting and harvesting times with appropriate adjustments made in grain yield.[3/]

The land rental activity (column 103) has both lower and upper bounds. The lower bound represents the amount of land that must be rented (i.e. land already contracted for). The upper bound represents the

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2/ For an explanation of the process used see page 35.

3/ All of the grain crops, with the exception of corn, have two plant and two harvest periods. Corn has three plant and three harvest periods.

limit on land available for rent including the land already contracted as represented by the lower bound.

Activities for hiring labor (columns 104-114) are available for each of the eleven labor periods. Upper bounds are placed on these activities representing the amount of labor available for hire during each of the periods.

The model contains activities for hiring custom combining (columns 115-117) and custom hay harvesting (columns 118-121). These activities are also bounded to limit them to levels which the user foresees as the amount of custom harvesting that he could possibly purchase.

The activities for selling hay (columns 122-127) are specific for each hay crop sold. There are selling activities for each hay crop produced and the activities are specific to allow selling of either early or late harvested hay.

The model also allows buying hay (column 128) of the quality specified by the user, at a price which is calculated as the maximum of selling prices of hay crops plus a margin.

The farmer may specify what kind of hay he is interested in buying or what kind of hay is available for him to purchase.

The model contains activities (columns 129-131) for selling any or all of the grain crops produced, and activities for buying two different kinds of grain (columns 129-130) as specified by the user.

Buying activities (columns 134-136) are also included for the purchase of protein supplements. The supplements available to the user is also user specified.

Activities (columns 201 and 202) to fill the need for herd replacements, as determined by the average life of animals in the herd, are provided to allow the model to optimally raise or purchase the required herd replacements or the model may find it optimal to do both.

The baby calves produced by the herd, not used in the production of replacements, are disposed of by activities (columns 12 and 55) for the selling of baby calves.

Activities are also provided to prepare crop land for planting (columns 207-214). This set of activities include land preparation during the fall, early spring, and late spring.

Constraints

The first row in the matrix is the cost function. This row contains the losses and gains in profit per unit of each activity in the model. Since the model is a cost minimizing model, the losses in profit are positive coefficients and the gains in profit are negative coefficients.

This row may be expressed as:

$$-C_k X_k + C_j X_j \leq T$$

Where:

X_k = the quantity of those activities which increase profit

X_j = the quantity of those activities which decrease profit

C = the amount by which each unit of each of the activities increase or decrease profit

T = total fixed cost for the farm

The first set of constraints (rows 2-4) defining the feasible region of the linear programming problem are land constraints. The first land constraint insures that no more land will be used than is available through ownership or through renting.

The second land constraint limits the type of crops that may be produced on the available land. This constraint defines that portion of the available land that may be used for crops that require any amount of tillage. Tillage activities are those which necessitate the use of tractors and machinery on the land.

The third land constraint limits the use of land for row crops, where row crops are defined as crops which are planted in such a way as to risk severe erosion problems on land unsuitable for such crops (e.g. corn, soybeans, and wheat).

Land rotation is handled in the use of the model by subtracting from the land suitable for row crops the number of acres of row crop land that should be in sod crops each year.

The land constraints may be expressed as:

$$-1X_1 + 1X_2 + 1X_3 + 1X_4 \leq b_1$$

$$-\alpha X_1 + 1X_3 + 1X_4 \leq b_2$$

$$-\beta X_1 + 1X_4 \leq b_3$$

Where:

X_1 = quanity of land rented

X_2 = quanity of non-tillable crops produced

X_3 = quanity of tillable, non-row crop crops produced

X_4 = quanity of row crops produced

β = percent of rented land suitable for row crops

α = percent of rented land that is tillable

b_1 = amount of owned land

b_2 = amount of owned land that is tillable

b_3 = amount of owned land suitable for row crops

The model is also constrained by the availability of labor. The labor constraints (rows 14-24) cover eleven time periods. These periods were developed from discussion with farm management extension agents and dairy specialists.[4/] Only those periods considered to be labor scarce are included. The labor periods constrained include; (1) December 9 to March 31, (2) April 1 to April 30, (3) May 1 to May 14, (4) May 15 to May 28, (5) May 29 to June 11, (6) June 12 to June 25, (7) June 26 to July 9, (8) September 10 to September 24, (9) September 25 to October 9, (10) October 10 to November 8, and (11) November 9 to December 8.

The labor constraints may be expressed as:

$$-1X_{1i} - E_i X_{2i} - \sigma_i X_{3i} + \sum_{a=1}^{n} \alpha a_i X_a + \sum_{B=1}^{m} \gamma\beta_{Bi} X_B + \rho X_{4i} + \sum_{c=1}^{L} \theta_{ci} X_c \leq b_i$$

Where:

X_{1i} = hours of seasonal labor hired in period "i"

X_{2i} = hours of custom combining hired in period "i"

X_{3i} = tons of custom hay harvesting hired in period "i"

X_a = quanity of feedstuff "a" fed

X_b = number of animals "B" included in operations

X_{4i} = acres of land prepared in period "i"

4/ The time periods were developed from discussions with Don Hill, Dairy Specialist, Purdue University; Robert Rades, Farm Management Extension, Purdue University; Art Howard, Extension Agent, Purdue University Cooperative Extension Service; and Norbert Moeller, Dairy Specialist, Purdue University.

X_c = acres of crop "c" produced

b_i = hours of permanent labor available in period "i" (b_i is calculated as hours of permanent labor avail- per day in period "i" X days in time period "i" suitable for field work (good days)

E_i = hours of labor required in period "i" per hour of combining in period "i"

σ_i = hours of labor required in period "i" per ton of hay harvested in period "i"

α_{ai} = hours of labor required in period "i" per ton of feedstuff "a" fed

β_{Bi} = hours of labor required in period "i" per animal in animal activity "B"

ρ = hours of labor required to prepare an acre of land

θ = hours of labor required in period "i" per acre of crop "c" produced

n = total number of feedstuffs available to feed times number of feeding periods (3)

m = total number of animal activities (m = 3)

L = total number of crops produced (variable)

γ = the number of "good days" in period "i"

Labor used for livestock is considered only on those days suitable for field work. This is because if labor is not constraining on those days it should not be constraining on those days during which field work cannot be attempted and all labor is devoted to livestock.

The model is constrained by field hours available to accomplish certain field tasks. Rows 25-32 limit the field hours available for land preparation. These constraints may be expressed as:

$$\alpha X_{1i} + \sum_{B=1}^{L} \beta_{Bi} X_B \leq b_i$$

Where:

X_{1i} = acres of land prepared in period "i"

X_B = acres of crop "B" planted sowed in period "i"

b_i = hours of field time available in period "i"

(b_i is calculated as hours of field time available per day in period "i" times number of "good days" available in period "i")

α = hours of field time required per acre of land prepared

β_{Bi} = hours of field time required for final preparation and planting operations of crop "B" in period "i"

L = total number of crops produced (variable)

i = 1, 2, ..., 5, 9, ..., 11

Rows 33 through 36 limit the field hours available for hay harvesting operations. These constraints may be expressed as:

$$-\alpha X_{1i} + \sum_{B=1}^{m} \beta_{Bi} X_B \leq b_i$$

Where:

X_{1i} = number of tons of custom hay harvesting hired in period "i"

X_B = acres of hay crop "B" produced

b_i = hours of field time available in period "i" (b_i is calculated as hours of field time available per day in period "i")

α = hours of field time required per ton of hay harvested

β_{bi} = hours of field time required in period "i" per acre of hay crop "B" produced

i = 4, 5, 6, 7

m = number of hay crops produced

Rows 37 through 42 limit the field hours available for grain harvesting. These constraints may be expressed as:

$$-1X_{1i} + \sum_{B=1}^{n} \beta_{Bi} X_B \leq b_i$$

Where:

X_{1i} = hours of custom grain harvesting hired in period "i"

X_B = acres of grain crop "B" produced

b_i = (same as for hay harvesting constraints)

β_{Bi} = hours of grain harvesting required in period "i" per acre of grain crop "B" produced

n = number of grain crops produced

i = 7, 8, ..., 12

The constraints on field time available for the harvesting of silage (rows 47-52) and green-chop crops (rows 43-46) may be expressed as:

$$\sum_{B=1}^{n} \alpha_{Bi} X_{Bi} \leq b_i$$

Where:

X_{Bi} = acres of crop "B" produced in period "i"

b_i = is calculated the same as for hay harvesting constraints

α = field hours required in period "i" for the harvesting of one acre of crop "B"

n = number of silage crops or number of green-chop crops

i = 4, 5, 6, 7 for green-chop crops, and 4, 5, 6, 7, 9, 10 for silage crops

Rows 86 through 96 constrain the model on availability of tractor hours for field operations. These constraints may be expressed as:

$$- \alpha X_{1i} - \beta X_{2i} + \sum_{c=1}^{n} E_{ci} X_c \leq b_i$$

Where:

X_{1i} = hours of custom combining hired in period "i"

X_{2i} = tons of custom hay harvesting hired in period "i"

X_c = acres of crop "c" produced

α = tractor hours used per hour of combining done

β = tractor hours used in period "i" per acre of crop "c" produced

b_i = tractor hours available in period "i" (b_i is calculated as total number of tractors available times hours of field time available per day in period "i" times number of "good days" in period "i")

i = period (i = 1, ..., 11)

n = total number of crops produced

The rows 53 and 54 limit the silage and high moisture corn storage capacity, respecively. These constraints may be expressed as:

$$\sum_{c=1}^{n} \alpha_c X_{1c} \leq b$$

Where:

α_c = silage storage capacity required to store an acre of silage crop "c" (or α_c = the high moisture corn storage capacity required to store 100 pounds of high moisture corn)

X_{1c} = acres of silage crop "c" produced (or the units of high moisture corn fed at 100 pounds per unit)

b = tons of silage (or high moisture corn (cwt)) storage capacity available

n = total number of silage crops produced (or total feeding periods in which high moisture corn is fed)

Rows 97 through 99 limit the amount of urea feed to 3 percent of the total of the remainder of the grains and supplements fed [9]. These constraints may be expressed as:

$$-\sum_{a=1}^{n} .03\, X_a + 1X_B \leq 0$$

Where:

X_a = hundred weights of grain or supplements fed excluding urea

X_B = hundred weights of urea fed

Rows 56 through 64 are nutrient transfer rows. The transfer rows for nutrients are actually constraints which require that nutrient requirements of the animals in the dairy enterprise must be fullfilled by either farm grown crops or by purchased feed.

The ration is balanced to assure that the livestock receive adequate amounts of crude protein and net energy, with a constraint placed on the consumption of dry matter to assure that the animals will consume all of the feed necessary to maintain the net energy and crude protein at an adequate level in their rations. These rows transfer nutrients from the feeding activities to the animal activities. There is a set of nutrient transfer rows for each of the three feeding periods. Each of the sets may be expressed as:

$$\sum_{a=1}^{n} \alpha_a X_{ai} - \sum_{b=1}^{m} \beta_{bi} X_b \geq 0$$

$$\sum_{a=1}^{n} E_a X_{ai} - \sum_{b=1}^{m} \Gamma_{bi} X_b \geq 0$$

$$-\sum_{a=1}^{n} \lambda_a X_{ai} + \sum_{b=1}^{m} \rho_{bi} X_b \geq 0$$

Where:

$_a$ = net energy yield per cwt of feed stuff "a"

X_{ai} = CWT of feedstuff "a" fed in feed period "i"

Γ_{bi} = net energy requirement per animal in animal enterprise "b" during period "i"

X_b = number of animals in enterprise "b"

E_a = crude protein yield per cwt of feedstuff "a"

β_{bi} = crude protein requirement per animal in animal enterprise "b" during period "i"

λ_a = dry matter per cwt of feedstuff "a"

ρ_{bi} = voluntary intake of dry matter per animal in enterprise "b" during period "i"

n = total number of feedstuffs fed

m = total number of possible animal enterprises

Rows 65 through 80 transfer the yield of crops produced to activities for feeding or selling these crops. These rows insure that the sum over each crop of the amount of the crop sold plus the amount of the crop fed minus the amount of the crop bought is not more than the amount of the crop produced.

Rows 81 through 85 transfer grains and protein supplement pruchased to activities to feed these feedstuffs.

