A COMPUTERIZED DECISION-MAKING MODEL FOR THE BEEF/FORAGE ENTERPRISE

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Regardless of the aid received throughout the course of this study, sole responsibility for any errors contained in the concept or text of this manuscript remain those of the author.

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ABSTRACT

Schwab, Gerald Dean, Ph.D., Purdue University, May 1974. A Computerized Decision-Making Model for the Beef/Forage Enterprise. Major Professor: John E. Kadlec

The purpose of this study was to develop a model and methodology which would enable the exploration and evaluation of alternative beef/forage production systems. This decision-making model was designed with sufficient flexibility to allow analysis of a multitude of alternative farm situations. The solutions rendered by the model are sensitive to farm situations which often vary with respect to available resources, managerial abilities, and price and production expectations.

Some major issues that were considered in developing this model were: (1) the goals of the farm business, (2) the appropriate length of planning period, (3) growth and capital investment, (4) indivisibility of investment projects, (5) discounting for risk and time, (6) technological change, (7) variability of price and production coefficients, (8) relevant production processes, and (9) possible constraints on the beef/forage enterprise.

A format was developed to gather the information unique to each farm situation. This information flows into a computer routine that transforms, generates, and arranges the data into a format suitable for the problem-solving algorithm. The resultant answers are then transformed and arranged into a format that is self-decipherable to the farm audience.

To delineate the issues surrounding the beef/forage complex; animal scientists, agronomists, agricultural engineers, and agricultural economists worked together in a multi-disciplinary effort.

The alternatives modelled concern the gamut of all major decisions required in initiating and/or operating a beef/forage enterprise. A decision must first be rendered on the economic feasibility of producing beef vis-a-vis employment of farm resources in an alternative external to the beef/forage enterprise. If beef activities are brought into solution, the major decision dichotomy is whether beef is produced by cow-calf systems or by buying weaner calves and selling yearlings. In the event that beef enter the solution, provision must be made for feedstuffs to maintain the animals. Decisions on forage production, harvesting, storage, and feeding systems are provided by this model.

Alternative beef cow-calf and calf-yearling activities compete for the resources of labor, machine-time, finances, and the forage/land supply. In addition to the actual beef/forage production decisions, provision was incorporated to enlarge the resource base, e.g., hiring of labor, renting of land, borrowing of funds, and investing in beef stock cows, machinery and buildings.

A zero-one mixed integer programming code was used to analyze the alternatives modelled for the beef/forage enterprise. In addition, an input form, a data/matrix generator, and a report writer were developed to facilitate routine use of the model by the farm clientele.

A representative farm was used as the structural framework within which to validate the model. Beef managerial

ability, forage managerial ability, and beef prices were defined as having predominant influence upon the possible success or failure of the beef/forage enterprise. Benchmark values were established for each variable and a central composite experimental design technique was used to indicate the observation point spacing for these specified independent variables. A performance function was then developed to indicate the sensitivity of the model's objective function; i.e., change in net worth of the enterprise to these specified parameters. Hypotheses were developed a priori, subsequently tested, and upheld.

This sensitivity testing of the model developed some realistic cost and production measures which provide positive indication of the model's validity. The results indicate cash flow problems in the early years following investment in beef cows. Also, investment in new but costly forage technology may not be economically feasible for all farm situations. The profitability of various forage production, harvesting, storage, and feeding systems depends upon the level of management for each farm. The model developed in this study provides an analysis framework to reflect the uniqueness of each farm situation.

The beef/forage model was developed to provide a decision-making aid for farmers wishing to evaluate alternative beef/forage production systems. The model can be used to evaluate the profitability of forage to beef production systems for alternative farm resource, management, and price situations. The payoffs to applied agricultural research in the beef/forage area can be identified by analyzing marginal value productivities of constraining resources, penalty costs of excluded activities, and response coefficients of the model's performance function.

CHAPTER I

INTRODUCTION

The purpose of this study is to develop a decision-making model which can be used by the farmer to evaluate alternative beef/forage production systems. The production of forage-fed beef is an area that rings with opinionated controversy. The intent of this research is to provide some methodology for objective evaluation of the alternatives in the beef/forage complex.

The energy required to maintain human life is most efficiently provided with vegetable matter. However the citizenry of the United States have expressed through the market place a preference for animal protein. With respect to the physical efficiency of animal protein production, the bovine animal compares unfavorably with such monogastric animals as poultry and swine. However, the ruminant does possess characteristics which give it certain advantages.

By definition, the ruminant animal has several stomachs which enable it to convert to animal protein certain vegetable matter than cannot be utilized by monogastric animals. This phenomenon enables the human to obtain animal protein produced with resources which have few alternative uses. In comparison with other ruminant animals, beef has found favor

in the market place. In 1950, average per capita consumption of beef was 63 pounds. By 1970 beef consumption per capita had increased to about 115 pounds. This per capita beef consumption is a positive function of per capital disposable income, of prices for food items which substitute for beef, and a negative function with respect to the price of beef.[1/] To the extent that the economy experiences an increased real gross national product combined with favorable price and production relationships for beef, per capita beef consumption will likely continue to increase as will total beef consumption which also increases with population.

The increase in domestic beef consumption since 1950 has encouraged rapid growth of beef cow herds and cattle feeding-finishing operations. Facilitating this increase in beef consumption has been the decline in dairy cow stock numbers. Not only did the slaughter of dairy cows provide a nonrecurring source of red meat, but the resources formerly employed by the dairy enterprise and thereby released were then available for possible employment by the beef cow enterprise.

However, future increases in the beef supply must come not from declining dairy cow numbers but from new additional resources. During the period from January 1, 1970 to

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[1/] Langemeier, L., and R. G. Thompson. "Demand, Supply, and Price Relationships for the Beef Sector, Post-World War II Period." AJAE, pp. 169-183. February 1967.

1972; all twelve (12) states in the north central region of the United States experienced an increase in beef cow numbers.[2/] One concern of this study is to provide an objective analytical procedure which can be used to evaluate the conditions under which it is economically feasible for the farm to employ resources in a beef enterprise.

A. The Problem Setting

The problem to which this thesis is addressed is to provide a model and methodology which will enable the farmer to explore and evaluate alternative beef/forage production systems.

Decisions with regard to beef and forage production are complex. Which variables are important in determining whether a particular farm's resources should be employed in some type of a beef enterprise? Which of the many possible types of beef/forage enterprises are optimal for each particular situation? What are the most important variables that determine success or failure of a beef/forage enterprise? These general types of questions must be considered in developing an analytical framework with which to evaluate the issue at bay.

B. Procedure

The research procedural steps used in this study are as follows:

[2/] USDA. Agricultural Statistics.

1. Identify the goals of the farmer.

2. Identify the important beef/forage enterprise decisions to be made by the farm entrepreneur and the relevant variables affecting these decisions.

3. Model the system. Use economic theory combined with knowledge of the applied agricultural disciplines to aid in establishing the interrelationships of the variables involved in the beef/forage enterprise. Recognize compromises of the specified model relative to the economic assumptions. Recognize the modeling simplifications as compared to the real world situation.

4. Develop a technique to gather required price expectations, technical coefficients, and the base resource data applicable for each unique farm.

5. Delineate the alternative problem-solving techniques and select the most appropriate one considering the goals and the economic theoretical underpinnings of the system being analyzed.

6. Develop computer programs that enable each set of input data to be reflective on the problem solution for each unique farm situation.

7. Validate the model to determine if the problem has been correctly defined and modelled so that the results are meaningful and helpful for decision-making by the user of the model.

C. Guide to Thesis

The remainder of this thesis will develop the research procedural steps listed above. Chapter II discusses modelling *per se* and the methodological aspects that ought to be considered in building a decision-making model. Chapter III describes the beef/forage model. Discussed herein are the decisions rendered by the model and the solution algorithm used to determine the enterprise plan. Chapter IV is a detailed discussion of the programming matrix developed to describe the beef/forage production processes. Chapter V discusses the 'hows' and 'whys' of using this decision-making model. Included herein is a brief discussion of the data/matrix generator and a detailed presentation of the model's output. Chapter VI is concerned with testing and validating the model. Chapter VII closes the thesis text with a summary discussion and suggestions on refinement and use of the beef/forage model.

CHAPTER II

METHODOLOGY

The modelling of an economic system is discussed in this chapter. The introductory section on modelling *per se* is followed by a discussion on the various economic and behavioral issues which ought to be considered in building a decision-making model.

A. Modelling

The general approach used in solving the questions being asked herein is that of model-building in the context of an operations or management research approach. By definition, modelling embodies a representation, and usually a simplification of reality. It is sufficient that the model include only the relevant features of the real system. In this manner, only the information required for making a decision is included in the decision-maker's frame of reference, and burdening the model with superfluous detail is avoided.

A valid question that might be raised is "Why have a model?" The justification for model building is that the net sum of the associated returns(+) and costs (-) for such an effort is greater than a similar sum for the alternative approach of experimentation with and observation of the actual phenomena. With a model, many alternatives can be evaluated in a relatively short time. To perform similar experiments on the farm might require several lifetimes.

As the developmental costs associated with building a model are not small, such an effort might not be economically feasible if the costs and returns were to be exclusively borne by only one farm. The philosophy underlying the building of this model is that of flexibility in the applicability of the model. It is desired that the developed model be applicable to numerous farm situations having a range of managerial ability, different price expectations, and divergent resource bases. The results from the model are then used in a normative fashion to advise and aid the farmers in their decision-making.

B. Modelling Considerations and Features of a Good Model[1/]

Development of a model to aid decision-making for those concerned with a beef/forage enterprise suggests the consideration of certain issues. For example, questions concerning the farmer's goals, the relevant planning horizon, growth and capital investment, indivisibilities, time pattern of funds flow, technological change, variability in price and production data, the alternative production processes which should be included or excluded, and the relevant constraints which potentially limit the activity levels

[1/] "Good" as used here does not carry any connotation about moral rights or wrongs. My usage of "good" is meant to imply the characteristics and qualities of a model which I have deemed necessary for consideration in building a model such that the model be helpful in solving the defined problem.

should all be given consideration. These issues will now be discussed.

1. Goals

Goals represent sought-after levels of achievement. Goals are a function of values and of the circumstances in which the goals are defined. When either one's normative values and/or the physical environment change, the choice and ranking of goals will probably be affected.

To solve a problem at the farm level, the goals of those incurring the problem must be known. It is desirable that the decision-making model achieve an optimal or near-optimal solution for the goals specified by the entreprenuer.

One difficulty in developing a decision-making model that is sufficiently flexible so as to be applicable to many different farm situations is that of defining and conceptualizing goals. Goals of individuals vary both in choice and relative weight.

It is likely that each individual will have more than one goal. A multi-dimensional goal structure can be handled in various ways. Economic theory as applied to consumers utilizes the concept of the indifference function. Each indifference curve represents a mix of goods that provides an equal amount of utility. Inherent in such a concept is the consumer's ability to evaluate and rank each potential good in his market basket. In a multigood world, by equating the market price ratio with the consumer's utilitarian

trade-off between goods, the consumer's market basket mix is selected. The amount of goods in the market basket is determined by the level of the consumer's budget.

Operation research techniques can use an analogous approach. One alternative is to specify a multi-dimensional objective function which requires the entrepreneur to rank his goals. With this approach, the only coefficients in the model's objective function are these relative rankings for each goal being considered. Parametric programming in the neighborhood of the initially specified goal weights would indicate the rate of substitution between these various goals.

Another alternative to reflect the multi-dimensional goal structure is via the constraints in the model. For example, assume a two-goal structure of: (1) minimum level of living that is acceptable to the farm family combined with (2) the maximization of profits from the farm business. The profit maximization goal can be indicated in an one-dimensional objective function of maximizing profits. The consumption or level of living goal(s) can be specified as a constraint(s) upon the particular farm business being analyzed. In this manner, farm business profits are maximized subject to maintaining a minimum level of living for the farm family. Many other goals can be formulated in this same manner; i.e., as 'restrictions' upon the farm business being analyzed.

