Economic Decision Support Systems For Dairies

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Dairy managers need to make decisions. Some decisions affect farm and business structure and thus have long term consequences. These strategic decisions have effects over a number of years, affect the fix cost structure of the business, and are based on long term planning. Tactical decisions are intermediate in term, with consequences over a year and are made within the context set by the long term strategic plans. Day-to-day operational decisions reflect the implementation of specific production practices within the framework of the tactical plans. Information is needed to support these decision activities and must aid in the translation of strategic financial plans into specific production practices. Farm level objectives need to be translated into specific strategies within organizational areas such as production and finance. Monitoring performance and making needed adjustments in a continual process of control is an additional function of management.

Many dairies try to use production information such as DHI reports when making economic decisions, but few successfully link it with economic information. It seems obvious that decisions must be based on economics, but this is difficult because it requires integrating production performance (milk production, dry matter intake, conception rate, involuntary culling, etc.), environmental influences (seasonal climatic effects, nutrient recycling, etc.), and financial information (expenses, revenues from outputs, capital investment, etc.). Data compiled for financial reporting, including tax reporting, usually are designed for external interests, for example lenders or the Internal Revenue Service. Although this information is often the only economic information available, many times it is not immediately useful for internal operations management of the production activities on the dairy. Even if the proper data are recorded and summarized in a historically descriptive form, they are rarely processed into a predictive and prescriptive form useful to aggressive managers. Economic decision support systems for management are needed. These systems should integrate historical production records with economic information using forecasting and optimization techniques, taking dairymen beyond production summaries toward useful economic decision-making tools.

The dairy business is composed of at least two inseparably linked components, a production entity and a financial entity. Traditionally, planning and management systems have been developed separately within these two entities with little functional (causal) connection between them. Comparative analysis commonly searches for relationships between production characteristics and financial measures, but this yields little more than correlations. However, economic models must contain causal components because managers are interested in the economic consequences of production management decisions. This functional link between production and finance is largely missing in current information systems, except for occasional sharing of database information. With the advent of microcomputers and spreadsheets many "economic" analysis tools have appeared, but most have not been scrutinized for economic validity or have ignored important factors such as interactions between production activities on dairies and variations in prices and costs. Most are formulated by animal scientists and simply assign costs and returns to a single production activity. Factors other than production affect profitability. These include constraints and opportunities created by the physical environment, prices received and prices paid, marketing arrangements, size and volume of the business, labor efficiency, cost control, capital efficiency, selection and combination of enterprises, and choice of production practices within enterprises.

Planning, Control and Models

Planning and controlling operations require information for describing past performance, monitoring on-going performance, forecasting future performance, and choosing and taking appropriate actions in a continual process of adjustment while seeking to achieve business goals. Information needs for decision support depend on the extent to which managers pursue these activities, and this informa-

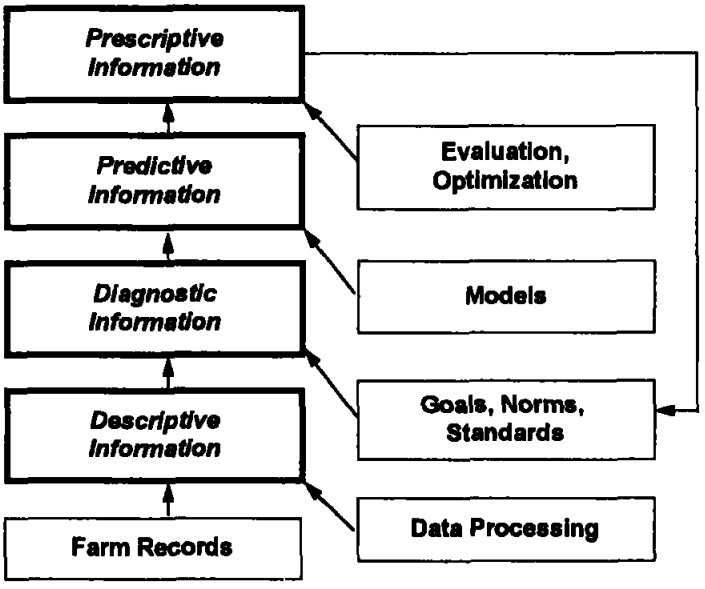

Figure 1: Different levels of information for decision support.

tion can be organized into a hierarchy reflecting the aggressiveness of management (Figure 1). The different kinds of information are generated from the interplay of data, data processing, norms and standards, quantitative models, rules, and optimization procedures.