Rows 10 and 11 transfer an acre of land to be prepared from the crop producing activities to land preparation activities, while rows 5 through 9 transfer the acres of land prepared to the cropping activities to be planted.

Rows 12 insures that every calf sold or raised for herd replacement can be produced by the cows in the herd, while row 13 insures that every cow in the herd has a replacement at the end of her producing life.

Row 55 insures that all of the male calves produced by the cow herd are either sold as baby calves or raised as dairy beef.

The constraints on grain feeding, rows 99 to 102, limit the amount of grain fed to not more than the amount of forages fed by weight.[5/]

Coefficients

The coefficients used in the planning model are arrived at by two methods. Some of the coefficients, which would be very difficult for the dairy farm manager to supply, are built into the model as assumptions. These coefficients are derived from Midwestern regional averages.

Other coefficients, necessary to develop a unique plan for the particular farm in question, are calculated from farmer supplied data.

The built-in coefficients are as follows:

A. Nutrient requirement coefficient for cows - The nutrient requirement coefficients are calculated by an equation derived from

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5/ These constraints were developed during discussions with Professor Norbert J. Moeller, Dairy Extension Specialist, Purdue University.

derived from dairy cattle feeding standards.[6/] (11, 27, 30, 32)

1. Net energy is considered as one of the major nutrient requirements for the balancing of dairy cattle rations. The net energy requirement equation is: Net energy requirement per cow per day = Net energy for maintenance + Net energy for production + Net energy for growth + Net energy for pregnancy.

Where:

a. Net energy for maintenance per cow per day = Average cow's weight$^{.87}$ X .146.

b. Net energy for production per cow per day = Average annual production per cow + 365 days per year X (Average butter fat percentage in the milk -3.01) + .5 X .02) + .26).

c. Net energy for pregnancy per cow per day = .167 X 5.1 (.167 is derived from the assumption that a cow only needs extra allowances of net energy during the last two months of her pregnancy).

6/ These equations assume a constant marginal rate of productivity for the nutrient inputs. This assumption proves to be valid for an average cow weight between 800 and 1600 pounds, an average butter fat test between 2.5 and 4.5 percent, and an average annual milk production between 10,000 and 16,000 pounds according to the aforementioned dairy feeding guidelines. Taking into consideration that the rations are balanced for total herds instead of individual animals, these equations should be relevant since nearly all herd averages will fall into these ranges.

d. Net energy for growth per cow per day = 1. ÷ Average producing life of the cow X 2.2 (This equation is based on the standard assumption that a cow only needs a growth allowance for the first two years of her producing life).

2. Crude protein is the other major nutrient considered in the balancing of the dairy cow ration. The crude protein requirement equations is:

Crude protein requirement per cow per day = Crude protein for maintenance + Crude protein for Production + Crude protein for growth + Crude protein for pregnancy.

Where:

a. Crude protein for maintenance per cow per day = ((Average cow's weight - 800) ÷ 100) X .095 + .95.

b. Crude protein for production per cow per day = (((Average butter fat percentage in the milk -3.01) ÷ .5 X .004) + .070) X Average annual production per cow ÷ 365.

c. Crude protein for growth per day = 1. ÷ Average producing life of cow X .60 (This equation is based on the standard assumption that a cow only needs a growth allowance for the first two years of her producing life).

d. Crude protein for pregnancy per day = .167 X 1.2 (See net energy for pregnancy).

3. The maximum voluntary intake is also considered a constraint when balancing dairy rations. Thus, coefficients are necessary for the voluntary intake of each of the forages fed according to the type of forage and the quality the forage, and for each of the grains and protein feeds according to the type of feed. The model assumes that for all of grains and protein feeds a cow will voluntarily consume three pounds of dry matter per 100 pounds of weight and that the cow will also consume three pounds of dry matter per 100 pounds of weight of ideal quality forage. The maximum voluntary consumption of the specific forage is then adjusted according to the forage type and the forage's quality, determined by the stage of maturity of the forage harvest time. (For specific reference to the maximum voluntary intake for each forage see Appendix A, Table A-3). The voluntary intake of dry matter for specific forages is handled by altering the dry matter coefficients of the forages according to the voluntary intake of the forage while holding the dry matter consumption coefficient for the cow constant.
(Example: Reducing dry matter intake of the cow by 4 percent is equivalent to increasing the dry matter content of the forage by 4 percent).

B. Similarly, nutrient requirement coefficients must be derived for dairy heifers and dairy beef.

1. The net energy requirement per animal per day for heifers and dairy beef is calculated as:

   Net energy requirement = ((Average weight of the animal[7] -400) ÷ 100 X .7) + 6.4.

2. The crude protein requirement per animal per day for heifers and dairy beef is calculated as:

   Crude protein requirement = (((Average weight of the animal[8] -400) ÷ 100) X .04) + 1.25.

3. The same assumption concerning voluntary intake is made with dairy heifers and dairy beef as was made with the dairy cows.

[7] The average weight of the dairy heifers is assumed to be equal to one-half of the average cow weight, because a continuous calving rate is assumed. Since the heifers would then be spread e evenly over the size range from newborn to fully grown, one-half of the grown weight should be a good approximation of the average heifer weight. The same argument is made with dairy beef except the grown weight is a farmer input since the grown weight for dairy beef would obviously differ from the grown cow's weight. In addition all coefficients for dairy beef are adjusted to a one-year period since the planning model is designed for a one year horizon.

[8] Ibid.

C. The effective life of sod crops is a built in coefficient. (For specific reference to the effective life of periodic crops see Appendix A, Table A-3).

The life of periodic crops affect time sets of constraints.

1. The life of periodic crops affect the amount of land that must be prepared each year. (For example: A hay crop that has an effective life of 4 years must be plowed up every 4 years or 25 percent of the total acerage of that crop must be plowed every year).
2. Also affected by the life of the periodic crops is the labor, field time, and machinery constraints. A crop which has a life of 4 years must be sown every four years or 25 percent of the total acreage of the crop must be sown every year. Thus, for every acre of such a crop produced an appropriate percent of the labor, field hours, and machinery requirement per acre must be used up.

D. The planting and harvest times of the various crops are built in as assumptions. (For a specific reference to the planting and harvest dates for all of the crops see Appendix A, Table A-1).

The individual crops are assigned different harvesting and planting periods associated with the planting period and harvesting period combinations which the multiple activities for the same crop represent.

1. The planting periods for each crop determine which constraint rows contain the coefficients for the amount of labor, field time, and tractor hours required to plant or seed the crop.

2. The harvest periods for each crop determine which constraint rows contain the coefficients for the amount of labor, field time, and tractor hours required to harvest the crop for each of the forage removal operations (i.e. first cutting, second cutting, etc.).

3. Also associated with the forage production activities are assumptions on the percent of the total yield that is harvested in each of the harvest periods.

E. Also, assumptions are made concerning the variation in the yield of the various crops associated with varying planting and harvest periods. These constants are used as multipliers for the average expected crop yield as specified by the model user, to arrive at expected crop yields for the individual crop production activities. (The constants used for each crop are reported in Appendix A, Table A-3).

The user may specify certain coefficients in those terms indicated on the input form. (Appendix). The question on the input form are stated in the terms most fimiliar to the dairy farm manager. In many cases the user specified data is mathematically manipulated in such a way as to make the data conform to the model structure.

The input data is considered to be revisions to the data for the base farm case, and is handled as such by the model. The user has the option of changing any input answers which differ from his farm situation.

Those coefficients arising from user specified data are:

A. The farm size and the acres that must be rented form the right-hand sides (RHS) for the land use constraints. The additional acres that may be rented form the upper bound on the land rent activity. The costs associated with owned land and land that must be rented are considered as fixed costs, while the cost of rented land form the cost coefficient for the land rent activity.

B. The cost coefficient on the cow activity is formed as:

Average selling price of milk X the average yearly milk production + (the average selling price of cull cows ÷ the average producing life of cows) - the variable cost per cow = The profit or loss per cow.

C. The average selling price of baby calves forms the cost coefficient for the calf selling activities.

D. The silo storage capacity and the high moisture corn storage capacity specify the RHS on the silage storage constraint and the high moisture corn storage constraint respectively.

E. The RHS's of the set of tractor constraint rows are determined as:

Total number of field work tractors available X machine hours per day for the respective season X the number of "good days" available during the respective time period = RHS of the tractor constraint for the respective time period.

F. The labor available (RHS) during a particular time period is determined as:

Man-hours of permanent labor available per day for the respective season X the number of "good days" available during the respective time period = RHS of the labor constraints for the respective time period.

G. The model user has the option of altering the weather assumptions implicit in the model through the use of the "good day multiplier." This multiplier is applied to the assumed number of working days per period to arrive at an adjusted "good days" figure for each time period. This multiplier allows the model user to adjust the average weather patterns and sail conditions for the state to more nearly fit the conditions in his particular area.

H. The farmer also may adjust the planting and harvesting periods for the grain crops to fit his own production practices. The beginning planting and harvet dates specified by the user are used to shift the boundaries of time periods to establish the time periods for his farm.

I. Feeding rates for silage, hay, and high moisture corn may be specified by the model user as determined by his equipment working rates and by his labor productivity. Also determined by labor productivity is the labor requirements for raising herd replacements and producing dairy beef.

J. The model user may specify the working rates of his crop production equipment. For land tillage equipment and planting equipment the user may specify the number of units of equipment that he uses and the working rates of the equipment. It is assumed that land tillage equipment and seed sowing equipment uses 1.05 man-hours per equipment hour and seed planting equipment uses 1.10 man-hours per equipment hour. The excess of labor requirements over equipment requirement allows for maintenance and hopper filling operations. The model user may provide the total harvesting capacity of his equipment along with the number of tractors and men used in the harvesting operations.

This data is used in the calculation of labor hours, tractor hours, and field hours required per acre of each crop produced.[8/]

K. The manure disposal system and the milking system specified by the farmer determines the labor requirements for these activities. (See input form, Appendix B, Section III). For the specified milking system, labor required for milking preparation, equipment clean-up, and fixed time per milking are considered as constants and do not vary with the number of cows milked. The variability in milking time incurred by change in the number of cows milked is taken into consideration in the additional time per cow for milking. Thus, the constant labor requirements are handled as fixed labor requirements and are used as reductions in labor availability.

L. If the model user wishes to consider raising dairy beef in combination with his dairy enterprise he may provide information concerning the beef system he wishes to consider. All of the information is adjusted to a 12-month basis by the model. (For example: Suppose the user wants to consider feeding dairy beef for 15 months before selling them, then the revenue generated by beef sales and finishing weight are adjusted by a factor of .80 to determine the annual revenue generated and the annual feed and labor requirements.)

M. The model user may specify, for each crop he would consider producing: the cost of production, the selling price (for hay and grain crops only), average yield, present acerage, average crude protein content (%), average net energy content (therms/100 lbs), and average dry matter content (%). The cost of production is used in budgeting a present plan to compare with the optimal plan. The present acerage of each crop determines the maximum amount of each crop that can be grown in the present plan budget. The average yield, crude protein content, net energy content, and dry matter content as afore mentioned are first adjusted to correspond to particular plant and harvest periods and then used as coefficients specifying the nutrients and dry matter added by each unit in the feeding activity.

N. Other coefficients may be specified which are used in the objective of function. The annual charge for owned land (owned acres X annual charge per acre), annual salaries for operator and permanent hired labor, and annual charge for equipment machinery, and buildings make up the fixed cost coefficient which is the beginning value in the RHS of the objective function. The cost per acre of land preparation activities. The variable cost of raising replacements, and the variable cost of feeding hay, silage, and high moisture corn form the objective function coefficients for the herd replacement production, the hay feeding, the silage feeding, and the high moisture corn activities, respectively. The objective function coefficient for the dairy beef production activity is formed as:

$$C = 12 + \alpha X \ \beta + 100 \ X \ E - P$$

Where:

α = the average selling age of dairy beef

β = average selling weight

E = selling price ($/cwt)

P = variable cost of raising dairy beef

CHAPTER IV

EMPIRICAL TESTING AND ANALYSIS OF RESULTS

General Discussion

The ability of the model to represent the operation of a dairy farm was tested by using the model in planning the operation of actual dairy farms.