The point to be made is that there are a multitude of alternative goals which could be considered. The discussion herein has considered only the optimization-type goals as discussed in economic theory. An alternative avenue of thought relates to the behavioral theory of the firm. Possibly the entrepreneur does not think in terms of optimization but rather desires to 'satisfice'.

2. The Planning Period

This study involves the consideration of production and capital investment activities. These activities as conducted in a biological-economic environment necessarily involve the passage of time. The decision to invest in a capital good is premised upon the anticipated flow of revenues and expenses which will result from the investment. The question now being presented is 'how long should the planning period be to properly evaluate alternative production and investment plans?'.

Weingartner comments that the planning period, T, is selected "... such that the set of accepted projects having outlays or revenues in year T or sooner are exactly the same whether the model makes use of an infinite horizon or a horizon set at T."[2/] However, in a dynamic environment

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[2/] Weingartner, H. Martin. Mathematical Programming and the Analysis of Capital Budgeting Problems. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, p. 153, 1963.

involving uncertainty and the passage of time, such a horizon as just defined may not be unique or may not even exist. In the event that T is not unique, the shortest horizon is chosen to minimize data gathering difficulties and computational problems. The presence of jointly contingent investment projects, mutually exclusive projects, or projects having different revenue patterns over time necessarily complicates the determination of the proper planning horizon.

Boussard states that it is always possible to define a planning horizon so long that the pricing of the desired commodities at the end of the horizon has no influence on the decisions of the first period.[3/] In this case salvage values would have no influence on input acquisition decisions. Boussard shows that the solution when maximizing a linear objective function in a system that has no absolute constraints; i.e., the resource base can be increased via investment or hiring of resources, depends only upon the initial capital stock and the periodic matrices of the input-output coefficients and becomes independent of the planning horizon, T.

Modigliani simply views the planning horizon as the time within which it is necessary to plan in order to make a decision for the first period.[4/] Modigliani recognizes

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[3/] Boussard, Jean-Marc. "Time Horizon, Objective Function, and Uncertainty in a Multi-period Model of Firm Growth." AJAE, Vol. 53, No. 3, p. 470. August 1971.

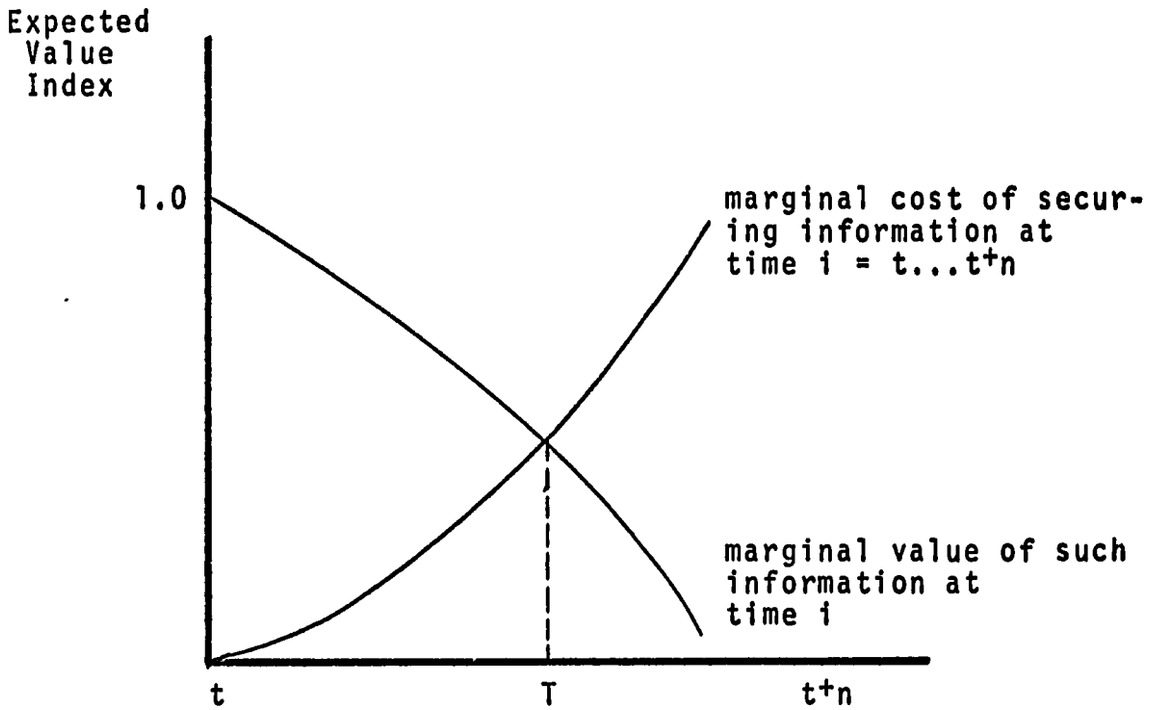
[4/] Modigliani, Franco. "The Measurement of Expectations." Econometrica, Vol. 20, pp. 481-482. July 1952.

that the results of a firm's decision may be affected by events of the future. However, knowledge of these future events is uncertain and can be determined only at a cost. His suggestion is that a current decision can be made with knowledge of a relevant subset of elements involved in the total system. The more important issue may be to determine the relevant set of parameters affecting the decision to be made at this point in time.

In concurrence with what Modigliani and Weingartner seem to be supporting, it appears that an adequate planning horizon is one which allows some consideration of future events. However, the cost of obtaining information about future events eventually surpasses the expected value of such information. The length of the planning horizon should be defined at the point where the value of information about the future equals the cost of such information. This conception is pictured in Figure 2.1.

3. Growth and Capital Investment

This study is not a growth investigation in the sense of tracing or determining the optimal growth path. However, elements of growth are considered in this study as some of the decision alternatives evaluated involve enlarging the resource base; e.g., increasing the number of beef stock cows, and investing in machinery and storage facilities. All such capital investments have the common characteristics of evoking a stream of revenues and expenses over time.



where: Cost of Information is some positive function of time.

$$\text{Expected Value} = \sum_{j=1}^{N} (\text{Value of Information}_i \cdot \text{Probability of accuracy}_i)$$

j pieces of information at time i

N = total number of different elements of information which are relevant for decision to be made

t = current time

n = number of time periods into the future

T = the defined planning horizon where MC = MV

MC = marginal cost = the change in total cost per unit of additional aggregated information gathered in each successive time period

MV = marginal value = the change in total revenue per unit of additional aggregated information gathered in each successive time period.

Figure 2.1. Definition of Planning Horizon, T.

The problem of capital investment has elicited the development of a multitude of theories. A few of these theories will now be reviewed.

The Lorie-Savage criterion is to rank all investment projects by the ratios of their net present value to cost and then to select projects from the top of the list until the budget is exhausted. The net present value of a project is defined as the algebraic sum of the elements of its stream of cash receipts and outlays discounted by the cost of capital. Lorie and Savage do not consider indivisibilities or project investment interrelationships. Each investment project has a stream of returns and costs which can be assigned to that project. Weingartner points out that this procedure fails when indivisibilities are present because the ranking is applied to projects singly, rather than to combinations of projects.[5/]

The payback (or payout) criterion ranks projects in an ordering starting first with the project which is the quickest to produce earnings sufficient to cover its costs. The basic weakness of this method is that it does not consider the productive length of time after the project has paid for itself. Also, not considered is the time pattern of receipts earned from the investment.

[5/] Weingartner, H. Martin. Mathematical Programming and the Analysis of Capital Budgeting Problems. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1963.

The so-called Ricardo effect maintains that a rise in real wages will induce substitution of capital for labor, and vice versa. This model assumes two (2) variable inputs - labor and capital - with each industry having identical capital/labor ratios and each capital item having the same expected life span. Land receives a surplus called rent. Although this theory does provide some insight, it avoids the capital budgeting problem by assuming homogeneous capital goods producing homogeneous products.

The marginal efficiency of investment (MEI) criterion suggests that investment is advisable so long as the MEI (also known as the internal rate of return) exceeds the cost of obtaining money to make the purchase. The average internal rate of return is defined as that rate of return which equates the project's discounted present value to the actual investment cost incurred. Although this concept is commonly termed MEI, this may be a misnomer as consideration is given to the entire stream of receipts not to just the additional amount of receipts. This distinction breaks down if the investment is non-divisible; i.e., a zero-one variable.

The Lutz's summarize the alternative objectives with respect to capital investment as follows:[6/]

a. Maximize (V - C)

where V is the discounted present value of the

[6/] Lutz, F. A., and V. Lutz. The Theory of Investment of the Firm. Princeton University Press, Princeton, 1956.

future revenue stream and C is the discounted present value of the future cost stream. This approach may be viewed as maximizing the absolute positive value of the change in net worth of the business being analyzed. This approach, as does the following one, requires specification of a discount or capitalization rate. The change in net worth can then be maximized when the marginal internal rate of return equals the market rate of interest.

b. Maximize (V/C)

This approach implies maximization of a growth rate per dollar of investment cost. This ratio is maximized when there is equality between the marginal and average internal rates of return.

c. Maximize the internal rate of return on the total capital sum invested. This is equivalent to maximizing the average internal rate of returns. This condition occurs when the average internal rate of return equals the marginal internal rate of return.

d. Maximize the internal rate of return on own equity invested. This approach is exploiting the usage of financial leverage. Via this technique, the farm business can more easily, relative to approach c, justify borrowing to increase the gross and net dollars generated by the business.

The investment theories mentioned in this section are suggestive and not exhaustive of the possible bases on which to model investment choices.

4. Indivisibility of Investment Projects

Capital investment decisions are characterized by an all or none situation. Either the decision is made to invest in the project or the project is not undertaken. Such decisions are said to involve discrete - not continuous - variables. This lumpiness characteristic is contrary to the assumptions of neoclassical production theory and also violates the assumptions of some mathematical programming algorithms.

It should also be recognized that discrete investment projects may not be independent of other such projects. The relationship between investments may be mutually exclusive, conditional, complementary or combinatorial.[7] Such interrelationships between projects - if they exist - ought to be

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[7] Projects 'A' and 'B' are independent when the probability of the occurrence of either project is not affected by the occurrence or nonoccurrence of the other; i.e., $P(A \cap B) = P(A) \cdot P(B)$.

Projects are mutually exclusive if the occurrence of one project prohibits the occurrence of another project; i.e., $P(A \cap B) = 0$.

Projects are conditional if the occurrence of one project (B) is dependent upon the prior occurrence of another project (A); i.e., $P(A \cap B) = P(A) \cdot P(B|A)$ and $P(B|A) < 1$.

Projects are complementary if the occurrence of one required the occurrence of another; i.e., $P(A \cap B) = 1$ or $P(B|A) = 1$.

at least conceptually recognized in a good model. If the actual model does not recognize such relationships, some judgmental interpretation of the results may be required.

5. Discount Rate

To recognize the impact that the time pattern of receipts and expenses might have upon the optimal decisions, the flow of dollars is discounted back to a present value.[8/] A most important question suggested by this technique pertains to the appropriate discount rate that should be used.

The appropriate discount rate is dependent upon the liquid capital available. In an unrationed capital market, capital availability will not be a constraint and the proper discount rate should include the interest rate at which the money can be borrowed. However, if a higher level of return can be attained by lending out one's money, the lending rate of interest should be used. The optimal solution in a perfect unrationed capital market is indicated by equality of the tradeoffs between present and future production with similar tradeoffs for the consumption or utility between these same time periods.[9/]

[8/] $\text{Present Value}_j = \sum_{i=1}^{n} r_j/(1+R)^i$

where r_j is the net returns from activity j in year i

R is the discount rate.

