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AN ANALYSIS OF THE EFFECTS OF FIELD OPERATIONS MANAGEMENT ON PRODUCTIVITY AND PROFITABILITY OF NEW YORK DAIRY FARMS

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ABSTRACT

Crop enterprises play an important role in the profitability of dairy farms. Efficiently managing field operations to plant and harvest crops in a timely manner maximizes profitability. This study examines the economic effects of crop field operation management practices on dairy farm businesses.

The objectives of this study are met through the following steps: Crop rotation and field operation schedules under efficient and inefficient field operation management are analyzed. The effects of different types of management on crop yields and quality, the feeding program, milk production levels, purchased feed expenses, crop expenses, and crop sales are determined. The resulting effects on profitability levels are measured.

To analyze each of these factors, efficient representative farms are modeled using enterprise budgeting and linear programming. Constraints are placed on these farms to simulate delayed field operations and daily inefficient use of time. Under these inefficient management scenarios, profitability is reduced significantly. Decreased profitability stems from hay nutrient losses and decreases in corn crop yields. These decreases in farm produced protein and energy are offset by increasing purchased feed. Minor changes also occur in crop expenses and crop sales.

The decreases in profitability are directly associated with the inefficient use of time and delayed field operations through shadow prices. Shadow prices are used to indicate the increased profitablity in gaining another hour of field operation time through efficient management.

Decreases in yields from late planted corn result in greater profitability loss than untimely hay harvesting. Thus, farms that have a proportionately high corn acreages are more affected by inefficient field operation management than farms that have proportionately higher hay acreages.

This study indicates that milk production per cow can decrease if poor quality farm produced hay is included in the rations. However, the decreases are usually small.

Correct sizing of equipment is important for optimal crop production, but using larger equipment does not make up for other field operation management inefficiencies. Using more than one tractor-implement combination at one time proved to be an effective way to improve timeliness.

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INTRODUCTION

Crop Enterprises on New York Dairy Farms

Crop production is an important component of Northeast and Lake State dairy farm businesses. Most dairy farms in these areas own or rent crop land to produce feed for their dairy enterprises and/or to produce cash crops to sell on the open market. Dairy farms in the New York Dairy Farm Business Summary (Smith 1980, 1981, 1982; Smith and Putnam, 1983, 1984) average over three acres of tillable cropland per cow. This average is fairly constant through all sizes (number of cows) of dairy farms. The primary use of this cropland is forage production for feed. Forage production on the 1983 Dairy Farm Business Summary farms average over 75% of total tillable acreage. Hay and corn crops produced on the farms account for a substantial portion of the dairy herd's feed requirement.

This interaction between dairy and crop enterprises has a large impact on the farm's profitability. Not only must the dairy enterprise be carefully managed to maximize returns, but the crop enterprises must also be carefully managed. The crop enterprises should be viewed as individual profit centers with the management goal of optimizing returns to the resources committed to those enterprises. Producing high quality and high yielding crops for feed in the dairy enterprise or for sale on the cash market contributes substantially to the farm's profitability.

The profitability of the cropping enterprises on the dairy farm is determined by many production and management factors. Important factors of crop management and production are the efficient use of available time, labor, and machinery field capacity to schedule and perform field operations in a manner that optimizes crop yields and quality. The untimely planting or harvesting of crops may reduce yields and quality of crops. This may lead to reduced income through decreases in milk production, increased purchased feed expenses, or a decrease in excess crops available to sell.

Management on dairy farms is predominantly focused on the dairy cow and replacement heifer enterprises. The dairy herd is the primary enterprise on the farm and receipts from milk production account for most of the cash farm receipts. Of 510 dairy farms participating in the 1983 New York Dairy Farm Business Summary (Smith and Putnam, 1983), 87% of cash receipts were attributed to milk sales, consequently many farm managers justify spending most of their management time on the dairy enterprise.

Furthermore, major improvements have been made in the areas of genetics, reproduction, nutrition, replacement management, herd health, physical facilities, personnel management, finance, and accounting. With the increased understanding of these factors of production, the daily mechanics of milking, breeding, feeding, and health care of dairy herds, as well as the planning of capital, labor, and facilities to handle them has made management of dairy enterprises complex and time consuming. Consequently, little of the dairy farmer's management time and efforts are left for management of the crop enterprise.

Because of the nature of the daily activities involved with the dairy livestock enterprises, the management of these enterprises develops into a relatively routine schedule with minimal variance from day to day. In contrast, the seasonal and weather dependent nature of the crop enterprises creates greater variance in the daily crop activity schedules. The integration of these almost opposing schedules is difficult at best. With the management focused on the dairy enterprises, crop production is often forced into the routinized schedule consistent with the dairy enterprises.

The emphasis on the dairy livestock enterprises diverts management away from the crop enterprises on many dairy farms with crop management becoming a secondary activity. At times this results in management decisions that produce suboptimal returns to the resources that have been committed to the crop enterprise. Poor crop management often appears in suboptimal scheduling of field operations; consequently, primary and secondary tillage, fertilizing, seeding and planting, spraying, cultivation, and harvesting are delayed. Climate and weather patterns, machinery field capacity, labor requirements, and crop rotation restrictions place limits on the time available for field operations. Postponing field work or making inefficient use of the limited time available may result in low crop yields or poor crop quality.

Timing of field operations affects both hay crop and corn production. The major impact on hay crop production is on the protein and energy composition of the forage. The crude protein percentage and the energy density (Mcals of energy per pound of hay crop dry matter) decline as the first cutting date is delayed. These nutrient losses are reflected in the annual average nutrient composition.

Figure 1 summarizes the findings of Fick and Onstad (1983), and Ramsey (1983). It shows the decline in annual average hay crude protein and energy density as the first cutting date is postponed from May 29 to June 26.

The annual average crude protein declines to 79% and the annual average energy density declines to 85% as the first cut hay harvest is delayed to June 26. These results reveal that a farm manager who does not schedule the hay crop harvest in a timely manner will see a large decline in

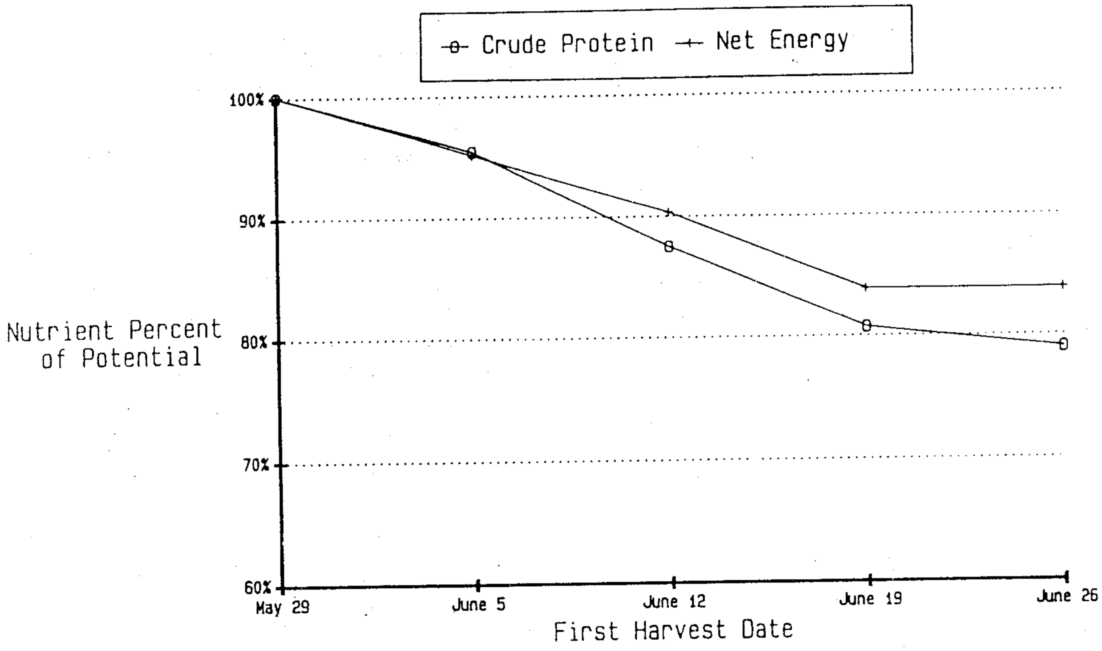

Figure 1: Annaul Average Nutrient Percent of Potential as First Cut Harvest is Delayed

the nutrient composition of the forage. This decline in nutrient composition may be partially offset by an increase in yield. Nevertheless, the nutrient density is important for meeting energy and protein requirements while staying within the dry matter intake limits.

The nutrient composition of the hay crop provides a strong incentive for farm managers to harvest hay crops on time. A farm manager who delays harvest may lower profitability. Purchased feed expenses can increase and/or crop sales can decrease. Milk production quantity and quality can also decrease.

Purchased feed expenses may increase for the following reasons. Nutrient composition in the total feed is important in maintaining the quantity and quality of milk production. To maintain milk production while decreasing nutrient composition of the forage crops, there must be an increased purchase of grains and concentrates to maintain the nutrient compositions. Increased feed purchases to supplement the cheaper farm-grown forages decrease profitability. A farm manager selling surplus hay on the open market may receive a lower price for the hay if the inefficiently managed hay is lower in quality.

A second effect of low quality and yielding feeds on profitability is in milk production. If the farm manager delays harvest and produces a low quality and quantity feed, the dry matter limitations and fiber requirements will prevent the cows from getting the nutrients necessary for high milk production. Milk production quality and quantity will decrease resulting in reduced receipts and a decrease in profitability. The higher nutrient density associated with good forage permits a higher nutrient intake while maintaining the fiber requirement. High quality feeds also encourage dry matter intake.

The timing of field operations also affects corn crop production. Planting and harvesting dates are significant determinants of yield and moisture content of both corn silage and corn grain. Cornell recommendations for corn (1983 Cornell Recommends for Field Crops) suggest that corn planted in late April or early May will consistently out-yield both for silage and corn grain planted later in May or June. Early planted corn also matures sooner and lodges less. Figure 2 shows the percentage of potential corn grain yields by planting and harvesting dates in New York. The percentage of potential yield declines an average of 35% as the planting date is delayed from early May to early June. Figure 4 shows similar results for corn silage yields. Silage yields may decrease 13% as planting is delayed from early May to early June.

Poor timing of field operations in corn production can affect dairy production in ways similar to poor timing of field operations in hay crop production. If the dairy farm manager is producing corn grain or corn silage for feed, then the decreased yields associated with delayed planting may result in lower quantity or quality of milk production, increased feed costs, or fewer excess crops to sell on the open market. In addition, late planting of corn may delay hay harvesting.

Because of the effects of planting and harvesting dates on profitability, farm managers must manage the crop enterprises carefully to schedule and perform field operations in a timely manner. While most farm managers generally understand the affect of field operation timing on yields and quality of crops produced, many do not realize the full impact on farm profitability. Many farm managers do not recognize the preparation required for timely crop operations.

Total understanding can come only after extensive enterprise budgeting in which many different field operation schedules are analyzed to determine the affect on profitability. The farm manager has to know the biological relationships of planting and harvesting dates to crop yields and crop quality as well as the nutritional

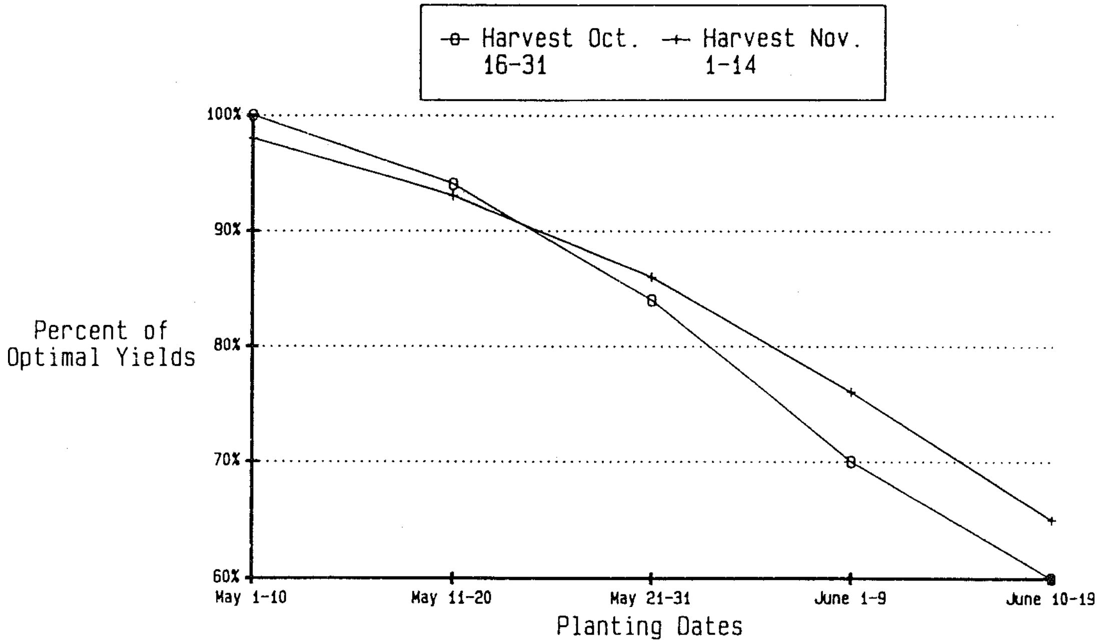

Figure 2: Percentage of Potential Corn Grain Yields for Various Planting and Harvesting Date Combinations

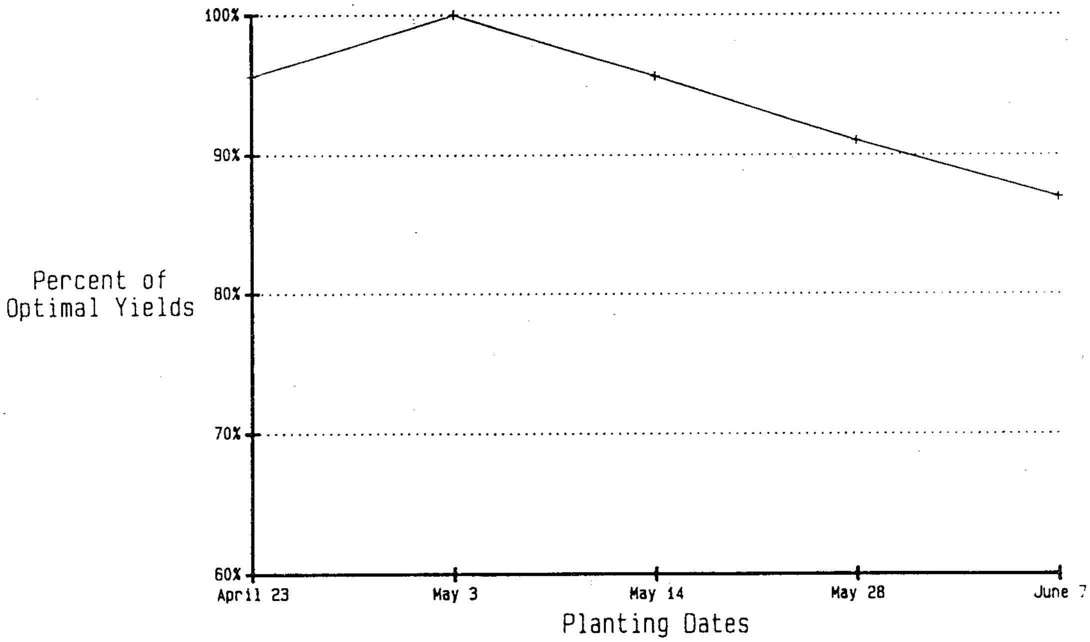

Figure 3: Percentage of Potential Corn Silage Yields for Various Planting Dates

relationships between quality of crops and milk production. This would require ration balancing using all of the different feeds that could be produced on the farm given the alternative crop production system and field operation schedules. With this information, the farm manager would then have to optimize crop production taking into consideration management, time, labor, and machinery constraints. Most farm managers cannot put in the time and effort that this type of analysis requires. Not knowing the full effect on profitability, the farm manager spends only the time he or she feels can be spared on the crops. Often the result of this type of management is suboptimal crop production.

This study analyzes the effects of different crop management methods on the profitability of the farm and aids farm managers in understanding the importance of field operation scheduling.

Objectives

This study examines the economic effects of crop management practices on dairy farm businesses. The primary objective is to analyze the impact on profitability of optimally managing field operations in terms of the time, labor, and capital resources which have been committed to the crop enterprises.

Farm profitability in this research is measured as return to the operator's labor and management, unpaid family labor, and the fixed resources of land, buildings, and machinery. This reflects the short term profitability of the farm. Most of crop management practices discussed are those that farm managers can apply in the short run, that is, a year or less, to improve crop programs.

To achieve these general objectives, the following specific objectives are set:

1. Determine the economically optimal crop rotations and field operation schedules for selected representative farms and analyze the effects of inefficient time management on the optimal crop rotations.

2. Determine the effects of deviations from the optimal schedule on the crop yields and quality, the feeding program, milk production levels, purchased feed expenses, crop expenses, and crop sales. Evaluate the effects on profitability of delaying field work to times other than those outlined in the optimal schedule.

3. Determine time periods and field operations that are most critical to increasing the profitability of the crop enterprises on different types of farms through the use of shadow prices.

4. Determine the value of increasing field capacity of machinery through increasing speed, efficiency, or size of equipment.

Background Principles: Time Availability and Timeliness of Field Operations

A discussion of some background principles establishes the framework in which the problem of timeliness of field operations can be analyzed. Timeliness of field operations is a function of two factors, the number of days available for field work and the amount of work that can be done on those days. The farmer has little control in the short run over the number of days he or she can get into the field, but has considerable control over how much field work can be done in the available days.

The time available for field work is a function of the climate, weather, and soil resources in a particular location. The climate reflects the average available days for field work per year over the long run. Weather is a short run concept that reflects the time in a given year that a farm manager can get into the field. It is the weather that causes the deviations from the long run average which the climate represents. Moisture is the major element of climate and weather affecting timeliness of operations. As moisture increases, soil tractability (ability of the tractor or power unit to pull an implement through the field) decreases. Even if the tractor can pull the implement through the field, the resulting seed bed may not be suitable for planting. Moisture may also delay harvesting of crops as the moisture content of the crops exceeds storable limits. Another element of climate and weather that has a minor influence on the days available to work is temperature. Some farm managers may delay planting corn until a cool weather trend or expectation of future cool weather passes.

Soil resources also affect the number of days the farm manager can get into the field. Soil tractability is increased on well drained soils permitting more days for performing field operations. Poorly drained soils restrict the number of days a farm manager can get into the field. This situation can be improved through drainage (see Wackernagel, 1979).

While the farmer has no control over the climate and weather, he or she can adapt the farm enterprises to the general climate and make provisions for years when there is an unexpected deviation from normal trends. As the farm manager does this, he or she affects timeliness of operations by exercising control over the amount of field work that can be done in the available time. There are three factors which affect the amount of work that can be done in the available days: management of field operations, field capacity, and labor availability. The farm manager has some control over each one of these.

Management of field operations is a broad concept relating to how a farm manager plans, implements, and controls the field work. The farm manager must determine how the primary and secondary tillage, planting, fertilizing, spraying, cultivating, and harvesting will be done. He or she must decide what implements will be used, determine who will do the field work and schedule when it will be done. The farmer must make sure the equipment is ready to use when the weather permits field operations. Inputs such as fuel, seed, fertilizer, and pesticides must be available when needed. As the field work begins, the farm manager must see that things are going smoothly, and as problems arise, find ways to cope with those problems. On a dairy farm, management of field operations is critical in accomplishing the maximum amount of work that can be done in the days available.

The second factor which affects the amount of work that can be done in the available days is field capacity. Effective field capacity is defined as how much work a machine can do and is usually measured in acres per hour or hours per acre. It is a function of the field efficiency of the machine, machine capacity, and operating speed. The following description explains each of these elements.