Descriptive information provides the foundation to generate diagnostic, predictive, and prescriptive information needed for management action. Examples include whether milk production is too low, dry matter intake is too low, feed costs are too high, net farm income or rate of return on assets are too low, or cash flow is below budget. The immediate utility of existing descriptive information systems depends on whether the data are summarized on items that are under management's control and which can be compared directly with standards important for achieving important financial goals. Thus, descriptive information coupled with norms and standards, derived externally (comparative analyses with other dairies) or internally (management goals), provide the basis for diagnostic evaluation. This type of analysis is generally well-developed in the dairy industry and has been an important tool for dairy extension activities.

Because of the disproportionate development and use of production recording systems compared to financial information tools, management decision making has often focused on production targets and norms. Production goals are clear, concrete and relatively easily defined, measured, and assumed to be an adequate proxy for more difficult economic goals. On the contrary, economic analysis demands the simultaneous consideration of input costs, output prices, input and output quantities, plus the functional relationship between inputs and outputs. In this way, for instance, the economics of pasture based systems can be correctly analyzed.

Besides providing descriptive and diagnostic information, useful management information systems must provide predictive information for planning, and prescriptive information (advice) for improvement. Prediction and recommendations are important to determine whether and what intervention is necessary to try to alter the future. This information depends on causal, or functional models. This will be discussed later, but a complete system uses a combination of data gathering, data summarization, simulation, and optimization or searching methods to produce the information at the four levels of the hierarchy shown in Figure 1. A key feature is that the production, economic, and financial models are totally integrated.

Accounting Information

Accounting records are a foundation for economic and financial planning. Some detail is appropriate in discussing accounting because of its importance to business success and the information systems being discussed. It is also the authors' experience suitable management accounting systems can be lacking on some dairies.

Accounting aids decision makers by matching corresponding output and input quantities with their prices and costs and summarizing this information

to generate reports in formats which describe business performance. Accounting information serves three broad purposes:

1). It provides routine information for cost management and controlling of production operations.

2). It provides special, or non-routine, information to managers for strategic and tactical decisions, capital investment, and formulation of overall policies and long-range plans.

3). It provides information through standardized financial statements and tax returns concerning the financial position of the business to external parties such as investors (e.g., lenders), government authorities (e.g., IRS), and others for financing, investing, and other decisions.

Unlike production records, accounting information necessarily serves many masters. In different instances the type of accounting information needed and its reporting format depends on whether the decision maker is internal (e.g., manager, owner) or external (e.g., investor, creditor). This duality in users leads to two main branches of accounting: management accounting and financial accounting. Tax accounting can arguably be considered as a third. The primary objective of financial accounting is an accurate representation of a firm's economic and financial transactions, while tax accounting follows what is called the 'least and latest' rule whereby the objective is to pay the least amount of taxes at the latest possible date within the law.

External Reporting. Reports generated by the financial and tax accounting systems include tax returns and schedules, and the principal financial statements: the balance sheet, the income statement, and the statement of cash flows. To maintain sources of capital inflow it is critical for dairy producers to provide investors and creditors with accurate information so they can assess the amount, timing, and uncertainty of cash flows to them. Cash flow prospects for investors and creditors are affected by the dairy's economic resources (assets) and the claims (liabilities) on these resources (balance sheet), the dairies financial performance (income statement), the dairy's sources and uses of cash (cash flow statement), and the dairy's overall stewardship of resources (all three financial statements).