[9/] The basic model was initially presented by I. Fisher and has been extended by:
Hirshleifer, Jack. "On the Theory of Optimal Investment Decision," Journal of Political Economy, Vol. 66, No. 4, pp. 329-352. June 1958.

Under the more realistic assumption of capital rationing where the firm would like to borrow more money than will be made available, the borrowing interest rate does not indicate the value of the capital. Under such conditions, the discount rate should include return on money that can be earned from the most profitable use of the marginal dollar. The shortcoming of this concept is that when one is attempting to simultaneously evaluate a multitude of alternative investment projects, such a rate is unknown apriori. Remembering that each firm is unique, the marginal value of money will also be unique and will depend upon the firm's liquid capital resources currently available and the earnings over time from each of the investments.

In addition to recognition of the marginal value of capital in the discount rate, the element of risk may also be included. The receipt of a dollar today is much more certain than the anticipated receipt of a dollar at some point in the future. For investment projects which are particularly risky, a higher risk element can be reflected via a higher discount rate.

The proper discount rate to be used (in a deterministic one-period model) is unique to each firm. It should include an apriori evaluation of the marginal value of capital and an additional add-on for risk consideration.

6. Technological Change

Technical change can be generally defined as "any kind of shift in the production function".[10/] When technological advance occurs, the present level of output for a given production function can then be produced with less input or the present level of inputs can then produce more output. If the relative mix of inputs does not change, the technological change is classified as neutral. Otherwise the change is classified as labor-saving or capital-saving depending on whether the change favors use of more capital or use of more labor, respectively. Alternative ways to define technological change are revealed in Hicks (25), Salter (55), and Nadiri (42).

Technological change is continually occurring. These changes alter the ability of man and machine to complete particular tasks. The point to be made is that a good decision-making model for a firm involved with physical production processes should recognize the differences in technological abilities of different firms. Different firms will have equipment which differs by type and by vintage. A technique ought to be provided whereby these equipment and methological differences can be recognized and routinely inserted as source data.

10/ Solow, R. "Technical Change and the Aggregate Production Function." Review of Economics and Statistics, pp. 312-320. August 1957.

7. Variability

Actions and events which take place over time in a biological-economic environment are subject to deviations from the mean outcome. A decision-making model contains structural data estimates concerning future yields, prices, technical coefficients, etc. These future events involved in the beef/forage enterprise are characterized by this variance. Certainly then a 'good' model should give at least conceptual recognition to the stochastic nature of the real world.

Deviation from the true mean can be partially attributed to two (2) general categorizations - risk and uncertainty. By definition, risky events have an associated known probability distribution concerning their probable occurrence.[11/] Uncertain events do not have a known probability distribution. Because of the probability distribution associated with populations of risky events, it can be said that risk is insurable in an actuarial sense but uncertainty is not.

Variability of events may be classified as being either technical or income related.[12/] Technical variation is associated with changes in the input-to-output transformation coefficients and the base resource availabilities. Income variation has to do with movement of price and yield

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11/ Knight, F. H. Risk, Uncertainty and Profit, Houghton Mifflin Co., Boston. 1921.

12/ Heady, Earl O. and Wilfred Candler. Linear Programming Methods, The Iowa State University Press. 1958.

coefficients as reflected in the objective function. This definitional distinction although providing some insight for the treatment of variability does break down when the model includes either multi-time periods or intermediate products. In each of these two cases, an output or yield becomes a technical coefficient for another time period or another product, respectively.

Heady and Candler delineate two (2) possible approaches to the handling of variable events. The 'passive' approach is concerned with the variability of the objective function and does not consider the effect of variability on selection of the optimal plan. The 'active' approach contends that the variability in the objective function should be dealt with at its source; i.e., in the choice of the farm plan *per se*. Such an approach demands that the variability associated with the 'risky' transformation coefficients be reflected via a probability distribution for each such coefficient. Such considerations require the use of a stochastic programming approach. In the event that the entrepreneur is a risk averter, special provisions may need to be incorporated for those activities with a relatively lower payoff but a higher probability of occurrence. This suggests an expected value technique for the objective function. Also, as the variability of the transformation coefficients directly relates to the values in the objective function, the stochastic programming problem may alternatively be formulated as a quadratic programming problem - the passive approach.

8. Production Processes

In order to build a 'good' model, realistic and relevant production processes must be considered. The concept of 'process' (also called activity) differs from that of a 'product' in that a process can be distinguished by either different methods to produce the same product or transaction; or by distinct and separate products. For example, a production function in which a product is produced via some implicit function of inputs could encompass several different processes if the product can be produced by alternative mixes of inputs. Dorfman states that "... two productive events are instances of the same process if they consume the same resources and in the same proportions. Otherwise, they are instances of different processes."[13/]

9. Constraints

Most economic systems and models of such are concerned with the allocation of three (3) basic scarce resources - land, labor, and capital - among competing wants. The model developed in this study has similar concerns.

Each farm situation should be provided the opportunity to have its own resource structure reflected in the decision results determined by the model. By requesting information from the farmer on the land, labor, and capital resources

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13/ Dorfman, Robert. Applications of Linear Programming to the Theory of the Firm. University of California Press, Berkeley, 1951.

available, the results from the model should be unique to that farm situation currently being analyzed.

C. Summary

Some basic modelling features that ought to be considered prior to building a model were discussed in this chapter. The extension of this general discussion to the particular model developed in this study is presented in the following chapter.

CHAPTER III

THE BEEF/FORAGE MODEL

The purpose of this chapter is to present the beef/forage model that was developed in this study. Discussed herein are: (1) the general characteristics of the beef/forage model, (2) the activities modelled from which the optimal enterprise plan is selected, and (3) the formal model and algorithm chosen to solve the defined problem.

A. Characteristics of the Beef/Forage Model

Models may be classified with respect to: (1) the specified objective function, (2) treatment of time, and (3) treatment of certainty of knowledge. These modelling features as well as the activities and constraints of the model are now discussed.

1. The Objective Function

The specified objective of the beef/forage model is the maximization of the change in net worth of the beef/forage enterprise. This objective may be expressed as:

$$\sum_{j=1}^{n} c_j x_j$$

where c_j represents the present value of all stocks and flows for the x_jth activity during the planning horizon.

Each c_j element may be discounted at some rate of interest. This objective function value, determined by the multiplicative sum of the linear production processes and single-valued net expectations, exhibits constant elasticity of production.

The objective as stated is equivalent to maximizing the present value of the net income earned by the beef/forage enterprise during the planning horizon.

As suggested earlier in Chapter II, section B1, it is possible to incorporate other goals by constraint formulation. Provisions are allowed in this model for the specification of particular forage production and forage harvesting techniques, and also for beef production systems and levels. Personal limitations on the amount of labor employed and capital invested can also be expressed. However, no allowance is provided for other farm family goals.

2. Treatment of Time

With respect to time, this model is KINETIC in that it gives some consideration to time entering the decision-making and resultant production processes.[1/] Specific consideration is given to the selection of production processes

[1/] Kinetics is defined as a situation where time is taken into account explicity but prices and transformation relationships are considered to be known with certainty. As defined in:
Eisgruber, Ludwig. Unpublished production economics notes, AGEC 614, Purdue University, Agricultural Economics Department, p. 95.

and to their scheduling within the confines of a one-year time period. These production activities are constrained by their demand for resources which can occur in any one of the nine (9) time periods (April through November plus winter). In addition, multi-year consideration is allowed with the discounting method. Activities which generate income and/or incur costs over time will have an objective function value represented by the net present value of that stream of revenue and expenses. Thus the beef/forage model is not a multi-period LP model *per se* but rather a one-period model whose value coefficients reflect the change over time of resource costs and product prices.

The rationale for modelling in this manner is to reflect a presumption that production and investment decisions are made not only with consideration of this year's price and production expectations but also with some consideration of expectations for events of the future. It is certain that price relationships will change during this planning horizon. However, an element of uncertainty surrounds the direction and magnitude of these price changes. An opportunity is provided the user of the model to utilize his own expectations for both the prices in year one and for the expected average prices in the last six (6) years of the planning horizon. Elements of uncertainty concerning these price predictions may be reflected by varying the level of the discount rate.

Additional rationale for modelling in this manner is increased efficiency with respect to use of computer time. Building a one-period model whose value coefficients (c_j's) reflect the stream of benefits and costs over a time period of seven (7) years eliminates the need of a large block diagonal model as necessitated by poly-period modelling.

This 7-year time period was selected on the basis that this period constitutes the approximate productive life of a stock cow. Any investments made in the beef-forage complex should make a positive net contribution to net worth within this period. This seven-year period may be considered as the maximum payback period for investments in breeding livestock.

3. Treatment of Certainty of Knowledge

With respect to knowledge certainty, this model may be classified as deterministic. That is, the base data entries and the data generated thereof are used as if there is no associated error term. All variables have an associated probability distribution of one.

4. Decisions Rendered by Model

The basic issue in this model is the optimal allocation of farm resources required to maximize net farm income. The practical question being asked is, "Should the resources be employed by some type of beef/forage operation or in some alternative external to such an enterprise?"

If the price and production relationships are such that beef activities enter the optimal farm plan, the mix of cow-calf and calf-yearling operations must be determined. If a cow-calf operation is economically optimal, the decisions under section 'a' are of concern. If the system of buying calves and selling yearlings enters the solution set, discussion section 'b' is relevant. Regardless of which beef production systems come into solution; forage production, harvesting, storage, and feeding systems must be selected. These issues are discussed in points c, d, e, and f of this section.

a. The Number of Beef Cows and Their Respective Herd Management System. The herd management system is defined by:

1) Calving month and the calf weaning percentage associated with that particular month. Each month of the year is a potential calving month. To reflect seasonal breeding and calving differentials, each month may have its own unique calf weaning percentage.
2) Calf weaning policy; i.e., the age at which the calves are separated from the brood cows. The calf weaning policy should affect the labor scheduling and the forage demand requirements.
3) Calf marketing policy; i.e., the age at which the calves are sold. For a given land base and forage supply, the calf marketing policy has a direct

influence on the number of beef cow-herd units that may be maintained. That is, the longer a calf is kept on the farm, the longer is the period that the calf competes with the cow for a limited forage resource. Therefore, the longer that calves are kept on forage, the fewer are the number of beef cow-herd units that can be supported.

4) Calf creep feeding policy. The question here is whether the benefit of increasing the weight of the weaner calf via creep feeding is worth the added cost of the concentrates fed.

5) Herd culling policy as determined by productive life of cow, and the herdman's policy toward barren cows and cows which lose their calves. Severe herd culling practices provide income from cull cow sales and should have a positive effect on the calf weaning rate. The tradeoff is that either a cost must be incurred to buy replacement stock, or reduced calf revenue results if additional heifers must be saved back for replacement stock.

6) Herd replacement policy as defined by the method of securing replacement breeding stock; e.g., raising replacement heifers, buying open replacement heifers, buying bred replacement heifers, or purchasing cows with calf.

7) Bull stocking rate; i.e., how many cows are to be serviced by each bull? The bull stocking rate should have a direct influence on the conception rate and resultant calf weaning rate.

Each cow-calf activity is defined by the user specifying the policies and associated coefficients for these seven (7) beef cow-herd management considerations.

b. The Number of Buy Calf-sell Yearling Units and Their Respective Management System. The management system is defined by the calf purchase month and the length of time which the calf may be carried on forage. By altering the length of time that the calf is maintained on forage, the sales weight and price per pound become the factors which differentiate the gross revenue among the alternative processes. The size of calf to be purchased is a parameter which does not vary among the systems modelled herein but can vary in alternative runs of the entire system.

c. Forage Production Policies; i.e., Which Soils Grow Which Forages and in What Quantity During Each Time Period. To provide the basic feed inputs for beef, the production of an intermediate product, forage, was modelled. Land which is physically able to produce forage tends to be quite heterogeneous with respect to topography and nutritive quality of the soil. This fact suggests the necessity of considering different soil management groupings combined with alternative forage varieties. Additional combinations

can be generated by combining these forage/land combinations with alternative relevant forms of land control, e.g., ownership v.s. rental.