> Machine capacity is the width of the machine. For example, with a grain combine it is the width of the grain head, and for a corn planter, machine width is the number of rows times the row spacing.
>
> Field efficiency is the percentage of the theoretical field work accomplished after deducting for losses resulting from failure to use the full width of the machines, turning and idle travel at the ends, clogging, filling and adjusting seed, fertilizer, and spray materials, unloading harvested crops, machine adjustments and minor repairs, lubrication, and other minor interruptions. It excludes waiting for supplies, wagons, or trucks, major breakdowns, and daily service activities. Field efficiency for a particular machine varies with the size and shape of the field, slope and field obstruction, pattern of the field operation, crop yield, moisture, and crop conditions. The size of the machine also

> influences field efficiency. Efficiency is reduced as larger machines are used. For example, the efficiency of corn planters and corn tillage tools is reduced about one percent for each row added, discs about one percent for each 30 inches of added width, and moldboard plows about two percent per bottom added.
>
> The speed of the implement is influenced by the size of power unit, effective speed of the implement, the draft of the implement, the physical characteristics of the land, and the dexterity of the operator. Generally, the effective speed of the implement determines the rate of travel. (Sprague, Knoblauch, and Milligan, 1980)

An implement's field capacity in terms of acres per hour can be computed by the formula:

$$\text{field capacity} = \frac{\underset{\text{(decimal)}}{\text{field efficiency}} \times \underset{\text{(feet)}}{\text{implement width}} \times \underset{\text{(mph)}}{\text{speed}}}{8.25}$$

The farm manager has some control over each of the elements in this formula. The farm manager can improve field efficiency by using a conscientious and competent operator who can effectively operate the implement. This operator should concentrate on minimizing overlap, establishing efficient turning routines on field ends, and avoiding field hazards which are under the operator control. Speed should be carefully monitored to avoid equipment overloading and clogging which can reduce field efficiency. Efficiency can be improved through improving field conditions. Some field hazards and obstructions can be removed. Cleaning and drainage can improve the size and shape of the fields to produce more efficient patterns of covering the field with an implement. The farm manager can streamline routine maintenance procedures on equipment and anticipate minor repairs by keeping replacement parts on hand. The farmer and/or operator should become familiar with the procedures for adjusting and calibrating equipment so that this can be done efficiently and quickly. Efficient methods of conveying and handling seed, fertilizers, pesticides, feed, and harvested crops should be employed. The key to field efficiency is consistency. Keeping the equipment going at a steady rate through the above management techniques produces the greatest field efficiency.

The implement width is determined by the farm manager at the time of purchase. This decision is made with consideration to farm size, field size, soil conditions, budget constraints, size of power unit, size of other implements within the machinery complement, expectation of future acreage expansion, transportability of the implement, and the effective working speed of the implement.

The farm manager has the least direct control over the speed of the implement. Speed is usually constrained by the effective speed for which the implement was designed to be used. Most implements have a maximum speed at which they can be used. For example, pulling tillage tools at a rate faster than what they are designed for produces a poor seedbed. A planter may skip seeds if pulled too fast. The operator has some control through adjusting implements for the operating speed, but this is limited by the implement design.

If the speed is constrained by the power unit or tractor, then using a larger tractor will increase the speed. If this is not possible, an alternative to this is keeping the machine tuned properly to use the tractor's full capabilities. Decreasing the draft of the implement could increase speed. For example, the angle on a tandem disk could be decreased. This would allow it to be pulled faster, but it may also have an adverse effect on the seedbed. All of these factors must be considered.

The combination of field efficiency, speed, and implement width gives the farm manager considerable control over field capacity which will in turn affect the amount of field work that can be accomplished in the time available.

Labor availability is the third factor affecting the work that can be done in the days available. Dairy enterprises have large labor requirements and routine labor schedules. Because of this, they receive the main focus of labor management and the crop enterprises often receive the residual management and labor time. An efficient farm manager optimizes labor usage. This usually means hiring additional part-time labor or extending hours for full-time workers during the peak labor demand periods of planting and harvesting. In addition, the farm manager may need to develop surplus labor flexibility to adapt to weather conditions. The farm manager must allocate the labor between the different tasks, putting experienced labor where it can be used most efficiently.

Overview of Methodology

Representative New York dairy farms are modeled and analyzed to meet the objectives of this study. Herd sizes, acreage bases, soil types and labor resources are the distinguishing characteristics of the representative farms. The capital resources of dairy facilities and machinery compliments are established. Nutrition needs are specified. Cropping alternatives and field operation requirements are determined. Time availability for field operations is determined. Prices, input levels, and production levels are specified. The relationship between all of these activities and factors are outlined. The analytical tool of enterprise budgeting is employed in this process to determine the enterprise receipts, variable expenses, and fixed expenses for various enterprise combinations.

The representative farms are modeled and analyzed using the mathematical optimizing algorithm of linear programming (LP). The objective is to maximize returns over selected variable expenses. The initial LP optimal solution represents farms that are fairly efficient in scheduling and performing field operations. These farms have normal resources with field operations constrained only by time available for field work and machinery capacity.

Under these conditions, the LP solution specifies the optimal schedule for field operations. The shadow prices for the different time periods will indicate those time periods, and consequently the field operations that are most critical in increasing profitability.

Inefficient crop management is represented by decreasing time availability and forcing field operations into suboptimal time periods. By observing how large these decreases must be before field operations are modified and profitability is reduced, conclusions can be drawn about the importance of management.

Decreased profitability through deviation from the optimal schedule will show up through increased purchased feed expenses, changes in crop sales, and decreased milk production.

Improved crop management techniques are represented by including simultaneous field operations and purchasing larger or more efficient equipment. The results can be seen in the profitability increases. Comparing this increase to machinery ownership and operating costs can determine if these are viable alternatives.

EXPLANATION OF REPRESENTATIVE FARMS AND LINEAR PROGRAMMING MODEL

In this study farms with two different resource levels are modeled to analyze the effects of field operation management on small and large farms commonly found in New York State. The following is a discussion of the farming situations and the LP model formulated to perform this analysis.

Representative Farms

The general characteristics of the two resource levels for the representative farms are defined in terms of herd size, livestock facilities, land resources, crop enterprise alternatives, necessary field operations, machinery resources, management resources, labor resources, and general constraints. The two resource levels are utilized to develop sixteen representative farms. These sixteen farms are designated as the large and small farms. In as much as possible, the characteristics of two sizes of dairy farms (40 to 80 cow, 80 to 150 cow herds) have been incorporated into the representative farms. These farms are also distinguished as farms where the crop program focus is on forage production to meet the roughage requirements of the dairy herd. Hay sale activities are included on the representative farms. Corn grain can be sold on the large farms. Sales are expected to be minimal, representing a small excess over the dairy enterprise's feed requirements. The characteristics of the two resource levels are summarized in Table 1.

The dairy herds on both farm sizes are fed in two production feed groups and a dry group. While cows are usually fed individually in a stanchion barn, they were grouped this way to simplify modeling of the feed program. The high production feed groups cover the first 17 weeks of lactation and the low production feed groups cover the last 27 weeks of lactation (Milligan 1985). The herds are grouped this way to focus on meeting the nutrient requirements during the peak lactation time interval. Three production levels are specified at 13,000, 16,000, and 18,000 pounds of milk per cow per lactation period. The actual optimum production levels are selected in the LP model.

Table 1: Summary of Representative Farm Resources

Resource	Small Farms	Large Farms
Livestock Resources	60 cows	120 cows
	1350 lbs. avg. weight[a]	1350 lbs. avg weight[a]
	50 replacement heifers[b]	100 repl. heifers[b]
	cow feed groups[a]	cow feed groups[a]
	high prod-1st 17 wks	high prod-1st 17 wks
	low prod-last 27 wks	low prod-last 27 wks
	dry group-8 weeks	dry group-8 weeks
	culling rate-28%[c]	Culling rate-28%[c]
Livestock Facilities	stanchion barn	freestall barn
	pipeline milking system	herringbone parlor
	tie stalls	manure scraped and hauled daily
	gutter cleaners	
	manure hauled daily	
	heifer barn	heifer barn
Feed Storage Facilities	silos,cement stave	silos, cement stave
	open pole barn for hay storage	open pole barn for hay storage
Machinery Complement	tractors	tractors
	100, 80, 40 hp	80, 60, 40 hp
	4 row implements	4 row implements
Land Resources[d]	165 tillable acres	270 tillable acres
	65 soil group 3	160 soil group 2
	100 soil group 5	110 soil group 4
Possible Crop Enterprises	hay crop silage	hay crop silage
	dry hay	dry hay
	corn silage	corn silage
		corn grain
	oats	oats
Management & Labor[e]	15.5 months/year operator labor & management	17 months/year operator labor & management
	seasonal hired labor	seasonal hired labor
	4 months/year family labor	2 months/year family labor
		1 full-time employee

Footnotes on following page.

Footnotes for Table 1

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a Milligan, R. A., 1985. personal communication. Dairy herds on both farms are fed in two production feed groups and a dry group. While cows in a stanchion barn are usually fed individually, they were grouped this way to simplify the modeling of the feed program.

b Typical herd size on farms in the New York Dairy Farm Business Summaries 1979, 1980, 1981, 1982, 1983.

c Knoblauch and Milligan, 1977; Wackernagel, Milligan, and Knoblauch, 1979; Knoblauch, 1981.

d Reid, S., 1985. personal communication.

e Average levels of operator labor and management found on farms in the New York Dairy Farm Business Summary (Smith and Putnam, 1983). These represent 1 full-time owner plus some additional management provided by another member of the family or hired labor.

Soil resources on the large farms include 160 acres of group 2 soil and 110 acres of group 4 soil[1]. Soil resources on the small farms include 65 acres of group 3 soil and 100 acres of group 5 soil (Reid, 1985). Hay and corn crops are the dominant enterprises because of nutritional, rotational, and land resource constraints. Mixed, mainly legume hay crops are produced consisting of varying ratios of alfalfa and timothy depending on soil group. Hay is seeded down with oats. The oats are harvested for grain with no cutting of hay taken off the first year. The hay rotation includes the establishment year and a minimum of three production years. There are three cuttings of hay taken off per year in the production years if hay is harvested before June 19. If harvested after that date, there are only two cuttings.

Corn crops are produced to help meet the concentrate requirements of the dairy herds. Corn production in the rotation is limited to levels reflecting good crop manage-

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[1] The soil groups referred to are the eight soil productivity groups used for use value assessment in New York. These groups are characterized by the land's potential yield. Yields are specified in tables 5 through 9.

ment practices and soil conservation[2]. Corn grain is limited to the better soil (group 2) on the large farms. Corn is grown mainly for silage, but there are options for harvesting it for corn grain. Purchased roughages and concentrates available to meet feed requirements include dry hay, corn grain, soybean oil meal, and required minerals.

The required crop enterprise field operations considered in the representative farms include the following. Land planted to oats with hay seeding or planted to corn is spring plowed. The soil is then disced twice and a spring tooth harrow is used for final seedbed preparation. The hay is seeded down with oats. Corn planting is accomplished with a planter equipped with fertilizer attachments. Hay crops harvested are mowed and raked. The hay is then baled or harvested as hay crop silage. Corn silage is harvested by the farmer. Corn grain and oats are custom harvested.

Construction of the LP Model

The objective of this model is to maximize returns to fixed resources. The benefits of timeliness of field operations are reflected in the yields and quality of crops produced and can be physically measured as the levels of nutrients produced. However, in maximizing returns, it is necessary to have a dollar measure of these benefits. Since most of the crops are consumed on the farm where they are produced, a dollar figure cannot easily be assigned to forage production.

On dairy farms the benefits of timeliness in field operations are reflected in increased returns in the dairy enterprise. Cash returns then, come primarily from the dairy enterprise. There may be some income from cash crop sales for which cash income is received, but this income is expected to be minimal since the representative farms focus primarily on forage production for use in the dairy enterprise. The value of quantity and quality of crops produced is in the milk produced and the feed purchase expenses defrayed.

The model contains approximately 350 activities and 150 constraints. The general categories of activities and constraints as well as the relationships between them are represented in a schematic of the model matrix in figure 4.

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[2] On group 2 soil, corn is grown no more than six out of ten years. On soil groups 3 and 4, corn is limited to five out of ten years. On soil group 5 corn is limited to four out of ten years (Knoblauch and Milligan, 1982).

	General Groups of Acitivities						
Objective function and constraints	Livestock Enterprises	Livestock Accounting	Purchased Feed	Farm Produced Feed	Crop Sales	Field Operations	Hired Labor
Returns to owner's labor, management, and fixed capital	X		X	X	X		X
Livestock Nutrient requirments	X		X	X			
Livestock constraints and accounting rows	X	X					
Time availability and labor constraints	X			X	X	X	X
Field operation sequencing constraints						X	
Acreage & rotational Contraints				X	X		

Figure 4: Schematic of LP Model

The X's in the matrix cells represent relationships between the activities and constraints. Reference to this schematic in each of the following sections clarifies the description of the activities and constraints. The density of this matrix is approximately 5.5%.

Time Framework of the LP Model

Since the focus of this study is to observe the impact of timeliness of field operations on a farm's profitability, it is important to establish the time framework by modeling the annual crop cycle in terms of increments that are short enough to reflect most of the individual scheduling problems that can have a major impact on crop yields. This framework is then the basis for most of the activities and constraints in the model. The model represents an annual planning horizon for the representative farms; however, a specific focus on the crop season from primary tillage through harvest is important in meeting the objectives of this study. The crop season is divided into thirteen periods (Table 2).

These periods were determined and the dates set after considering three factors: the general type of field operations which occur during the time periods, the possible scheduling problems and time constraints associated with the time periods, and time period groupings of data used in calculating certain technical coefficients. Table 2 contains the field operations which can be performed during each time period. Other time periods not included in this model are also important, but they are excluded for one of two reasons. First, they do not have an affect on the objective of this analysis. These periods include the non-cropping periods. Second, a proxy measurement of their affect can be obtained through the time periods defined in the model. For example the amount of second and third cut hay is limited by the amount of first cut hay. Most scheduling problems in hay harvesting show up in the first cut hay.

Table 2: Time Framework of Model

Period	Dates	Field Operations performed
1	April 1 - 20	Primary and secondary tillage Seed hay and plant oats
2	April 21-May 10	Primary and secondary tillage Seed hay and plant oats Plant corn
3	May 11 - 20	Primary and secondary tillage Seed hay and plant oats Plant corn
4	May 21 - 31	Primary and secondary tillage Seed hay and plant oats Plant corn Harvest dry hay & hay crop silage
5	June 1 - 7	Plant corn Harvest dry hay & hay crop silage
6	June 8 - 14	Harvest dry hay & hay crop silage
7	June 15 - 21	Harvest dry hay & hay crop silage
8	June 22 - 30	Harvest dry hay & hay crop silage
9	September 1-15	Harvest corn silage
10	September 16-30	Harvest corn silage
11	October 1 - 15	Harvest corn silage Harvest corn grain
12	October 16 - 31	Harvest corn grain
13	November 1 - 14	Harvest corn grain

Crop Production and Utilization

The LP model defines crop enterprise activities by their planting and/or harvesting period. Furthermore, the crop activities are characterized by how they are utilized. The hay and corn crops can either be fed or sold. If they are fed, they can be fed in one of several livestock activities. The crop enterprise activities are also characterized by how they are harvested. The hay crops can be harvested as dry hay or as hay crop silage. Corn can be harvested as silage or as grain. Finally, the crop activities are characterized by the soil productivity class on which they are grown. A crop activity is defined for each of these combinations of characteristics since each combination has a different yield and/or nutrient value.

An example clarifies these characteristics. A crop enterprise activity is defined for hay that is harvested as hay crop silage in period 5 (June 1 - June 7) on soil class 4 and fed to the high producing feed group at the 16,000 pound milk production level.

The unit of measurement for these activities is an acre. The objective function coefficients reflect the variable expenses for the crops consumed in the dairy enterprises and return over variable expenses for crops that are sold. Coefficients representing the nutrient value per acre for each crop enterprise activity are also calculated. These nutrient values include dry matter, crude protein, net energy, and acid detergent fiber. Finally coefficients are calculated for the time requirements in hours per acre for each crop enterprise activity in each time period.

Sequencing of Field Operation Activities

The crop enterprise activities in the preceding section require that field operations be performed in the proper sequence. This section discusses the field operations and the constraints that are employed to assure proper sequencing.

Groups of field operation activities corresponding to the first eight time periods listed in Table 2 are established in the model. From these groups of activities, the required field operations must be selected and sequenced for any crop enterprise activity that comes into the solution of the model.

To force the required field operation into the solution of the model, the following technique is used. The crop harvesting time requirement coefficients are included in the columns of each crop enterprise activity so that the crops cannot be utilized unless they are first harvested. A series of constraints force field operations directly preceding other field operations to cover equal or greater acreages. For example, for corn or hay to be planted, the numbers of acres harrowed must equal or exceed the number of acres to be planted. Likewise, the number of acres disced and plowed must equal or exceed the number of acres to be harrowed (Figure 5).

	Period 1				Period 2					Period 3					--- RHS
	Pw	Dk	Hw	Sd	Pw	Dk	Hw	Sd	Pt	Pw	Dk	Hw	Sd	Pt	
Period 1															
Pw>Dk	1	-1													0
Dk>Hw		1	-1												0
Hw>Sd			1	-1											0
Period 2															
Pw>Dk	1	-1			1	-1									0
Dk>Hw		1	-1			1	-1								0
Hw>Sd & Pt			1	-1			1	-1	-1						0
Period 3															
Pw>Dk	1	-1			1	-1				1	-1				0
Dk>Hw		1	-1			1	-1				1	-1			0
Hw>Sd & Pt			1	-1			1	-1	-1			1	-1	-1	0

Pw=Plow, Dk=Disk, Hw=Harrow, Sd=Seed Hay, Pt=Plant Corn

Figure 5: Illustration of Field Operation Sequencing Constraints in the LP Model

This sequencing of field operations is followed for all combinations of field operations from the first time period through the last time period. In addition, the constraints are set up in such a way that the summation of certain field operations must always exceed the summation of other field operations. For example, the summation of land plowed from period 1 through period 3 must always exceed the summation of land disced in period one through period three. This prevents the unrealistic situation in which corn could be planted on land that was plowed in period two but disced in period 1. These constraints assure proper sequencing of field operations.

Time, Management, and Labor Considerations

An important part of this model is a series of constraints that represent the relationships between requirements and availability of time, labor, and management. Meeting the objectives of this study is mainly accomplished through manipulation of these constraints to observe the effects on crop and dairy enterprise activities.

A set of constraints is defined for each of the first 10 periods to represent time, labor, and management requirements and availability. The last three periods are not considered since harvesting corn grain is the only field operation and this is custom harvested which minimizes the management and labor requirements for the representative farms. The following constraints affect the dairy enterprise activities, the crop enterprise activities, and the field operation activities for each of the first ten periods.

Constraints are defined for each time period to limit the dairy and crop activities so that the labor time requirements of those activities during that time period do not exceed the amount of operator, family, and hired labor available during that time period. Other constraints are defined for each time period to limit the crop activities so that the time required for field operations, given the field capacity of the machinery complement, does not exceed the time available for the field operations, considering weather and soil constraints. There is more than one constraint for some time periods since some weather conditions permit some, but not all field operations to be performed. An example of this is the harvesting of hay crops. Because of weather conditions, more time is usually available in a time period to harvest hay crop silage than to harvest dry hay. These situations are considered when formulating the constraints.

These constraints can be manipulated to observe the effects of various levels of labor, management, and capital on the farm's profitability. This, in turn, reflects the value of those resources in the farm operation.

The coefficients required in these constraints include the time or labor requirements for the various dairy and crop enterprise activities. In the dairy enterprise activities these coefficients are measured as the time in hours per period to maintain a cow including all incidental labor requirements. In the crop enterprise activities, these time or labor coefficients are measured in hours per acre for the various required field operations. The hours per acre are reflected in the field capacity of the implements. Also required are coefficients which reflect the operator, family, and hired labor which can be found on the representative farms during each of the time periods.

Livestock Activities

Since the increase in profitability from timeliness of operations is realized primarily through the dairy enterprise, it is important that the dairy enterprise activities are modeled so that the effects of various crop schedules can be seen on milk production and purchased feed costs. For this reason, dairy cow activities are introduced into the model for three production levels: 13,000, 16,000, and 18,000 pounds of milk per lactation period. The model determines the actual level of production. The herds are fed in high and low production groups as well as a dry cow group so the dairy cow activities are further distinguished by these characteristics. A dairy replacement heifer activity is also included. The unit of activity, then, is a dairy cow or replacement heifer with each activity being distinguished by the above characteristics. For example, an activity is defined for a dairy cow in a high feed group producing 16,000 pounds of milk per lactation period. One other livestock activity includes sales of bred heifers.