Because financial accounting is geared to producing information for decision makers external to the business, it is critical that the information be reported in a format recognized by all potential users of the information. In the United States the principal financial statements for public firms (publicly owned = selling stock) must be prepared to conform with generally accepted accounting principles (GAAP). These rules have evolved over time or have been promulgated by official rule-making bodies such as the Financial Accounting Standards Board (FASB) as sanctioned by the Securities and Exchange Commission (SEC).

Agricultural firms generally fall outside of the domain of the FASB and the SEC. Therefore, much less uniformity exists among financial statements for firms in the agricultural sector. In some ways this can be a problem, because it makes comparing financial performance across farms more difficult for advisers and potential capital sources. To overcome this problem the Farm Financial Standards Task Force (FFSTF) was formed in 1989 and published the Financial Guidelines for Agricultural Producers in 1991 (FFSTF, 1991). The intent of the FFSTF guidelines are to bring greater standardization to financial reporting and analysis for agricultural producers and to move agricultural financial reporting into closer conformation with GAAP while maintaining aspects unique to agriculture. It is always of interest to compare performance, yet this is only possible if there is uniformity in reporting. Selection or design of a system for recording, organizing and summarizing financial accounting information should conform to the FFSTF guidelines.

Internal Reporting. Management accounting focuses on serving the first two functions of accounting information and is primarily aimed at the needs of internal decision makers. For this reason, complete standardization of management accounting systems across all dairy enterprises is probably an unrealistic and undesirable goal. Useful similarities can be expected, however.

In the dairy business the primary use of management accounting information is by managers for cost control. This type of accounting is sometimes called cost or enterprise accounting and is widely used and highly developed in most major corporations. However, it has rarely been implemented in a consistent and systematic way by dairy producers. In the dairy industry, financial accounting has generally been the sole source of financial information, and because dairy financial accounting may be relegated to outside professionals whose primary role is preparation of the tax return, financial reports can be difficult for producers to use for cost control and analysis, especially at the tactical and operational level. Financial statements are usually highly aggregated; therefore, they are ill-suited for specific analyses such as determining the cost of specific production activities.

Well developed management accounting systems can provide the needed information because they are organized around items or activities for which separate measurements are useful. Figure 2 illustrates this in comparison to financial accounting. Management cost information may provide routine information necessary for culling and breeding decisions for individual cows or nonroutine information necessary for making longer range strategic decisions such as whether to raise or purchase replacements, or grow or purchase feed. On dairies typical cost items can span several levels of aggregation such as the cost of the entire milking herd, cost of individual cow lactations, cost per pound dry matter, or cost per hundredweight of milk. The same accounting information can have multiple uses depending on which decisions are required.

Thus, the system must have the capability to accumulate all cost data according to 'natural' dairy business classifications, such as feed, breeding, labor, etc. It must be possible to allocate, or trace, costs to individual items or activities. For example, a load of feed may be coded for the milking herd in general, for a specific group of cows, and for a specificindividual cow(s). Direct costs can be traced easily, while indirect costs can not. For example it is relatively easy to directly trace feed costs (a direct material) and milking labor (direct labor) costs to the milking herd. However, it is difficult, if not impossible, to directly trace costs like electricity, insurance, property taxes and supervisory compensation to the milking herd, especially if the dairy consists of multiple enterprises (e.g., crop production, replacement rearing, etc.). Indirect costs, or overhead, can often be allocated using a formula.

Especially on large dairies, the proportion of total costs that are direct costs would be much higher for the milking herd than for individual

Financial	***Management***
Income	**Income**
...	...
Expenses	**Expenses**
Feed	**Feed**
Labor	**Commodities**
Supplies	**Labor**
Depreciation	**Overhead**
Interest	**Replacements**
Other	**Purchased animals**
	Feed
	Labor
	Overhead
	Other
	Labor
	Materials
	Overhead

Figure 2. Example of financial versus management accounting.

cows. For example, the veterinary and medicine expense for the entire milking herd would be relatively easy to directly trace. However, the true veterinary and medicine cost may be difficult to trace directly to individual cows.