The ten (10) forages that were modelled for consideration are: (1) native pasture, (2) Korean lespedeza, (3) birdsfoot trefoil, (4) new seeding, (5) orchard grass, (6) tall fescue, (7) alfalfa/grass mixture, (8) red clover/grass mixture, (9) aftermath from small grains and/or soybeans, and (10) cornstalk refuse.

The details on the calculation method used to determine the specific amount of each forage available from each acre in each time period (April through November plus a winter period) is presented in Appendix B, Program FORAGE.

d. Forage Harvesting Policies and Any Necessary Accompanying Machine Investment. Provision was made for the mechanical harvest of forages. These mechanically harvested forages combined with the alternative soil management groupings and forms of land control are the alternative forage activities which provide winter feed.

Tall fescue, orchard grass, alfalfa/grass, and red clover/grass are the specific forages which may be mechanically harvested. Provision is allowed that from zero to three mechanical harvests may occur for each forage/soil management activity.

Eight (8) alternative mechanical forage harvesting processes are considered. These systems are: (1) regular

square bale - manually stacked in shed, (2) regular square bale - manually stacked outside, (3) regular square bale - mechanically stacked outside, (4) small square bale, handled via bale thrower into wagons and dumped in shed, (5) mechanical stack system of compressing loose hay into small stacks, (6) small round bales - left in field and picked up during slack time, (7) large round bale - left in field, and (8) haylage via chopper and stored in silo.

Additional detailed discussion on the calculation of the coefficients for the forage harvesting activities is presented in Appendix B, Program FORHR, section (2).

e. Forage Storage Systems and Building Investment. Regardless of the forage package that is mechanically harvested, all forage packages require being stored until used. Forage packages utilizing inside-storage require the resource of storage structure facilities. If such facilities are not available, either the storage structure must be constructed or the particular forage packaging activity cannot be utilized. Appendix B, Program STORAGE presents additional details on specifying the availability and costs of forage storage facilities.

In addition, a forage carryover activity allows leftover forage to be transferred from period 't' to period '$t^{+}1$'. These activities provide forage storage 'on the stump'. That is, grazed forages which are available but not completely harvested in the 't'th time period can be carried over to provide a forage supply in the '$t^{+}1$'time period.

f. Systems for Winter Feeding of Stored Forages. The four (4) winter feeding systems included in this model are: (1) full feed on ground or at field stack, (2) limit feed on ground or at field stack, (3) full feed in bunks, or (4) limit feed in bunks.

Each of the five (5) different sized forage packages may be handled by any one of the winter feeding systems. Each forage package-winter feeding combination has associated costs, labor requirements, and forage wastage indices which are unique to that system. It is the evaluation of these factors that partially determines the optimal winter feeding system. In addition, the decision on the winter feeding system cannot be made in isolation from the harvesting system. For example, it would be impossible to use a system feeding large round bales unless such a package was mechanically harvested.

5. Constraints Upon the Beef/Forage Enterprise

To realistically represent the situation and to avoid an objective function value of either zero or infinity (which could occur with an unconstrained linear single-valued objective function), resource constraints limit the expansion of the activities.

a. Land Constraints. The land is composed of three different soil management groupings (bottomland, hillsides, and upland) subject to two (2) alternative forms of land control (ownership or cash rental). The availability of each

land category represents a potential constraint on the farm's ability to supply forage.

b. Hour Constraints for Labor and Machinery. To transform forage growing in the field to forage available for winter feeding requires a mechanical harvest process. Each such process requires a mix of man and machine time. The availability of labor and machine hours during the harvest periods represents a potential constraint for the provision of winter forage.

The winter feeding activities require man-hours of labor for each unit of forage fed. This labor requirement is modelled separately and in addition to that labor required for normal maintenance and observation of the animal unit. For each time period that an animal unit is on the farm premises, a declared amount of man-hours is required to oversee each respective animal unit.

Additional detailed discussion on the calculation of man-hours required to support each beef activity is provided in Appendix B, Program LABOR.

c. Forage Supply. For each time period that an animal unit is on the farm, digestible energy in the form of forage is required to maintain each animal. The availability or lack thereof of an adequate forage supply provides a potential limit to the level of the beef activities which may be sustained.

The method used to calculate the demand for forage by each beef activity is presented in Appendix B, Program TDNR.

d. Forage Storage. The availability of forage storage facilities provides potential limitations to the level of particular forage harvesting activities. For example, forage harvesting systems #1 and #4 (square bales) require a facility for inside storage of their respective forage packages. The provision of haylage via forage harvesting system #8 requires a silo for storage purposes. In the event that such forage storage structures are not available and cannot justify the cost of investment, these particular forage harvesting activities are prohibited from entering the optimal farm plan.

e. Capital Constraints. The availability of inside and outside liquid capital provide potential constraints to all capital-good investment activities. Three (3) outside capital constraints; i.e., maximum debt limits, were modelled to indicate upper bounds on borrowing for investment in (1) machinery, (2) buildings, and (3) beef animals. The determination of the capital required for each of these investment activities is accomplished with data provided by the user of the model. Manipulation of the base data is indicated in Appendix B, Program FORHR, Program STORAGE and Program PVBEEF for investments in machinery, building, and beef animals, respectively.

The initial funds-on-hand (inside capital) can also be specified. Such funds may be used for investment in any of the capital goods. An accounting constraint was not modelled to limit operating expenditures.

B. Choosing an Algorithm

An appropriate mathematical programming technique must be selected when developing the methodology that enables the farmer to explore and evaluate alternative beef/forage systems. In choosing an algorithm several considerations should be included in one's decision-making framework for algorithmic evaluation. Among these considerations are:

1. The purpose of the study; i.e., what are the questions that require an answer? As Candler, Boehlje, and Saathoff[2/] indicate, the computer software and data requirements differ due to the difference in the questions asked by research vis-a-vis extension personnel. Research personnel may be interested in alternative economic structures in which the system may operate, whereas the extension worker desires to determine the effect upon the system when the planning data change for a given structural environment.

2. The conceptual approaches available, and the reliability of the operational numerical techniques (computer software) that can be adopted and/or adapted for use.

[2/] Candler, Wilfred, Michael Boehlje and Robert Saathoff. "Computer Software for Farm Management Extension." AJAE. Vol. 52, pp. 71-90. February 1970.

3. The assumptions underlying each particular approach; i.e., the realism of the model. How compatible is the particular model with the real world problem being studied? This compatability issue raises the philosophical question relative to evaluation; i.e., should a model be evaluated for appropriateness on the basis of its assumptions (a form of synthetic a priorism) or of its results (a form of positivism)?

4. The computational effort and cost involved.

5. The cost of securing computer codes.

6. The information required for data input and the cost of securing such information.

7. The realistic quality of the information provided via the solution.

8. The communicability of the entire solution process. Can the solution technique be made known with the results capable of being reproduced by other interested participants?

Appendix A discusses the modelling alternatives and algorithms available. It should be recognized that the modelling furcation presented therein may be somewhat artificial for the applied problem-solver vis-a-vis the technique-oriented types. As a problem-oriented discipline, concern should be with the adequacy of the approach in providing aid for a decision-making problem. If it is deemed desirable that an adequate problem-solution requires a

hybridized technique, so be it. The point to be made is that there may not be 'the' one best approach. This may necessitate a compromise of pure techniques for realism. Such compromises should be recognized in the interpretation of the solution results.

C. Algorithm Selected

Due to the inherent nature; i.e., lumpiness, of the associated capital investment activities in the beef/forage enterprise, it was felt that a realistic decision-making tool should reflect the fact that such investment is an all or none type proposition. Therefore, a mixed integer algorithm (MIPZ1) was selected for use in this study. Linear programming could have been used with the levels of these activities truncated to the closest integer value. However, for investment activities requiring large capital sums, such a technique could lead to either non-feasible solutions or non-optimal solutions.

Such a situation is pictured in Figure 3.1. Assume that the n-dimensional decisional sphere can be compressed to two (2) dimensions with both dimensions being integerized activities.

The feasible set is OXYZ as constrained by VZ and XG. The dotted lines are iso-values and indicate the tradeoffs between projects A and B. Solution determination by rounding to the closest value would result in project combinations expressed by point T - an infeasible solution. Solution

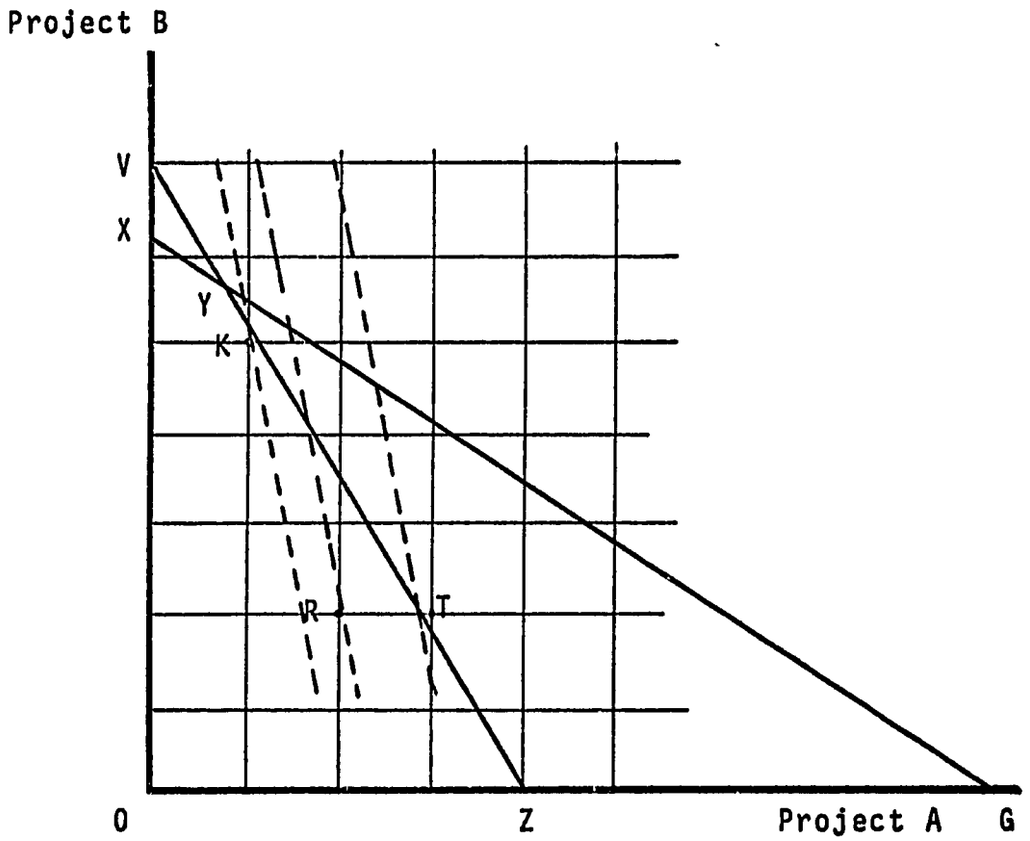


Figure 3.1. Grid of Integerized Activities.

determination by truncating downward to the closest value would result in project combination expressed by point K - a feasible but non-optimal solution. Solution R is the optimal combination of projects as valued by the defined goal structure and indicated by the dotted lines.

The problem situation as defined for the beef/forage enterprise includes several potential machinery and building investments. The machinery investments are constrained by the liquid capital available for such purposes. A similar situation exists for the building considerations. As only two (2) constraints limit this set of activities, only two (2) 'integerized' activities could possibly enter the ordinary LP solution in a continuously divisible form. However, as indicated in discussion of Figure 3.1., a rounding-off solution could prove to be infeasible or non-optimal.