Receipts over variable expenses for each level of production over the entire lactation cycle are entered into the model through the high production group activities. Returns incidental to the dairy enterprise such as cull cow, and calf sales are included in the receipts over variable expenses. There are no receipts over variable expenses associated with the low production feed group cow or dry cow activities. These activities enter the solution through equality constraints which require the number of cows in the low production groups and dry cow groups to equal the number of cows in the high production group.

No returns are associated with the replacement heifers, but production expenses are considered in the objective function. Replacement heifers are forced into the solution through equality constraints just as the low feed group cows and dry cows.

The nutritional requirements that are included in this study are: maximum dry matter intake, minimum net energy, minimum crude protein, and minimum acid detergent fiber. Meeting the requirements of other nutrients does not significantly affect the outcome of this study so they are excluded from the analysis. The units of measurement for the included nutrients are pounds per head per year for the dry matter, crude protein, and fiber requirements, and Mcals per head per year for the energy requirement.

Four groups of constraints are established to provide for the nutritional needs of the dairy herd. There is a group of constraints for the high and low production feed groups, the dry cows, and the replacement heifers. These constraints are set up in typical fashion with a constraint for each nutrient for each group (Figure 6).

The specified nutrient needs for the particular group are required to equal or exceed the nutrient value of the purchased and farm-grown feeds designated for that particular herd group. This convention is followed for dry matter, crude protein, and net energy requirements of the four feed groups.

The acid detergent fiber requirement is handled in the following way. An accounting row is used to sum up the total dry matter intake of the cow and this value is transferred to an accounting column. A minimum acid detergent fiber row sums up the pounds of fiber intake. This summation is required to equal or exceed a certain percentage of the dry matter found in the accounting column. Using these constraints, the nutritional requirements of the dairy livestock are met.

		Livestock Activities											Feed Activities									
Obj. func.&	Constraint	High production feed group				Low production feed group				Dry		Repl	Purcahsed corn					May 11 corn silage soil 2					
constraints	Type	13cwt	16cwt	18cwt	DMacct	13cwt	16cwt	18cwt	DMacct	cows	Dmacct	heif	high	low	dry	heif	···	high	low	dry	heif	···	RHS
Obj. function		1444	1805	2038								-48	-3.75	-3.75	-3.75	-3.75		-144	-144	-144	-144		
number of cows	E	1	1	1																			120
Max DM (lb.)	L	-4634	-5074	-5366									47.0					9481					0
DMacct high	E				-1								47.0					9481					0
Min CP (lb.)	G	-674	-799	-883									4.7					806					0
Min NE (Mcal)	G	-3517	-4118	-4530									43.0					7490					0
Min ADF (%DM)	G				-0.15								0.65					2655					0
Max DM (lb.)	L					-6565	-7079	-7423						47.0					9481				0
DMacct low	E								-1					47.0					9481				0
Min CP (lb.)	G					-843	-990	-1088						4.7					806				0
Min NE (Mcal)	G					-4540	-5212	-5670						43.0					7490				0
Min ADF (% DM)	G								-0.15					0.65					2655				0
Max DM (lb.)	L									-1482					47.0					9481			0
DM acct dry	E										-1				47.0					9481			0
Min CP (lb.)	G									-113					4.7					806			0
Min NE (Mcal)	G									-727					43.0					7490			0
Min ADF (% DM)	G										-0.15				0.65					2655			0
Max DM (lb.)	L											-5287				47.0					9481		0
Min CP (lb.)	G											-558				4.7					806		0
Min NE (Mcal)	G											-4071				43.0					7490		0
Low acct 13	E	1				-1																	0
Low acct 16	E		1				-1																0
Low acct 18	E			1				-1															0
Dry acct	E	1	1	1						-1													0
Min heiefers	G	-0.65	-0.65	-0.65								1											0

Figure 6: Illustration of Livestock and Ration balancing Constraints

DETERMINATION OF RECEIPTS, EXPENSES, AND TECHNICAL COEFFICIENTS

Receipts, expenses, and technical coefficients used to quantify the activities, constraints, and associated technical coefficients in the model are determined using 1983 data. In cases where the 1983 information is not available, data are extrapolated from other years using indexing or subjective judgement. The values required for the LP model are divided into four main areas: enterprise receipts and expenses, time coefficients, crop yields and nutrient values, and livestock nutritional requirements.

Enterprise Receipts and Expenses

Receipts and selected variable expenses for the dairy cow enterprises are required on an annual per cow basis for each of the three levels of milk production. Receipts are required for the bred heifers sold and variable expenses are required for replacement heifer enterprise. Receipts are required for crops sold and expenses are required for both crops sold and crops consumed in the livestock enterprises. Enterprise budgeting is used to determine the receipts and expenses for livestock and crop activities.

Receipts and variable expenses for the three dairy cow production levels are found in Table 3. Variable expenses for these enterprises do not include labor expenses, purchased feed expenses, or grown feed expenses since these are separate activities in the LP model with their own associated costs.

These budgets were calculated with a specific forage ration in mind consisting of 2/3 mixed, mainly legume dry hay or hay crop silage and 1/3 corn silage. Composition is expected to be similar to the optimal ration selected by the model. These expenses would vary only slightly for other forage combinations.

Returns for bred heifer sales and expenses for all raised heifers are in Table 4. Expenses cover the period from birth to freshening and are reduced to an annual basis for the model. Returns for replacement heifers are not calculated because they are implicit in the dairy cow enterprises. However, prices are included for the bred heifers sold activity. Ten bred heifers are sold on the large farms and five are sold on the small farms.

Receipts over variable expenses are calculated for hay and grain crops that are sold. The unit of measurement is an acre. Receipts are calculated as the price times the yield per acre. The price for corn grain is $3.75 per bushel (New York Agricultural Statistics, 1983). Hay is valued at $79 per ton (Kelleher and Lazarus, 1985).

Table 3: Dairy Cow Income and Selected Variable Expenses

Production Level-lbs.:	13000	16000	18000
INCOME:			
Milk sales[a]	1754	2159	2429
Cull sales[b]	141	141	141
Calf sales[c]	25	25	25
Total Receipts	$1,920	$2,325	$2,595
VARIABLE EXPENSES:			
Power and machinery			
Repair & maintenance[d]	16	16	16
Fuel/oil/grease[d]	18	18	18
Bld., feed stor., & equip.			
Repairs & maintenance[d]	77	77	77
Livestock			
Bedding[d]	32	32	32
Breeding fees[e]	30	30	30
Vet. & medicine[e]	39	39	39
Milk marketing[e]	118	145	164
Supplies[d]	32	37	43
Utilities[d]	61	61	61
Other[d]	32	43	53
Dical[f]	12	13	14
Salt[f]	4	4	4
Interest[g]	5	5	6
Total Selected Variable Expenses	$476	$520	$557
Returns Over Selected Variable Expenses	$1,444	$1,805	$2,038

Footnotes are on the following page.
Note: Utilities and breeding expenses were slightly lower on the large farm.

Footnotes for Cow and Heifer Budgets: Tables 3 and 4

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a Losses from home consumption, feed, and waste are 1.5% (Knoblauch, 1981; Wackernagel, 1979; Knoblauch et al., 1978; Knoblauch and Milligan, 1977). Milk price is $13.70 per cwt. (New York Agricultural Statistics, 1983).

b Cull sales are calculated using a 28% culling rate, (Knoblauch, 1981; Wackernagel, 1979; Knoblauch et al., 1978; Knoblauch and Milligan, 1977), a 13.5 cwt. weight per cow ("Ibid"), and a price of $37.20 per cwt. (New York Agricultural Statistics, 1983).

c Calf sales are .425 per cow (Knoblauch and Milligan 1977). Other budgets set calf sales at .85 per cow, however, on the representative farms, it is assumed that heifers are held and raised for replacement. Weight is 100 pounds per calf (Knoblauch, 1981; Wackernagel, 1979; Knoblauch et al., 1978; Knoblauch and Milligan, 1977) and price is $59.20 per cwt. (New York Agricultural Statistics, 1983).

d These expenses were based on Knoblauch (1981). The figures in this source appear to be slightly higher than other budgets even after inflation. It was felt that these higher figures better reflected actual dairy farms. An index of 107 derived from New York Agricultural Statistics (1983) was used to calculate a 1983 equivalent.

e The 1983 New York Dairy Farm Business Summary (DFBS) contains categories for these expenses. It was felt that these would accurately represent actual farms. Expenses were determined by calculating the corresponding average expense per cow for similar sized farms on the 1983 DFBS.

f Knoblauch, 1979; Wackernagel, 1979; Knoblauch et al. 1978; Knoblauch and Milligan, 1977.

g Interest charged on operating expenses for one month (Knoblauch, 1979; Wackernagel, 1979; Knoblauch et al. 1978; Knoblauch and Milligan, 1977) at 12.3% annual percentage rate of interest for 1983 (Twentyman, 1984).

h Bred heifer sales for excess heifers not used as replacements is $950 per head (New York Agricultural Statistics, 1983).

Table 4: Replacement Heifer Return and Variable Expenses, Birth to Freshening

RECEIPTS:	
Bred heifer value[h]	$950.00
VARIABLE EXPENSES:	
<u>Power & Machinery</u>	
Machine repair & maintenance[f]	14.00
Fuel, oil, & grease[f]	5.00
<u>Building, Feed Storage, & Equipment</u>	
Repairs and maintenance	(covered under dairy cow)
<u>Livestock</u>	
Bedding[f]	30.00
Breeding fees	(covered under dairy cow)
Veterinary and medicine	(covered under dairy cow)
Supplies & utilities[f]	16.00
Milk replacer[f]	12.00
Dical[f]	5.00
Salt[f]	3.00
<u>Interest</u>	24.00
Total Selected Variable Expenses	109.00

Footnotes on previous page

Variable expenses are determined for all the crop selling and crop feeding activities on the representative farms and are based on soil productivity groups. These expenses are totaled for each crop enterprise and each soil productivity group and used directly in the objective function row for crops used in the feeding activities. The variable expenses are subtracted from receipts for hay and corn grain selling activities to get objective function values for the selling activities.

The variable expenses for the hay, corn, and oat enterprises are found in Tables 5 to 9. Because crop activities are designated by soil productivity, it is also necessary to calculate the expense by soil productivity group. Economic profiles have been constructed for New York farms providing information on corn and hay expenses for the various soil classifications (Knoblauch and Milligan, 1981, 1982; Knoblauch, Lazarus, and Milligan, 1983; Twentyman, 1984).

Purchased feed and labor expenses are valued at the market rate. Corn grain is valued at $3.75 per bushel (New York Agriculture Statistics, 1983) and 44% soybean oil meal is valued at $14.80 per cwt. (New York Agricultural Statistics, 1983). Labor is valued at $5.00 per hour.

Time and Labor Coefficients

The model requires the calculation of labor or time requirements for performing activities associated with the dairy and crop enterprises, the calculation of the available operator, family, and hired labor needed to perform these activities in each time period, and the calculation of the time available for performing field operations for each time period.

The tasks to be completed in the dairy and crop enterprises determine the labor or time requirements for those activities. The tasks to be completed in the dairy enterprises are those associated with maintaining the dairy and replacement herds as well as maintaining the feed and housing facilities. The time required for these tasks is derived from Hoglund (1976). The time in hours per cow per year for the 60 and 120 cow representative farms are calculated by interpolating between the time requirement for the herd sizes specified by Hoglund (1976). These figures are then converted to an hour per time period basis.

The crop enterprise time or labor requirements for each time period are reflected in the total time required for field operations. This is reflected in the field capacity in hours per acre for the implements used in each of the field operations.

Table 5: Dry Hay Selected Variable Expenses Per Acre

	Soil Productivity Groups							
		2		3		4		5
Annual yield (tons DM) with first cut on June 5		3.6		3.1		2.6		2.1
VARIABLE EXPENSES:								
<u>Growing</u>								
Seed[a]								
Alfalfa	(12)	9.60	(11)	8.80	(11)	8.80	(6)	4.80
Timothy	(4)	0.90	(5)	1.10	(5)	1.10	(4)	0.90
Fertilizer[b]								
Phosphorus	(50)	12.80	(45)	10.80	(45)	10.80	(40)	9.60
Potassium	(75)	11.25	(65)	9.75	(65)	9.75	(55)	8.25
Lime[c]		11.95		11.95		11.95		11.95
Chemicals[d]		4.44		4.25		4.25		0.63
Power & Equipment[d]								
Fuel,oil,grease		2.88		2.60		2.60		2.54
Repair & maint.		2.08		1.92		1.87		1.85
Other		2.00		2.00		2.00		2.00
Total Growing		57.90		53.17		53.12		42.52
<u>Harvesting</u>								
Power & Equipment[d]								
Fuel,oil,grease		11.45		11.05		8.57		8.72
Repair & maint.		8.89		8.55		5.87		5.94
Twined		6.12		5.61		4.93		4.59
Other		3.00		3.00		3.00		3.00
Total Harvesting		29.46		28.21		22.37		22.25
Interest[e]		5.38		5.01		4.65		3.99
Total Selected Variable Expenses		$92.74		$86.39		$80.14		$68.76

Footnotes on page 34.

Table 6: Hay Crop Silage Selected Variable Expenses Per Acre

	Soil Productivity Groups							
		2		3		4		5
Annual yield (tons DM) with first cut on June 5		4.3		3.8		3.1		2.6
VARIABLE EXPENSES:								
Growing								
Seed[a]								
Alfalfa	(12)	9.60	(11)	8.80	(11)	8.80	(6)	4.80
Timothy	(4)	0.90	(5)	1.10	(5)	1.10	(4)	0.90
Fertilizer[b]								
Phosphorus	(50)	12.80	(45)	10.80	(45)	10.80	(40)	9.60
Potassium	(75)	11.25	(65)	9.75	(65)	9.75	(55)	8.25
Lime[c]		11.95		11.95		11.95		11.95
Chemicals[d]		4.44		4.25		4.25		0.63
Power & Equipment[d]								
Fuel,oil,grease		2.88		2.60		2.60		2.54
Repair & maint.		2.08		1.92		1.87		1.85
Other		2.00		2.00		2.00		2.00
Total Growing		57.90		53.17		53.12		42.52
Harvesting								
Power & equipment								
Fuel,oil,grease		19.00		17.00		15.00		15.00
Repair & maint.		15.00		13.50		13.50		12.00
Other		3.00		3.00		3.00		3.00
Total Harvesting		37.00		33.50		31.50		30.00
Interest[e]		5.84		5.33		5.21		4.46
Total Selected Var. Expenses		$100.74		$92.00		$89.83		$76.98

Footnotes on page 34.

Table 7: Corn Silage Selected Variable Expenses Per Acre

		Soil Productivity Groups			
		2	3	4	5
Yield (tons) with corn planted on May 3		17.40	16.10	14.40	13.30
VARIABLE EXPENSES:					
Growing					
Seed[f]		20.00	20.00	20.00	20.00
Fertilizer[b]					
Nitrogen	60 lbs	16.80	16.80	16.80	16.80
Phosphorus	60 lbs	14.44	14.44	14.44	14.44
Potassium	60 lbs	9.00	9.00	9.00	9.00
Lime[c]	.5 tons	11.95	11.95	11.95	11.95
Chemicals[d]		26.58	25.10	25.10	22.87
Power & Equipment[d]					
Fuel,oil, & grease		7.40	7.40	7.40	7.77
Repair & maintenance		4.99	4.96	4.81	5.02
Other		5.00	5.00	5.00	5.00
Total Growing		116.16	114.65	114.50	112.85
Harvesting					
Power & Equipment[d]					
Fuel,oil, & grease		10.15	9.45	8.54	8.35
Repair & maintenance		6.90	6.28	5.41	5.17
Other		2.00	2.00	2.00	2.00
Total Harvesting		19.05	17.73	15.95	15.52
Interest[e]		8.32	8.15	8.03	7.90
Total Selected Variable Expenses		143.53	140.53	138.48	136.27

Footnotes on page 34.

Table 8: Corn Grain Selected Variable Expenses Per Acre on Soil Productivity Group 2

Yield (Bu.) with corn planted on May 3		100.00
VARIABLE EXPENSES:		
Growing		
Seed[g]		18.40
Fertilizer[b]		
Nitrogen	60 lbs.	16.80
Phosphorus	60 lbs	14.44
Potassium	60 lbs	9.00
Lime[c]	.5 tons	11.95
Chemicals[d]		26.58
Power & Equipment[d]		
Fuel, oil, & grease		7.40
Repair & maintenance		4.99
Other		5.00
Total Growing		114.56
Harvesting		
Power & Equipment[h]		
Fuel, oil, & grease		1.50
Repair & maintenance		1.25
Custom Harvesting[i]		24.00
Total Harvesting		26.75
Interest[e]		8.70
Total Selected Variable Expenses		$150.01

Footnotes on page 34.

Table 9: Oats Selected Variable Expenses Per Acre

	Soil Productivity Groups							
		2		3		4		5
Yield (bu.)		50		50		50		50
VARIABLE EXPENSES:								
Growing								
Seed[j]		12.63		12.63		12.63		12.63
Fertilizer[k]								
Phosphorus	(50)	12.80	(45)	10.80	(45)	10.80	(40)	9.60
Potassium	(75)	11.25	(65)	9.75	(65)	9.75	(55)	8.25
Lime[k]		11.95		11.95		11.95		11.95
Chemicals[k]		4.44		4.25		4.25		0.63
Power & Equipment[k]								
Fuel,oil,grease		2.88		2.60		2.60		2.54
Repair & maint.		2.08		1.92		1.87		1.85
Other		2.00		2.00		2.00		2.00
Total Growing		60.03		55.90		55.85		49.45
Harvesting								
Power & Equipment[h]								
Fuel,oil,grease		1.50		1.50		1.50		1.50
Repair & maint.		1.25		1.25		1.25		1.25
Custom Harvesting[i]		24.00		24.00		24.00		24.00
Total Harvesting		26.75		26.75		26.75		26.75
Interest[e]		5.34		5.09		5.08		4.69
Total Selected Variable Expenses		$92.12		$87.74		$87.68		$80.89

Footnotes on page 34.

Footnotes for Crop Enterprises: Tables 5 to 9

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a Seeding rate suggested by Cornell Recommends (1983), price of alfalfa seed is $2.40 per pound (New York Agricultural Statistics, 1983). The price of timothy seed is $.65 per pound (Twentyman, 1984). Seeding costs are allocated to the three production years.

b Fertilization rates suggested by Cornell Recommends (1983), nitrogen is $.28 per lb., phosphorus is $.24 per lb., and potassium is $.15 per pound (Twentyman, 1984). Rates for the establishment years are averaged over the four year life of the stand.

c Lime rate is set at 1/2 ton per acre (Knoblauch and Milligan, 1982; Lazarus, 1983). Price of lime is $23.90 per ton (New York Agricultural Statistics, 1983).

d One of the distinguishing characteristics of the crop activities is the crop expenses by soil group. Economic profiles for hay, corn, and pasture were calculated by the New York State Board of Equalization and Assessment (Twentyman, 1984) for 1983 which specifies crop expenses by soil classification. These values were based on previous work by Lazarus (1984), Knoblauch, Lazarus and Milligan (1983), and Knoblauch and Milligan (1981), (1982). Various crop expenses for the crop budgets in this study are taken from these sources.

e Interest on operating expenses is 12.3% (Twentyman, 1984) APR for six months.

f 25,000 seeds per acre (Cornell Recommends, 1983) $64.00 per 80,000 seeds (New York Agricultural Statistics,1983).

g 23,000 seeds per acre (Cornell Recommends, 1983), $64 per 80,000 seeds (New York Agricultural Statistics, 1983).

h Costs for machinery used in transporting and handling.

i Cost for custom harvesting $24.00 per acre.

j 2.5 bushels per acre (Cornell Recommends, 1983), $5.05 per bushel for seed (N.Y. Agricultural Statistics, 1983)

k Growing expenses (excluding seed) for hay crops and oats have been averaged over the establishment year and three hay production years.

The parameters necessary for estimating implement field capacity are implement width, speed, and field efficiency. The width of the implement is predetermined. Field efficiency for each operation is initially set at 5% below the maximum estimated by the American Society of Agricultural Engineers to represent a farmer who efficiently performs field operations under New York conditions.