The dairy farm operators were asked to supply the information requested on the Dairy Farm Management Aid Input Form. (See Appendix B)

This information was then processed using the computer model, which budgeted present operations as well as the optimal operations plan, given the resource restrictions.

Although during the testing of the model, the case farmers were not charged for runs, estimates of the cost of running the model were made.

Based on the cost of the six case farm runs, the average cost of central processor was 5.15 dollars per run with a range of 2.98 dollars to 8.36 dollars. The average central processor seconds used was 59 with a range of 29 seconds to 97 seconds.

Using the Cooperative Extension Service's computer system the normal time required to submit the input data for one farm is approximately thirty minutes and the time required to print the output report via remote terminal is five minutes. Thus, in a normal session requiring thirty minutes to submit the input data, five minutes to print the output, and five minutes between submitting the job and receiving the output, the total connect time for long distance telephone calls would be forty minutes.

In most cases it was necessary to make one revised run for every investment decision that the farmer was interested in exploring. In the six case farms, the farmers averaged approximately one revised run in addition to the initial run. In these revised runs, which required only minor changes to the input data, an additional fifteen minutes of connect time was necessary.

Thus, in the case farms, the average total cost of the initial run and one revised run was approximately ten dollars plus the cost of a long distance telephone call for fifty-five minutes.

Case Farm One

Case farm one was located in Eastern Indiana. The farm was operated by the son of the farm owner. The size of the milking herd was 52 cows with the operator interested in expanding the herd to 110 cows. The average yearly milk production for the herd was 10,500 pounds per cow per year. All labor for the farm operations was supplied by the farm family. The operator was working full-time on the farm with part-time labor coming from the operator's wife, father, and younger brother.

Currently, no hay was being raised, but the farm operator was considering going into some hay production. Corn, oat, and alfalfa silage was being fed along with corn, soybean oil meal, urea, and a commercial protein supplement. The cows were on pasture during the spring and summer months.

The cows were milked in a double-4 herringbone milking parlor with a pipeline milking system.

Manure disposal was accomplished using a frequent haul-out system.

In addition to the dairy enterprise, the operator also had a dairy beef enterprise in which steers produced by the milking herd were fed out to 1000 pounds.

The farm consisted of 300 acres, with approximately half of the farm devoted to forage production and the balance devoted to production of corn, soybeans, and wheat.

The silage crops, which were the bulk of the forage produced, were stored in a sealed silo (400 ton capacity), and two concrete silos (600 ton capacity). The silage was fed to the milking herd in a feedlot in bunk feeders, and to herd replacements and dry cows in feed bunks in the fields.

Forage testing was practiced by the operator and the results from the forage tests were also provided on the input form.

The farm operator was considering a number of changes on his farm which the model was designed to help him evaluate. These changes included: (1) hiring outside labor; (2) expanding the herd size; (3) producing hay crops for forage; (4) changing his concentrate mixture; and (5) changing his forage harvesting schedule.

Results[1]

The initial model run using case farm one data resulted in high shadow prices on labor,suggesting that a move toward hiring labor could be highly profitable.

The farmer preferred to further pursue the results by trying a revised run in which he indicated that he could hire an additional man at increased wage rates.

Based on the results of the revised run the extension agent could recommend that the farmer do the following:

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[1] For the specific results, see Appendix C.

1) hire an additional man at least during the spring and fall months.
2) increase his herd size to at least double his present herd.
3) reduce the ratio of forages to concentrates fed, thus allowing grain crops to supply a larger proportion of the herd's nutrient requirements.
4) feed all 104 acres of corn produced to the milking herd and sell all 138 acres of soybeans as a cash crop (under current prices).
5) concentrate heavily on alfalfa silage as the principal forage and strive for an earlier harvest of this alfalfa silage.
6) consider constructing a manure pit for manure disposal.
7) continue the use of urea in the concentrate mixture.
8) discontinue the dairy-beef enterprise and sell all of the unneeded baby calves.

Case Farm Two

Case farm two was located in Eastern Indiana. The farm, consisting of 475 acres, was owner-operated. The farmer was currently milking 104 cows and had little interest in increasing his herd size. The average yearly milk production for the herd was 13,000 pound per cow per year. The farmer and one permanently hired man was providing all of the labor for the farm.

The forages currently being produced consisted of alfalfa hay, alfalfa silage, and corn silage. The farm was used intensively for grain crops with 250 acres used for corn, soybeans, and wheat.

The concentrate mixture for the cows currently consisted of home grown grains with a commercial protein supplement being used in the concentrate mixture.

The silage crops were stored in upright silos with a 1000 ton capacity. These silage crops were fed in feed bunks on drylots, although the cows were allowed access to 75 acres of pasture during the summer months.

Although the farm owner was not particularly interested in expanding his herd size, he was considering doing so in order to hire another full-time employee to take part of the immense work-load away from himself.

The farm owner was also interested in the structural changes that his farm should undergo if there was a drastic decline in grain prices from their current level.

Results[2]

Based on the results of using case farm two data with the planning model, the extension agent could make the following recommendations:

1) increase the cow herd size to the extent of the farmers management ability, indicated to be 120 cows. This increase in herd size can be accomplished with the existing labor supply by buying all herd replacements.
2) for the 120 cow herd, 255 tons of hay would have to be purchased.
3) corn silage should be the only forage produced on the farm.
4) the concentrate ration for the herd sould consist of home grown corn and soybeans.
5) all the major part of the corn crop as a cash crop and feed the soybeans to the livestock.
6) the high shadow prices on the labor supply indicates that labor should be hired during the month of May.

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[2] For the specific results, see Appendix C.

7) a decline in grain prices should cause little or no change in the farm structure.

Case Farm Three

Case farm three was located in East Central Indiana. It consisted of a 763 acre farm rented by two brothers from their father on a partnership basis.

The two brothers were currently milking 134 cows with slight interest in any large increases in herd size. The cows were producing an average of 14,280 pounds of milk per cow per year.

The forages produced on the farm consisted of alfalfa hay, alfalfa silage, and corn silage. The silage crops were stored in upright silos, some of which were sealed silos which were being filled one and a half times per year, for a total silo capacity of 2200.

In addition to the 140 acres of hay and silage crops, 122 acres was was devoted to permanent pasture. The remaining 500 acres of land was used for the production of 350 acres of corn and 150 acres of soybeans.

The cows were milked in a double-5 herringbone parlor with a pipeline milking system. Manure disposal was accomplished with frequent haul-out, although the operators were considering going to a manure pit for the purpose of being better able to time the manure disposal operations.

These farm operators were also interested in the effect which a decline in grain prices would have on the structure of their farm.

One of the farm operators was also interested in the possibility of rasing dairy beef.

Results[3]

The results of using case farm three's data with the planning model

[3] For the specific results, see Appendix C.

provides the extension agent with the basis for the following recommendations:

1) herd expansion to the limit established by the farmers, 140 cows, would be profitable.
2) In order to meet the proposed plan, 533 hours of labor would need to be hired during the spring, summer and fall months.
3) The forage requirements of the expanded herd could be fulfilled most profitably by producing 25 acres of alfalfa hay, and 80 acres of alfalfa silage.
4) This forage ration could most profitably be supplemented with 12,550 bushels of corn to fulfill the total nutrient requirements of the dairy herd.
5) In addition to the dairy enterprise, the resources available could produce 200 tons of alfalfa hay, 58,000 bushels of corn, and 900 bushels of soybeans which could be sold as cash crops.
6) To meet the optimal plan, at least one-half of the necessary herd replacements should be purchased.
7) The high shadow prices on the labor supply indicates that additional labor should be hired during the spring and fall months.
8) Drop the dairy beef enterprise from the farming program.
9) The report shows little shift in operations if gra n prices fall, although there would be a proportionate decrease in income from sales of these grains.

Case Farm Four

This farm was located in Northeastern Indiana. The farm,consisting of 263 acres, was operated by the farm owner with the aid of family labor.

The farm currently had a milking herd of 67 cows, which were producing an average of 13,500 pounds of milk per cow annually, which the operator was not interested in expanding because his sons, who were supplying some labor while attending high school, were planning on leaving the farm.

The forages currently produced consisted of alfalfa silage and corn silage which were stored in upright silos with a total storage capacity of 1500 tons.

In addition to the forage crops an additional 63 acres was devoted to producing corn, all of which was being fed to the cows in a concentrate mixture. The concentrate mixture was being supplemented with a 38 percent crude protein commercial protein supplement.

The cows were being milked in a double-4 herringbone milking parlor with a pipeline milking system.

Manure disposal was accomplished using a system of frequent haul-out.

This farm operator was not interested in making any changes to his farming operation. His only interest in the dairy planning model seemed to be one of using the model to verify that he was doing the best job that he could with his resources.

Results[4]

The report from the planning model using case farm four's data would support the extension agent in the following recommendations:

1) Expansion of the dairy herd to the maximum limit, 70 cows, established by the operator would be profitable.
2) The most profitable combination of forages would be 460 tons of alfalfa silage and 250 tons of corn silage.
3) The concentrate mixture could most profitably be formulated with 8873 bushels (4969 cwt) of corn and 82 hundred pounds of urea.

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[4] For specific results, see Appendix C.

4) An additional 5,033 bushels of corn could be produced to sell as a cash crop.

5) In addition to the dairy enterprise, the report indicates that the available resources could be used to produce 21 head of dairy beef each year.

6) The report also indicates that additional labor should be hired during the spring and fall months.

Case Farm Five

Case farm five is located in Eastern Indiana. The farm consists of 80 acres with another 90 acres of land rented under contract. There is also another 80 acres of land that is available to rent.

The farm is operated by the owner with additional labor supplied by the family.

The farmer was currently milking 28 cows and was very interested in expanding his herd to 50 cows.

The only forage grown currently was alfalfa hay. The farm had no sil storage; however the farmer was interested in building a silo and expanding his forage production to include alfalfa and corn silages.

In addition to the 40 acres of alfalfa hay currently produced, 80 acres of corn and 60 acres of soybeans were also produced on the owned and rented lands.

The cows were being milked in a stanchion barn with pail milkers.

Manure disposal was handled by bedding the cows in a loose housing situation with the manure being hauled out in the spring. The farmer was considering constructing a manure pit to lessen the labor requirements for manure disposal.

The farmer also had a small dairy beef enterprise which he was considering expanding as he expanded his dairy herd.

In addition to the aforementioned pending decisions, the farmer was also interested in using the planning model to help plan possible purchases of corn and oats for use in his concentrate mixture. To supplement the concentrate mixture he was currently using a 42 percent crude protein commercial protein supplement, but he was also interested in the profitability of using soybean oil meal and alfalfa meal instead of the commercial supplement.

Results[5]

Using the results obtained for case farm five, the extension agent could make the following recommendations:

1) The results from the planning model showed an increase in profit could be obtained through herd expansion , at least to 5.5 cows.
2) This expansion of herd size would require that 135 hours of seasonal labor be hired.
3) The results also showed that all of the available land that could be rented could be put to a profitable use with a break-even rent for an additional acre of $197.00 per acre.
4) In addition to feeding the dairy herd, 147 tons of hay and 14,500 bushels of corn would be available to sell.
5) The report also showed that all replacements should be purchased.
6) In the optimal plan, a labor shortage was very evident during the spring months. This would indicate that constructing a manure pit for manure disposal could be a profitable move by reducing labor requirements during the spring months.

[5] See Appendix C for a specific reference to case farm five's results.

7) The dairy beef enterprise should be dropped.

8) An investment should be made in a silo of at least 500 ton capacity, and revised model runs showed that the smaller the supply of labor, the more profitable the silo would be.

9) A protein supplement would not be needed in the concentrate ration.

Case Farm Six

Case farm six was a 300 acre dairy farm located in Northeastern Indiana. The farm was operated by the farm owner with additional labor being supplied from several teenage sons who were attending high school.

The farmer was currently milking 30 cows, with an average annual milk production of 12,000 pounds per cow, but was considering expanding to 45 cows.

The forages being produced consisted primarily of 50 acres of alfalfa hay with 15 acres of corn silage being produced to store in a 200 ton upright silo. The cows were pastured during the spring and summer months on 15 acres of permanent pasture.