Management information systems capable of providing dairy managers with reliable forecasts or profit maximizing strategies demand accurate and well-designed management accounting systems at their core. Cost control is critical. But additionally, it is difficult to choose between production alternatives without knowing the resulting costs, so costs must be known so that production decisions can be based on economic criteria.

Economics

Economic evaluation is not the same as accounting. If we assume that profitability is the primary goal of the dairy business, then economic planning, management and analysis is about managing the dairy farm resources profitably. Finance deals with the flow of funds and measures financial performance. Economics is broader and includes concepts of valuing resources as they contribute to profitability. These concepts include opportunity costs, marginal analysis, equimarginal returns, input substitution, contribution margin, and the time value of money (discounting) which are not all typically considered part of financial accounting. They are, however, important in economic analysis when determining which strategies and tactics increase profit.

Tactical and Operational Decisions. Whenever there is a way to increase profitability, it is economically rational to do so, other things being equal. This means that economic planning and management requires knowing not only what is profitable, but what is most profitable, and hence the notions of opportunity cost, equimarginal return, input substitution, etc. become important. Optimization is fundamental because economics is largely the science of choice. Business goals and limited resource availability force choice. There are normally multiple production possibilities, some more desirable than others, as measured by some criteria, and it is the essence of optimization to make the best choice.

Application of economic principles, at least theoretically, requires the revenue and cost accounting of all production possibilities, and then application of the appropriate economic principles to choose the most profitable alternative. Greatest profitability occurs when the greatest difference between total input costs and revenues is achieved, not necessarily at the lowest input costs, or most efficient ratio of inputs to outputs, although sometimes, of course, these will be the same.This is fundamentally different from simply doing an accounting exercise of costs and returns. An example (Table 1) using opportunity cost helps to illustrate the difference between accounting and economic information. The example considers the calculation of cow profitability for ranking cows for culling on economic, not production or accounting, information.

Two popular measures of dairy cow profit, total profit (similar to "lifetime") and average profit (similar to profit per day of herd life), are incorrectly applied for culling decisions, relying on untenable assumptions (van Arendonk, 1991). They are simply accounting definitions of profit, assuming that either no replacements enter the herd (total profit) or every cow is replaced by a heifer having identical characteristics as the cow leaving (average profit). The correct economic analysis considers both the future profitability of the cow and the opportunity cost of postponed replacement. Approaches which do not consider opportunity cost are not correct. The correct approach eliminates confusion caused by definitions which superficially appear to make, or reflect, common sense, but on analysis are incorrect.

Strategic Decisions, Unknowns, and Risk. It has been argued that the goal of maximum profit (implying optimization) forces simplifications of real world problems into computable representations of reality and assumes unrealistic omniscience with respect to site-specific parameter values, future product prices and input costs, and other model variables. Further, the decision maker's goal may not be equivalent to a straight forward measure of profit. A more reasonable approach, it is argued, may be to

Table 1. Differences between total profit, average profit, and real profitability.

	Profit in year						
Cow	1	2	3	4	TOT[1]	AVG[1]	REAL[1]
A	100	200	250	200	750	188	-50
B	150	250	---	---	400	200	0
C	200	300	---	---	500	250	100
D	200	250	300	250	1000	250	200

[1]TOT = Total "lifetime" profit, AVG = average profit, REAL = profit accounting for opportunity cost of 200/year. Adapted from Van Arendonk (1991).

strive for constant improvement while finding satisfactory solutions for a more realistic world. Simon called this "satisficing", reasonable men making reasonable choices (Simon, 1979) in the face of complexity, numerous constraints, imperfect knowledge, unknowns, and risk.

It is true the dairy business is inherently risky due to the biological nature of milk and crop production, weather, input costs, and output prices. Decisions are also difficult because knowledge is always imperfect, information about alternatives may arrive slowly, and we often know far less than we would like about our alternatives. Actions usually create sunk costs which may be impossible to recoup and the economic environment is uncertain.