D. The Formal Model

1. The Primal

(1) Maximize $z = \sum_{j=1}^{n} c_j x_j$

subject to:

(2) $\sum_{j=1}^{n} a_{ij} x_j \leq b_i$ for $i = 1 \ldots m$ resources

(3) $x_j \geq 0$ for $j = 1 \ldots n$ activities

(4) $x_j = 0$ for $j = 1...jj$ activities; $jj \leq n$

or

$x_j = 1$

where z = discounted present value of the beef/forage enterprise;

c_j - discounted present value of the stream of revenues and expenses for activity x_j which were generated over the planning horizon. A c_j may be either negative or positive. A positive c_j expresses a positive contribution to the present value of the enterprise, and vice versa with respect to negative c_j's.

For the integerized activities (j=1...jj), involving capital investment, the c_j is necessarily negative reflecting the fixed costs of investment and the fact that the investment projects considered produce only an intermediate - non-revenue generating - product.

x_j = activity or process.

a_{ij} = technical input-output coefficient. A positive a_{ij} coefficient indicates usage of resources; a negative coefficient indicates supplying of resources. (With respect to greater than constraints, to satisfy the inequality as expressed in equation 2, both the a_{ij} and the b_i could be expressed as a negative quantity.)

b_i = amount of the ith resource on hand at beginning cf period; the vector of b_i's provides the right hand side (RHS).

n = number of activities being considered; n is then the number of columns in the base tableau for a maximization problem.

m = number of constraints (and accounting equations); m is the number of rows in the base tableau for the maximization problem.

2. The Dual

For each primal problem, there is a dual problem. That is, each problem involves the allocation of resources and the marginal valuation of these same resources. When the primal is defined as maximizing the generated output as measured by net income, present value, etc.; the dual problem is to minimize the marginal productivity value of the scarce resources subject to a required level of production. An answer for one problem necessarily provides the answer for the other problem.

(1) Minimize $zz = \sum_{i=1}^{m} w_i b_i$

subject to:

(2) $\sum_{j=1}^{m} w_i a_{ij} \geq c_j$; i.e., the resources used will never be at less than the value of the product produced.

(3) $w_i \geq 0$ for $i = 1 \ldots m$ resources

where zz = summation of the marginal value of the scarce resources

m = number of activities

n = number of constraints

a_{ij} = technical input-output coefficient

b_i = activity or process

w_i = inputed value of the last additional resource 'i' that enters the production process; w_i may be viewed as the lagrangian multiplier associated with the constraint of the maximization problem; $w_i = MVP_i = \frac{\partial zz}{\partial b_i}$

c_j = value of the jth production technique.

It is seen that the coefficients of the objective function of the primal problem are constant terms of the constraints of the dual. The constant terms of the primal constraints are the coefficients of the objective function of the dual.

This discussion is based upon and can be summarized by Dantzig's Duality theorem which states that the maximization problem has as a solution a feasible vector X°, such that CX° = max CX if and only if the minimum problem has a solution that is a feasible vector W°, such that W°B = min WB. Moreover, the equality CX° = W°B holds if and only if X° and W° are solutions to their respective problems.[3/]

However when the primal problem is constrained by integrization considerations as indicated by equation E.1. (4), the duality theorem does not strictly hold. This is due to the fact that a recomputation of the supplemental Gomory

[3/] Dantzig, G. B. and P. Wolfe. "Decomposition Principle for Linear Programs." Operations Research, Vol 8, pp. 101-111. 1960.

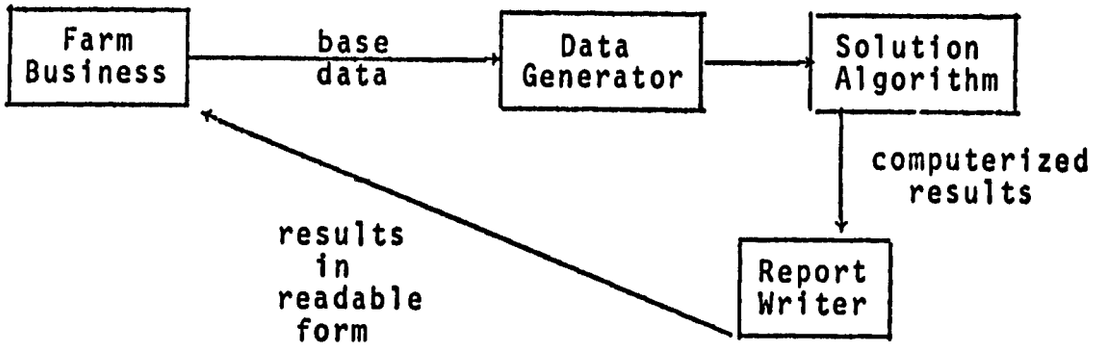
constraints back to the original constraints to give the dual prices depends upon the actual course of calculation. Thus the recomputed duals depend on the choice of cutting planes (Gomory constraints) and are not totally consistent with the duality theorem of optimality.[4/]

E. Summary of the Conceptual Model

The problem has now been defined, the decisions to be made delineated, and a problem-solving strategy selected. A schematic conceptualization of the model's goals, required inputs, and desired output is presented in Figure 3.2.

A substantial amount of the impetus for building this model was to provide a decision-making aid for the man in the field. To facilitate the gathering of data and the subsequent return of information to the user of the model, some functional and some purely liaison techniques are required. An input form has been developed to gather the data; a data generator written to calculate the technical coefficients and to place these and other coefficients in the proper format; and a report writer developed to return the solution results to the farmer. The circular flow of information is as pictured below.

[4/] Gomory, R. E. and W. J. Baumol. "Integer Programming and Pricing", Econometrica, Vol 28, No. 3, pp. 521-550. July 1960.



Further elaboration on the model's data generator is presented in Appendix B. Chapter IV discusses the modelling tactics used to match the activities and technical coefficients. Chapter V presents the report writer.

Model's Purpose: To aid in planning whether to have a beef cow-calf enterprise, age of product to market, choosing the best beef management system and accompanying forage management system.

I. Goal
Maximize net worth at the end of a seven year period

Farm Manager

Given
- a. Resources available
- b. Management efficiency factors
- c. Prices of products & costs of inputs
- d. Risk preference

II. Conditions Specified
- A. Resources Available
  1. Land
  2. Labor
  3. Cash & debt
  4. Livestock inventory
  5. Forage storage facilities
  6. Machinery & equipment
- B. Management-efficiency Factors
  1. Forage yields
  2. Calf weaning rate
  3. Weaner calf weight and rate of gain after weaning
  4. Labor requirements
  5. Feed requirements
  6. Machine time requirements
- C. Expected Prices
  1. Weaner calves
  2. Cull cows
  3. Breeding stock
  4. Corn
  5. Corn silage
  6. Hay
- D. Risk Preferences
  1. Maximum debt
  2. Livestock debt limits
  3. Machinery debt limits

III. Business Organization Alternatives
- A. Products to Produce
  1. Forages
  2. Beef - calves or yearlings
- B. Production Scheduling
- C. Production Systems
  1. Forage harvest
     - a. Square baler
     - b. Small round baler
     - c. Large round baler
     - d. Haylage
  2. Forage Storage
     - a. in field
     - b. in shed, barn
  3. Forage Feeding
     - a. limit feeding in rack (bunk)
     - b. limit feeding on ground
     - c. free choice in rack (bunk)
     - d. free choice on ground

IV. Output
- A. Physical Farm Plan
  1. Beef Management System
  2. Forage Management System
  3. Size & Type of Enterprise
- B. Capital Situation
  1. Net Income Statement
  2. Assets by type
  3. Debts by type
- C. Cash Flow Summary

Figure 3.2. Schematic for Beef Cow-Calf Profit Planning Model.

CHAPTER IV

THE PROGRAMMING MATRIX

Chapter III closed with a discussion of the informational flow of the farm-specific data as it is processed through the beef/forage model. It was noted that the function of the data/matrix generator is to calculate, place, and organize the coefficients into the format required for the algorithm. This format is known as the programming matrix. Chapter IV will present and discuss the relationships modelled - as indicated in the programming matrix - for the linearly programmed beef/forage enterprise.

The programming matrix is an arrangement of equations that includes an objective function, and the constraints which potentially limit both the level of the production activities and of the input acquisition processes.

The objective function is the first equation in the matrix and is used to show the dollar contribution to net worth for one unit of each process. The variables in this equation are the activities or processes being considered in the beef/forage enterprise analysis. Each coefficient in the objective function indicates the dollar contribution of that activity to the objective of maximizing change in net worth. A positive coefficient in the objective function

increases the value of the function whereas a negative coefficient indicates a cost that decreases the net worth of the enterprise.

The remainder of the equations or rows in the matrix are used to indicate the resources available (RHS) and the amount of each resource required by each process or activity. The variable in each equation represent the activities being affected by this particular constraint. The coefficient for each of these variables indicates the resources required for each unit of the respective activity. A positive coefficient states that resources are being used by the particular activity. A negative coefficient indicates that resources are being supplied by this particular activity.

Attempts were made to model the enterprise in blocks or categories of: (1) integerized input activities and (2) divisible input and output activities. Within the category of divisible activities, subcategories are: (a) intermediate products which serve as inputs for the beef activities, (b) land rented out, (c) land rented in, (d) forage harvesting systems, (e) forage carryover activities, (f) stored feeding activities, (g) beef cow-calf production activities, (h) 'buy calf-sell yearling' beef production activities, and (i) hire-in labor and machine services. In addition, there are accounting and transferal activities which link together these various blocks of activities and provide an accounting for the total amounts of resources used. These modelling blocks will be discussed in the remainder of this chapter.

The maximum dimensions of the programming matrix are 150 rows or constraints and 284 columns or activities. The code for these activities and constraints is defined and explained in Appendix C.

A. Integerized Input Activities

There are twenty-one (21) activities to reflect purchase of machinery items. Two (2) additional activities are used for consideration of investment in forage storage facilities. The purchase of a machinery item or of a building is usually a non-divisible purchase. Such a purchase is not consistent with the basic linear programming assumption of divisibility. The decision to treat such activities as integer and not as continuous variables was based on *a priori* knowledge that the level of these activities would likely be small and investments in each unit would be substantial. Where the level of the activity is expected to be high, the problem may be more efficiently solved with continuous variables with the answer truncated and written out in integer format. The rounding-off approach is used with the beef-production activities and should have only negligible effect on the optimum solution.

Investment in capital goods such as machinery and buildings necessitates the consideration of three (3) basic production and financial accounting relationships.

1. Such investment requires the exchange of cash and/or credit for a productive resource.

2. This resource purchase provides inputs which are, in turn, used to produce either an intermediate or final product.

3. The ownership and usage of a capital asset involves an expense of depreciation - a fixed cost - plus the operating costs.

These relationships are reflected in the c_j's and the constraints as they are modelled for this particular section.

Availability of cash and/or credit limits the amount of capital assets which can be purchased. The amount of cash available, the amount of credit that can be procured for machinery purchases, and the amount of credit that can be obtained for investment in buildings provide three (3) restraints on the amount of investment activities that can be undertaken. Each of these three (3) dollar amounts are modelled as a right hand side for the respective constraint. The a_{ij} for the investment activities as constrained by the available finances will be a positive coefficient indicating the purchase cost for the jth activity. As explained in Appendix B, Program FORHR, this purchase cost may not be the entire cost of the item if the respective item is to be used in enterprises in addition to the beef operation.

Investment in machinery and buildings assets is made for the explicit purpose of increasing the productive resource base. The amount of resources supplied by the machinery and building investments is indicated by negative

a_{ij}'s - capacity coefficients - for each of the respective activities. As modelled each machine investment activity provides machine hours for each of two (2) forage harvesting periods: i.e., for the first cutting and for the second-third cuttings of forage. For tractor-drawn machinery items, the a_{ij} is the hours of machine-time that the purchased implement can be made available during the ith period. For purchased tractor activities, the a_{ij} consists of the 'horsepower-hours' that the particular tractor can provide during the period.[1/] These machine-hour amounts provide the negative a_{ij}'s for the jth machine purchase activity in the row or restraint indicating machine-hour limitations for the ith machine/time-of-year combination.