In addition to the 80 acres used to produce forage crops, 60 acres of land was used in the production of corn, 10 acres was used for soybean production, and 17 acres of wheat was produced.

The cows were being milked in a stanchion barn with a pipeline milking system.

Manure disposal was being accomplished by scraping the lots and hauling the manure to the fields once every week.

The farmer was interested in using the planning model to predict pur chasing corn and oats for his concentrate mixture.

He was using a 44 percent crude protein commercial protein supplement, but was interested in the possibility of purchasing soybean oil meal or cottonseed meal for use in his concentrate mixture.

The dairymen was also very interested in the possibility of building a larger silo with a modern feeding system and changing his operations to a year-round drylot system. He felt that he would prefer to make this change if he could do so without a loss in income.

Results[6]

Based on the results of using case farm six data with the planning model, the extension agent could make the following recommendations:

1) Expand the dairy herd to the maximum size of 45 cows as specified by the farm operator.
2) The livestock should be fed with 179 tons of alfalfa hay, 125 tons of corn silage, and 4400 bushels of corn.
3) The high shadow price on labor in May, indicates that additional labor should be hired in that month.
4) In addition to the forages and grains needed to feed the dairy herd, 162 tons of alfalfa hay and 8100 bushels of corn could be produced for sale as a cash crop.
5) Thirteen head of dairy beef could also be included in the farm operations.
6) All herd replacements should be raised.

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[6] For a specific reference to case farm six's results see Appendix C.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

This study was undertaken in an effort to develop a computerized dairy planning model which could be used through the Cooperative Extension Program to help dairy farmers more profitably plan their total farm operations.

The planning model includes such information as planting and harvesting schedules for both forage and grain crops; a profit and loss statement which includes sales of all animal and crop products, purchases of all requirements for the total farm including feed purchasing, and a budgeting of fixed costs; a projected land preparation schedule; a projected labor use schedule which includes permanent and seasonal labor; a projected feeding schedule which includes both forages and concentrate feeds; and a schedule of values of additional resources which indicates shortages and the break-even price of additional resources.

The development of the model required the aggregation of data from various sources on the effect of timeliness of plant and harvest dates on the quantity and quality of various crops and the effect which the quality of the forage had upon voluntary intake of dry matter by dairy cows and the effect upon nutrient content of the various crops encountered on a dairy farm.

The development of the model also required the derivation of nutrient requirement formulas for dairy cows, dairy heifers, and dairy beef.

To aid in the use of the planning model as an extension tool, a concise input form was developed which would allow the farmer's input data to be entered into the data processing system through an on-line terminal system.

The model was tested for extension use using case farms which were selected by extension agents. These farms varied as to size of the milking herd, size of the farm, crops produced and the availability of resources.

Total farm plans were developed for these case farms using the planning model in conjunction with the farmers input data, and the reactions of the farmers to these optimized plans were observed.

Conclusions

The results obtained using the planning model on test farms were quite varied. Although all of the farm operators seemed to recognize an increase in farm income in the optimized plans, the reactions to the plans differed. While some of the farmers were fast in accepting the feasibility of the optimized plans for their farms, others were extremely reluctant to do so. In fact, some of the farmers were quite skeptical that they could make such a plan profitable for their farm.

Some of the skepticism seemed to be based on the practice of some of the farmers of feeding forages free-choice to their milking herd. When the optimized plan develops a feeding schedule it feeds the cows on the basis of nutrient requirements only; thus, in many cases the cows are receiving less total forage per head than the farmer would normally be feeding. Since the farmer is used to feeding excessive amounts of forage, the extension agent is confronted with the problem of convincing the farmer that he could possibly be over-feeding his cows.

The amount of the increase in net income for the optimized plan as compared to actual operations is difficult to ascertain because most of the farmers did not reveal their actual farm income. The budgeted "present" plans, in all case farms, show lower present net income than the optimized plan. For five of the six case farms, the average increase in the net income figures for the optimized plan was 78.2 percent over the budgeted "present" plan. The optimized plan for Case Farm Three had a budgeted present net income of a negative $7,058 and an optimized net income of positive $40,944, which resulted in an infinite percentage increase in net income with the optimized plan.

In addition to its purpose of optimizing farm operations, the planning model may serve the purpose of bringing some management issues, such as the over-feeding problem discussed above, to the forefront, and thus, suggesting to the dairyman that he should evaluate his management practices, possibly with the end result of improving the management ability of the dairy farmer.

Thus, the planning model may effectively serve two purposes. The first being one of providing the dairy farmer with a farm evaluation tool. And the second purpose of improving the dairy farmer's skill at managing his farm.

Implications for Future Research and Extension Work

Extension Applications

This study has some significant implications to the work of extension personnel. Extension agents now have one more tool to use in their endeavor in improving the farming practices of farmers. They are now confronted with the task of learning to use the tool effectively and in such a way as to increase the confidence which the farmer will place in this management tool.

Future Research

As mentioned in the problem statement, the model was developed to include the possibility of expanding it to a general planning model for forage consuming livestock. Although this further expansion is beyond the scope of this study, the model structure is such that expanding the model to include beef production is a relatively simple task. All of the crop production activities and the feeding activities would remain the same; therefore, the addition of beef production activities would convert the dairy planning model to a beef planning model.

This study has also shown the need for further research by agronomists and dairy researchers on the effect of stage of maturity of forage crops on the quality and quantity of the crops produced. A considerable amount of research has been done in this area; however, there seems to be considerable disagreement on the results of the research.

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Table A-1 - Crop Data on Harvest and Plant Period of Various Crops.[1/] (4, 6, 8, 17, 19, 33, 39, 41, 43)

Crop	Dec. 9 Mar. 31	Apr. 1 Apr. 30	May 1 May 14	May 15 May 28	May 29 Jun 11	Jun 12 Jun 26	Jun 26 Jul 9	Jul 10 Jul 23	Sep 10 Sep 24	Sep 26 Oct 9	Oct 10 Nov 8	Nov 9 Dec 8
Alfalfa Hay (E)	P			H		h						
Alfalfa Hay (L)	P				H		h					
Red Clover Hay (E)	P				H		h					
Red Clover Hay (L)	P					H		h				
Bromegrass Hay (E)	P			H		h						
Bromegrass Hay (L)	P				H		h					
Orchardgrass Hay (E)	P			H			h					
Orchardgrass Hay (L)	P				H			h				
Birdsfoot Trefoil Hay (E)	P				H		h					
Birdsfoot Trefoil Hay (L)	P					H		h				
Timothy Hay (E)	P				H		h					
Timothy Hay (L)	P					H		h				
Lespedeza Hay (E)	P				H			h				
Lespedeza Hay (L)	P					H			h			
Wheat Silage (E)						H			P			
Wheat Silage (L)							H		P			
Alfalfa Silage (E)	P			H		h						
Alfalfa Silage (L)	P				H		h					
Grass Silage (E)	P			H		h						
Grass Silage (L)	P				H		h					
Corn Silage (E)			P							H		
Corn Silage (L)			P								H	
Sorghum Silage (E)			P							H		
Sorghum Silage (L)			P								H	
Alf. Greenchop (E)	P			H		h						
Alf. Greenchop (L)	P				H		h					
Sorghum-Sudan G.C.(E)			P			H	h					
Sorghum-Sudan G.C.(L)			P				H					
Grass Greenchop (E)	P			H		h						
Grass Greenchop (L)	P				H		h					

1/ "P" indicates the plant period for the various crops. "H" indicates the harvest period of the various crops, and in the case of multiple harvest crops "H" indicates the first cutting harvest period, and "h" indicates the second cutting harvest period.

Table A-1 – (Con't)

Crop	Dec. 9 May 31	Apr. 1 Apr. 30	May 1 May 14	May 15 May 28	May 29 Jun 11	Jun 12 Jun 26	Jun 26 Jul 9	Jul 10 Jul 23	Sep 10 Sep 24	Sep 25 Oct 9	Oct 10 Nov 8	Nov 9 Dec 8
Corn 11			P							H		
Corn 12			P								H	
Corn 13			P									H
Corn 21				P						H		
Corn 22				P							H	
Corn 23				P								H
Corn 31					P					H		
Corn 32					P						H	
Corn 33					P							H
Soybeans 11				P						H		
Soybeans 12				P							H	
Soybeans 21					P					H		
Soybeans 22					P							H
Wheat 11							H		P			
Wheat 12								H	P			
Wheat 21							H			P		
Wheat 22								H		P		
Oats 11		P					H					
Oats 12		P						H				
Oats 21			P				H					
Oats 22			P					H				
Milo 11				P						H		
Milo 12				P							H	
Milo 21					P					H		
Milo 22				P							H	
Barley 11							H		P			
Barley 12								H	P			
Barley 21							H			P		
Barley 22								H		P		

1/ "P" indicates the plant period for the various crops. "H" indicates the harvest period of the various crops, and in the case of multiple harvest crops, "H" indicates the first cutting harvest period, and "h" indicates the second cutting harvest period.

Table A-2 - Base Data on Nutrient Contents and Yields of Early Harvested Crops and Purchased Protein Supplements. (2, 11, 28, 29)

Crop	Crude Protein (Percent)	Net Energy (Therms)	Dry Matter (Percent)	Yield
Hay Crops:				(Tons/Acre)
Alfalfa	15.4	41.5	90.5	5.4
Red Clover	13.5	45.0	88.3	2.3
Bromegrass	10.9	38.0	90.3	2.7
Orchardgrass	10.5	40.0	88.7	2.3
Birdsfoot Trefoil	14.2	45.4	91.2	3.5
Timothy	7.6	39.8	89.0	2.6
Lespedeza	14.3	38.0	89.1	1.5
Silage Crops:				
Wheat	1.5	13.8	32.0	?
Alfalfa	6.3	17.6	36.2	13.5
Grass	4.0	17.9	37.3	5.5
Corn	1.8	11.0	20.3	20.0
Sorghum	1.5	13.0	25.0	5.9
Greenchop Crops:				
Alfalfa	4.6	12.0	22.5	21.73
Sorghum-Sudan	3.0	12.3	20.8	7.1
Grass	3.8	12.7	22.0	9.27
Grain Crops:				(Bu./Acre)
Corn (Avg.)	9.1	80.1	85.0	125.
Soybeans (Avg.)	37.9	87.6	90.0	40.
Wheat (Avg.)	13.2	80.0	89.5	41.
Oats (Avg.)	12.0	80.1	90.2	70.
Milo (Avg.)	10.9	77.8	89.0	65.
Barley (Avg.)	12.7	70.5	89.4	46.
				(Tons/Acre)
Pasture	4.7	13.8	23.9	1.7
Protein Supplements:				
Soybean Oil Meal	45.7	79.6	90.4	----
Cottonseed Meal	45.6	76.8	94.3	----
Linseed Meal	35.2	77.0	91.1	----
Corn Gluten Meal	24.8	80.2	90.3	----
Urea	262.	0.	0.	----
Wheat Bran	16.4	56.9	90.1	----
Alfalfa Meal	17.7	47.1	92.7	----
Commercial Protein Supplement	36.	0.	0.	----

Table A-3 - Crop Data on Productive Life, Yield, and Voluntary Intake of Crops as Related to Harvest Time and Maturity. (2, 3, 4, 5, 6, 8, 15, 17, 18, 21, 31, 34, 35, 36, 39, 40, 41, 44, 19)

Crop	Average Productive Life of Crop	Deviations of Crop Yield From Expected Yield By Harvest or Plant Dates	Maximum Voluntary Intake of Dry Matter per 100 lbs. of Body Weight
Hay Crops:	(Years)	(Percent)	(Pounds)
Alfalfa (Early)	4	+7	2.7
Alfalfa (Late)	4	-7	2.3
Red Clover (Early)	2	+4	2.5
Red Clover (Late)	2	-4	2.2
Bromegrass (Early)	4	+4	2.3
Bromegrass (Late)	4	-4	2.0
Orchard grass (Early)	4	+5	2.2
Orchard grass (Late)	4	-5	1.9
Birdsfoot Trefoil (Early)	4	+7	2.7
Birdsfoot Trefoil (Late)	4	-7	2.3
Timothy (Early)	4	+4	2.2
Timothy (Late)	4	-4	1.9
Lespedeza (Early)	2	+20	2.4
Lespedeza (Late)	2	-20	2.2
Silage Crops:			
Wheat (Early)	1	+4	2.0
Wheat (Late)	1	-4	2.0
Alfalfa (Early)	4	+7	2.4
Alfalfa (Late)	4	-7	2.2
Grass (Early)	5	+5	2.3
Grass (Late)	5	-5	2.0
Corn (Early)	1	+3	2.0
Corn (Late)	1	-3	2.0
Sorghum (Early)	1	+4	2.0
Sorghum (Late)	1	-4	2.0
Green-Chop Crops:			
Alfalfa (Early)	4	+13	2.7
Alfalfa (Late)	4	-13	2.3
Sorghum-Sudan (Early)	1	+8	2.0
Sorghum-Sudan (Late)	1	-8	2.0
Grass (Early)	5	+20	2.0
Grass (Late)	5	-20	2.0
Grain Crops:			
Corn (11)	1	+13	3.0
Corn (12)	1	+11	3.0
Corn (13)	1	+6	3.0
Corn (21)	1	0	3.0
Corn (22)	1	+1	3.0
Corn (23)	1	-6	3.0
Corn (31)	1	0	3.0
Corn (32)	1	-9	3.0
Corn (33)	1	-17	3.0

(cont.)