The speed for plowing, discing, harrowing, planting, seeding, mowing, raking, and harvesting of corn silage is set by following procedures outlined in Russel (1981). This method involves both formulas based on agricultural engineering relationships as well as subjective judgements of those experienced with field operations on New York farms. The engineering formulas establish the maximum speed for the implements while subjective judgement reduces unrealistic speeds to those commonly found. The speeds for harvesting hay crops were based on Milligan and Ramsey (1982). Table 10 specifies the implement width, speed, and field efficiency parameters along with the resulting field capacities used on the representative farms.

The hours of operator, family, and full-time hired labor were determined by examining these figures for farms of corresponding size on the 1983 Dairy Farm Business Summary (Smith and Putnam, 1983). Operator labor was calculated as the number of months of operator labor available multiplied by 230 hours per month divided by 365 days per year which equals operator labor per day. This is 9.9 hours per day for the small farm and 10.9 hours per day for the large farm.

Family labor was calculated using unpaid family labor information from the New York Dairy Farm Business Summary (Smith and Putnam, 1983) for the farms of comparable size to the representative farms in this study. Family labor is calculated to be 2.5 hours per day on the small farm and 1.4 hours per day on the large farm. There is no full-time hired labor on the small farm. The large farm has one full-time employee working 230 hours a month or 7.6 hours per day. Seasonal hired labor is unconstrained in the LP model so it is not necessary to calculate a value for it. The operator, family, and full-time hired labor per period derived from the per day figures are listed in Table 11.

Table 10: Implement Field Capacity

Implement	Width (ft)	Speed (mph)	Field Efficiency	Field Capacity Acre/hr.	Field Capacity Hrs./acre
Plow 4-18"	6	2.9	85%	1.79	0.56
Plow 5-18"	7.5	2.9	85%	2.24	0.45
Disk	12	4.5	85%	5.56	0.18
Disk	15.5	4.5	85%	7.19	0.14
Harrow	12	5.0	85%	6.18	0.16
Harrow	16	4.1	85%	6.76	0.15
Planter	10	6.0	80%	5.82	0.17
Drill 18-7"	10.5	6.0	80%	6.11	0.16
Drill 21-7"	12.25	6.0	80%	7.13	0.14
Mower-cond.	8.5	5.0	80%	4.12	0.24
Rake	8.5	4.5	80%	3.71	0.27
Baler	8.5	4.0	80%	3.30	0.30
Harvester HCS	8.5	4.0	70%	2.88	0.35
Harvester corn 1 row head	2.5	3.5	70%	0.74	1.35
Harvester corn 2 row head	5	3.0	70%	1.27	0.79

SOURCES: American Society of Agricultural Engineers 1982, Russel 1981, Milligan & Ramsey 1982, Ramsey 1983.

Table 11: Labor Resource Hours per Period

	60 Cow Farm		120 Cow Farm		
Time Period	Operator	Family	Operator	Family	Hired
April 1-20	198	50	218	28	152
Apr 21-May 10	198	50	218	28	152
May 11-20	99	25	109	14	76
May 21-31	109	28	120	15	84
June 1-7	69	18	76	10	53
June 8-14	69	18	76	10	53
June 15-21	69	18	76	10	53
June 21-30	99	25	109	14	76
September 1-15	149	38	164	21	114
September 16-30	149	38	164	21	114

Source: Smith and Putnum 1983.

The days available per time period due to weather restrictions as well as the hours per day were derived from figures found in Sprague et al. (1980) and Ramsey (1983). These figures can be found in Table 12.

Crop Yields and Nutrient Values

Yields and nutrient values are determined for 40 different hay crop activities. These activities are characterized by two harvesting methods, five harvesting dates by date of first cutting, and four soil productivity groups. Harvesting methods include harvesting as dry hay and harvesting as hay crop silage. First cut harvesting dates include May 29, June 5, June 12, June 19, and June 26. These dates correspond to the fourth through eighth periods outlined in the model. Soil productivity groups include soil groups 2, 3, 4, and 5.

Harvested yields measured in dry matter pounds per acre are calculated for each of the 40 activities. Storage and feed losses are deducted to determine the pounds of dry matter per acre that are consumed by the dairy livestock. From these figures the pounds of crude protein, Mcals of net energy, and pounds of adjusted acid detergent fiber are calculated.

Data originating with Fick and Onstad (1982) and tabulated by Ramsey (1983) are used in deriving the yields and nutrient values for the hay crop enterprise activities. The yields in these data appear to be higher than yields found on many New York farms. Reducing the yields 30% resulted in values similar to those found on New York farms as suggested in Knoblaugh and Milligan (1981) (1982), Knoblauch, Lazerus, and Milligan (1983) and Twentyman (1984).

Table 12: Time Available for Field Operations by Period

Time period	Days per Period	Till & Plant hrs/day	Till & Plant total	Hay Crop Silage hrs/day	Hay Crop Silage total	Dry Hay hrs/day	Dry Hay total	Corn Silage hrs/day	Corn Silage total
April 1-20	4.1								
large farms		9	36.9						
small farms		8	32.8						
Apr 21-May 10	6.9								
large farms		9	62.1						
small farms		8	55.2						
May 11-20	2.6								
large farms		9	23.4						
small farms		8	20.8						
May 21-31	4.4			6	26.4	5	22.0		
large farms		9	39.6						
small farms		8	35.2						
June 1-7	3.4			6	20.4	5	17.0		
large farms		9	30.6						
small farms		8	27.2						
June 8-14	3.3			6	19.8	5	16.5		
June 15-21	3.2			6	19.2	5	16.0		
June 21-30	4.1			6	24.6	5	20.5		
Sept. 1-15	11.0								
large farms								8	88.0
small farms								7	77.0
Sept. 16-30	11.0								
large farms								8	88.0
small farms								7	77.0

Sources: Sprague et al., 1980; Ramsey, 1983.

Yields and nutrient values are determined for sixteen different corn silage activities. These activities are characterized by the four soil groups and four planting periods. Four planting periods correspond to the second through fifth periods outlined in the model.

The value for each of these activities is derived using data from Knapp and Reid (1981). They found that corn silage harvested from corn planted on May 14 yielded only 96% as much as corn silage harvested from corn planted on May 3. Corn planted on May 28 yielded only 90% as much corn silage as corn planted on May 3. Extrapolating this trend to corn planted on June 7 puts corn silage yields at 87% of the May 3 potential. From this information, corn silage yields are calculated as follows. Potential corn silage yields in tons per acre are estimated for corn planted on May 3 on each of four soil groups. These estimates are taken from Knoblauch and Milligan (1981) (1982), Knoblauch, Lazarus, and Milligan (1983) and Twentyman (1984). From these potential yields, the percentages mentioned above are applied to arrive at a yield for each of the other planting periods on each soil group. The yields are converted to a dry matter pound per acre basis, then storage and feed losses are deducted. Crude protein, net energy, and acid detergent fiber values are calculated based on Milligan et al. (1981).

Yields and nutritional values are determined for 11 different corn grain activities. It is assumed that corn grain can only be harvested from corn planted on group 2 soil. The distinguishing characteristic of the corn grain activity is planting and harvesting dates. Each activity represents a different planting-harvesting date combination.

To determine the yields and nutritional values for each of the planting date-harvesting date combinations, a procedure similar to that used for the corn silage was followed. A yield estimate is made for corn that is planted and harvested during the most optimal periods. These yields are then calculated by multiplying the potential yield for the optimal planting -harvesting date combination by the percentage reduction for all other planting-harvesting date combinations. These percentage reductions were taken from Sprague et al.(1980)

Corn planted in the time period from April 21 to May 10 and harvested in the time period from October 16 to October 31 results in 100% of the potential yield. This is estimated to be 100 bushels per acre. The following conversion factor is used to compare corn grain yields to corn silage yields.

Corn Grain (bu.) = 5.8 x Tons Corn Silage

The 100 bushel per acre yield is consistent with the corn silage yields for group 2 land. It is slightly higher than the average for farms on the New York Dairy Farm Business Summary (Smith and Putnam, 1983), but this is consistent with the assumption of efficiency on the initial representative farms.

Storage and feed losses are deducted from the yield for each activity. Crude protein, net energy, and acid detergent fiber values are then calculated based on Milligan et al. (1981). It is assumed that nutrient percentages do not vary with planting and harvesting dates. Nutritional values for purchased corn, soybean oil meal, and grown oats are taken from Milligan et al. (1981).

Livestock Nutritional Requirements

To meet the annual feed requirements for the production groups, dry cows, and replacement heifers on the two representative farms, it is necessary to know the following daily nutrient requirements: maximum dry matter intake, minimum net energy, minimum crude protein, and minimum acid detergent fiber.

The following steps are taken to calculate these requirements for the two production feed groups.

1. Establish the desired production levels.
2. Determine production groups and lactation time cows spend in each group.
3. Calculate average daily fat corrected milk(FCM) production per cow for each group at each production level and adjust for lead factor (LF), then calculate daily nutrient requirements from the (FCMLF).
4. Calculate annual requirements.

An explanation of production levels and herd groups was in section 2.2. Average daily milk production for each group at each production level is calculated using an electronic spreadsheet template (Lazarus and Milligan 1984) which is based on Wood's equation. Formulas from Cornell's Least-Cost Balanced Dairy Return Program (Milligan et al. 1981) are used to calculate the FCMLF as well as calculate the daily nutrient requirements from the FCMLF. These equations are based on NRC (1972) A 3.5% butterfat content for both groups and a lead factor of 1.1 for the high producing groups and 1.15 for the low producing groups (Milligan, 1985) is used in calculating the FCMLF. A summary of the formulas, and coefficients for the annual nutrient requirement is found in Appendix tables 1-3.

An additional adjustment is made to the net energy requirements because a cow's energy utilization from feed declines as milk production increases. Adjusting for this characteristic is usually accomplished by decreasing the energy value of the feed (Milligan et al. 1981). Normally a discount factor is multiplied by a maintenance increment; that is, a number representing the increase in energy needs of a lactating cow beyond maintenance. The product of the discount factor and maintenance increment is the percentage by which the energy value of the feed is decreased.

In this study, the adjustment is made by increasing the energy requirement of the cows. This procedure is adopted to allow the incorporation of this characteristic into the LP model[3]. An example of this adjustment follows. If a lactating cow's daily energy requirement is 34.62 Mcals and its maintenance requirements are 9.93 Mcals, then its maintenance increment is calculated as 34.62/9.93 - 1 = 2.49. Multiplying 2.49 by a discount rate of 4% arrives at an adjustment figure of 9.96%. The cow's daily energy requirement is calculated as 34.92/(100% - 9.96%) = 38.44 Mcals which reflects the increased energy requirements for less energy efficient lactating cows.

Nutritional requirements for dry cows are calculated using formulas in Milligan et al. (1981). Nutritional requirements for replacement heifers are taken from Russel (1981). The minimum requirement for adjusted acid detergent fiber is set at 15% of dry matter (Milligan et al., 1981).

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[3] Feed activities for three production levels are included in the same row so the normal procedure of decreasing the feed value could not be used because the feed value would be different for each group.

INITIAL REPRESENTATIVE FARMS AND MODEL EVALUATION

The following is a discussion of the initial representative farms and model evaluation. The initial solutions from the representative farm of the LP model are discussed. Receipts, variable expenses, and fixed expenses are presented in a financial summary. This information and production levels are compared to information derived from actual dairy farm data to show the strengths and weaknesses of the model. The comparison information used is the 1983 New York Dairy Farm Business Summary (Smith & Putnam).

The Initial Representative Farms

The model was run for each of the resource levels to produce the optimal allocation of resources for the large and small farms. Constraints were then placed in the model to simulate other farm situations. These constraints created a total of sixteen representative farms representing two resource levels or farm sizes, two maximum milk production levels, and four crop management scenarios. These initial representative farms are identified by their distinguishing characteristics which are found in Table 13.

Table 13: Characteristics of Initial Representative Farms

Farms	Herd Size	Milk Production Level(lbs/cow/yr)	Hay Harvest Method	Relative Level Corn Planted
L18HCSHC	120	18000	Hay Crop Silage	High
L18HCSLC	120	18000	Hay Crop Silage	Low
L18DHHC	120	18000	Dry Hay	High
L18DHLC	120	18000	Dry Hay	Low
L16HCSHC	120	16000	Hay Crop Silage	High
L16HCSLC	120	16000	Hay Crop Silage	Low
L16DHHC	120	16000	Dry Hay	High
L16DHLC	120	16000	Dry Hay	Low
S18HCSHC	60	18000	Hay Crop Silage	High
S18HCSLC	60	18000	Hay Crop Silage	Low
S18DHHC	60	18000	Dry Hay	High
S18DHLC	60	18000	Dry Hay	Low
S16HCSHC	60	16000	Hay Crop Silage	High
S16HCSLC	60	16000	Hay Crop Silage	Low
S16DHHC	60	16000	Dry Hay	High
S16DHLC	60	16000	Dry Hay	Low

The initial optimal solutions of the model set the milk production level for both herd sizes at 18,000 pounds per cow. This was expected since the initial farms were to represent efficient farm management practices. One of the objectives of the study is to determine the affect of crop management practices on milk production levels. It was hypothesized that the lower yields and quality of forages associated with poor crop management practices might force milk production levels down because the purchased corn grain and soybean oil meal could not balance with the lower quality forages to produce a ration that would meet the protein and energy requirements while meeting the fiber requirements and dry matter limits. This, however, proved not to be the case. Given the nutritional constraints in the model, all the feed requirements can be met even with suboptimal crop management practices, although formulation of a balanced ration becomes increasingly difficult as forage quality deteriorates. In actual practice, this increased difficulty could be reflected in lower milk production.

There are many other factors which influence the milk production levels. These include herd genetics, reproduction management, replacement management, herd health, condition of facilities, milking procedures, and feed management unrelated to crop management. Because many dairy farm managers are unable to produce an average of 18,000 pounds per cow, the first sensitivity factor on the two sizes of farms was to constrain the model to analyze farms that have a 16,000 pound per cow of average milk production.

In the base analysis discussed in this chapter, the hay crop is harvested as hay crop silage. Others (Hughes et al., 1962; Ramsey, 1983; Savoie et al., 1981) have discussed the advantages and disadvantages in harvesting hay as hay crop silage: lower variable costs, but higher fixed costs. Since linear programming is short-run by nature, it is not the appropriate tool to consider the hay harvesting method. Hay crop silage and dry hay activities are included in the base model; however, the solution contains hay crop silage. The model is, therefore, run with the hay crop silage activities removed for each farm size and each milk production level to represent farms that harvest hay crops as dry hay. On the representative farm that produces hay crop silage, excess production is harvested as dry hay and sold. It is assumed that a minor portion of the crop may be harvested as dry hay for use in the livestock enterprises such as feed for replacement heifers or dry cows, but the model does not take this in to account.

On the initial farms, acres of corn are constrained to the limits required for sound soil conservation practices On these farms corn was produced at the maximum permitted. While this occurs on some dairy farms, particularly larger dairy farms, most dairy farms in New York produce less than this amount. The final sensitivity factor is to add constraints to limit the amount of corn to half of the amount possible. The model is run with the corn production constraint for each of the combinations of characteristics previously discussed. All corn was harvested as silage. Corn grain production proved to be uneconomical.

Financial Summary of Representative Farms

The crop management practices analyzed in this study are changeable in the short run; that is, a farm manager has considerable control in the given crop year over those factors which allow him or her to schedule and perform field operations in a timely manner. Because these are short run management decisions, the profitability from various management strategies can be measured by analyzing receipts over variable costs. In analyzing the marginal effects of timeliness of operations on profitability, it is not necessary to consider fixed costs. However, fixed costs are included in analyzing the initial representative farm to get a better view of the financial picture of the representative farms. In addition we can get a better idea of the magnitude of the effects of poor crop management on return to operator's labor, management, and equity capital. Finally we can make a better comparison of the information on the representative farms with the information on the farms found in the New York Dairy Farm Management Business Summary (Smith & Putnam, 1983).

Income statements are generated from initial solutions of the LP model to provide a financial summary of the representative farms. These income statements require information on all receipts, variable expenses, and fixed expenses. The model includes the receipts and variable expenses necessary in making the analysis of the affects of timing of field operations. Additional information on fixed costs not generated by the model is required to complete the income statement.

Enterprise budgeting is used to determine receipts and variable expenses for each livestock and crop enterprise. These totals are then entered into the LP model from which the optimal farm management plan is determined and maximum returns over variable expenses are generated. The individual receipts and expense items from the enterprise budgets are multiplied by the enterprise activity levels included in the solution to obtain receipt and expense categories for the income statement for the representative farms (Appendix table 4).

The labor costs in the model include only the part-time hired labor required during those times which are analyzed. Part-time labor hired from October 1 through March 31 and from July 1 through August 31 are added to those labor expenses generated by the model. Additional part-time hired labor expenses for the eight unaccounted months are set at $3,000 for both farms. The labor expenses for the full-time hired employee on the large farm are set at $20,000 which includes salary and benefits.

Property taxes are calculated on a per acre basis. New York Agricultural Statistics (1983) reveal that 143.8 million dollars were collected in 1982 property taxes on a total New York farm acreage of 9.5 million acres. This averages out to $15.10 per acre. This value is multiplied by the total acreage base for the representative farms to obtain a property tax expense of $5,285 for the large farms and $3,246 for the small farms. Since land is taxed on its agricultural use value, or its income generating capacity from agricultural production, these figures may be overstated for the small farm with poorer soil and understated for the large farm with the better soil. However, they are considered accurate enough for this comparison.

Insurance expenses include insurance premiums on all farm buildings and machinery. The rate on buildings is set at 1.5% of the initial value of the structure (Hogland, 1976). The rate on machinery and equipment is set at 0.5% the initial value (Campbell, 1978).

Interest expenses were not included in this financial analysis since it is difficult to estimate the equity capital on the representative farms. By not including interest, the income measure becomes returns to operator and management, unpaid family labor, and all capital.

Depreciation on buildings is calculated at 5% of the initial value minus a 10% salvage value (Hogland, 1976). Silo unloaders are depreciated at 12.5% (Hogland, 1976). Machinery is depreciated according to a method found in Campbell (1978) based on an agricultural engineering depreciation schedule plus 12% of the average values during the year. All machinery was considered to be five years old. While all machinery will not be five years old this procedure places an accurate cost on an equipment complement that is an average of five years old. Therefore, the average of five years old is a realistic assumptions.

Comparison of Representative Farms and DFBS Farms

The initial farms are modeled to represent efficient or above average livestock and crop management so that the effects of suboptimal crop management can be determined. This results in higher production levels than the DFBS farm. Table 14 compares the average production levels for the large and small representative farms with the average production levels for the top 10% of DFBS farms by labor and management income per operator.

Table 14: Production Levels-Representative vs. DFBS Farms[a]

Enterprise	Representative Small Farms	Representative Large Farms	Top 10% DFBS Farms[b]
Milk sold lbs/cow	17730 15760	17730 15760	16496
Corn Silage tons/acre	14.3	16.0	14.8
Hay DM tons per/acre	3.2	3.4	2.9

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[a] 1983 Dairy Farm Management Business Summary (Smith & Putnam)

[b] Top 10% DFBS farms by labor & manag. income per operator.

The efficient management on the representative farms is reflected in production levels similar to the top DFBS farms. Although the productivities for the large farm are higher than the top 10% of DFBS farms, the production levels are within ranges attained by farms in New York with very good management.

The efficiency of the representative farms is reflected in their profitability. The receipts, variable expenses, and fixed expenses on the representative farms discussed in the previous section are tabulated into income statements in Appendix table 4. These income statements are compared with receipt and expense information on the DFBS farms of similar size which are in the last column of this tables.

Receipts on both the large and small representative farms are substantially higher than the corresponding DFBS farms. Milk receipts are higher because of the higher quantities of milk sold on the representative farms compared to the average DFBS farms. The receipts for dairy cattle sold are higher for the representative farms than for the DFBS farms, but these values are close enough to be comparable. Other livestock sales include calf sales and bred heifer sales. Adjustments need to be made in this category for the representative farms before a comparison can be made with the DFBS farms. The reason for this is that the representative farms have an assumed constant herd size, therefore all excess bred heifers are sold and no value is associated with the increase in livestock or the expense of expansion livestock.