Each building activity provides an annual tonnage amount of available storage. This amount is indicated by a negative coefficient - a_{ij} - for the jth building activity in the ith row reflecting annual storage capacity limitations for the jth building type.

Purchase of a capital asset entails ownership and user costs in the form of depreciation and operating costs, respectively. These costs have a negative impact on net worth and are modelled via negative c_j's in the objective function. The technique of calculation for these c_j's is

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[1/] Horsepower-hours available is defined as size in horsepower of the tractor multiplied by the hours that the particular tractor is available for the beef/forage enterprise.

discussed in Appendix B, Program FORHR for the machine items, and Program STORAGE for the building items. In addition, the borrowed capital accounting activities have a negative c_j which indicates the interest rate charged on the borrowed capital. Table 4.1 presents the tableau for these activities and constraints.

The coefficient code for all tables in this chapter is as follows:

E	coefficient is	$\geq$	1000.000
D	coefficient is	$\geq$	100.000
C	coefficient is	$\geq$	1.000
B	coefficient is	$\geq$	.001
A	coefficient is	$\geq$	.000
1	coefficient is	$\geq$	-.001
2	coefficient is	$\geq$	-1.000
3	coefficient is	$\geq$	-100.000
4	coefficient is	$\geq$	-1000.000
5	coefficient is	$\leq$	-1000.000

In addition, the type of constraint is indicated by a letter to the left of the row numeric identifier. The alphabetic codes of 'L', 'E', and 'G' indicate that $\sum_{j=1}^{n} a_{ij}X_j$ <, = ,> b_i, respectively for each ith resource.

B. Divisible Input/Output Activities

The discussion in this section pertains to the remainder of the activities considered in the beef/forage enterprise. These activities were handled as divisible units. This procedural assumption is invalid with respect to animals which are discrete by nature. However, the cow-calf activities are based on an animal unit which is defined to include one stock cow plus her share of the calf crop, of the required

Table 4.1. Investment in Machinery and Buildings.

		Investment and Associated Finance Activities[1/]																													
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	6		
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	8	5	6	2		
		0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	0	0	0	0	0	0	0		
		1	2	3	4	5	6	7	8	9	0	1	1	2	3	4	6	7	8	9	0	1	1	2	3	1	1	1			
Obj Function	N 20000	5	5	5	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	5	5	4	5	5	2			2			
K account for Mach	L 31001	E	E	E	E	E	E	E	E	E	E	D	E	D	E	E	E	E	E	E	E	D					2	2			
Beginning Cash	L 31002																										C		C		
Borrowed K - Mach	L 31003																											C			
Tractor Horsepower-Hours																															
Harvest Period #1	L 31101	5	5	5	5	5	5	5	5	5	5																				
Harvest Period #2	L 31102	5	5	5	5	5	5	5	5	5	5																				
Machine Hours																															
Harvest Period #1																															
Mower	L 31201											3																			
Conditioner	L 31202												3																		
Rake	L 31203													3																	
Sq baler	L 31204														3																
Sq baler w/accum	L 31205															3															
Sq baler w/throw	L 31206																3														
Stack system	L 31207																	3													
Small rd baler	L 31208																		3												
Large rd baler	L 31209																			3											
Chopper & wagon	L 31210																				3										
Blower	L 31211																					3									
Harvest Period #2																															
Mower	L 31301											3																			
Conditioner	L 31302												3																		
Rake	L 31303													3																	
Sq baler	L 31304														3																
Sq baler w/accum	L 31305															3															
Sq baler w/throw	L 31306																3														
Stack system	L 31307																	3													
Small rd baler	L 31308																		3												
Large rd baler	L 31309																			3											
Chopper & wagon	L 31310																				3										
Blower	L 31311																					3									
Chopper Hours-Sept	L 34102																				3										
Stack System-Hours-Nov	L 34201																	3													
K account for Bldgs	L 32001																						E	E	2			2			
Borrowed K - Bldgs	L 32002																								C						
Barn Storage	L 32301																						3								
Silo Storage	L 32302																							3							

1/ Code for Activities:

11001 - 11010 Investment in tractor(s) - 10 different sizes
11011 - 11021 Investment in pulled machinery - 10 different implements
12801 Investment in Barn
12802 Investment in Silo
12803 Accounting Activity for Capital Borrowed for building investment
11501 Beginning Cash - Invested in Machinery
11601 Accounting activity for capital borrowed for machinery investment
16201 Beginning Cash - Invested in Buildings

replacement stock, and of the bull. As this 'animal unit' is not composed of a discrete number of animals, provision was made in the report writer to round each animal category to the nearest whole number. Rounding aids the realistic appearance of the results and will usually have only slight effect on the accuracy of the solution.

1. Intermediate Activities

Intermediate processes are those which produce a product that, in turn, serves as an input for another process. Forage is such a product which is produced and then provides an input - feed - for the beef production activities.

The forage production activities are combinations of 11 forage varieties, three (3) soil groupings, and two (2) types of land control. In addition, four (4) of the forages may be either grazed, mechanically harvested, or a combination of both. This combination of 66 grazed forage activities, 24 mechanically harvested and/or grazed forages plus one activity for production of corn silage provides 91 possible forage production activities. The common unit of measure for these activities is one acre. Explicit discussion of the development of these activities occurs in Appendix B, section entitled Program FORAGE.

Each of the forage production activities is constrained by the amount of land available. Considering each of the possible forage production activities that compete for an acre of land, there are 66 land constraints. In addition,

there are four (4) land accounting activities - one each for bottomland acres, hillside acres, upland acres, and the total acres available for forage production. Each a_{ij} for the forage/land combinations is one (1). This a_{ij} of one indicates that production of one (1) acre of the jth forage on the ith land type requires one acre of this particular land category.

The production and mechanical harvesting of forage requires an input of labor. The labor required for a ton of forage that is mechanically harvested will vary with the mechanical harvest system employed. This labor requirement will be discussed in the section concerning forage harvest systems. It is also recognized that the maintenance of grazed pasture acres requires labor. However, the maintenance of pasture facilities is not an activity that requires a great deal of timeliness. Pasture maintenance tasks are performed if and when time becomes available. In accordance with this presumption, the labor required to maintain an acre of grazed pasture land was not included in the model as a constraint.

The variable capital required to grow an acre of a particular forage on a particular soil grouping was modelled as a negative c_j in the objective function for that respective activity. The actual calculation of these c_j's is discussed in Appendix B, section entitled Program PVLAND.

Each of the forage production activities provides a flow of forage during the year. The amount of this flow is affected by:

1. the agronomic growth pattern of the particular forage,

2. the total digestible nutrient composition of the forage during each time period, and

3. the method of harvest.

The production of this forage during each time period is represented by a negative a_{ij}. Each a_{ij} indicates the amount (in tons or portions thereof) of total digestible nutrients provided by one acre of the forage-land combination during the ith time period.

Table 4.2 summarizes the discussion in this section.

2. Land Opportunity Cost Activities

The land opportunity cost activities allow alternative employment of owned land. Each forage-land activity has an opportunity cost. This opportunity cost activity indicates the net returns possible per acre from the most profitable land employment alternative which is external to the model. These alternative employment opportunities compete with the forage production activities for use of each acre of the owned land resources available.

As there are 33 categories of owned land (11 forage varieties grown on 3 different soil groupings), there are 33 activities in this block. Each such activity is

Table 4.2. Intermediate Activities.

		Selected Forage Production Activities																	
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4
		4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	5
		0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
		1	2	3	4	5	6	7	8	9	0	1	1	2	1	2	3	4	1
Obj Function	N 20000	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	4	4	4
Silo Storage	L 32302																		C
Owned Land																			
Bottomland	L 33001																		
Hillsides	L 33101	C	C	C	C	C	C	C	C	C	C	C							
Upland	L 33201												C	C					
Total Acres	L 33301	C	C	C	C	C	C	C	C	C	C	C	C	C					
Owned Hillsides																			
Native Pasture	G 33501	C																	
Korean Lespedeza	G 33502		C																
BFT	G 33503			C															
New Seeding	G 33504				C														
Orchard Grass	G 33505					C													
Tall Fescue	G 33506						C												
Alfalfa/grass	G 33507							C											
Red clover/grass	G 33508								C										
Straw & aftermath	G 33509									C									
Cornstalks - graze	G 33510										C								
Cornstalks - mech hvt	G 33511											C							
Owned Upland																			
Native Pasture	G 33601												C						
Korean Lespedeza	G 33602													C					
Rented Upland																			
Orchard Grass	L 33905														C				
Tall Fescue	L 33906															C			
Alfalfa/grass	L 33907																C		
Red clover/grass	L 33908																	C	
TDN Account/period																			
April	E 34001	2		2		2	2	2					2						
May	E 34002	2		2		2	2	2	2				2						
June	E 34003	2	2	2		2	2	2	2				2	2					
July	E 34004	2	2	2	2	2	2	2	2	2			2	2	2	2		2	
August	E 34005	2	2	2	2	2	2	2	2	2			2	2	2	2		2	
September	E 34006	2	2	2	2	2	2	2	2	2			2	2	2	2			3
October	E 34007	2	2			2	2		2	2	2	2	2	2	2	2		2	
November	E 34008	2				2	2	2			2	2	2		2	2	2		
Wtr - 2nd & 3rd cuts	E 34009					2	2				2	2			2	2	2	2	
Wtr - 1st cut hay	E 34010														2	2	2	2	
Transfer hvt forage	E 34011																		
Transfer stored forage	E 34012																		
Corn Silage Acres	L 34101																		C
Corn Silage hvt hrs	L 34102																		B
Stack Hvt hrs - Nov	L 34201											B							
Labor Account/period																			
April	L 34501																		
May	L 34502																		
June	L 34503																		
July	L 34504																		
August	L 34505																		
September	L 34506																	B	
October	L 34507																		
November	L 34508											C							

constrained by the amount of land available. Thirty-three (33) of the constraints are of the 'greater than' type and simply provide an accounting of the land use. The four (4) constraints which limit the land-use activities and are of the 'less than' type are those reflecting the amount of bottomland, hillsides, upland, and total acres available. Each a_{ij} in this block is a one (1). Such an a_{ij} reflects that land employment by the jth land opportunity cost activity requires one acre of the ith land type. The c_j or objective function value for each land opportunity cost activity is the net return from one acre of that land type as employed by this alternative activity. The calculation method for this c_j is discussed in Appendix B, section entitled Program PVLAND.

Table 4.3 summarizes the discussion in this section.

3. Land Rental Activities

Land rental is one form of land control that provides an alternative to land ownership. To simplify the model, only cash rental of land is considered.

Much of the discussion in the section on Intermediate activities is applicable to the land rental activities and will not be repeated here. Suffice to say, is that land is rented for the purpose of providing an intermediate product - forage - for the production of beef.

There are forty-five (33 forages harvested via grazing plus 12 forages which can be mechanically harvested) land

Table 4.3. Land Opportunity Cost Tableau.