Table A-3 (cont.)

Crop	Average Productive Life of Crop	Deviations of Crop Yield From Expected Yield By Harvest or Plant Dates	Maximum Voluntary Intake of Dry Matter per 100 lbs. of Body Weight
Grain Crops (cont.)	(Years)	(Percent)	(Pounds)
Soybeans (11)	1	+9	3.0
Soybeans (12)	1	-1	3.0
Soybeans (21)	1	-1	3.0
Soybeans (22)	1	-6	3.0
Wheat (11)	1	+7	3.0
Wheat (12)	1	+4	3.0
Wheat (21)	1	-5	3.0
Wheat (22)	1	-5	3.0
Oats (11)	1	+18	3.0
Oats (12)	1	+6	3.0
Oats (21)	1	-8	3.0
Oats (22)	1	-15	3.0
Milo (11)	1	+7	3.0
Milo (12)	1	+4	3.0
Milo (21)	1	-4	3.0
Milo (22)	1	-7	3.0
Barley (11)	1	+9	3.0
Barley (12)	1	+6	3.0
Barley (21)	1	-6	3.0
Barley (22)	1	-9	3.0
Pasture (Period 1)	5	0.7	1.7
Pasture (Period 2)	5	0.3	1.3

Table A-4 - Deviations of Crop Nutrients From Early Harvest Time Nutrient Content of Crops. (2, 3, 4, 5, 6, 8, 15, 17, 18, 21, 31, 34, 35, 38, 39, 40, 41, 44)

Crop	Percent Change in % Crude Protein	Percent Change in Therms of Net Energy	Percent Change in % Dry Matter
	(%)	(%)	(%)
Hay Crops:			
Alfalfa (Early)	0.	0.	0.
Alfalfa (Late)	-5.2	-3.4	0.
Red Clover (Early)	0.	0.	0.
Red Clover (Late)	-7.4	-4.4	-.03
Bromegrass (Early)	0.	0.	0.
Bromegrass (Late)	+8.07	-3.0	-3.0
Orchardgrass (Early)	0.	0.	0.
Orchardgrass (Late)	-2.3	-4.0	0.
Birdsfoot Trefoil (Early)	0.	0.	0.
Birdsfoot Trefoil (Late)	-5.2	-4.0	0.
Timothy (Early)	0.	0.	0.
Timothy (Late)	-16.0	-2.5	0.
Lespedeza (Early)	0.	0.	0.
Lespedeza (Late)	-9.0	-4.0	0.
Silage Crops:			
Wheat (Early)	0.	0.	0.
Wheat (Late)	+7.0	-6.0	+2.0
Alfalfa (Early)	0.	0.	0.
Alfalfa (Late)	-5.0	-6.0	0.
Grass (Early)	0.	0.	0.
Grass (Late)	-17.5	0.	0.
Corn (Early)	0.	0.	0.
Corn (Late)	+28.	+38.	+36.0
Sorghum (Early)	0.	0.	0.
Sorghum (Late)	+7.	-6.	+2.4
Green-Chop Crops:			
Alfalfa (Early)	0.	0.	0.
Alfalfa (Late)	0.	+8.0	+24.
Sorghum-Sudan (Early)	0.	0.	0.
Sorghum-Sudan (Late)	-40.	+5.7	+13.5
Grass (Early)	0.	0.	0.
Grass (Late)	-8.	+31.	+50.
Grain Crops:			
Corn (11)	0.	0.	0.
Corn (12)	0.	0.	0.
Corn (13)	0.	0.	0.
Corn (21)	0.	0.	0.
Corn (22)	0.	0.	0.
Corn (23)	0.	0.	0.
Corn (31)	0.	0.	0.
Corn (32)	0.	0.	0.
Corn (33)	0.	0.	0.

(cont.)

Table A-4. (cont.)

Crop	Percent Change in % Crude Protein	Percent Change in Therms of Net Energy	Percent Change in % Dry Matter
Grain Crops: (cont.)			
Soybeans (11)	0.	0.	0.
Soybeans (12)	0.	0.	0.
Soybeans (21)	0.	0.	0.
Soybeans (22)	0.	0.	0.
Wheat (11)	0.	0.	0.
Wheat (12)	0.	0.	0.
Wheat (21)	0.	0.	0.
Wheat (22)	0.	0.	0.
Oats (11)	0.	0.	0.
Oats (12)	0.	0.	0.
Oats (21)	0.	0.	0.
Oats (22)	0.	0.	0.
Milo (11)	0.	0.	0.
Milo (12)	0.	0.	0.
Milo (21)	0.	0.	0.
Milo (22)	0.	0.	0.
Barley (11)	0.	0.	0.
Barley (12)	0.	0.	0.
Barley (21)	0.	0.	0.
Barley (22)	0.	0.	0.

APPENDIX B

Purdue Dairy Farm Management Aid

Model

) **For:** ______________________________

This computerized planning model is designed for total farm planning on a dairy farm. This plan includes crop production schedules, land preparation schedules, labor usage schedules, milk production and dairy beef production schedules, herd replacement procurement schedules, and feeding schedules for the dairy herd.

You will supply data on resources available; crops produced; production infromation on both crops and livestock; and equipment, machinery and labor working rates.

The computer will assume typical losses in the yield and quality of crops for late planting and/or late harvest.

The computer will also assume typical losses of nutrients in hay and silage crops while these crops are in storage.

The computer establishes nutrient needs for your livestock according to guidelines set up by commonly used feeding standards.

Section I

Dairy Farm Enterprise Budget
Farmer Input Data

ID The first six letters of your name label your plan
Other identification may be added
This plan is for....________________

Description

Your plan description....________ ________________

General Data

When farming non-owned land on other than normal rented basis, such as land owned by a member of your family, this may be considered owned land and the annual charge for owned land may be entered as the approximate payment for the use of this land.

1.	Acres of owned land	1. ________acres
2.	Annual charge for owned land	2.$____.____/acre

Tillable land may be considered to be land that is at least suitable for hay crops and row crop land may be considered to be land suitable for grain crops.

3.	Acres of owned land that is tillable	3. ________acres
4.	Acres of owned land suitable for row crops	4. ________acres
5.	Acres of land that must be rented	5. ________acres
6.	Additional acres of land that may be rented	6. ________acres
7.	Cash rent for rented land	7.$________/acre
8.	Average percentage of rentable land that is tillable	8. ________percent
9.	Average percentage of rentable land that is suitable for row crops	9. ________percent
10.	Total annual wages for operator and permanent hired labor	10.$____.____
11.	Hourly wage for seasonal or part-time labor	11.$____.____/hr
12.	Average selling price of milk	12.$____.____/cwt
13.	Average selling price of cull cows	13.$____.____/cow
14.	Average buying price of young cows	14.$________/cow
15.	Average yearly milk production	15. ________lbs/cow/year
16.	Average butterfat test	16. ________percent
17.	Average weight of cows	17. ________pounds

18. Average producing life of cows 18. ______ years

19. Average selling price of baby calves 19.$______/calf

20. Minimum number of cows you would consider milking 20. ______ cows

21. Maximum number of cows you would consider milking 21. ______ cows

22. Number of cows you are currently milking 22. ______ cows

23. Total silo storage capacity 23. ______ tons

24. Total high moisture corn storage capacity 24. ______ bushels

25. Would you consider feeding soybeans as a grain to your cows (1 = yes, 2 = no) 25. ______

If you are feeding urea in your dairy ration, the computer will not consider feeding raw soybeans since these two feeds are incompatible.

Tractors:

1. How many field work tractors do you have? 26/______
2. How many of these tractors are used in grain harvesting operations? 27/______
3. How many of these tractors are used in hay harvesting operations? 28/______
4. How many of these tractors are used in green chopping operations? 29/______
5. How many of those tractors are used in silage harvesting operations? 30/______

__Time Available:__

For each of the good days you have allowed, we need to have the following information on time your men and machines can work:

(a) Permanent men, man-hours per day: Time you and your permanent hired labor have available for work on the farm. Be sure to include time used for livestock. If more than one person, add their hours together.

(b) Seasonal help, man-hours per day: The maximum amount of temporary help that you could obtain, if needed. If you could hire two men to work four hours each, enter 8 man hours.

(c) Machines hours/day: Time that your machines could be working. They might be operated by you or your hired help.

Time Available:	Permanent men Man-hours/day	Seasonal men Man-hours/day	Machine hours /day
Winter	31	32	33
Spring & Summer	34	35	36
Fall	37	38	39

__Working Day in Indiana:__

Weather conditions in Indiana over the past 20 years have been analyzed and indicated that in approximately 15 years out of 20, you can expect at least the number of "good" week days shown in the table below.

Working days:

A. If your soil dries out faster (or slower) than average, you may have somewhat more (or less) working days. What multiplier should we use on "our" good week days to get the good week days for your farm? (A number greater than 1.0 will increase the good days) 40______

B. Will you work Sundays? (1) Never (3) Yes, Fall
41.________ (2) Yes, Spring (4) Yes, both

C. What is the earliest possible date you begin planting?

42.______/______
Mo Day

D. What is the earliest possible date you could begin combining?

43.______/______
Mo Day

Equipment and labor working rates:

44. What is your silage feeding rate — 44.______lbs/man-hr
45. What is your hay feeding rate — 45.______lbs/man-hr
46. What is your high moisture corn feeding rate — 46.______bu/hr
47. How many man-hours/day/calf are required for raising herd replacements — 47.______man-hrs./d calf
48. How many hours/day are required for miscellanious chores (breeding, record keeping, etc.) — 48.______hours/day

ustom Work:

49. Charge for custom combining $________/acre
50. Charge for custom hay harvesting $______/acre

Acres/period that hay harvesting and grain combining can be hired

	Summer	Early Fall	Late Fall
Hay harvesting	51/ Acres	------------	------------
Grain combining	52/ Bushels	53/ Bushels	54/ Bushels

Machinery Working Rates:	No. of Units of Equipment	Working Rates Per Unit
Land Preparation Operations:		
______	55 ______	56 ______ acres/hr
______	57 ______	58 ______ acres/hr
______	59 ______	60 ______ acres/hr
______	61 ______	62 ______ acres/hr
Planting:		
______	63 ______	64 ______ acres/hr
______	65 ______	66 ______ acres/hr
Seeding:		
______	67 ______	68 ______ acres/hr
______	69 ______	70 ______ acres/hr

	Total for All Units	Total for All Units
Silage Harvesting & Hauling	71 ______ acres/hr	72 ______ Man hr/ acre
Green Chopping & Hauling	73 ______ acres/hr	74 ______ Man hr/ acre
Grain Harvesting & Hauling		
Corn	75 ______ bu/hr	76 ______ Man hrs/ Combine hr
Soybeans	77 ______ bu/hr	78 ______ Man hrs/ Combine hr
Small Grains	79 ______ bu/hr	80 ______ Man hrs/ Combine hr