In addition, there are no purchased replacement livestock on the representative farms. The following example shows the adjustments necessary for comparing livestock sales. In Farm L18HCSHC the total of $12,500 for other livestock sales should be reduced by $5,724 (Increase in livestock from DFBS farm) to reflect decreases in bred heifer sales and increases in herd inventory on the representative farms. To represent the expense of expansion livestock, $1,016 (Expansion livestock on DFBS farms) should then be deducted. Accounting for purchase of replacement livestock is more difficult since an increase in purchased replacement livestock should also be offset by an increase in bred heifers sold. Considering that the number of heifers on the representative farms is similar to the number of heifers on the DFBS farms, there appears to be a discrepancy in the livestock sales category. This may be due to death loss.

The crop sales on the low milk producing representative farms are similar to the corresponding DFBS farms. On the high milk producing representative farms, crop sales are higher since increased milk production requires the substitution of higher nutrient grains and concentrates for forages creating excess forages to be sold. The model does not include any government payment or other receipts so miscellaneous receipts are lower on the representative farms.

In general, the expenses on the representative farms appear to be less than DFBS farms probably reflecting better cost control resulting from the above average management. The higher production levels which increase the milk receipts should also increase expenses (although not proportionately). The expense categories of hired labor, other feed, machinery hire, breeding fees, veterinary expense, milk marketing, taxes and insurance, and utilities are all similar to corresponding figures on the DFBS farms.

The feed and concentrate expense on the representative farms appear to be lower than DFBS farms. Those farms with the high milk production levels (18,000 lbs. per cow) have similar feed and concentrate expenses to the DFBS farms, but these expenses would normally be higher because of the increased needs for high nutrient density feeds. The representative farms with the lower milk production levels (16,000 lbs. per cow) have lower feed and concentrate expenses than the DFBS farms. The feed costs on the representative farms are lower, however, because higher yields and quality of farm produced feeds lower the purchased feed requirements.

Those farms that plant a higher proportion of acres in corn for silage have lower purchased feed expenses. It appears to be more economical to meet the energy requirements through farm produced feed than to meet the protein requirements through farm produced feed. Purchased feed expenses are also lower on those farms that harvest hay as hay crop silage rather than dry hay because of the increased protein density of hay crop silage. However, no conclusions can be drawn about this without an analysis of the fixed costs which has not been attempted in this study.

There appear to be considerable discrepancies in comparing the expense categories: machinery repair, auto expense, gas and oil, other livestock expenses, structure repairs, utilities, and miscellaneous expenses. In comparing the representative farms to the DFBS farms, the combined expense totals for these categories are similar. The differences in individual categories may reflect misallocation of expenses to categories. The fact that the totals are similar gives confidence that most expenses are accounted for.

The crop expenses for the representative farms are similar to the DFBS farm averages. Again this probably reflects the better cost control with above average management since with higher crop production one would expect higher costs.

Machinery depreciation on the large representative farms is comparable to corresponding DFBS farm averages. On the small representative farms, this figure is higher. Building depreciation on both sizes of representative farms is higher than the DFBS farm averages. The source of these discrepancies could be either in the depreciation rates on the DFBS and representative farms or overcapitalization in building and machinery on the representative farms.

Summary of Model Evaluation

The efficiency built into the representative farms leads higher rates of livestock and crop production than the average of similar sized farms on the New York Dairy Farm Business Summary. These higher production rates and the expected improved cost control are reflected in the higher returns to all capital and operator and family labor and management.

It appears that the model captures the effect of high yields and quality of crops on the purchased feed expenses which is important in analyzing timeliness of operations. While most of the expenses on the representative farms are lower than those on the average of the DFBS farms, the purchased feed is considerably lower which reflects the higher quality and quantity of crops on the representative farms and improved cost control.

ANALYSIS OF TIMELINESS IN PERFORMING FIELD OPERATIONS

The level of management efficiency in field operation timing affects several segments of the farm business. A change in efficiency in one segment triggers changes in other segments of the business. Figure 7 illustrates the relationships between various segments of the dairy farm business. The effects of field operation management efficiency on these individual segments and relationships are analyzed in the following sections.

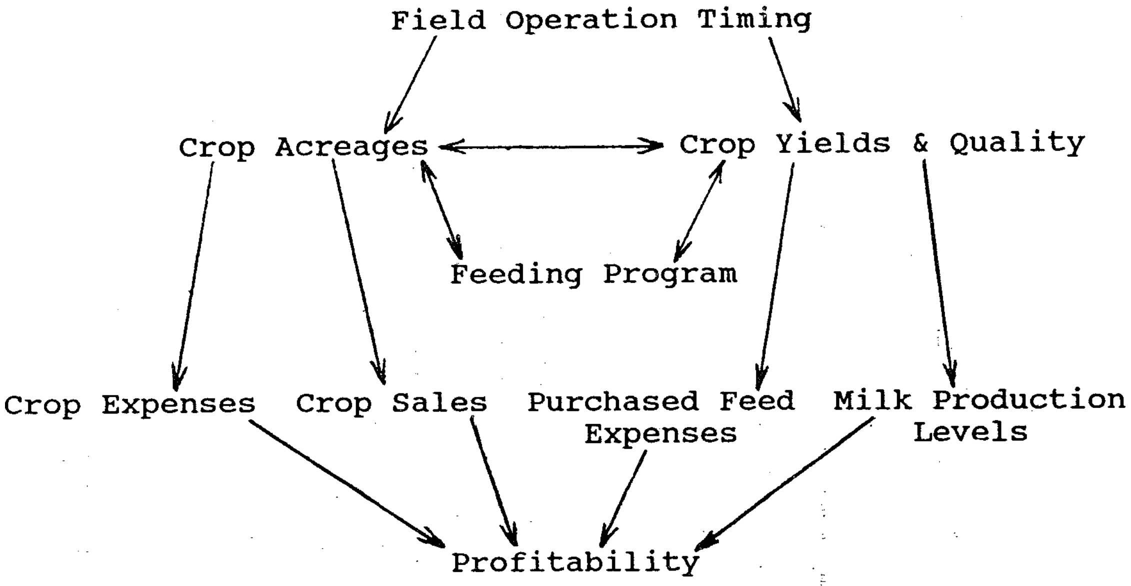


Figure 7: Relationships Between Segments of a Dairy Farm Business

The Inefficient Field Operation Management Scenarios

The initial representative farms reflect farm managers who efficiently schedule and perform field operations. In contrast with these initial farms, inefficient field operation management scenarios are developed by altering the model sequencing and time constraints (Table 15).

Field operation scenarios DFO1 and DFO2 represent the delayed field operations of farm managers who are unprepared for field work. Plowing and planting are &delayed past the time soil conditions first permit these operations. Hay crop harvest is delayed beyond the growth stage of optimal yields and protein percentages.

In contrast to scenarios DFO1 and DFO2, scenarios DTL1 and DTL2 represent farmers who start field work on time, but have daily time losses. Scenario DTL1 represents a daily time loss of one hour during tillage, planting, and corn harvesting operations and a half hour loss per day during hay harvesting operations. Scenario DTL2 represents a daily time loss of two hours during tillage, planting, and corn harvesting and one hour in hay harvesting. The small farms are not as sensitive to daily time losses because the machinery complement is larger relative to the acreage to be worked; consequently, scenario DTL1 is not reported for the small farms and scenario DTL2 is adjusted to represent a three hour daily time loss during tillage, planting, and corn harvesting and a two hour daily time loss during hay harvesting. The final scenario, COM, is a combination of scenario DFO1 and DTL1. These farm managers delay field operations and once started, they do not make full use of the daily time available.

Table 15: Inefficient Field Operation Management Scenarios

Scenario	Farms Applied To	Characteristics
Delayed Field Operation		
DFO1	All	Delay tillage until April 21 Delay corn planting until May 11 Delay hay crop harvest until June 1
DFO2	All	Delay tillage until April 21 Delay corn planting until May 21 Delay hay crop harvest until June 8
Daily Time Loss		
DTL1	Large	Tillage, planting, and corn silage harvest decreased 1 hour per day Hay crop harvesting decreased 1/2 hour per day
DTL2	Large	Tillage, planting, and corn silage harvest decreased 2 hours per day Hay crop harvesting decreased 1 hour per day
DTL2	Small	Tillage, planting, and corn silage harvest decreased 3 hours per day Hay crop harvesting decreased 2 hours per day
Combination		
COM	Large	Scenario DFO1 and DTL1 combined
COM	Small	Scenario DFO1 with additional one hour per day decrease

Contrasting these scenarios with those on the initial representative farms identifies changes in profitability, crop rotation, quality and yields of farm produced feeds, field operation schedules, purchased feed costs, crop sales, crop expenses, and milk production levels. These changes result from untimeliness which could be corrected with improved management.

Profitability

The timeliness of field operations ultimately affects the profitability of the farm business. Most of the scenarios analyzed have a significant affect on the profitability of the initial representative farms (Table 16). The loss in profitability ranges from just over $1600 to over $21,000 for the large farms with more than half of the scenarios in excess of $10,000. For the small farms, the decreases are less; however, several exceed $5,000.

Table 16: Reduction in Returns to Operator's Labor, Management, and Fixed Capital from Inefficient Management Scenarios

Rep.	Field Operation Management Scenarios				
Farms	DFO1	DFO2	DTL1	DTL2	COM
L18HCSHC	$13,635	$16,787	$6,263	$13,420	$19,290
L18HCSLC	$6,321	$11,973	$2,462	$5,943	$9,909
L18DHHC	$14,626	$17,025	$6,043	$13,635	$20,515
L18DHLC	$4,700	$9,898	$1,644	$4,084	$7,977
L16HCSHC	$13,722	$16,873	$6,262	$13,687	$19,699
L16HCSLC	$6,815	$12,433	$3,044	$6,476	$10,325
L16DHHC	$15,271	$17,764	$6,525	$14,932	$7,407
L16DHLC	$4,848	$10,262	$1,807	$4,672	$4,007
S18HCSHC	$1.985	$5,492		$5,171	$3,555
S18HCSLC	$1,121	$5,016		$1,995	$1,798
S18DHHC	$2,120	$5,055		$4,955	$3,623
S18DHLC	$497	$2,511		$2,135	$934
S16HCSHC	$2,225	$6,031		$5,783	$3,841
S16HCSLC	$1,542	$5,537		$1,898	$2,262
S16DHHC	$2,252	$5,346		$5,629	$3,757
S16DHLC	$1,404	$4,170		$1,790	$1,885

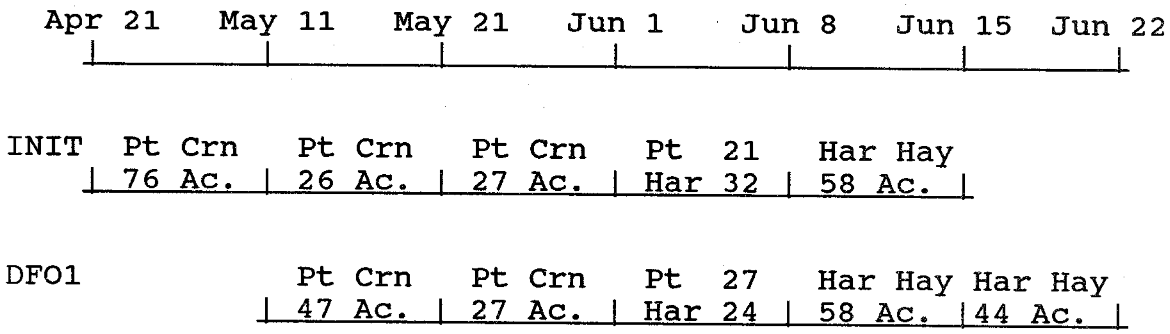
See table 13 for characteristics of farms.
See table 15 for characteristics of management scenarios.

Large high-corn farms have the greatest decreases in profitability ranging from $6,043 to $21,664 as field operations are delayed. Large high-hay farms also have significant decreases in profitability ranging from $1,644 to $12,433. There were smaller decreases in profitability on the small farms ranging from $934 to $6,031. These small losses are inherent in the fact that the smaller farms have less to lose from inefficiency than the large farms. In addition the smaller farms have a proportionately larger equipment complement to compensate for inefficient management.

There are Larger losses on the large farms than there are on the small farms. Farms that have high acreages of corn have larger losses than farms that have low acreages of corn. There are also larger losses with delayed field operations than there are with daily time losses.

Crop Acreages Under the Various Inefficient Scenarios

Field operation timing directly influences the crop acreages (Figure 8). The crop rotations are further dependent on interactions with the feeding program and crop yields and quality. Crop acreages are adapted to meet the requirements of the feeding program, but the feeding program must also be managed within the constraints of the crop acreages. Changes in yield and quality from field operation inefficiency cause variations in crop acreages while the crop acreage also effects yield and quality. Crop rotations also directly affect crop expense levels and crop sales. Because of these interactions, crop acreages vary greatly under the inefficient field operation scenarios (Table 17).



Note: As planting is delayed to May 11, there is a greater conflict between planting and harvesting during the week of June 1. In this situation total corn acreage is reduced and hay acreage is increased.

Figure 8: Conflicts in Field Operations as Corn Planting is Delayed

Table 17: Acres of Corn and Hay by Field Operation Management Scenarios

	Operation Management Scenario											
Rep.	Initial		DFO1		DFO2		DTD1		DTD2		COM	
Farm	Corn	Hay	Corn	Hay	Corn	Hay	Corn	Hay	Corn	Hay	Corn	Hay
L18HCSHC	150	120	101	168	113	157	133	129	112	128	95	135
L18DHHC	150	120	131	96	113	157	149	90	119	102	101	119
L16HCSHC	150	120	103	163	113	157	131	134	106	147	86	163
L16DHHC	150	120	110	140	113	157	136	117	109	136	90	152
Large Low Corn	80	190	80	190	80	190	80	190	80	190	80	190
Small High Corn	70	95	70	95	65	100			65	76	70	95
Small Low Corn	35	130	35	130	35	130			35	130	35	130

Note: Hay acreages include both seeding year and producing years. See table 13 for characteristics of farms. See Table 15 for characteristics of management scenarios.

On the high-corn farms, field operations for corn production and hay production conflict. These conflicts are minimal on the small high-corn farms because equipment complements are large enough to compensate for most time losses. However, on the large high-corn farms there are more serious conflicts as farm managers become inefficient. The following examples illustrate these conflicts. On Farm L18HCSHC, scenario DFO1, corn acreage is reduced 49 acres which is made up in hay crop acreage. Under this strategy corn planting is delayed to May 11.

However, because of tillage and hay seeding, corn planting is not completed before June 1 at which time it conflicts with hay harvesting (Figure 8). Under these circumstances, it is more economical to meet livestock protein requirements by increasing hay crop acreage and meet energy requirements with purchased corn rather than corn silage[4].

A similar situation exists on L18DHHC which harvests hay as dry hay rather than hay crop silage. Under DFO1 plowing, corn planting, and harvesting are also delayed, but in this case corn acreage is only reduced by 20 acres instead of 50 acres as in L18HCSHC. It is more economical to meet livestock energy requirements through corn silage and meet protein requirements through purchased

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[4] This is not a decision that can be made on June 1, but rather a representation of what happens in the long run under inefficient management.

concentrates rather than hay because the dry hay produced on this farm is lower in nutrient density than the hay crop silage produced on L18HCSHC. In fact, corn silage is so much more profitable than dry hay that corn planting takes precedence over hay seeding which decreases the total crop acreage.

Other examples of changes in crop rotations can be seen in Farms L16HCSLC and L16DHHC. Under field operation COM, there are both delayed field operations and daily time losses. The results for L16HCSLC are similar to Farm L18HCSHC in the previous example. Corn acreage is decreased and hay crop silage is increased because energy is more economically substituted through purchased feeds than through purchased protein. However in contrast to Farm L18DHHC in the previous example, Farm L16DHHC also decreases corn acreage and increases hay acreage even though hay is harvested as dry hay which is lower in nutrient density. Because milk production per cow is less on these farms, protein and energy requirements are lower. With these lower requirements, it is still more economical to meet the livestock protein requirements with dry hay and purchase corn to meet the energy requirements.

In scenario DFO2, all of the high corn producing farms decrease corn production and increase hay production from the initial representative farms. Reasons for the substitution of hay for corn can be found in the previous examples. In addition, if corn planting is delayed this long, much of it will not be planted until June. In fact, most of the corn on the representative farms under this scenario are planted after June 1. This reduces yield substantially. Even though hay quality is decreased through harvesting delay, it is still more economical than late planted corn. For corn to be economically competitive with hay, it must be planted early. This is further supported by the fact that in the initial representative farms where high corn production is allowed, corn acreage is higher than hay acreage and when constrained, it is produced to the allowed limits.

Effects of Delayed Field Operations on Production and Use of Feed Nutrients

Under the inefficient field operation scenarios, the average protein percentage of hay was reduced from 0.1 to 2.1 percentage points depending on the scenario. Figure 9 shows protein percentages for inefficient strategies on farm L18HCSLC. Scenario DFO2 is the extreme case with average protein declining by more than two percentage points. Delayed field operations have a greater impact than daily time losses.

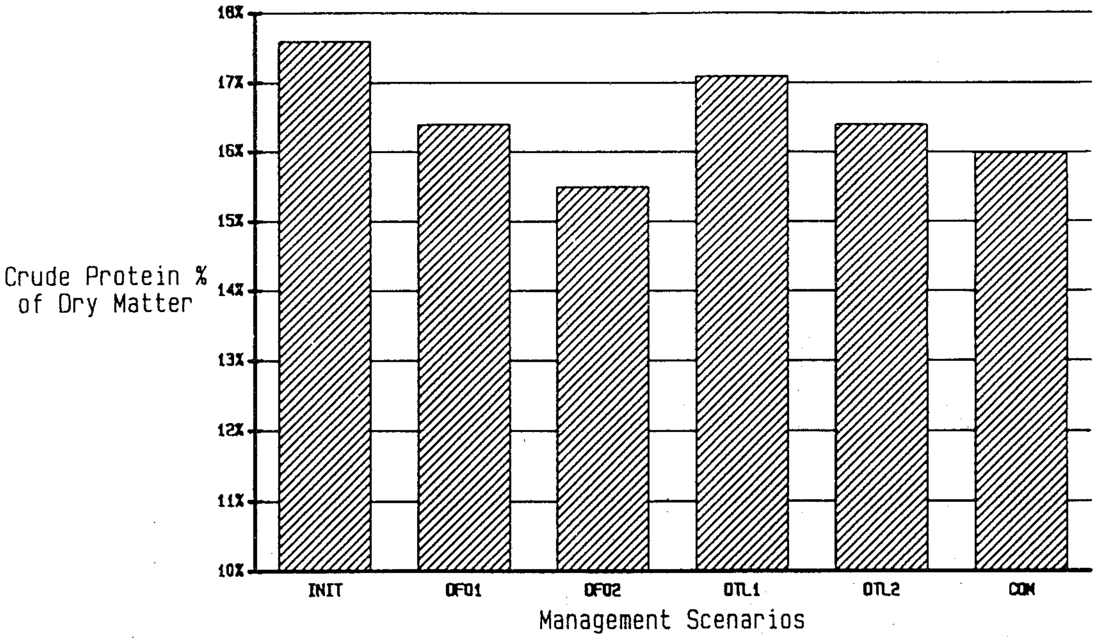

Figure 9: Average Hay Protein Percent of Dry Matter Under Various Management Scenarios on Farm L18HCSLC

On most of the representative farms corn silage yields as field operations were delayed. On the large low-corn farms and all small farms, there is a strong relationship between field operation inefficiency and yield per acre. Figure 10 shows the corn silage tons per acre under the inefficient scenarios for the large low-corn farms. Scenario COM is the extreme case with corn silage yields decreasing up to 1.4 tons per acre.

Reductions in corn silage yields did not occur on all of the farms. On some of the large high-corn farms, the yield per acre actually increased under the inefficient farm management scenarios. Corn acreages are reduced substantially under these strategies because planting corn at less than ideal times is replaced by hay operations and there is sufficient time for early planting of the limited acreage.