Dairy decision support methods that take advantage of optimization are most widely used for repetitive tactical decision making such as ration balancing, sire selection, and to a lesser degree culling and replacement. Although long-term strategic decisions can be analyzed using optimization techniques, for the reasons mentioned above, simulations and other forecasting methods are often found useful to determined the effects of external price changes (such as milk or feed price) and other factors effecting the success of investment decisions. Variability in potential outcomes, and thus risk, is also important to try to predict. If the risk can be described, than there are methods to incorporate it into the decision framework.

Forecasting Revenues and Costs. Forecasts will never be perfect and the activity may be more important than the result because of what it tells the planner about the business and other forces at work, but planning is a part of control. Economic and financial planning requires predicting revenues and costs. Revenues would include at least milk yield, cull cows, number of calves sold, calf income, income from sale of assets, and investment income. Costs result from feed, replacements, labor, and other inputs. Forecasting based on last year's figures is useful if the business remains substantially the same from year to year, without improvements in management, production performance, or other factors. But with this approach there is little basis to generate predictions if the herd or management changes. Modeling the herd can be useful to predict future milk production, animal sales, and required inputs, and thus produce a detailed budget for the dairy based on:

1). known production performance from production records,

2). the current status of the dairy, including status of the dairy herd,

3). aggregation over all cows, and

4). constantly updated production data from the production recording scheme as well as the cost and price data from the managerial accounting system.

Outputs of these models can be part of the integrated planning system because they create cash flow budgets, inventories, income statements, replacement forecasts and future feed needs. Also, forecasts can be changed with different price or performance outlooks to determine business ramifications in a"what-if" framework. The future scenarios described are reported in financial terms to assess financial impacts. In a sense, this is a rigorous budgeting exercise.

Useable Information Systems

Decision support systems which include economic evaluation are beginning to appear. This paper will deal with one, but there are others which differ in numerous ways. The purpose is to illustrate the use of combining production and financial data to generate economic information in a useful format for dairy managers, not to promote one system. Simulation and optimization are used, and the overall purpose is to provide better information to dairymen as they try to make necessary decisions to control their businesses. The specific application that will be discussed is the Florida Dairy Management Project (FDMP), because the authors are most familiar with it. The information system is called the FDMP-MIS.

An overview of the production and economic data collected from each dairy is listed in Table 2. These data are dairy specific and are delivered through several methods. Although not required, all current FDMP dairies are enrolled on DHIA testing and the herd production history, current herd production, and cow reproductive records are downloaded directly from the appropriate DRPC and maintained in a database. Other data summarized by DHIA (e.g., monthly conception rates, heat detection rates, 2X 305d ME, cow mortality rates) are directly recorded/calculated from the DHI Herd Summary file. Additional data on actual milk sold per month, animal inventories, feedstuff nutrient analysis, ration composition, feed usage, etc. are provided directly by the dairy producer. Most economic data come directly from the producer and primarily consist of monthly income statements, forecasted milk prices, feedstuff costs, replacement costs, carcass and calf prices, short-term interest rates, etc. Financial and economic data are summarized and maintained in a database.

Models. At the heart of the FDMP-MIS are two models which:

1). are causal because they predict production possibilities based on individual cow and herd production characteristics specific to each dairy,

2). integrate production and economic data specific to each dairy,

3). base decisions on economic criteria, and

4). generate predictive and prescriptive information for management decision making specific to the production and economic conditions existing, or predicted for, each dairy.

The first model is a dynamic programming (DP) model developed by DeLorenzo et al. (1992). This model finds profit maximizing insemination and culling/replacement policies. It maximizes profit from each cow position in the herd. The model integrates dairy-specific production and economic data (Table 2) to calculate the net present values for every cow. Essentially, the model makes one of three decisions for every month of a cow's life:

1). keep,

2). replace, or

3). if a cow is kept, and she is open, whether to breed her at her next estrus.