Hay Harvesting & Hauling	Number of Tractors Used	Working Rates Per Unit	Total for all Units - No. of Men Used
Mowing	81 ______	82 ______ acres/hr	83 ______
Raking	84 ______	85 ______ acres/hr	86 ______
Bailing	87 ______	88 ______ bales/hr	89 ______
Hauling	90 ______	91 ______ bales/hr	92 ______

Average pounds of hay/bale 93 ______ lbs/bale

Which of the following supplements would you consider using in your feed mixture? (choose not more than three)

1. Soybean Oil Meal
2. Cottonseed Meal
3. Linseed Meal
4. Corn gluten meal
5. Urea
6. Wheat Bran
7. Alfalfa Meal
8. Commercial protein supplement

For the supplement(s) that you choose, provide the Buying Price:

94._____ 95.$____/cwt

96._____ 97.$____/cwt

98._____ 99.$____/cwt

Which of the following grains would you consider using in your feed mixture?
(Choose not more than two)

1. Corn
2. Soybeans
3. Wheat
4. Oats
5. Milo
6. Barley

For the Grain(s) that you choose provide the buying price:

100._____ 101.$_____/cwt

102._____ 103.$_____/cwt

104. Which of the following types of manure disposal systems do you have? __________
1. None (cows on year-round pasture)
2. Seasonal haul-out
3. Frequent haul-out (every day, every week, etc.)
4. Manure pit
5. Lagoon

105 Which of the following types of milking systems do you have? __________
1. Stanchion with pipeline
2. Stanchion with pail milkers
3. Side-opening with pipeline
4. Side-opening with pail milkers
5. Herringbone with pipeline
6. Herringbone with pail milkers

106 What is the total annual charge for all equipment, machinery, buildings? (See worksheet #1) $__________

107. Cost/Acre of land preparation (Fuel,Oil, & Repairs) $____.____/acre

108. Variable cost/cow in the milking herd $____.____/cow
(See worksheet #3)

109. Variable cost/heifer of raising replacement $____.____/heifer
If you consider raising dairy beef, complete the following:
If not, price = $__0___.

110. Variable cost/ton (power costs) of feeding hay $___.____/ton
111. Variable cost/ton (power costs) of feeding silage $____.____/ton
112. Variable cost/ton (power costs) of feeding high moisture corn $____.____bu/ton
113. Selling price of dairy beef $____.____/cwt
114. Selling weight of dairy beef ________lbs.
115. Selling age of dairy beef ________months
116. Variable cost/animal of raising dairy beef $____.____animal/year
(See worksheet##4)

Production Considerations

For the crops that you choose, fill in the following:

Which of the following crop would you consider producing:	See Worksheet #2 Direct cost of Production/Acre	Selling Price ton Per Ton	Average Yield in tons Tons	Present Acreage
Hay: (Choose not more than three)				
1. Alfalfa Hay	117	118	119	120
2. Red Clover Hay	121	122	123	124
3. Bromegrass Hay	125	126	127	128
4. Orchardgrass Hay	129	130	131	132
5. Birds Foot Trefoil Hay	133	134	135	136
6. Timothy Hay	137	138	139	140
7. Lespedeza Hay	141	142	143	144
Silages: (Choose not more than three)	xxx	xxx	xxx	xxx
8. Wheat Silage	145	xxx	146	147
9. Alfalfa Silage	148	xxx	149	150
10. Grass Silage	151	xxx	152	153
11. Corn Silage	154	xxx	155	156
12. Sorghrum Silage	157	- xxx	158	169
Green Chop: (choose not more than two)	xxx	xxx	xxx	xxx
13. Alfalfa green-chop	160	xxx	161	162
14. Sorghrum-Sudan green chop	163	xxx	164	165
15. Grass green-chop	166	xxx	167	168
Grain: (choose not more than three)	xxx	xxx per bu.	xxx bu.	xxx
16. Corn	169	170	171	172
17. Soybeans	173	174	175	176
18. Wheat	177	178	179	180
19. Oats	181	182	183	184

Worksheet #1

Annual Charge for Equipment, Machinery, and Buildings

Depreciation on feeding system	$________/yr.	
Depreciation on housing and manure systems	$________/yr.	
Depreciation on milking system	$________/yr.	
Depreciation on calf raising system	$________/yr.	
Depreciation on machinery and equipment	$________/yr.	
Total Depreciation		$________/yr.
Insurance	$________/yr.	
Building Repairs	$________/yr.	
Interest on Debts	$________/yr.	
Miscellaneous Cash Expenses	$________/yr.	
Total Cash Expenses		$________/yr.

*Total Annual Charge for all Equipment, Machinery, and Buildings

$________/yr.

*Enter this charge for question #106.

Worksheet #2

Direct Costs of Production[1]

Crop #1__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

Crop #2__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

Crop #3__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

Crop #4__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

Crop #5__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

Crop #6__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

Crop #7__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

Crop #8__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

Crop #9__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

Crop #10__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

Crop #11__________

Fertilizer and lime $__________/acre/yr.
Seed $__________/acre/yr.
Chemicals $__________/acre/yr.
Fuel costs $__________/acre/yr.
Total $__________/acre/yr.

1 For crops that produce more than one year divide the costs associated with establishing the crop by the number of expected years before reseed-

Worksheet #3

Variable cost/cow in the milking herd (besides feed costs)

Vet and medicine	$__________1 yr.
Breeding	$__________1 yr.
Marketing	$__________1 yr.
Miscellaneous	$__________1 yr.
Total variable cost/cow	$__________

Variable cost/heifer of raising replacements (besides feed costs)

Vet and medicine	$__________1 yr.
Miscellaneous	$__________1 yr.
Total variable cost/heifer	$__________

Worksheet #4

Variable cost/steer of raising dairy beef (excluding beef costs)

Vet and medicine	$__________1 steer
Marketing	$__________1 steer
Miscellaneous	$__________1 steer
Total variable cost/steer	$__________

Section II

This section need only be completed if the farmer has good estimates (Forage analysis, etc.) concerning the crops on his particular farm which differ from the base plan. Change only those entries which differ from the base case. Any entries remaining unchanged will be taken from the base plan. If there are no entries, go to section III.

	Crude Protein %		Net Energy Therms/100 lbs		Dry Matter %	
	Our Plan	Your Plan	Our Plan	Your Plan	Our Plan	Your Plan
Alfalfa Hay	15.4	201	41.5	202	90.5	203
Red Clover Hay	13.5	204	45.0	205	88.3	206
Bromegrass Hay	10.9	207	38.0	208	90.3	209
Orchardgrass Hay	10.5	210	40.0	211	88.7	212
Birds Food Trefoil Hay	14.2	213	45.4	214	91.8	215
Timothy Hay	7.6	216	39.8	217	89.0	218
Lespedeza Hay	14.3	219	39.0	220	89.1	221
Wheat Silage	1.5	222	13.8	223	32.0	224
Alfalfa Silage	6.3	225	17.6	226	36.2	227
Grass Silage	4.0	228	17.9	229	37.3	230
Corn Silage	1.8	231	11.0	232	20.3	233
Sorghum Silage	1.5	234	13.0	235	25.0	236
Alfalfa Green-Chop	4.6	237	12.0	238	22.5	239
Sorghum Green-Chop	3.0	240	12.3	241	20.8	242
Grass Green-Chop	3.8	243	12.1	244	22.0	245
Corn	9.1	246	80.1	247	85.0	248
Soybeans	37.9	249	87.6	250	90.0	251
Wheat	13.2	252	80.0	253	89.5	254
Oats	12.0	255	80.1	256	90.2	257
Milo	10.9	258	77.8	259	89.0	260
Barley	12.7	261	70.5	262	89.4	263
Pasture	6.7	264	13.8	265	23.9	266

	Crude Protein %		Net Energy Therms/100 lbs		Dry Matter %	
	Our Plan	Your Plan	Our Plan	Your Plan	Our Plan	Your Plan
Purchased Hay	12.0	267	38.0	268	91.0	269
Soybean Oil Meal	45.7	270	79.6	271	90.4	272
Cottonseed Meal	45.6	273	76.8	274	94.3	275
Linseed Meal	35.2	276	77.0	277	91.1	278
Corn Gluten Meal	24.8	279	80.2	280	90.3	281
Urea	262.0	282	0.	283	100.0	284
Wheat Bran	16.4	285	56.9	286	90.1	287
Alfalfa Meal	17.7	288	47.1	289	92.7	290
Commercial Protein Supplement	36.0	291	50.	292	100.	293

Section III

This section need only be completed if the farmer has good estimates for the labor requirements for his own particular systems. Change only those entries which differ from the base plan. Any entries unchanged will be taken from the base plan.

Labor Requirement for Milking and Care for the Dairy Animals

Milking:	Preparation for Milking hrs/day	Clean up of Equipment hrs/day	Fixed Time Per Milking- hrs/day	Additional time/cow for Milking hrs/cow
1. Stanchion with pipe-line	.54	.79	.02	.09
2. Stanchion with pails	.41	1.09	.02	.11
3. Side-opening with pipeline	.54	.79	.61	.057
4. Side-opening with pail	.41	1.09	.81	.06
5. Herringbone with pipe-line	.54	.79	.18	.05
6. Herringbone with pail	.41	1.09	.22	.053
7. Your system	294	295	296	297

Manure Disposal	Hrs/month Required in Fall & Winter	Hrs/month Required in Early Spring	Hrs/month Required in Late Spring & Summer
1. None (cows on year-round pasture)	0.	0.	0.
2. Seasonal haulout	.14	4.14	.14
3. Frequent haulout	.64	.64	.64
4. Manure Pit	.34	.34	.34
5. Lagoon	.24	.24	.24
6. Your system	298	299	300

<u>Analyzing Your Report</u>

Your report is prepared in two parts. A present plan is prepared based on your present crop production and number of cows milked presently. You should study this plan to see if it resembles your present operation. You may need to revise some input figures.

Table 1. Crop Production Schedule

A. Planting Schedule:
A planting schedule is reported for all crops with the period in which the crop was planted and the number of acres planted. (Note: Since hay and hay silage is not replanted every year, only that part that is planted is reported.)

B. Harvest Schedule:
A harvest schedule is reported for all crops with the period in which the crop was harvested, the number of acres harvested, and the yield per acre for that time period.

Table 2. Profit and Loss Statement
All sales, including hay and grain for cash crops, milk sales, calf sales, and cull cow sales, are reported.

All expenses, including land rent, hired labor, custom work hired, crop production expenses, crop feeding expenses, variable costs for cows and replacements, cost of purchased replacements, and fixed costs, are reported.

Gross profit is the figure which the computer maximized in obtaining your "Best " plan. This is the amount which could be divided among the fixed cost resources. (Note: Fixed costs for equipment, machinery, and buildings also includes insurance, building repairs, and interest on debts. After paying these expenses the remainder would be available for paying off principal on debts.)

Table 3. Projected Land Preparation Schedule
The land preparation schedule gives an indication of when land preparation should occur. (Note: Late spring preparation indicates planting may have been delayed while finishing land preparation.)

Table 4. Projected Labor Use
The seasonal labor is within the amounts you said could be used in questions 32, 35, and 38.

Permanent labor used includes only the labor used on the "good days". (i.e. Labor used for livestock on non-field work days is not included in the total.)

able 5. Projected Feeding Schedule
The crops and concentrate feeds, which are fed to the dairy herd, herd replacements, and dairy beef cattle, are reported with the amount fed. The amount fed is reported in each of the three periods. The three feeding periods include: (a) Fall - Winter - which extends from October 10 to March 31, 173 days. (b) Spring - which extends from April 1 to June 11, 72 days. (c) Summer - which extends from June 12 to October 9, 120 days.

able 6. Value of Additional Resources
The resources which limited your plan are taken one-at-a-time to determine how much one added unit of the resource would be worth. This indicates a "pressure" toward increased profit.

Usually more than one unit of the resource would add the stated amount, or somewhat less per unit. Also, adding two or more resources at a time may be very profitable, but these figures are calculated for only one resource at a time. Since most resources come in whole machines or a change in operation which adds working hours or acres covered to each day, you should make a revised plan to test the total effect of changes suggested by this table.