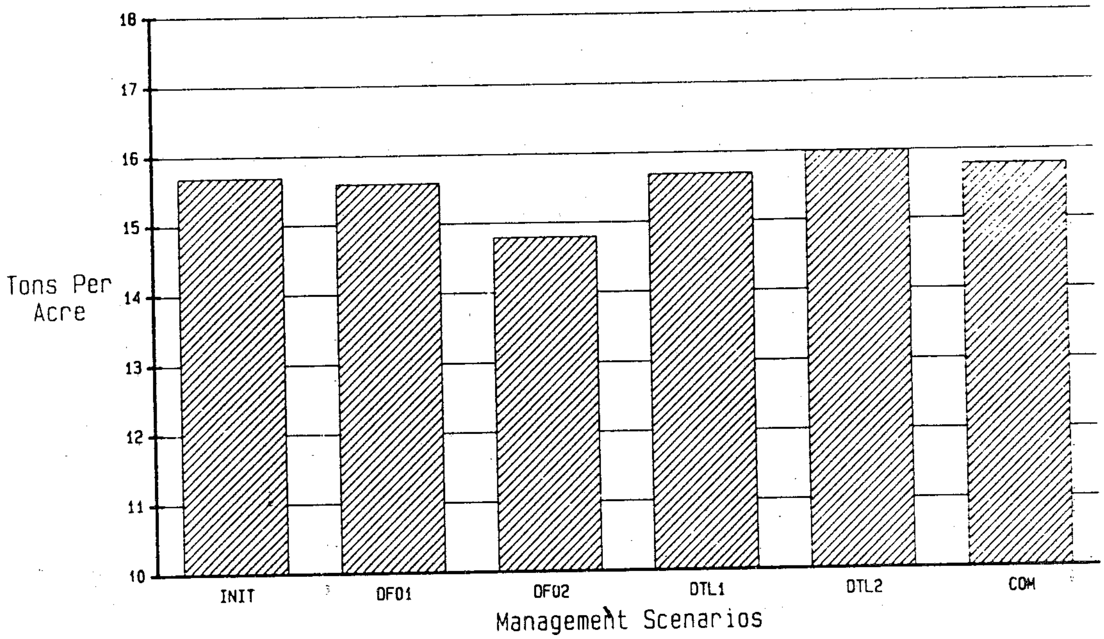

Figure 10: Average Corn Silage Yields Under the Management Scenarios on the Large Low-Corn Farms

In addition to the changes in hay quality and corn silage yields, there are also changes in the total tons of hay and corn silage produced under the inefficient strategies. The major source of these changes in total tons are the shifts in crop acreage. With the shift from corn production to hay production, there are decreases ranging from 8 tons to 847 tons in total corn silage production on the farms under the inefficient strategies. Decreases in corn production are partially offset by increases in hay production on many of the farms. Figure 11 illustrates changes in the total production of corn and hay on L18HCSHC.

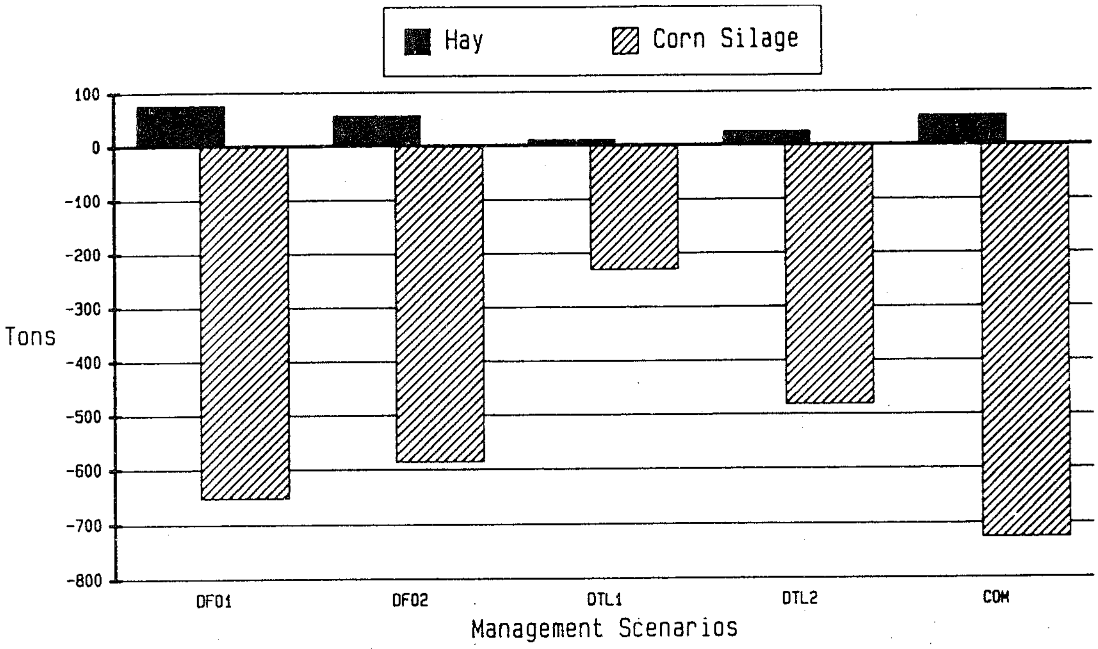

Figure 11: Change in Total Production of Corn and Hay Under the Inefficient Management Scenarios on Farm L18HCSHC

The changes in quality, yield, and total production associated with delayed field operations have a strong impact on the feeding program and crop sales. The effects on the feeding program can be measured by the total available amounts of energy and protein from feed produced on the farm. Any decrease in farm produced energy and protein must be offset by increased purchased feed.

This is illustrated by Farm L16HCSHC. Under efficient management this farm purchases only 12% of its livestock energy requirements and 27% of the protein requirements because most feed requirements are met with farm produced feeds. As field operations are delayed under scenarios DFO1, DFO2, and COM, purchased energy increases to 26%, 27%, and 32% of the total requirements (Figure 12). Similar increases are found in scenarios DTL1 and DTL2. There is also an increase in purchased protein under inefficient field operation management scenarios, (Figure 13).

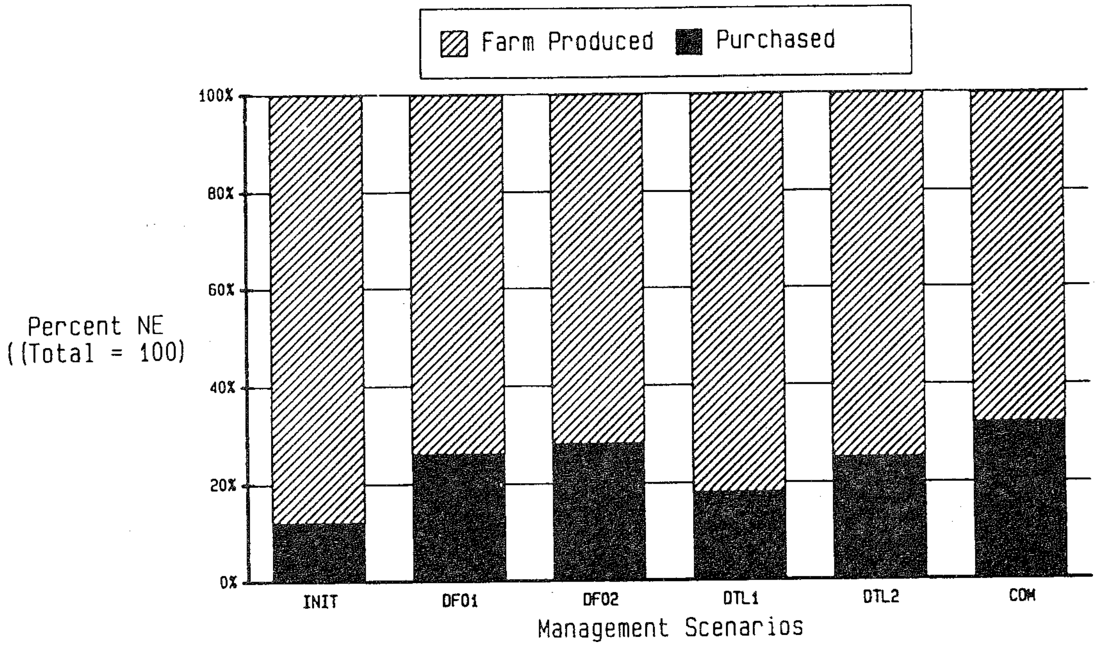

Figure 12: Purchased vs. Farm Produced Energy Under the Management Scenarios on Farm L16HCSHC

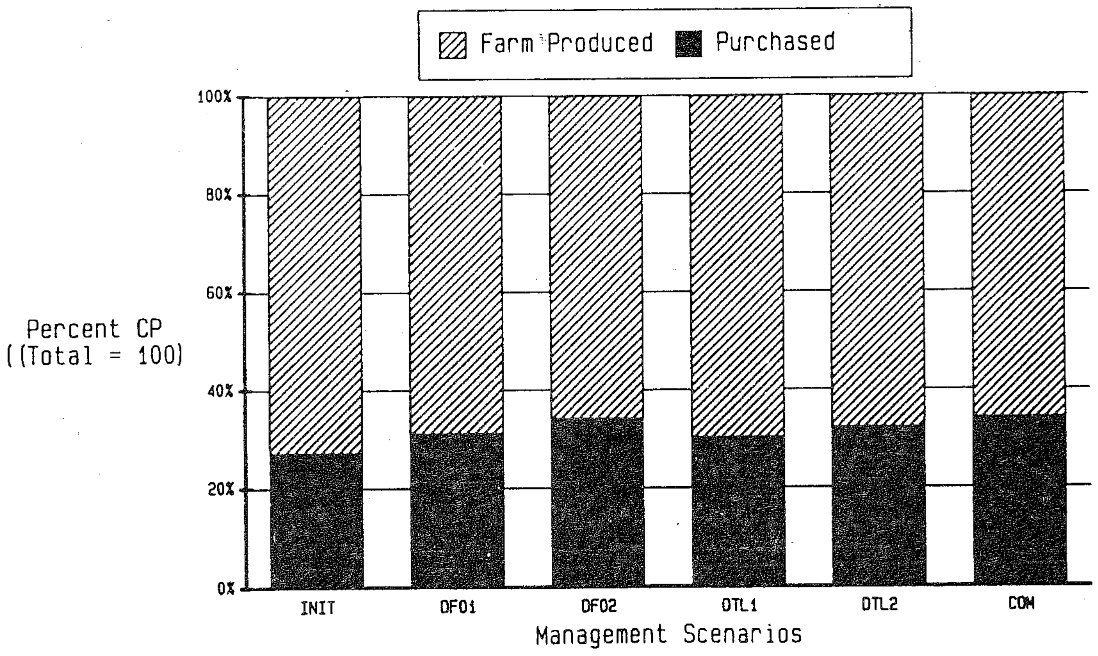

Figure 13: Purchased vs. Farm Produced Protein Under the Managemtn Scenarios on Farm L16HCSHC

The following analysis of scenario COM on L16HCSLC shows the actual changes in the amount of purchased and grown nutrients. Under this scenario, corn and hay acreage remain constant so all increases in purchased protein and corn are a reflection of the lower quality of hay and lower yielding corn silage and hay. Corn silage production decreases from 1108 tons to 1011 tons and protein percentages decrease 1.4 percent. The changes in the source of nutrients in the initial farm L16HCSHC and scenario COM are contrasted in Table 18.

Table 18: Comparison of Sources of Protein and Energy Under Efficient Management (Initial) and Inefficient Management (COM) on Farm L16HCSLC

	Protein (tons)		Energy (1,000 Mcals)	
	Initial	COM	Initial	COM
Corn Purchased	24	28	415	490
Soybean Oil Meal	13	21	48	78
Oats	4	4	54	52
Corn Silage	32	29	578	530
Hay Crops	71	62	514	460
Total Required	144	144	1,610	1,610

Because of inefficiency in scenario COM, the nutrients supplied by farm produced feeds have decreased and corn grain and soybean oil meal purchases have increased. There were similar results for other farms and field operation management scenarios. All farms show significant decreases in farm supplied nutrients as field operations are delayed. Offsetting these farm supplied nutrients with purchased nutrients decreases profitability by increasing purchased feed costs.

Impact of Timeliness on Purchased Feed Expenses, Crop Expenses, and Crop Sales

Changes in the crop rotations and the feeding program from inefficient management have a direct affect on the purchased feed expenses, crop expenses, and crop sales. Figure 14 illustrates the change in these three components of the farm business on farm L18HCSHC under scenarios DFO2 AND DTL2.

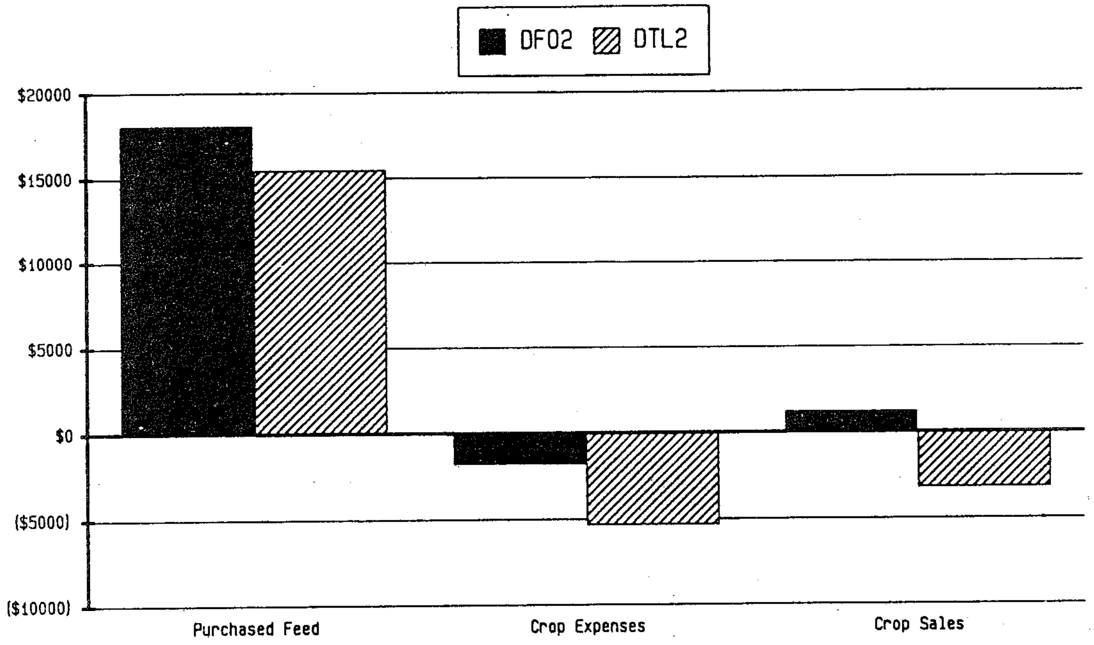

Figure 14: Change in Purchased Feed Expenses, Crop Expense and Crop Sales Under Scenarios DFO2 and DTL2 on Farm L18HCSHC

The greatest impact of inefficiency of field operations is on purchased feed costs. The percentage of farm produced protein and energy in the feed ration decreases significantly as field operations are delayed which requires increases in purchased nutrients. The results of these increases can be seen in Table 19 which shows the dollar increases in purchased feed expenses for the inefficient field operation management strategies.

All of the inefficient strategies show significant increases in purchased feed costs. The effects of delayed field operations discussed in the previous three sections can be seen in the levels of these changes. The large high corn farms have the highest increases in purchased feed costs. The losses of energy from decreased corn silage yields and shifts from corn production to hay production must be offset by purchasing corn. The small high-corn farms are not as affected by delayed field operations because of the relatively larger machinery complements.

Table 19: Change in Purchased Feed Expenses by Farm and Management Scenario

Rep.	Field Operation Management Scenarios				
Farms	DFO1	DFO2	DTD1	DTD2	COM
	-thousands of dollars-				
L18HCSHC	18.1	19.9	8.1	15.5	21.6
L18HCSLC	7.3	12.9	3.9	8.3	10.3
L18DHHC	12.6	19.7	3.9	13.0	21.0
L18DHLC	6.1	10.8	3.4	6.2	7.7
L16HCSHC	16.8	19.1	7.6	16.2	23.4
L16HCSLC	8.9	11.6	3.9	8.5	11.9
L16DHHC	17.0	20.9	6.5	17.2	25.3
L16DHLC	7.5	13.8	2.8	7.4	10.9
S18HCSHC	2.0	6.0		5.5	3.8
S18HCSLC	3.2	6.0		3.0	3.7
S18DHHC	2.1	4.6		3.9	3.7
S18DHLC	3.2	5.6		5.1	3.5
S16HCSHC	2.7	6.5		7.7	5.8
S16HCSLC	4.4	6.9		4.2	5.3
S16DHHC	3.2	7.9		6.7	4.8
S16DHLC	3.2	7.5		3.0	3.5

Note: See sections table 13 for characteristics of farms. See Table 15 for characteristics of management scenarios.

The large high-hay farms have lower increases in purchased feed costs than the large high-corn farms. The high-hay farms had higher purchased feed costs under the initial strategy because there are lower levels of corn production. Delays in field operations do not significantly affect the corn production on these farms; however, hay production is affected. Much of the increase in purchased feed costs is from soybean oil meal in contrast to the high-corn producing farms where the increase is due mainly to corn grain.

On the small farms, increases in purchased feed costs range from $2000 to $7900. These farms have proportionately larger equipment complements than the large farms so tillage and planting periods are less limited and corn production is not affected as much as on the large farms. Much of the increase in purchased feed comes from soybean oil meal to supplement the decreases in the quality of hay produced.

The effects of inefficient field operations on crop expenses vary by farm situation. The small farms and the large high-hay farms are relatively unaffected by changes in crop expenses. However, on the large high-corn farms, crop expenses decrease (ranging from $1,491 to $8,503) as land usage was shifted from corn to hay production.

The quantity of hay sold on the representative farms is a function of many different factors and there is little relationship between characteristics of farms and the amount of hay sold. The large farms tend to sell more than the small farms, but not proportionately more.

There does appear to be a relationship between field operation efficiency and sales. With lower efficiency, sales tend to decrease on the farms that have high corn production. On high-corn farms, a decrease in efficiency lowers the yields and acreage of corn produced which, in turn, lowers the amount of corn silage in the ration. This is partially offset by an increased proportion of hay in the ration which decreases hay sales. On the low-corn farms, the major impact of inefficiency is on the quality of hay produced. The lower quality of hay from reduced efficiency cannot be offset by increasing hay consumption in the feeding program. More concentrates must be purchased to supplement decreased quality, thus, excess low quality hay is sold.

Decreases in Milk Production Levels

Reduced yields and quality of feed from inefficient field operation management can affect the farm business by reducing milk production levels. In the inefficient field operation scenarios discussed thus far, the nutrient levels are maintained by reducing the poor quality hay in the ration and increasing the amount of corn silage and concentrate in the ration, particularly the ration for the high producing groups in the dairy herds. However, this is not always realistic. Most farmers will maintain certain proportions of hay in the feed ration. If the proportion of hay in the ration is maintained at given levels and the quality of that hay decreases, then milk production could fall. The decrease in the nutrient levels from the lower quality hay could not be offset by increased grain and concentrate in the ration because this would exceed the dry matter consumption limits.

The reduction in milk production levels from maintaining a minimum level of hay is illustrated through Farm L18HCSLC. An additional constraint is added in this farm which requires that the amount of hay in the ration be at least 5.5% of the total dry matter intake. With this additional constraint, the model was rerun for the initial representative farm, scenarios DFO1, DFO2, and COM. With this minimum hay requirement milk production dipped slightly with inefficient field operation management. Milk production dropped 7000 lbs. per year per farm in scenario DFO1 and COM. It dropped 12,000 lbs. per year per farm under scenario DFO2. This translates to a drop in receipts of $959 under scenarios DFO1 and COM and $1685 under scenario DFO2. The expenses were also lower so profitability only decreased slightly. However, this effect on profitability occurred with only a small minimum level of hay in the ration (5.5%). Farmers who maintain higher levels of hay in the ration may see substantially higher profitability decreases under inefficient field operation management practices that decrease the quality of hay produced.

Shadow Prices

Decreases in profitability can be related directly to field operation timing through shadow prices generated by the model. This discussion focuses on two types of shadow prices. The first type are those related to the plowing, corn planting, and hay harvesting field operations. The second type are those related to time periods in which the field operations can be carried out.

The shadow prices for the field operations are associated with constraints that delay field operations in scenarios DFO1, DFO2, and COM. These shadow prices are interpreted as the increase in profitability from plowing, planting, or harvesting one acre during the time period in which the operation is not performed because of inefficient management. This is illustrated by the plowing, corn planting, and hay harvesting shadow prices under scenario DFO1 and DFO2 on Farm L18HCSLC (Figure 15).