The decision to keep or replace considers the opportunity cost of postponed replacement because the cow is kept only if her net present value is higher than the average first-calf heifer competing for her position in the herd. The production and economic characteristics of the first-calf heifers are based on dairy-specific data on first-calf heifers calving in the month of replacement.

The second model is a simulation model which is integrated with the DP. The simulation model predicts the herd's monthly milk production, feed costs, herd structure (total herd size, number of dry and milking cows), number of culls, number of calvings, and number of pregnancies. On a routine basis (each month) two scenarios are calculated. The first

scenario is predictive and produces a forecast for the dairy under the assumption that the dairy producer will continue to follow present breeding and culling policies. The second scenario is prescriptive and produces a forecast, or goal, under the assumption that the producer is following optimal breeding and culling policies as prescribed by the DP model.

An important feature of the FDMP-MIS is the flexibility of the DP and simulation models in allowing a wide variety of possible production and economic scenarios to be examined. Dairy producers often request special scenarios examining a multitude of possible management strategies (e.g., BST use, A.I. vs natural service breeding, etc.), alterations to farm structure (e.g., expansion, heat stress abatement structures and equipment, etc.), and changes to herd structure (e.g., timing effects of additional heifer purchases, etc.). The strategy of using dairy-specific data is essential to the success of the basic FDMP services and allows the special scenarios to provide meaningful information. It insures that the information received by a dairy manager has been tailored to the unique conditions found on his dairy. Accurate accounting data is required. The breeding and

Table 2. Production and economic data used by the Florida Dairy Management Project.

Production	Economic
Cow milk production history	Actual milk price by month
Cow current milk production level	Forecasted milk price by month
Cow current reproductive status	Milk fat differential
Herd milk production level	Milk protein differential
Milk fat %	Feed cost per lb DM (high producers)
Milk protein %	Feed cost per lb DM (low producers)
Monthly conception rates	Beef salvage price
Estrus detection rates	Replacement cost
Ration NDF concentration	Calf values
Cow body weights by parity	Discount rate
Calf body weights by sex and parity at calving	Short-term interest rate for purchased replacements
Calf mortality by parity	Feedstuff prices
Involuntary culling rate	Actual monthly revenues and expenses
Genetic progress per year	
Animal inventory	
Actual pounds milk sold per month	
Projected heifers to freshen by month for next 12 months	
Feed information:	
feedstuff nutrient content	
ration composition	
group daily intake	
cow numbers per group	
Minimum milk per day (high producers)	

culling model is particularly useful to account for complex seasonal patterns of milk price, milk production, and reproductive performance.

Once the herd's production characteristics have been generated for the next 12 calendar months this information is further integrated with expense and revenue data from dairy-specific income statements. Integration of these production and economic data allow the generation of descriptive (actual/past), predictive (forecast), and prescriptive (goal) cash flow and/or income statements for the next 12 calendar months. This final link in the process allows dairy managers to ascertain the economic consequences of following current breeding and culling policies, optimized breeding and culling policies, or any proposed management change capable of being captured by the DP and simulation models.

Subsidiary production and economic summaries and graphs are also prepared using spreadsheets and databases. These summaries and graphs may contain all levels of information (descriptive, predictive, and prescriptive) or be limited to descriptive and diagnostic information for monitoring purposes. Such items as milk production and income per month, purchased replacements, labor costs per cwt. of milk, dry matter intake, feed cost per cwt. of milk, etc. are summarized on a monthly basis.

Management Reports. A report received by FDMP dairy managers each month are a set of breeding and culling guides. Table 3 shows a portion of an actual breeding guide and Table 4 a portion of an actual culling guide. These guides suggest, for the current month, from a profit-maximizing standpoint, which cows in their herd should receive the highest priority for breeding and those that are likely cull candidates. In the breeding guide each open cow in the herd has a value (Value Insemin.) indicating the expected net discounted return from inseminating her at her next estrus versus waiting. The relative breeding values can be viewed as a priority list for breeding. Thus, cow #3019 should receive the highest heat detection intensity. The culling guide shows the net present value of keeping a cow versus replacing her with an average first-calf heifer calving in the month of replacement. For example, it is recommended that cow #6 be culled, other things being equal, even though her expected net cash return over the next

Table 3. Sample breeding guide.