APPENDIX C

PURDUE DAIRY FARM MANAGEMENT AID
FOR CASE FARM ONE

TABLE 1. PROJECTED CROP PRODUCTION SCHEDULE BY PERIODS

PLANTING PERIOD	CROP	ACRES
DEC 9-MAR21	ALFALF SIL	11.
APR24-MAY14	CORN	69.
MAY15-MAY28	SOYBEANS	108.
MAY29-JUN11	SOYBEANS	71.

FIRST(ONLY) HARVEST DATE	CROP	ACRES	YIELD
MAY15-MAY28	ALFALF SIL	26.	7.2(TNS/AC)
MAY29-JUN11	ALFALF SIL.	17.	6.2(TNS/AC)
SEP25-OCT 9	SOYBEANS	108.	43.6(BU/AC)
OCT10-NOV 8	CORN	21.	138.?(BU/AC)
OCT10-NOV 8	SOYBEANS	71.	37.6(BU/AC)
NOV 9-DEC 3	CORN	48.	13?.5(BU/AC)

TABLE 2. PROJECTED ANNUAL PROFIT AND LOSS STATEMENT

```
  SOYBEANS SALES(  7369 BU AT $  4.20)     $ 30949.
  MILK     SALES(  757560 LBS AT $ 7.50)   $ 56840
  BABY CALF SALES(  47 HEAD AT  80.00/HEAD) $  3754.
  CULL COW SALES (  18 HEAD AT300.00/HEAD) $  5414.

      TOTAL SALES. . . . . . . . . . . . . . . . . . .$  96964.
VARIABLE COSTS
  VARIABLE COST OF CROP PRODUCTION        $ 13182.
  VARIABLE COST OF FORAGE FEEDING         $   526.
  UREA              PURCHASED
               (   92 CWT AT $14.00/CWT)$  1282.
  MISC. VARIABLE COST PER COW
               (  72 COWS AT $100.00/COW)$  7219.
  MISC. VARIABLE COST OF RAISING REPL
               (  18 REPL AT $ 20.00/REPL)$   361.
      TOTAL VARIABLE COSTS                           $  21683.
                                                     --------
GROSS PROFIT                                         $  75281

FIXED COSTS
  OWNED LAND ( 300. ACRES AT $ 45.00/ACRE)$ 13500.
  PERMANENT LABOR                        $  6000.
  EQUIPMENT, MACHINERY, AND BUILDINGS    $ 20800
      TOTAL FIXED COSTS                              $  40300.
                                                     --------
NET PROFIT                                           $  34981.
```

TABLE 3. PROJECTED LAND PREPARATION SCHEDULE

1. ACRES PREPARED IN FALL
204. ACRES PREPARED IN EARLY SPRING
53. ACRES PREPARED IN LATE SPRING

TABLE 4. PROJECTED LABOR USE

SEASON	PERMANENT LABOR(HRS)	SEASONAL LABOR(HRS)	TOTAL LABOR(HRS)
DEC 9-MAR31	491.	0.	491.
APR 1-MAY28	388.	0	388.
MAY29-JUL 9	279.	0.	279.
SEP16-DEC 8	829.	0.	829.
TOTAL	1987.	0.	1987.

TABLE 5 PROJECTED FEEDING SCHEDULE

FEED		AMOUNT FED BY SEASON			TOTAL
		FALL-WINTER	SPRING	SUMMER	
ALFALF SIL	(TONS)	124.	52.	87.	263.
CORN	(BU)	4357.	1812.	3061.	9230.
*PREM	(CWT)	43.	18.	31.	92.

*R[illegible]ERS TO PURCHASED FEED

TABLE 6. VALUE OF ADDITIONAL RESOURCES

LABOR SHORTAGE PERIODS	BREAK-EVEN WAGE
DEC 9-MAR31	24.69
APR 1-APR23	24.69
APR24-MAY14	24.69
MAY15-MAY28	64.41
MAY29-JUN11	24.69
SEP16-SEP24	43.18
SEP25-OCT 9	27.59
OCT10-NOV 8	24.69

PURDUE DAIRY FARM MANAGEMENT AID
FOR CASE FARM TWO

TABLE 1 PROJECTED CROP PRODUCTION SCHEDULE BY PERIODS

PLANTING PERIOD	CROP	ACRES
APR25-MAY14	CORN SIL	52.
APR25-MAY14	CORN	206.
MAY15-MAY28	CORN	81.
MAY15-MAY28	SOYBEANS	60.

FIRST(OR ONLY) HARVEST DATE	CROP	ACRES	YIELD
SEP25-OCT 9	CORN	185.	135.6(BU/AC)
SEP25-OCT 9	SOYBEANS	60	49.0(BU/AC)
OCT10-NOV 8	CORN SIL	52.	19.4(TNS/AC)
OCT10-NOV 8	CORN	102	12[illegible].7(BU/AC)

TABLE 2 PROJECTED ANNUAL PROFIT AND LOSS STATEMENT

CORN SALES(3[illegible] BU AT $ 2.50)	$ 82302	
MILK SALES(1500000LBS AT $ 8.00)	$124000	
BABY CALF SALES(10[illegible] HEAD AT 0.00/HEAD)	$ 0	
CULL COW SALES (24 HEAD AT416.00/EACH)	$ 9984.	
TOTAL SALES		$ 217006.
VARIABLE COSTS		
VARIABLE COST OF CROP PRODUCTION	$ 22752	
VARIABLE COST OF FORAGE FEEDING	$ 455	
HAY PURCHASED([illegible] TN AT$[illegible].00/TN)	$ 3828	
MISC VARIABLE COST PER COW (120 COWS AT $ 75.00/COW)	$ 9000.	
COST OF REPLACEMENTS BOUGHT (24 REPL AT $475.00/REP)	$ 11400.	
TOTAL VARIABLE COSTS		$ 46980.
GROSS PROFIT		$ 170106.
FIXED COSTS		
OWNED LAND (475 ACRES AT $ 40.00/ACRE)	$ 19000	
PERMANENT LABOR	$ 14000.	
EQUIPMENT, MACHINERY, AND BUILDINGS	$ 10000.	
TOTAL FIXED COSTS		$ 43000.
NET PROFIT		$ 127106.

TABLE 3. PROJECTED LAND PREPARATION SCHEDULE

399. ACRES PREPARED IN EARLY SPRING

TABLE 4. PROJECTED LABOR USE

SEASON	PERMANENT LABOR(HRS)	SEASONAL LABOR(HRS)	TOTAL LABOR(HRS)
DEC 9-MAR31	922	0.	922.
APR 1-MAY28	594.	0.	594.
MAY29-JUL 9	564.	0.	564.
SEP24-DEC 8	1323	0.	1323
TOTAL.	3403.	0.	3403.

TABLE 5. PROJECTED FEEDING SCHEDULE

FEED		AMOUNT FED BY SEASON			TOTAL
		FALL-WINTER	SPRING	SUMMER	
ALFALFA HY	(TONS)	6	0	0	6
PURCHASED HAY(TONS)		243	0	0	243.
CORN SIL	(TONS)	685	84.	140	909
CORN	(BU)	0	1831	3051	4882
SOYBEANS	(BU)	0.	1100	1832.	2932

*REFERS TO PURCHASED FEED

TABLE 6 VALUE OF ADDITIONAL RESOURCES

LABOR SHORTAGE PERIODS	BREAK-EVEN WAGE
APR 25-MAY14	66 83
MAY15-MAY28	2 24
SEP14-SEP24	11.06

ADDITIONAL SILAGE STORAGE IS WORTH $ 1.06/TON

```
PURDUE DAIRY FARM MANAGEMENT AID
FOR CASE FARM THREE

TABLE 1  PROJECTED CROP PRODUCTION SCHEDULE BY PERIODS

PLANTING       CROP        ACRES
PERIOD

FEB-MAR      ALFALFA HY       8.
DEC 9-MAR31  ALFALF SIL      20.
APR20-MAY14  CORN           346.
MAY15-MAY28  SOYBEANS       240.


FIRST(OR ONLY) CROP       ACRES  YIELD
HARVEST DATE

MAY15-MAY28 ALFALFA HY       5.      6.4(TNS/AC)
MAY15-MAY28 ALFALF SIL      79.     12.8(TNS/AC)
MAY29-JUN11 ALFALFA HY      28       5.6(TNS/AC)
SEP25-OCT 9 SOYBEANS       240      43.6(BU/AC)
OCT10 NOV 8 CORN           155     123.2(BU/AC)
NOV 9-DEC 8 CORN           191     127.2(BU/AC)


TABLE 2  PROJECTED ANNUAL PROFIT AND LOSS STATEMENT
  HAY       SALES(  29 TONS AT $ 80.00)       $   2340
  CORN      SALES( 32561 BU AT $  2.00)       $  65121
  SOYBEANS  SALES( 1011[illegible] BU AT $  5.[illegible]0)       $  59199
  MILK      SALES(  19[illegible]00 LBS AT $ 8.00)   $159[illegible]26
  BABY CALF SALES( 11[illegible] HEAD AT100.00/HEAD) $  11339
  CULL COW SALES (  2[illegible] HEAD AT [illegible]4.00/HEAD) $   8960

       TOTAL SALES     .   . . . . .   . . . . . . . . $ 306195.
VARIABLE COSTS
  LAND RENT         (  55  ACRES AT $60.00)$   3300
  HIRED LABOR       ( 256 HRS AT $ 2.00/HR)$    513.
  CUSTOM HAY HARV (    8 TNS AT $23.50/T )$    251
  VARIABLE COST OF CROP PRODUCTION         $  33530
  VARIABLE COST OF FORAGE FEEDING          $    668
  MISC  VARIABLE COST PER COW
                ( 140 COWS AT $110.00/COW)$ 15400.
  MISC  VARIABLE COST OF RAISING REPL
                (  1[illegible] REPL AT $ 25.00/REP)$    315.
  COST OF REPLACEMENTS BOUGHT
                (  11 REPL AT $[illegible]00.00/REP)$   8578.
       TOTAL VARIABLE COSTS                          $  61573.
                                                    ---------
GROSS PROFIT                                         $ 244622.

FIXED COSTS
  OWNED LAND ( 763 ACRES AT $ 45.00/ACRE)$ 34335.
  PERMANENT LABOR                         $ 24000
  EQUIPMENT, MACHINERY, AND BUILDINGS     $ 20000.
       TOTAL FIXED COSTS                             $  78335
                                                    ---------
NET PROFIT                                           $ 166287.
```

\ LE 3. PROJECTED LAND PREPARATION SCHEDULE

614. ACRES PREPARED IN EARLY SPRING

TABLE 4. PROJECTED LABOR USE

SEASON	PERMANENT LABOR(HRS)	SEASONAL LABOR(HRS)	TOTAL LABOR(HRS)
DEC 9-MAR31	576	0	576.
APR 1-MAY28	514	50.	564.
MAY29-JUL 9	455 ,	29.	484.
SEP20-DEC 8	903	177.	1005.
TOTAL	2452	256	2709.

TABLE 5 PROJECTED FEEDING SCHEDULE

FEED		AMOUNT FED BY SEASON			TOTAL
		FALL-WINTER	SPRING	SUMMER	
ALFALFA HY	(TONS)	70	29	49	149.
ALFALF SIL	(TONS)	435	181	301.	917.
ORN	(BU)	5904	2457.	4095	12456

*REFERS TO PURCHASED FEED

TABLE 6 VALUE OF ADDITIONAL RESOURCES

LABOR SHORTAGE PERIODS	BREAK-EVEN WAGE
MAY15-MAY23	67.80
SEP20-SEP24	33.84
SEP25-OCT 9	29.95
OCT10-NOV 8	19.57

THE VALUE OF AN ADDITIONAL COW IS $ 579. /COW

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P U R D U E   D A I R Y   F A R M   M A N A G E M E N T   A I D
FOR CASE FARM FOUR


TABLE 1. PROJECTED CROP PRODUCTION SCHEDULE BY PERIODS

PLANTING        CROP        ACRES
PERIOD

DEC 9-MAR31 ALFALF SIL         7.
MAY 1-MAY14 CORN SIL          26.
MAY 1-MAY14 CORN              78.
MAY15-MAY20 SOYBEANS          55.