Under scenario DFO1 these shadow prices are $38, $23, and $109 for plowing, corn planting, and hay harvesting for the time periods in which the farm manager does not perform the operation. In other words if the farmer plowed prior to April 21 rather than after this date, then profitability would increase $38 per acre. If corn was planted before May 10 rather than after May 10 profitability would increase $23 per acre and if the farm manager harvested hay before June 1 then profitability would increase $109 an acre[5].

The profitability increases for early plowing and planting are directly associated with higher corn yields and decreased purchased energy. The profitability increase from hay harvesting is directly associated with increases quality of hay and less purchased protein. Because this farm focuses on hay production, harvest time during optimal periods is more limited than tillage and planting time and so the shadow price for hay harvesting is higher than the other two field operations.

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[5] Technically these are the marginal values for the first acre, but it illustrates the value of performing field operations early.

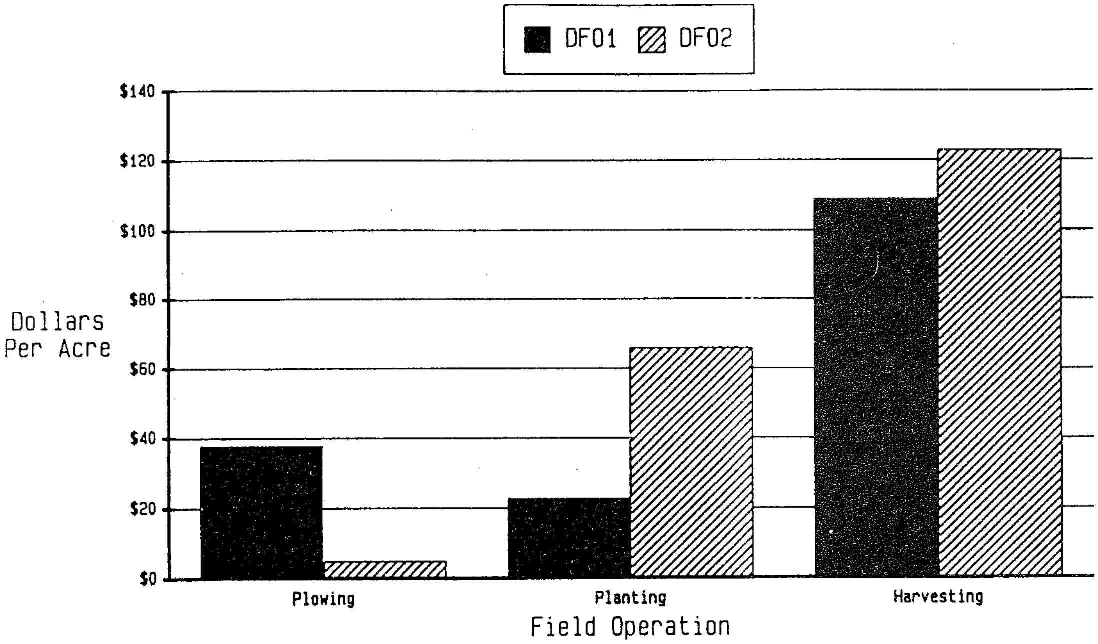

Figure 15: Shadow Prices for Timely Field Operations Under Ineficient Management Scenarios DFO1 and DFO2 on Farm L18HCSLC

With the additional delays of scenario DFO2 the shadow prices for the plowing and corn planting field operations increases to $66 and $123. These managers that delay field operations have even more to gain by increasing efficiency so that planting and harvesting can be finished earlier.

The shadow price for plowing actually decreased under scenario DFO2. The reason for this is that corn planting was delayed an additional period but plowing was not. This allowed sufficient time for the plowing. The practical application of this is that a farmer gets tillage operations done early, but if planting is delayed, the early tillage operations do not really increase profitability.

These shadow prices for the field operations are typical of the other representative farms under these scenarios. However, on the high corn producing farms, plowing and corn planting shadow prices tend to be higher than the hay harvesting shadow prices because the high percentage of corn acres tend to limit time available for plowing and planting. Given the machinery compliment on the large and small farms, shadow prices also tend to be higher for the large farms than the small farms because of the relatively larger equipment complement on the small farms.

The discussion of shadow prices has focused on the costs of delaying field operations for extended periods. Other shadow prices are associated with daily time losses. In scenarios DTL1 and DTL2 the hours of daily time available are constrained to represent farm managers who do not use all of the time each day that is available. Shadow prices associated with these constraints are interpreted as the value of obtaining another hour of time during these time periods. This is illustrated by looking at Farm L18HCSHC (Table 20).

Table 20: Shadow Prices for an Hour of Time Under Scenarios DTL1 and DTL2 on Farm L18HCSHC

Time Period	DTL1	DTL2
April 1 - 20	374	391
April 21 - May 10	374	386
May 11 - 20	348	360
May 21 - 31	330	341
June 1 - 7	126	135
June 8 - 14	131	173

These shadow prices are very large and have several implications. While they are strictly defined as the value of another hour of time during these periods, this can mean several things. These values can be associated with an hour on a good day that a farmer uses to get inputs such as seed which could have been purchased on days when the weather did not permit field work. They can represent the value of an additional hour of hired labor if labor is constraining the farm manager from working a full day in the field. They can represent the price that could be paid for an hour of custom machine hire.

These shadow prices are typical of those on the other farms. Again the shadow prices tend to be lower on the small farms. However the high values on all of the farms indicate that farm managers have much to gain by using all of the time available to them.

Improved Efficiency Scenarios

The large initial representative farms show high shadow prices for time availability constraints indicating an increase in profitability if more time is available or if available time is used more efficiently. Since the initial representative farms are already relatively efficient, options for improving efficiency are limited. However, two options are available.

The first option is to perform more than one field operation at a time by putting an additional tractor -

implement into the field at the same time that another field operation is being performed. The second is to purchase larger equipment.

The initial representative farms are modeled such that only one tractor-implement combination is operated at a time. This is fairly realistic since putting two tractor-implement combinations into the field and performing livestock chores often requires unavailable labor and management. However, it is possible to put two tractor-implement combinations in the field simultaneously with good management and additional hired labor. Discing is often performed simultaneously with other field operations. The farm managers can put a second tractor and disc into the field after plowing has begun with the first tractor so that both plow and discing are being done at the same time. Likewise, the farm manager can put a tractor and harrow or tractor and planter into the field soon after discing is started.

This situation was modeled by deleting the time requirement for discing in the field operation sequencing restraints which is equivalent to allowing discing to be performed at the same time as other field operations without increasing the time requirement. This method of managing field operations is contrasted with the single tractor implement method on the large farms in Figure 16.

This figure illustrates the time requirement for field operations on the initial large farms. With only one tractor-implement combination in the field at a time, total time requirements for tillage and planting is 188 hours on the high corn producing farms and 128 hours on the high hay producing farms. By putting a second tractor and disc in the field while plowing and harrowing, the total time requirement is reduced by 50 hours on the high corn farms and 36 hours on the high hay farms.

These reductions in time requirements result in more timely corn planting and hay harvesting and increased profits (Table 21) The range of increase in income is $2,149 to $3,261 on the high corn farms and $539 to $606 on the high hay farms.

```
Hours of time
0          40          80          120         160        200
|__________|___________|___________|___________|__________|
```

Large High Corn Farms

188 hours required for successive field operations

```
                                       harrow   plnt crn
                                       tractor  seed hay
|    plow-tractor 1      |disc-tractor2| 1 or 3  |tractor2|
```

138 hours required for simultaneous field operations

```
|    plow-tractor 1      |        plnt crn  50 hour time
               |disc-tractor2|    seed hay    decrease
                        |hrw 1or3|tractor2|..............|
```

Large High Hay Farms

128 hours required for successive field operations

```
                               plnt crn
                    disc   hrrw seed hay
| plow-tractor 1 |tractor2|1 - 3|trtr 2|
```

92 hours required for simultaneous field operations

```
| plow-tractor 1 |
               disc
            |tractor2|
                       plnt crn 36 hr time
                  hrrw seed hay decrease
                 |1 - 3|trtr 2|........|
```

Figure 16: Decrease in Field Operation Time Requirement Through Simultaneous Field Operations

Table 21: Value of Extra Labor for Simultaneous Field Operations

Farm	Increase in receipts	Additional labor requirement (hr)	Value of extra labor ($/hr)
L18HCSHC	$2,204	50	44
L18DHHC	$2,149	50	43
L16HCSHC	$3,261	50	65
L16DHHC	$2,348	50	47
L18HCSLC	$539	36	15
L18DHLC	$606	36	17
L16HCSLC	$539	36	15
116DHLC	$604	36	17

For characteristics of farms see table 13.

While this method of field operation management requires the same total man-hours and equipment hours as when only one tractor-implement combination is in the field, additional labor is required to operate the second tractor- implement. Assuming this additional labor must be hired, Table 21 shows the maximum wage per hour the farmer would be willing to pay for that labor. The total increase in income from the simultaneous field operation is divided by the additional labor requirement. On the high hay farms it may not be profitable for the farmer to hire the extra labor, but it would be profitable on the high corn farms.

The other option for covering more acres in the limited amount of time is to use larger equipment. The size of some implements in the large farm equipment complement is increased to determine the effect on profitability on the large initial farms. The changes in profitability are illustrated in Table 22.

Table 22: Changes in Profitability From Using Larger Equipment on Initial Representative Farms

Farm	Increase in receipts	Net after subtracting annual cost of larger equipment ($2,479)
L18HCSHC	$2,111	($368)
L18DHHC	$2,114	($365)
L16HCSHC	$3,285	$806
L16DHHC	$2,289	($190)
L18HCSLC	$58	($2,421)
L18DHLC	$578	($1,901)
L16HCSLC	$1,036	($1,443)
L16DHLC	$618	($1,861)

For characteristics of farms see table 13.

The increase ranged from $2111 to $3285 on the high corn farms and from $58 to $1036 on the high hay farms. These increases must be offset by the additional costs of the larger implements. The total average annual costs for the larger implements is $12,850. The total annual costs for the equipment that was replaced is $10,371 for a difference of $2,479. The increases in profitability usually do not cover the additional costs of the machinery so larger equipment is not economical on the initial representative farms. Contrasting these two methods indicates that improving management is more important than increasing equipment size.

The larger equipment was also applied to Scenario DFO1 on the large farms. This represents farm managers who delay field operations, but also purchase larger equipment to compensate for inefficient management. Using the larger equipment on the inefficient farms under scenario DFO1 produced mixed results (Table 23).

Table 23: Changes in Profitability From Using Larger Equipment Under Scenario DFO1

Farm	Loss in profits without larger equipment	Loss in profits with larger equipment	Change in profits with larger equipment
L18HCSHC	($13,635)	($8,597)	$5,038
L18DHHC	($14,626)	($9,827)	$4,799
L16HCSHC	($13,722)	($8,309)	$5,413
L16DHHC	($15,271)	($9,886)	$5,385
L18HCSLC	($6,321)	($6,589)	($268)
L18DHLC	($4,700)	($6,361)	($1,661)
L16HCSLC	($6,815)	($6,952)	($137)
L16DHLC	($4,848)	($6,486)	($1,638)

On those farms that produce a high level of corn, it would be economical to have the larger equipment. For example, on farm L16HCSHC, the decrease in profitability from inefficiency under scenario DFO1 is $13,722. With the larger equipment the decrease in profitability from inefficiency is only $5,830 for a difference of $7,892. After subtracting out the annual costs of the equipment, the increased profits due to the larger equipment is $5,413. Even though it would be profitable to have the larger equipment, the larger equipment still does not make up for decreased profitability from untimeliness.

It would not pay to have the larger equipment on the farms that produce mostly hay. The increases in profitability do not offset the increases in machinery costs.The practical application of this is that it is much more important to improve time and labor management in field operations than to purchase larger equipment.

SUMMARY AND CONCLUSIONS

Crop enterprises are a critical component of dairy farm businesses. Good management of these enterprises can increase productivity and profitability through improved quality and quantity of feeds provided for the dairy livestock enterprises or sold on the cash market. However, when competing with the dairy livestock enterprises for limited management time, crops may be undermanaged. Inefficient crop management often shows up in scheduling and performance of field operations. Poor timing in tillage, planting, and harvesting reduces crop yields, quality, and ultimately, profits.

This study presents a detailed analysis of the affects of inefficient management in scheduling and performing field operations on dairy farms in New York. A total of sixteen representative farms with two different resource levels, designated as large and small farms, are analyzed. Linear programing is used to model the sixteen farms. The objective function of the model is to maximize returns to the operator labor and management, unpaid family labor, and the fixed resources of land, buildings, and machinery. Activities are defined to represent crop and livestock production and utilization. Constraints and accounting rows developed in the model analyze the affects of efficient and inefficient field operation management on the crop and livestock enterprises.

Enterprise budgeting is used to determine values for the prices, returns, expenses, and technical coefficients in the model. Crop and livestock budgets are calculated to determine the receipts and variable expenses for these enterprises. Returns to the resources mentioned above are calculated for the dairy cow enterprise, heifer sales, and crop sales. Returns for farm consumed crops are implicit in returns to the livestock enterprises.

Income statements are calculated for the sixteen representative farms. The representative farms are evaluated by comparing receipts and expenses from these income statements with average receipts and expenses for farms of corresponding size on the 1983 New York Dairy Farm Business Management Summary (Smith and Putnam).

The effects of timeliness in field operations on crop and livestock enterprises are analyzed by manipulating the model to represent various levels of efficiency in managing field operations. Inefficiency is represented by delaying field operations and constraining daily time spent in field operations. Gains in efficiency are represented by using larger equipment to increase field capacity and putting more than one tractor-implement combination in the field at a time (simultaneous field operations). The changes in profitability, crop rotations, production and usage of feed nutrients, purchased feed and crop expenses, crop sales, and milk production levels are then analyzed.

Summary of Analysis

This study of field operation management efficiency on dairy farms analyzes a series of general cause and effects that originate with the management decisions and end with profitability. This is illustrated in Figure 17. A farm manager works within the limits of land, capital, labor, management, and environmental constraints in managing the field operations of crop enterprises. However, within these constraints the farmer has considerable control over factors which influence the amount of field work done in the time available. Conscientious management of these factors results in efficient time use, optimal planting and harvesting dates, high crop yields and quality, control of receipts and expenses, and eventual profitability. Inefficient management follows an opposite course to decreased profitability.

In this study, the quality of field operation management efficiency on the representative farms was modeled by using the time use effects of management as a proxy for the actual management process. These time use effects are listed in boxes 2 and 3 in Figure 17. By analyzing these time use effects on the representative farms the objectives of this study are met.

Decreases in field operation management efficiency reduce profitability on all of the representative farms. These reductions vary widely depending on the characteristics of the farm and the level of inefficiency (table 24).

Table 24: Ranges in Profitability Reductions Farm Type

Farm Type	Range of Decrease in Profitability From Inefficient Management in Dollars
Large High Corn[a]	\$6,045 - \$21,668
Large Low Corn[b]	\$1,809 - \$12,435
Small High Corn[c]	\$1,264 - \$6,005
Small Low Corn[d]	\$1,402 - \$7,154

[a] Maximum of 150 acres of corn
[b] Maximum of 80 acres of corn
[c] Maximum of 70 acres of corn
[d] Maximum of 35 acres of corn

Given the resources specified, the large representative farms are affected more than the small farms by inefficient field operation management. High corn producing farms are also affected more than high hay

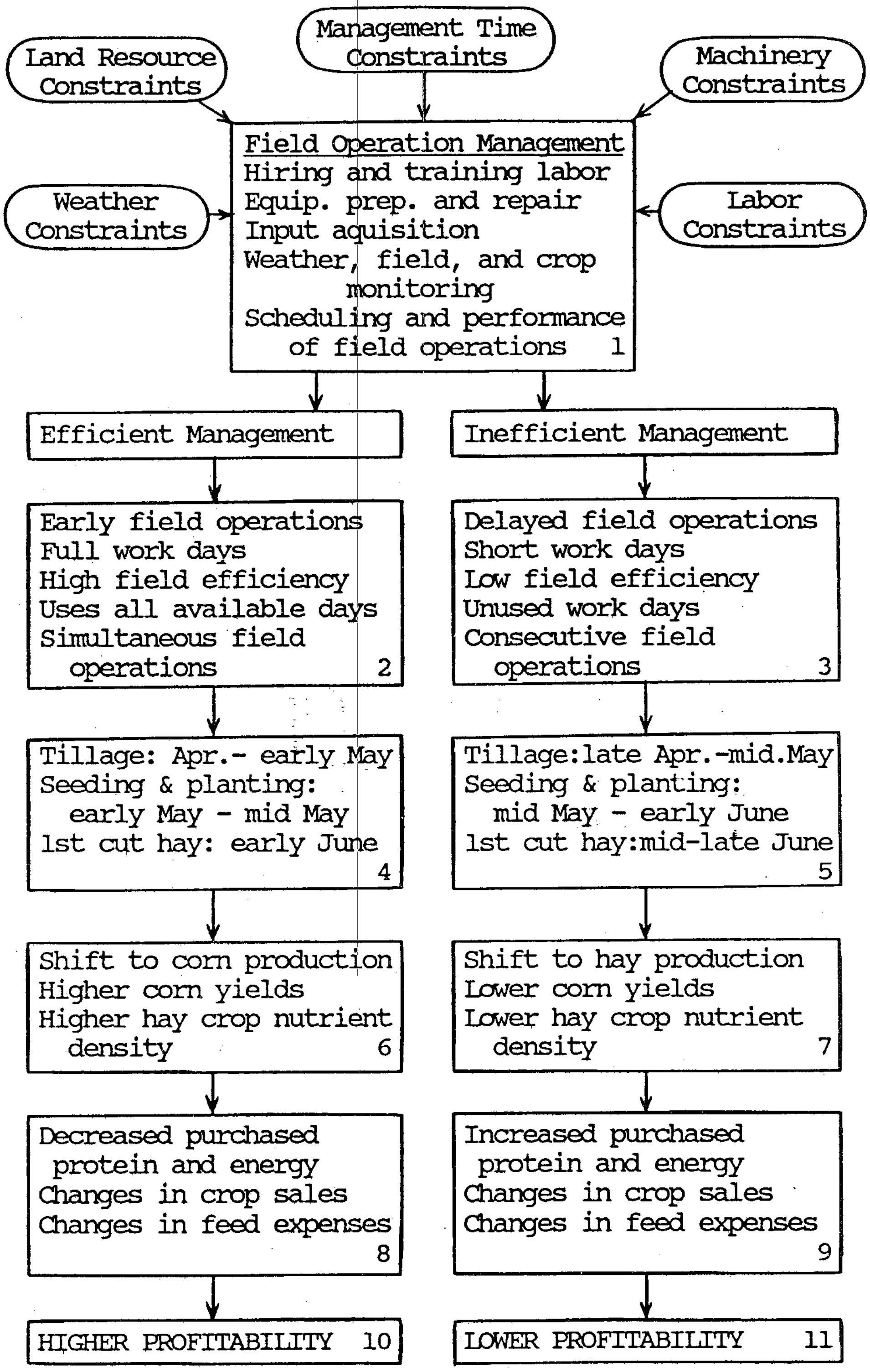

Figure 17: Flow of Cause and Effects From Farm Mangement Decisions to Farm Profitablity

producing farms. These two characteristics are related. Corn production is affected more by inefficient management than hay production. The yield decrease from late corn planting results in greater decreases in profitability than the reduced quality of hay from untimely hay harvesting. Thus the high corn producing farms are affected more than the high hay producing farms. The large farms grow a higher proportion of corn than the small farms because of better soils, hence, they are also affected more by inefficient management than the small farms. Another reason that the smaller farms are not affected as much as the larger farms is that they have a proportionately larger equipment compliment for the amount of acres. This larger machinery capacity per acre provides a buffer against inefficient management.

Delaying field operations has more effect on profitability than daily time losses. With daily time losses some time is still available each day for field operations so some corn can be planted or hay harvested despite the loss of time. However, with the delay of several days all corn planting and hay harvesting is set back which results in greater losses in profitability.

The crop rotations on all of the efficient farms focuses on corn production. On these farms corn acreage is planted to the maximum allowed by the corn acre limits established for good soil conservation and fertility and constraints placed in the model to represent many farms in New York that focus on hay production rather than corn production. These acreage levels are summarized in Table 25 along with the changes under inefficient management.