	Land Opportunity Cost Activities for Owned Land[1]																															
	13001	13002	13003	13004	13005	13006	13007	13008	13009	13010	13011	13101	13102	13103	13104	13105	13106	13107	13108	13109	13110	13111	13201	13202	13203	13204	13205	13206	13207	13208	13209	13210	13211
N 20000	D	D	D	D	D	D	D	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
L 33001	C	C	C	C	C	C	C	C	C	C	C																						
L 33101												C	C	C	C	C	C	C	C	C	C	C											
L 33201																							C	C	C	C	C	C	C	C	C	C	C
L 33301	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
G 33401	C																																
G 33402		C																															
G 33403			C																														
G 33404				C																													
G 33405					C																												
G 33406						C																											
G 33407							C																										
G 33408								C																									
G 33409									C																								
G 33410										C																							
G 33411											C																						
Hillside Acres																																	
G 33501												C																					
G 33502													C																				
G 33503														C																			
G 33504															C																		
G 33505																C																	
G 33506																	C																
G 33507																		C															
G 33508																			C														
G 33509																				C													
G 33510																					C												
G 33511																						C											
Upland Acres																																	
G 33601																							C										
G 33602																								C									
G 33603																									C								
G 33604																										C							
G 33605																											C						
G 33606																												C					
G 33607																													C				
G 33608																														C			
G 33609																															C		
G 33610																																C	
G 33611																																	C

[1] 13001 - 13011 Bottomland Activities
13101 - 13111 Hillside Land Activities
13201 - 13211 Upland Activities

rental activities. Each activity is limited by an analogous 'less than' restraint for that forage-soil combination. The RHS for each of these constraints is the acreage amount of the forage-land combination which can be rented. Each a_{ij} is one and reflects that one acre of the jth forage-land activity requires one acre of the ith land type. The c_j for each rented acre reflects the cash rental costs plus other variable production costs. Calculation of this c_j is discussed in Appendix B, section entitled Program PVLAND.

Sections of Table 4.2 can be consulted as a capsule summary of this section.

4. Forage Harvesting Systems

Eight (8) different mechanical harvest systems were modelled for each of two (2) forage harvesting periods. This combination provides sixteen (16) alternative forage harvesting activities. The common unit of measure for each of these systems is tons of total digestible nutrients (TDN).

The purpose of these harvest systems is to provide a mechanism for transferring the forage in the field to a form of stored forage available for winter feeding.

Each harvest system requires a resource mix of man and machine. The availability of each resource (as indicated by the RHS) presents a possible constraint to the feasible level of the beef/forage activities. The a_{ij}'s representing these considerations will be positive indicating a demand for the particular resource. Such an a_{ij} indicates the requirements

for the ith resource in order to harvest one ton of TDN via the jth harvest system.

Each harvest system provides a means to transfer forage in the field to forage available for stored feeding. The efficiency of this transfer is variable between harvest systems and between farms. This transferral is modelled via rows 34010 and 34011. For the first cutting of forage, row 34010 accounts for transferring the forage from the field to a harvest system. Row 34011 reflects the efficiency of the respective harvest system in transferring the forage to a particular winter feeding system. For example, an a_{ij} of -.80 indicates that the jth harvest system converted 80 percent of the forage in the field to forage available for stored feeding.

Each forage harvest system is limited to one field of choices for alternative stored feeding systems. These 'mutually exclusive' type constraints are modelled in the following rows:

34901 - feeding small bales (square or round) that were stored in shed,

34902 - feeding small bales (square or round) that were stored in outside stack or field,

34903 - feeding compressed stacks of hay that were stored outside,

34904 - feeding large round bales that were stored outside,

34905 - feeding haylage that was stored in silo.

The c_j for each forage harvest system consists of the variable costs per ton TDN to operate the complex of machinery peculiar to each respective harvest system. The calculation of this c_j is discussed in Appendix B, section entitles Program FORHR.

Table 4.4 summarizes the discussion in this section. Table F.7 in Appendix F presents some of the actual forage harvesting coefficients that were developed and used in the model experimentation.

5. Forage Carryover Activities

Forage is produced by the land and is demanded by the cattle for their growth and maintenance. As modelled, the forage supply can never be less than the forage demand. In the event that during any particular time period, the forage supply is greater than the forage demand, the excess forage is placed in the carryover activity for that period. Thus the carryover activity acts in a programming sense as an equation balancer or slack demand; and in a realistic context provides the means whereby forage 'on the stump' can be carried forward - stored - from time period 't' to time period 't + 1'. In this sense, the carryover activity acts as a mechanism to transfer forage from one time period to the next period.

There are eight (8) forage carryover activities - one activity for each time period interval. These eight

Table 4.4. Forage Harvesting Systems.

		Activities for Forage Harvest Systems & Custom Hire Services[1]																													
		12050	12051	12052	12053	12054	12055	12056	12057	12058	12060	12061	12062	12063	12064	12065	12066	12067	12068	12070	12071	12072	12073	12074	12075	12076	12077	12078	12079	12080	12081	12082	12083	12084	12085	12086	12087	12088	12089	12090	12091
Obj function	N 20000	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4
Tractor Horsepower-Hours Acct																																									
Harvest Period #1	L 31101	C	C	C	C	C	C	C	C																			3	3	3	3	3	3	3	3	3	3	3	3	3	3
Harvest Period #2	L 31102										C	C	C	C	C	C	C	C																							
Machine Hrs - HVST Period 1																																									
Mower	L 31201	B	B	B	B	B	B	B	B																		2														
Conditioner	L 31202	B	B	B	B	B	B	B	B																			2													
Rake	L 31203	B	B	B	B	B	B	B	B																				2												
Sq baler	L 31204	B	B																											2											
Sq baler w/accum	L 31205			B																											2										
Sq baler w/throw	L 31206				B																											2									
Stack system	L 31207					B																											2								
Small rd baler	L 31208						B																											2							
Large rd baler	L 31209							B																											2						
Chopper & wagon	L 31210								B																											2					
Blower	L 31211								B																												2				
Machine Hrs - HVST Period 2																																									
Mower	L 31301										B	B	B	B	B	B	B	B																							
Conditioner	L 31302										B	B	B	B	B	B	B	B																							
Rake	L 31303										B	B	B	B	B	B	B	B																							
Sq baler	L 31304										B	B																													
Sq baler w/accum	L 31305												B																												
Sq baler w/thro	L 31306													B																											
Stack system	L 31307														B																										
Small rd baler	L 31308															B																									
Large rd baler	L 31309																B																								
Chopper & wagon	L 31310																	B																							
Blower	L 31311																	B																							
Forage Storage Req																																									
Barn	L 32301	C			C						C				C																										
Silo	L 32302									C								C																							
TDN Account/period																																									
Wtr feed - 1 cut	E 34010	C	C	C	C	C	C	C	C																																
Forage transfer	E 34011	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2																							
Wtr feed - 2 & 3 cuts	E 34013										C	C	C	C	C	C	C	C																							
Labor Account																																									
May	L 34502	C	C	C	C	B	B	B	C																		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
June	L 34503	C	C	C	C	B	B	B	C																		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
July	L 34504										B	B	B	B	B	B	B	B																							
August	L 34505										B	B	B	B	B	B	B	B																							
September	L 34506										B	B	B	B	B	B	B	B																							
October	L 34507										B	B	B	B	B	B	B	B																							
Wtr Feed System Account																																									
sm bales - inside	E 34901	C			C						C				C																										
sm bales -outside	E 34902		C	C			C					C	C				C																								
Stacks - loose	E 34903					C										C																									
Large bales	E 34904							C										C																							
Haylage	E 34905								C										C																						

[1] 12501 - 12508 Forage Harvest System for May period.
12601 - 12608 Forage Harvest System for June period.
12701 - 12710 Custom hire-in Services for May period.

activities transfer to time period 't + 1' that forage produced but not consumed in time period 't'. In addition, there is: (1) an activity that transfers available but unconsumed forage in November to winter feeding availability, (2) an activity that transfers harvested forage to next year's beginning forage inventory, and (3) an accounting activity for each of three (3) types of beginning forage inventory, i.e., hay, haylage, and corn silage; plus an activity that allows this beginning forage inventory to become available for current year's livestock production.

Each forage carryover activity has only two (2) a_{ij}'s and no c_j. The first a_{ij} in each activity is the coefficient of one. This a_{ij} simply balances the supply and demand for forage during the ith (i = j) time period. The second a_{ij} for each carryover activity represents the percentage amount of the TDN that can be 'stored on the stump' and carried forward to the following time period. For example, an a_{ij} (i = j + 1) of -.95 indicates that 95 percent of the forage TDN produced but not consumed in the jth time period can be carried forward to the ith time period. (The actual a_{ij}'s used are presented in Appendix B, Program LABEL.) No variable cost is associated with this forage carryover. Thus the c_j for each carryover activity is zero.

This section is summarized in Table 4.5.

Table 4.5. Forage Inventory and Carryover Tableau.

		Forage Inventory & Carryover Activities[1/]													
		12901	12902	12903	12904	14801	14802	14803	14804	14805	14806	14807	14808	19909	19910
Forage Storage Req															
Barn	L 32301	C													
Silo	L 32302		C	C											
Forage Inventory															
Hay	L 32401	C													
Haylage	L 32402		C												
Corn Silage	L 32403			C											
Total Forage	L 32404	2	2	2	C										
TDN Account/period															
April	E 34001				2	C									
May	E 34002					2	C								
June	E 34003						2	C							
July	E 34004							2	C						
August	E 34005								2	C					
September	E 34006									2	C				
October	E 34007										2	C			
November	E 34008											2	C		
Wtr	E 34009												2	C	
1st cut	E 34010														
transfer	E 34011				2									2	C
Desired Forage Inv	G 39909														C

1/ 12901 - 12903 Hay, Haylage, and Corn Silage Inventory Activities, respecively.
12904 Total forage inventory transferred and made available for use during year.
14801 - 14808 Forage Carryover Activities
19909 Transfer of unconsummed forage to winter availability.
19910 Transfer of harvested forage to carryover inventory for next year.

6. Stored Feeding Activities

As discussed in Appendix B, Program MISC; there are four (4) basically different winter feeding systems. Combining these four (4) systems with the five (5) alternative forage packages presented in section 4 of this chapter results in twenty (20) stored feeding activities.

The purpose of these stored feeding activities is to transfer forage which was stored during the growing season to an available winter feed for the cattle. Only via these activities can cattle be maintained during the winter season. The common unit of measure for each feeding activity is tons of total digestible nutrients (TDN).

Each stored feeding system has an associated efficiency index representing the portion of the forage fed that is actually utilized by the beef animal. This conversion is represented in rows 34011 and 34012. The a_{ij}'s in row 34011 are each one and simply indicate that a ton of TDN fed via the jth feeding activity will require one ton of forage TDN from one of the forage harvesting activities. The a_{ij}'s in row 34012 represent the conversion efficiency - a forage wastage indicator. For example, an a_{ij} of -.85 indicates that 85 percent of the forage fed via the jth system is actually utilized by the beef animal.

Each stored feeding activity has an associated labor requirement. This coefficient is given in row 34509. For example, an a_{ij} of 0.5 indicates that 0.5 man-hours are

required to feed one ton of TDN via the jth feeding system.

Rows 34901 through 34905 are mutually exclusive type restraints. Each a_{ij} in these rows is -1.0. These negative coefficients are balanced by the positive a_{ij}'s of one in the forage harvesting activities. These constraints simply match each forage harvest system to a particular set of efficiency and labor coefficients for the feeding of that particular forage. These constraints are necessary in order to evaluate the different labor requirements and feed efficiency indexes for the different types of forage packages. For example, different input-output coefficients would be required for the feeding of large round bales vis-a-vis small round bales.

Table 4.6 summarizes the discussion of this section.

7. Beef Cow-Calf Production and Finance Systems

There are thirty (30) alternative beef cow-calf production activities included for evaluation in this model. These activities result from six (6) alternative calving months being combined with (5) different sets of beef management system parameters. These beef management systems reflect alternatives with respect to calving schedules, calf weaning rates, herd replacement policies, calf marketing policies, and the bull stocking rate. In addition to these production activities, there are two (2) activities to indicate the beef cow-calf systems currently being operated

Table 4.6. Winter Stored Feeding Systems.