FIRST(OR ONLY) CROP         ACRES  YIELD
HARVEST DATE

MAY15-MAY28 ALFALF SIL.       28.     10.7(TNS/AC)
MAY29-JUN11 ALFALFA HY         2.      4.6(TNS/AC)
SEP25-OCT 9 CORN              27.    113.0(BU/AC)
SEP25-OCT 9 SOYBEANS          55.     38.1(BU/AC)
OCT10-NOV 8 CORN SIL          26.     17.5(TNS/AC)
OCT10-NOV 8 CORN               1.    111.0(BU/AC)
NOV 9-DEC 8 CORN              50.    106.0(BU/AC)


TABLE 2  PROJECTED ANNUAL PROFIT AND LOSS STATEMENT
  SOYBEANS SALES(  2088 BU AT $   6.00)      $ 12528
  MILK      SALES(   945000LBS AT $ 7.00)    $ 66150.
  DAIRY BEEF SALES(  15 HEAD AT
        $40.00/CWT FOR 1000 LB ANIMALS)       $ 5802
  BABY CALF SALES(  27 HEAD AT 50.00/HEAD) $  1362
  CULL COW SALES (  14 HEAD AT450.00/HEAD) $  6300.

        TOTAL SALES  . . . . . . . . . . . . . . . . . .$  92142
VARIABLE COSTS
  HIRED LABOR        (  26 HRS AT $ 3.00/HR)$      79.
  VARIABLE COST OF CROP PRODUCTION          $  8334.
  VARIABLE COST OF FORAGE FEEDING           $   218.
  UREA                 PURCHASED
                  (  141 CWT AT $ 7.50/CWT)$  1060.
  MISC  VARIABLE COST PER COW
                 (  70 COWS AT $100.00/COW)$  7000.
  MISC. VARIABLE COST OF RAISING HFR
                 (  14 HFR AT $ 25.00/HFR)$    350.
  VARIABLE COST OF PRODUCING DAIRY BEEF
                 (  15 HEAD AT $ 16.25 00/HEAD)$   242.
        TOTAL VARIABLE COSTS                          $  16715.
                                                      ---------
GROSS PROFIT                                          $  75427.

FIXED COSTS
  OWNED LAND ( 263. ACRES AT $ 40.00/ACRE)$ 10520.
  PERMANENT LABOR                          $ 10000
  EQUIPMENT, MACHINERY, AND BUILDINGS      $  7500.
        TOTAL FIXED COSTS                             $  28020.
                                                      ---------
NET PROFIT                                            $  47407.
```

TABLE 3. PROJECTED LAND PREPARATION SCHEDULE

47. ACRES PREPARED IN FALL
118. ACRES PREPARED IN EARLY SPRING

TABLE 4. PROJECTED LABOR USE

SEASON	PERMANENT LABOR(HRS)	SEASONAL LABOR(HRS)	TOTAL LABOR(HRS)
DEC 9-MAR31	356	0.	356.
APR 1-MAY28	225.	8.	233.
MAY29-JUL 9	181.	0.	181
SEP24-DEC 8	555.	18.	573.
TOTAL	1317.	26.	1343.

TABLE 5 PROJECTED FEEDING SCHEDULE

FEED		AMOUNT FED BY SEASON			TOTAL
		FALL-WINTER	SPRING	SUMMER	
ALFALFA HY	(TONS)	8	0	0.	8.
ALFALF SIL	(TONS)	123	57.	95	275.
CORN SIL	(TONS)	191	81	134	406.
CORN	(BU)	3985.	1659	2765.	8410.
*UREA	(CWT)	67.	20.	46.	141.

*REFERS TO PURCHASED FEED

TABLE 6. VALUE OF ADDITIONAL RESOURCES

LABOR SHORTAGE PERIODS	BREAK-EVEN WAGE
MAY 1-MAY14	63.30
MAY15-MAY28	39.61
SEP24-SEP24	18.79
SEP25-OCT 9	13.66

THE VALUE OF AN ADDITIONAL COW IS $ 400. /COW

P U R D U E   D A I R Y   F A R M   M A N A G E M E N T   A I D
FOR CASE FARM FIVE

TABLE 1. PROJECTED CROP PRODUCTION SCHEDULE BY PERIODS

PLANTING PERIOD	CROP	ACRES
FEB-MAR	ALFALFA HY	10.
DEC 9-MAR31	ALFALF SIL	5.
MAY 1-MAY14	CORN SIL	12.
MAY 1-MAY14	CORN	86.
MAY29-JUN11	CORN	94.

FIRST(OR ONLY) CROP HARVEST DATE		ACRES	YIELD
MAY15-MAY28	ALFALFA HY	23.	6.4(TNS/AC)
MAY15-MAY28	ALFALF SIL	20.	12.8(TNS/AC)
MAY29-JUN11	ALFALFA HY	16.	5.6(TNS/AC)
SEP25-OCT 9	CORN	86.	113.0(BU/AC)
OCT10-NOV 8	CORN SIL	12.	19.4(TNS/AC)
OCT10-NOV 8	CORN	94	91.0(BU/AC)

TABLE 2. PROJECTED ANNUAL PROFIT AND LOSS STATEMENT

HAY	SALES(147 TONS AT $ 80.00)	$ 11742	
CORN	SALES(14690 BU AT $ 2.80)	$ 41132.	
MILK	SALES(684750LBS AT $ 8.00)	$ 54780	
BABY CALF SALES(	50 HEAD AT100.00/HEAD)	$ 4990	
CULL COW SALES (	11 HEAD AT330.00/HEAD)	$ 3630.	
TOTAL SALES			$ 116233.
VARIABLE COSTS			
LAND RENT	(170 ACRES AT 160.00)	$ 10200	
HIRED LABOR	(135 HRS AT $ 2.00/HR)	$ 270.	
CUSTOM HAY HARV	(10 TNS AT $[illegible]/T.)	$ 335	
VARIABLE COST OF CROP PRODUCTION		$ 12614.	
VARIABLE COST OF LIVESTOCK FEEDING		$ 330	
MISC VARIABLE COST PER COW	(55 COWS AT $110.00/COW)	$ 6050.	
COST OF REPLACEMENTS BOUGHT	(11 REPL AT $750.00/REP)	$ 8250.	
TOTAL VARIABLE COSTS			$ 37719.
GROSS PROFIT			$ 78514.
FIXED COSTS			
OWNED LAND	(80 ACRES AT $ 27.50/ACRE)	$ 2200	
PERMANENT LABOR		$ 9500	
EQUIPMENT, MACHINERY, AND BUILDINGS		$ 19000	
TOTAL FIXED COSTS			$ 30700.
NET PROFIT			$ 47814.

BLE 3 PROJECTED LAND PREPARATION SCHEDULE

206. ACRES PREPARED IN EARLY SPRING

BLE 4. PROJECTED LABOR USE

SON	PERMANENT LABOR(HRS)	SEASONAL LABOR(HRS)	TOTAL LABOR(HRS)
9-MAR31	182	0.	182
1-MAY28	364	76.	440.
9-JUL 9	305	59.	364
20-DEC 9	434	0	434
OTAL	1225.	135.	1421.

LE 5 PROJECTED FEEDING SCHEDULE

D		AMOUNT FED BY SEASON			TOTAL
		FALL-WINTER	SPRING	SUMMER	
ALFA HY	(TONS)	84.	0	0.	84.
ALF SIL	(TONS)	20.	78.	130.	228.
N SIL	(TONS)	108.	39.	65	212.
N	(BU)	1668.	709.	1181	3558.

TRS TO PURCHASED FEED

LE 6 VALUE OF ADDITIONAL RESOURCES

BOR SHORTAGE PERIODS	BREAK EVEN WAGE
PR 1-MAY14	104. 46
MAY15-MAY28	52. 86
MAY29-JUN11	3. 6C

REAK-EVEN RENT FOR AN ADDED ACRE IS $ 197. 56

E VALUE OF AN ADDITIONAL COW IS $ 761. /COW

PURDUE DAIRY FARM MANAGEMENT AID
FOR CASE FARM SIX

TABLE 1. PROJECTED CROP PRODUCTION SCHEDULE BY PERIODS

PLANTING PERIOD	CROP	ACRES
FEB-MAR	ALFALFA HY	13.
DEC 9-MAR 1	ALFALF SIL	4.
MAY 1-MAY14	CORN SIL	18.
MAY 1-MAY14	CORN	102.

FIRST(OR ONLY) CROP HARVEST DATE		ACRES	YIELD
MAY15-MAY29	ALFALFA HY	35.	5.3(TNS/AC)
MAY15-MAY29	ALFALF SIL	17.	10.7(TNS/AC)
MAY20 JUN11	ALFALFA HY	18.	4.6(TNS/AC)
SEP25-OCT 9	CORN	49.	113.0(BU/AC)
OCT10 NOV 8	CORN SIL	18.	17.5(TNS/AC)
OCT10-NOV 8	CORN	53.	111.0(BU/AC)

TABLE 2. PROJECTED ANNUAL PROFIT AND LOSS STATEMENT

HAY SALES(152 TONS AT $ 40.00) $ 6080
CORN SALES(7??? BU AT $ 2.??) $ 17036
MILK SALES(5??000 LBS AT $ 7.00) $ 40?50
DAIRY HEIFER SALES(17 HEAD AT
$10.00/CWT FOR 1000 LB ANIMALS) $ 5400
BABY CALF SALES(11 HEAD AT 50.00 EACH) $ 691
CULL COW SALES (6 HEAD AT 400.00 PER HD) $ 2571.

TOTAL SALES . . . . $ 73539.

VARIABLE COSTS
VARIABLE COST OF CROP PRODUCTION $ 8640.
MISC. VARIABLE COST PER COW
(45 COWS AT $ 97.50/COW)$ 4387.
MISC VARIABLE COST OF RAISING REPL.
(6.REPL AT $ 25.00/REP)$ 161.
VARIABLE COST OF PRODUCING DAIRY HEIF
(13 HEAD AT $ 25.00EACH)$ 275.
TOTAL VARIABLE COSTS $ 13253.

GROSS PROFIT $ 60286.

FIXED COSTS
OWNED LAND (300 ACRES AT $ 40.00/ACRE)$ 12000.
PERMANENT LABOR $ 10000.
EQUIPMENT, MACHINERY, AND BUILDINGS $ 4400.
TOTAL FIXED COSTS $ 26400.

NET PROFIT $ 33886.

TABLE 3. PROJECTED LAND PREPARATION SCHEDULE

120. ACRES PREPARED IN EARLY SPRING
52. ACRES PREPARED IN LATE SPRING

TABLE 4. PROJECTED LABOR USE

SEASON	PERMANENT LABOR(HRS)	SEASONAL LABOR(HRS)	TOTAL LABOR(HRS)
DEC 9-MAR31	390.	0.	390
APR 1-MAY20	402.	0.	402
MAY20-JUL 9	356.	0.	356.
JUL20 DEC 8	651	0.	651
TOTAL	1800	0.	1800.

TABLE 5. PROJECTED FEEDING SCHEDULE

FEED		AMOUNT FED BY SEASON			TOTAL
		FALL-WINTER	SPRING	SUMMER	
*ALFALFA HAY	(TONS)	84.	0	27	111.
ALFALF SIL	(TONS)	0.	87.	82	170
CORN SIL.	(TONS)	136.	59.	89.	285.
CORN	(BU)	1709.	627.	1165.	3500.

*REFERS TO PURCHASED FEED

TABLE 6. VALUE OF ADDITIONAL RESOURCES

LABOR SHORTAGE PERIODS	BREAK-EVEN WAGE
MAY15-MAY20	23.79
SEP20-SEP24	2.49

ADDITIONAL SILAGE STORAGE IS WORTH $ .64/TON

THE VALUE OF AN ADDITIONAL COW IS $ 518./COW

APPENDIX D

Table D-1 - "Good Days" Weather Data. (25)

Period No.	Dates Covered by Period	Good Days Per Period
1	December 9 - March 31	34.4
2	April 1 - April 30	11.2
3	May 1 - May 14	4.28
4	May 15 - May 28	6.0
5	May 29 - June 11	6.6
6	June 12 - June 25	6.6
7	June 25 - July 9	6.6
8	July 10 - July 23	6.6
9	September 10 - September 24	7.3
10	September 25 - October 9	7.45
11	October 10 - November 8	14.77
12	November 9 - December 8	17.44