Table 25: Crop production under efficient and inefficient field operation management

	Efficient Management		Inefficient Management	
Farm Type	Corn	Hay	Corn	Hay
		-acres-		
Large High Corn	150	120	86-149	90-168
Large Low Corn	80	190	no change	
Small High Corn	70	95	no change	
Small Low Corn	35	130	no change	

Crop acreage remains fairly constant for both efficient and inefficient farms on all but the large high-corn producing farms. On these farms corn acreage decreased significantly. The high amounts of corn grown on these farms cause a conflict between corn planting and harvesting hay. With inefficient field operation management that pushes corn planting into hay harvesting periods, it is more profitable to shift to higher hay production.

The field operation schedules on the efficient and inefficient farms follow those outlined in boxes 4 and 5 of Figure 17. Under efficient management corn is planted in early to mid May and hay is harvested in early June. Under inefficient management, corn is planted in late May and early June and conflicts with hay harvesting.

On the high-corn producing farms, total corn production is significantly reduced by inefficient field operation management. These reductions come from the shifts away from corn production and the decreases in yields. On these farms hay production generally increase partially offsetting the decreases in corn production. These changes are more significant for the large farms than for the small farms.

On high-hay producing farms, corn silage production is reduced slightly through yield reductions as field operation efficiency decreases. On these farms hay production stays relatively constant; however, quality decreases with crude protein reductions.

These changes in crop rotations, total production, yields, and quality affect the nutrients available for use in the feeding program. The decreases in yields of corn and quality of hay and shifts in crop rotation due to inefficiency results in reduced farm produced feed nutrients. Both farm produced protein and energy are decreased. These reductions must be offset by increased purchased feed. The purchase of energy feeds increases on all farms. The biggest increase in purchased energy feeds is on large high-corn producing farms. These larger increases are mainly due to the shifts from corn production mentioned earlier. The increase in energy feed purchased on the other farms is mainly due to corn silage yield decreases.

The purchase of protein feeds increase on all farms except the large high-corn producing farms. The increase is due mostly to the decrease in quality of hay crops produced on the farm.

Total purchased feed expenses increase on all farms because of decreased field operation efficiency. These increases are greater on the large farms than on the small farms. The high-hay farms are affected the most.

Decreases in field operation efficiency also have an affect on crop expenses. These effects are minor on the small farms and the large high-hay producing farms. On the large high-corn producing farms, crop expenses decrease significantly as corn acreage is shifted to hay crop acreage and land is idled.

Hay sales increase on all but the large high-corn producing farms. These increases are due mainly to substitute of purchased feeds for the low quality hay that results from the decreased field operation efficiency. On the large high-corn producing farms, hay sales decrease as hay is substituted for corn silage.

Milk production levels remain constant under both efficient and inefficient field operation management. Any decrease in yield or quality from farm produced feeds can be offset by increasing purchased feed. However, many farmers feed a minimum amount of farm produced forage even when the quality of those forages may be poor. The effects of this type of management are considered by requiring farm produced hay to be at least 5.5% of dry matter intake on the representative farms. With this constraint, the lower quality of hay from inefficient management decreases milk production, however this decrease is only slight ranging from 7000 lbs to 12000 lbs per farm per year as efficiency decreases.

The time periods and field operations that are most critical on the representative farms are associated with the primary crop grown (Table 26).

Table 26: Ranges of time and field operation shadow prices for large farms under various levels of inefficiency

	High Corn Producing Farms	High Hay Producing Farms
Shadow prices for an hour of time between April 1 and May 20	\$360-\$405	\$135-\$180
Shadow Prices for an Hour of Time Between June 1 and June 14	\$94-\$213	\$128-\$282
Shadow Prices for plowing and planting an acre during an optimal time period	144-\$393	\$5- \$65
Shadow prices for harvesting an acre of hay during an optimal time period	\$0-\$116	\$64-\$139

On high-corn producing farms, April 1 through May 20 are the most important time periods with plowing and planting being the most critical field operations. On high-hay producing farms, the first week in June is the most critical period with hay harvesting being the most important field operation. The shadow prices associated with field operation and time are generally higher for high-corn producing farms than high-hay producing farms. They are also higher for the large farms than the small farms. The shadow prices for field operation and time periods on small farms are very low except under very inefficient field operation management.

Two methods of improving efficiency are analyzed: purchasing larger equipment and simultaneous field operations. After including the increased annual costs associated with larger equipment, it appeared that larger equipment would be profitable on farms that have inefficiency in field operation management. The larger capacity equipment would offset some of the losses from inefficiency. However, larger equipment would not be profitable on farms that were already efficient. The increased return would not cover the additional annual costs of the larger equipment. The larger equipment also brought the results from the larger farms more in line with the results for the small farms which indicates that the initial machinery complement on the larger farms had proportionately less capacity than the small farms.

The effects of simultaneous field operations are analyzed by taking the time requirement for the discing field operation out of the model. This represents performing this operation at the same time other operations such as plowing, harrowing, or planting are being performed. This resulted in higher profitability on the large representative farms.

Conclusions and Limitations of the Study

The following conclusions are drawn from this study.

1. Inefficiency in field operation management significantly reduces profitability on dairy farms.

2. As farm managers delay field operations or fail to use the time available each day, yield of corn crop and quality of hay crops are reduced. The loss of these nutrients must be offset by increases in purchased feeds in order to maintain milk production.

3. Decreases in yields from late planted corn results in greater loss in profitability than untimely hay harvesting. Because of this, farms that have high corn production are more affected by field operation management than farms that have high hay production. Large farms that grow a higher proportion of corn crops are more affected by field operation management than smaller farms that have higher proportions of hay crops.

4. Milk production per cow can decrease if poor quality hay produced on the farm is included in the ration.

5. Correct sizing of equipment is important for optimal crop production, but using larger equipment does not necessarily make up for other management inefficiencies. Having more than one tractor implement combination operating at one time such as one person plowing while another follows behind with a disk is an effective management strategy for improving timeliness.

Most farm managers understand the importance of timeliness in field operations. The fact that late planted corn yields less and late harvested first cut hay is lower in protein are common knowledge, yet many farm managers fail to prepare adequately for spring work. A shear bolt on a plow may cause several hours of delay as the operator goes to town for this commonly replaced part. Poor labor scheduling puts the equipment operator in the milking parlor when the planting should be done. The baler may still be in the shop long after the hay should have been made. These reasons as well as unavoidable problems that reduce efficiency can decrease profitability.

Many farm managers do not understand how much they are losing. This study sought to put a dollar figure on poor field operation management. This was difficult for many reasons. Every farm is different. Modeling farms to represent the many actual farm situations is difficult. In this study sixteen farms were modeled. Yet these farms may only be "representative" of a few actual farms. Another problem is that field operation management is an integral part of the management of the entire farm. Holding other things constant while delaying the field operation management is not "representative" of what really happens. Another problem is in the actual model itself. A farm is very complex and it is difficult to get even a small part of the interrelationships into the model. For example, it took a great amount of time to model the relationship of farm produced feeds and the livestock enterprise. Another problem is in putting accurate values on the returns, expenses, and technical coefficients. Not only is this data hard to get, but often the values vary greatly from farm to farm. It is hard to know where to put the values when you have them. For example allocating expenses in different farm enterprises is difficult and sometimes ambiguous.

An attempt is made to evaluate these farms to see if they are representative. Some strengths and weaknesses appeared both in the farms and in the evaluation. These strengths and weaknesses should be considered in interpreting the results of this study.

Implications for Future Research

Future research could focus on the specific management process involved with both efficient and inefficient management. A case study involving several actual farms could lead to specific detailed suggestions on how field operation efficiency is obtained on some farms and how these techniques might be used on other farms. This might also provide more information on the relationship between crop management and livestock management. This study looks specifically at crop management. Livestock management was considered a constant variable when in reality the two are interrelated and sometimes conflicting. Research in this area could provide suggestions on how farm managers could cope with these conflicts.

The approval and adoption of the Bovine growth hormone (Kalter et al. 1984) in commercial dairy production will increase the need for high quality feed on dairy farms. Under these conditions efficient management of crops to produce high quality feeds will be even more important. Further research should focus on the crop management under these circumstances.

APPENDIX

Table A.1: Dry Matter Intake Limitations

The following formulas are used to calculate the maximum daily Dry Matter intake for dairy cows

Formula-Lactating Cows

$$\overbrace{(1.85 \times BW)}^{\text{Maintenance}} + 0.305 \times \overbrace{(0.4 \times DP + 15 \times BF)}^{\text{FCM}} \times LF$$

Formula-Dry Cows

$$2 \times BW$$

FCM = fat corrected milk
BW = body weight in cwt
DP = daily production in lbs.
BF = daily butterfat production in lbs.
LF = lead factor
Source: Milligan et al., 1981

Annual Dry Matter Intake Limitation per Cow - lbs.

Prod. Level	Feed Group	Avg Day Prod.	Daily DM limit	Mineral[a] Allowance	Days in Group	Annual Max.DM
18000	high	71.4	46.2	45.1	119	5366
18000	low	50.3	40.4	39.3	189	7423
16000	high	63.4	43.7	42.6	119	5074
16000	low	44.7	38.6	37.5	189	7079
13000	high	51.5	40.0	38.9	119	4634
13000	low	36.3	35.8	34.7	189	6565
NA	dry	NA	26.0	NA	57	1482
NA	Heifers	NA	14.9	NA	356	5287

[a] Daily Dry Matter Limit after an allowance for mineral consumption has been deducted.

Source: Average Days of Production (Lazarus & Milligan, 1984). Days in Group (Milligan, 1985)

Table A.2: Nutrient Coefficients - Crude Protein

The following formulas are used to calculate the minimum daily crude protein requirements for dairy cows.

Formula - Lactating Cows

$$\overbrace{(0.32 + 0.06 \times BW)}^{\text{Maintenance}} + 0.087 \times \overbrace{(0.4 \times DM + 15 \times BF)}^{\text{FCM}} \times LF$$

Formula - Dry Cows

$$0.56 + 0.11 * BW$$

FCM = fat corrected milk
BW = body weight in cwt
DP = daily production in lbs.
BF = daily butterfat production in lbs.
LF = lead factor
Source: Milligan et al., 1981

Annual Crude Protein Requirement per Cow - lbs.

Prod. Level	Feed Group	Daily Prod.	Butterfat Percent	Daily Requir.	Days in Group	Annual Requir.
18000	high	71.4	3.5	7.4	119	883
18000	low	50.3	3.5	5.8	189	1088
16000	high	63.4	3.5	6.7	119	799
16000	low	44.7	3.5	5.2	189	990
13000	high	51.5	3.5	5.7	119	674
13000	low	36.3	3.5	4.5	189	843
NA	dry	NA	NA	2.0	57	113
NA	heifer	NA	NA	1.5	365	558

Source: Daily Production (Lazarus & Milligan, 1984)
Days in Group (Milligan, 1985)

Table A.3: Nutrient Coefficients - Energy

The following formulas are used to calculate the minimum daily net energy requirements for dairy cows.

Formula - Lactating Cows

$$\overbrace{(2.1 + 0.58 \times BW)}^{\text{Maintenance}} + 0.34 \times \overbrace{(0.4 \times DM + 15 \times BF)}^{\text{FCM}} \times LF$$

Formula - Dry Cows

$$2.77 + 0.074 \times BW$$

FCM = fat corrected milk
BW = body weight in cwt
DP = daily production in lbs.
BF = daily butterfat production in lbs.
LF = lead factor
Source: Milligan et al., 1981

Annual Energy Requirements per Cow (Mcals)

Prod. Level	Feed Group	Daily Requir.	Maint. Increment	Disc. Factor	Increas. Requir.	Days in Group	Annual Require
18000	high	34.3	2.46	4%	38.1	119	4530
18000	low	27.8	1.80	4%	30.0	189	5670
16000	high	31.6	2.18	4%	34.6	119	4118
16000	low	25.8	1.60	4%	27.6	189	5212
13000	high	27.5	1.77	4%	29.6	119	3517
13000	low	22.8	1.29	4%	24.0	189	4540
NA	dry	12.8	NA	NA	12.8	57	727
NA	heifer	11.2	NA	NA	NA	365	4071

Source: Daily Requirements (Lazarus & Milligan, 1984).
Days in Group (Milligan, 1985)

Table A.4: Financial Summary of Representative Farms

	Representative Farms				
	L18HCSHC	L18HCSLC	L18DHHC	L18DHLC	DFBS
Receipts					
Milk sales	291480	291480	291480	291480	247849
Dairy cattle sold	16920	16920	16920	16920	14575
Other stock sold	12500	12500	12500	12500	3842
Crop sales	6004	6238	8019	6859	2306
Misc. receipts					5743
Total Cash Receipts	326904	327138	328919	327759	274315
Livestock Increase					5724
Feed/Supply Increase					4630
TOTAL FARM RECEIPTS	326904	327138	328919	327759	284669
Expenses					
Hired labor	24506	24346	24538	24315	24817
Purchased feed	48625	63516	55578	73557	59535
Other feed	3017	3017	3017	3017	3919
Machinery hire	720	1041	720	1041	1586
Machinery repair	5792	5833	5283	5057	12342
Auto expense					617
Fuel and oil	6754	6669	5349	5818	9871
Replacement stock					2292
Breeding fees	3120	3120	3120	3120	3159
Vet. & medicine	4680	4680	4680	4680	4738
Milk marketing	19560	19560	19560	19560	16589
Cattle lease					261
Other stock	17360	17360	17360	17360	9139
Fertilizer & lime	11928	10699	11956	10699	12280
Seeds & plants	4299	3649	4299	3649	4395
Crop pesticides	4428	2902	4428	2902	3514
Building repair	9960	9960	9960	9960	3234
Taxes & insurance	11255	10820	11053	10756	10163
Utilities	6360	6360	6360	6360	6402
Misc. expenses	1664	1482	2062	2162	9806
Total Cash Expenses	184028	195014	189323	204013	198659
Expansion Livestock					1016
Machinery depre.	19337	19337	19337	19337	19044
Building depre.	15781	14594	14817	13571	9440
TOTAL FARM EXPENSES	219146	228945	223477	236921	228159
Return to operator's labor, management, & capital	107758	98193	104889	90838	56510

Comparison with average for 1983 Dairy Farm Business Summary farms with herd sizes between 100 and 149 cows.

Table A.4 continued: Financial Summary of Representative Farms

	Representative Farms				
	L16HCSHC	L16HCSLC	L16DHHC	L16DHLC	DFBS
Receipts					
Milk sales	259080	259080	259080	259080	247849
Dairy cattle sold	16920	16920	16920	16920	14575
Other stock sold	12500	12500	12500	12500	3842
Crop sales	1621	3158	2775	3766	2306
Misc. receipts					5743
Total Cash Receipts	290121	291658	291275	292266	274315
Livestock increase					5724
Feed/supply increase					4630
TOTAL FARM RECEIPTS	290121	291658	291275	292266	284669
Expenses					
Hired labor	24498	24342	24538	24315	24817
Purchased feed	30076	45462	37168	56727	59535
Other feed	2897	2897	2897	2897	3919
Machinery hire	780	1041	720	1041	1586
Machinery repair	5865	5925	5283	5057	12342
Auto expense					617
Fuel and oil	6844	6745	6249	5818	9871
Replacement animals					2292
Breeding fees	3120	3120	3120	3120	3159
Vet. & medicine	4680	4680	4680	4680	4738
Milk marketing	17400	17400	17400	17400	16589
Cattle lease					261
Other livestock	15411	15411	15411	15411	9139
Fertilizer & lime	11956	10699	11956	10699	12280
Seeds & plants	4299	3649	4299	3649	4395
Crop pesticides	4428	2902	4428	2902	3514
Building repair	9497	9497	9497	9497	3234
Taxes & insurance	11255	6819	11120	10787	10163
Utilities	6360	6360	6360	6360	6402
Misc. expenses	1591	1423	2062	2162	9806
Total Cash Expenses	160957	168372	167188	182522	198659
Expansion Livestock					1016
Machinery depre.	19337	19337	19337	19337	19044
Building depre.	15781	15029	15018	13663	9440
TOTAL FARM EXPENSES	196075	202731	201543	215522	228159
Return to operator's labor, management & capital	94046	88920	89732	76744	56510

Comparison with average for 1983 Dairy Farm Business Summary farms with herd sizes between 100 and 140 cows.

Table A.4 continued: Financial Summary of Representative Farms

	Representative Farms				
	S18HCSHC	S18HCSLC	S18DHHC	S18DHLC	DFBS
Receipts					
Milk sales	145740	145740	145740	145740	127435
Dairy cattle sold	8460	8460	8460	8460	7799
Other stock sales	6250	6250	6250	6250	1656
Crop sales	3267	2649	4835	2111	1661
Misc. receipts					3160
Total Cash Receipts	163717	163099	165285	162561	141711
Increase in stock					2714
Supply/feed increase					2726
TOTAL FARM RECEIPTS	163717	163099	165285	162561	147151
Expenses					
Hired labor	5763	5473	5661	5452	7306
Purchased feed	25210	33771	29938	39180	32132
Other feed	1509	1509	1509	1509	1452
Machinery hire	531	708	531	708	1600
Machinery repair	3073	3137	2763	2658	5858
Auto expense					481
Fuel and oil	3662	3636	3318	3108	4611
Replacement stock					1292
Breeding fees	1800	1800	1800	1800	1890
Vet. & medicine	2340	2340	2340	2340	2431
Milk marketing	9840	9840	9840	9840	8683
Cattle lease					32
Other livestock	8666	8666	8666	8666	5203
Fertilizer & lime	6579	5836	6579	5836	5441
Seeds & plants	2217	1822	2217	1822	1901
Crop pesticides	1854	1097	1854	1097	1352
Building repair	5109	5109	5109	5109	1506
Taxes & insurance	6783	6706	6613	6157	5766
Utilities	3180	3180	3180	3180	3863
Misc. expenses	962	854	1609	1245	3483
Total Cash Expenses	89078	95484	93527	99707	96283
Expansion Livestock					460
Machinery depre.	15849	15849	15849	15849	10016
Building depre.	8637	8345	7831	7629	4914
TOTAL FARM EXPENSES	113564	119678	117207	123185	111673
Return to operator's labor, management & capital	50153	43421	48076	39376	35478

Comparison with average for 1983 Dairy Farm Business Summary farms with herd sizes between 55 and 69.

Table A.4 continued: Financial Summary of Representative Farms

	Representative Farms				
	S16HCSHC	S16HCSLC	S16DHHC	S16DHLC	DFBS
Receipts					
Milk sales	129540	129540	129540	129540	127435
Dairy cattle sold	8460	8460	8460	8460	7799
Other stock sales	6250	6250	6250	6250	1656
Crop sales	62	0	1206	1531	1661
Misc. receipts					3160
Total Cash Receipts	144312	144250	145456	145781	141711
Increase in livestock					2714
Supply/Feed Increase					2726
TOTAL FARM RECEIPTS	144312	144250	145456	145781	147151
Expenses					
Hired labor	5737	5476	5719	5452	7306
Purchased feed	14561	23064	19703	30158	32132
Other feed	1509	1509	1509	1509	1452
Machinery hire	531	708	531	708	1600
Machinery repair	3164	3209	2762	2658	5858
Auto expense					481
Fuel and oil	3473	3711	3318	3108	4611
Replacement stock					1292
Breeding fees	1800	1800	1800	1800	1890
Vet. & medicine	2340	2340	2340	2340	2431
Milk marketing	8700	8700	8700	8700	8683
Cattle lease					32
Other livestock	7706	7706	7706	7706	5203
Fertilizer & lime	6579	5836	6579	5836	5441
Seeds & plants	2217	1822	2217	1822	1901
Crop pesticides	1854	1097	1854	1097	1352
Building repair	4749	4749	4749	4749	1506
Taxes & insurance	6783	6719	6665	5587	5766
Utilities	3180	3180	3180	3180	3863
Misc. expenses	893	799	1245	1288	3483
Total Cash Expenses	75776	82425	80576	87797	96283
Expansion Livestock					460
Machinery depre.	15849	15849	15849	15849	10016
Building depre.	8637	8444	7987	7701	4914
TOTAL FARM EXPENSES	100262	106718	104413	111248	111673
Return to operator's labor, management & capital	44050	37532	41044	34533	35478

Comparison with average for 1983 Dairy Farm Business Summary farms with herd sizes between 55 and 69 cows.

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