Barn Name	Lact Num	Month Milk	Cow ME/ Herd ME	305ME	LTD Milk	Repro Code	Value Insemin($)
3019	2	6.7	1.26	25,442	79		319
908	1	3.1	1.01	20,505	71		36
106	2	7.0	.72	14,497	48	C	0
911	1	3.0	1.11	22,477	81		0

Table 4. Sample culling guide.

Barn Name	Lact Num	Month Milk	Cow ME/ Herd ME	305ME	LTD Milk	Keep vs Cull ($)	Net Cash ($) 12 Mos
9579	4	2.2	1.19	24,103	118	1,564	2,227
909	1	6.3	1.14	23,172	70	532	769
6	2	5.9	.83	16,749	55	-117	371
9396	1	10.9	.93	18,761	38	-305	-29

12 months is positive, because a first-calf heifer taking her position would provide a higher net present return ($117). These are specific reports which recommend specific herd management actions to increase farm profitability.

The second set of outputs received by FDMP dairy managers each month are a set of cash flow reports reflecting the economic consequences on the dairy businesses' cash flow of following current versus optimal breeding and culling policies. In addition, actual cash flows are summarized for monitoring purposes and a variety of subsidiary production and economic summaries and graphs are prepared. Table 5 shows a reduced schematic example listing descriptive (past), predictive (forecast), and prescriptive (goal) cash flows. The revenue and expense categories in this example are highly aggregated and summarized on a yearly basis for illustrative purposes. In reality, three cash flow reports (past, forecast, goal) are received by the dairy manager containing 12 months of information and there are up to 25 expense categories. As indicated in Table 5, following optimal breeding and culling policies for this dairy would be expected to produce a yearly cash flow over $106,000 higher than following current policies. Various graphs are also provided to dairy managers on a monthly basis. The graphs provide varying levels of information (descriptive, predictive, prescriptive) depending on the item of interest. Dairy managers who desire to examine possible changes in other management strategies, alterations to farm structure, and/or changes to herd structure would also be provided with a full set of cash flows, summaries, and graphs in addition to those provided on a regular monthly basis.

Table 5. Example results of integrating herd-specific production and economic data using causal models to produce descriptive (past), predictive (forecast), and prescriptive (goal) cash flows. Shown in reduced schematic form only.

Item	Past	Forecast	Goal
Income			
Milk	$7,765,194	$8,437,720	$8,859,128
Culls	314,194	316,327	418,355
Calves	81,476	59,495	67,025
Expenses			
Feed	$2,981,398	$3,495,649	$3,646,727
Labor	1,139,964	1,300,742	1,300,742
Replacements	470,543	148,800	422,400
Net	$3,568,959	$3,868,351	$3,974,639

Human Factors. The ultimate use of the information described above is dependent upon the interactions between the dairy manager and the FDMP consultant. The reports are only one source of information for the overall decision process. The dialogue between the dairy manager and consultant is the most important vehicle for delivering the decision aids. Initially, some dairymen more readily accept quantitative decision tools than others, although there are some similarities across all dairy managers. One of the most important concepts that the dairy manager must understand is the dairy-specific nature of the FDMP-MIS recommendations. Once this realization occurs, the information is more meaningful than if only a "representative" farm were described.

Conclusions

Defining management problems correctly in economic terms is important. Production recording and accounting data need to be combined into economic information to correctly support management decisions. Interactions between various factors must be considered and models that incorporate interactions between the various components of the production system are important. Information and knowledge will always be incomplete and risk is a major consideration for decision makers, especially for long term strategic decisions. The use of causal models and optimization can generate alternatives,

and although not perfect, predictions can help steer decisions and provide some measure of risk. For tactical and operation decisions that are often repetitive, profit maximizing techniques are useful and can yield specific management guides suggesting specific actions, although other information must always be included as well.

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notes