	Stored Feeding Activities																			
	14901	14902	14903	14904	14905	14906	14907	14908	14909	14910	14911	14912	14913	14914	14915	14916	14917	14918	14919	14920
Transfer hvst forage to stored forage E 34011	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Transfer stored forage to cattle E 34012	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Labor Account/period																				
April L 34501																				
May L 34502																				
June L 34503																				
July L 34504																				
August L 34505																				
September L 34506																				
October L 34507																				
November L 34508																				
Winter L 34509	C	C	C	C	C	C	C	C	B	B	B	B	B	B	B	B	B	B	B	C
Winter Feed System Account																				
sm bales-inside E 34901	2	2	2	2																
sm bales-outside E 34902					2	2	2	2												
Stacks - loose E 34903									2	2	2	2								
Large bales E 34904													2	2	2	2				
Haylage E 34905																	2	2	2	2

by the firm. The common unit of measure for these thirty-two (32) activities is the beef cow-herd unit. The components of this measure are explained in Appendix B, section entitled Program TDNR.

Each cow-calf activity involves: (1) generating a flow of net revenue (can be either negative or positive), (2) an annual capital outlay for replacement stock unless all such stock is raised from present cows on hand, (3) feed inputs for growth and maintenance, and (4) man-hours of labor.

The net revenue contribution is based on gross product sales minus stock purchase and replacement costs, and production costs. This contribution is modelled as the c_j in the objective function for each respective jth beef production activity. The actual technique of calculation is discussed in Appendix B, section entitled Program PVBEEF.

The required capital investment for the first year is modelled in row 34601. Each a_{ij} indicates the dollar investment cost for stock cows in the jth beef activity. This capital is obtained from the cash on hand at beginning of period and/or a line of credit available for purchase of beef animals. Each a_{ij} in these finance activities is a one (1) indicating that each dollar for the jth activity requires one dollar from the ith resource; i.e., the cash on hand or credit. Cash on hand is furnished at zero cost whereas credit is obtained at the prevailing interest rates. These costs are reflected in the c_j's for the jth source of funds.

The required forage inputs per time period are shown in rows 34001 - 34008 and 34012. Each a_{ij} indicates the tons (or portions thereof) of TDN required by the jth beef production activity during the ith time period.

The required labor input is indicated in rows 34501 - 34509. Each a_{ij} signifies the man-hours of labor required per beef cow-herd unit for each time period. For example, an a_{ij} of 1.2 states that the jth beef cow-calf production activity requires 1.2 man-hours of labor during the ith time period.

Table 4.7. summarizes the discussion in this section.

8. 'Buy Calf-Sell Yearling' Production and Finance Systems

The purchase and feeding of calves provides a forage-utilization technique that does not require the maintenance of beef stock cows. Calves may be purchased in four (4) alternative time periods during the year. Such calves may be carried on forage for five (5) different lengths of time. In this manner, twenty (20) alternative calf-yearling systems are provided. The common unit of measure for these activities is one (1) calf.

The modelling discussion in the previous section is applicable to the calf-yearling activities and will not be repeated herein. It should be made apparent that the calf activities are in direct competition with the cow-calf processes. The forage, labor, and financial resources may be

Table 4.7. Beef Production and Finance Systems.

		Selected Cow-Calf, Calf-Yearling Activities[1]																			
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6
		0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	6	6	6	1	3
		0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	0	0	0	0	0
		1	2	3	4	5	6	7	8	9	0	6	7	8	9	0	1	2	1	1	1
Obj Function	N 20000	D	D	D	D	D	D	D	D	D	D	4	C	C	D	D	E	E	2		
Beginning cash	L 31002																			C	
TDN Account/period																					
April	E 34001	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B	B			
May	E 34002	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B	B			
June	E 34003	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B	B			
July	E 34004	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B	B			
August	E 34005	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B	B			
September	E 34006	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B	B			
October	E 34007	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B	B			
November	E 34008	B	B	B	B	B	B	B	B	B	B			B	B	B	B	B			
Wtr - Carryover	C 34009																				
Wtr - 1st cut	E 34010																				
Transfer -hvst	E 34011																				
Transfer - store	E 34012	C	C	C	C	C	C	C	C	C	B	B	B	B	B	B	C	C			
Labor Account/period																					
April	L 34501	C	C	C	C	C	C	C	C	C	C		B	B	B	B	C	C			
May	L 34502	C	C	C	C	C	C	C	C	C	C		B	B	B	B	C	C			
June	L 34503	C	C	C	C	C	C	C	C	C	C		B	B	B	B	C	C			
July	L 34504	C	C	C	C	C	C	C	C	C	C		B	B	B	B	C	C			
August	L 34505	C	C	C	C	C	C	C	C	C	C		B	B	B	B	C	C			
September	L 34506	C	C	C	C	C	C	C	C	C	C		B	B	B	B	C	C			
October	L 34507	C	C	C	C	C	C	C	C	C	C		B	B	B	B	C	C			
November	L 34508	C	C	C	C	C	C	C	C	C	C			B	B	B	C	C			
Winter	L 34509	C	C	C	C	C	C	C	C	C	C	B	B	B	B	C	C	C			
K account for livestock	L 34601	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D		C	2	2	
Borrowed K-livestock	L 34602																		C		
Present Beef Cow Inventory																					
Mgt System 1	L 34701																C				
Mgt System 2	L 34702																	C			

[1] 15001 - 15030 Beef cow-calf production activities
15501 - 15520 'Purchase calf - sell yearling' production activities
15601 - 15602 Two activities representing present beef cow systems
16101 Borrow capital to purchase beef livestock
16301 Beginning Cash - Invested in livestock

used by any one of the cow-calf or calf-yearling processes. However, once a resource unit is used by a particular activity, that one unit is exhausted and cannot again be used by another activity.

Table 4.7 presents the modelling of these beef production activities.

9. Hire-in Labor and Machine Services

The activities discussed in this section are included as a means of increasing the resource base of the farm.

a. Labor-hiring Activities. There are nine (9) activities which enable man-hours of labor to be hired in each of the nine (9) time periods. Each hire-in labor activity has a c_j representing the cost per hour of that labor. This c_j is not simply a wage rate but is the present value (cost) of that hour of labor hired in each year of the planning horizon. Each hired labor activity has only two (2) a_{ij}'s. Each a_{ij} is a one (1) and indicates that the hiring of the jth labor activity contributes one (1) hour of labor in the ith (i = j) time period and also exhausts one (1) hour of the limit on hired labor for this ith time period. The modelling structure of these activities is shown in Table 4.8.

b. Machine-hiring Activities. There are twenty (20) activities which allow the hiring-in of ten (10) different machine services during each of the two (2) forage harvest periods. The common unit of measure for each service

Table 4.8. Hired Labor Tableau.

		Hired-in Labor Activities								
		16001	16002	16003	16004	16005	16006	16007	16008	16009
Obj Function	N 20000	3	3	3	3	3	3	3	3	3
Labor Account/period										
April	L 34501	2								
May	L 34502		2							
June	L 34503			2						
July	L 34504				2					
August	L 34505					2				
September	L 34506						2			
October	L 34507							2		
November	L 34508								2	
Winter	L 34509									2
Hired Labor/period										
April	L 36001	C								
May	L 36002		C							
June	L 36003			C						
July	L 36004				C					
August	L 36005					C				
September	L 36006						C			
October	L 36007							C		
November	L 36008								C	
Winter	L 36009									C

activity is one (1) hour. These custom-hired-in machine services provide an alternative to the ownership of forage harvesting machinery.

Each hired-in machine service has four (4) coefficients associated with it.

1. Cost of machine service - This coefficient is shown in the objective function. Each such c_j indicates the dollar cost per hour for the jth machine service hired. The calculation of this c_j is discussed in Appendix B, section Program FORHR.

2. A power component to propel the implement - This provision of power is indicated by the size in horsepower. For example, an a_{ij} of sixty (60) indicates that the hiring of the jth machine service for one (1) hour provides sixty (60) horsepower-hours to propel this implement.

3. An hour of machine time - This is indicated by an a_{ij} of one (1) which simply states that hiring of one (1) hour of the jth machine service provides one (1) hour of the ith machine resource (i = j).

4. An hour of man time - This is indicated by an a_{ij} of one (1) which states that the hiring of one (1) hour of the jth machine service also provides one (1) hour of man time during the particular forage harvesting period.

Table 4.4 presents the modelling of these machine custom-hire activities.

C. Intent and Summarization of the LP Programming Matrix

The intent and logic of this programming matrix is to model activities of the beef/forage enterprise in such a manner that realistic answers can be provided to those decision problems posed in Chapter III. Answers to these problems should reflect the effect of the resource situation, management efficiency factors, price expectations, and scheduling problems which are unique to each farm.

With respect to the beef production systems *per se*, decisions are rendered on the number of animals in each system which enters the basis (answer set). If no beef systems enter the basis, all resources are employed in their best alternative use. In the event that beef activities enter the solution, the forage production, harvesting and storage systems to provide forage feedstuffs are determined.

Each forage production system is evaluated as to which system(s) most adequately fulfill the forage demand of the beef production systems. The selection of a forage production activity is based upon the cost of production, the total amount of forage produced, the annual distribution of this yield, and the method of harvest; i.e., grazing vs. mechanical harvest.

In the event that the beef enterprise is maintained as a year-round enterprise, e.g., beef cow-calf systems enter the basis; some provision to supply forage feedstuffs during the winter period is necessary. In such a situation,

it is necessary to mechanically harvest forages and store such feedstuffs until demanded in the winter period. To recognize this problem area, some forage production activities are modelled which allow mechanical harvesting of this growth. Several alternative mechanical harvest techniques are included in order that the optimal harvest system may be selected. The choice of the forage harvest-storage system(s) considers currently available machine and building facilities, labor available during harvest periods, the variable cost per ton for each harvest system, and the physical resource requirements; i.e., man-hours, tractor horsepower-hours and machine hours required to harvest each ton of forage TDN. Once the forage is harvested and stored, alternative winter feeding systems are evaluated as the means to transfer the supply of stored forage to meet the forage demand by the beef animals.

It may be profitable to bring in additional resources if the currently available resources are inadequate to handle a particular level of beef/forage production activities. Such alternatives are provided via the inclusion of activities for custom-hiring machine services, machine and building investment, and hiring-in labor services. If it is profitable to further expand the beef production activities, land to produce forage may be rented-in, and money may be borrowed to finance purchase of additional beef animals.

This chapter has been very specific in explaining the activity-resource relationships that are modelled in the programming matrix for the beef/forage enterprise. The following chapter will briefly discuss the flow of information into, through, and out of this programming matrix.

CHAPTER V

ACCESSING AND USING THE BEEF/FORAGE MODEL

The algorithmic and modelling relationships of the beef/forage model have now been specified in detail. This chapter will proceed with a discussion of the mechanical techniques required to access and use the beef/forage model. Discussed herein will be the input form, the data/matrix generator, the algorithm, and the report writer. The chapter will close with suggested alternative usages of the beef/forage model.

A. Collecting the Data - The Input Form

As indicated in section E, Chapter III; the information flow is initiated by the user completing an input form. The input form was developed in order to make this model available for extension application. A well-developed input form enables farmers to easily provide coefficients required to describe their unique situation. The data gathered by the input form may then be processed, transformed, and generated into the format required by the algorithm.

1. Characteristics of the Input Form

One prerequisite for obtaining a realistic solution for each unique farm situation is user-flexibility in entering

reliable data to provide an accurate description of the farm resource situation, production coefficients, expected prices, etc. To aid in the securing of reliable information, two (2) safeguards were incorporated into the input form. The first safeguard is that all requested information be in terms familiar to the farmer-user. In this manner, farmers can use their own experience, instinct, and farm records in evaluating the reasonableness of each coefficient. This safeguard can be described as the Clarity requirement of the input form.

A second safeguard to insure reliability of the input data is the provision of base plan data for each potential data entry. With this provision, the user need only change those data entries with which he disagrees or which are inappropriate in providing an accurate description of his situation. An additional benefit is that the user has an example data entry which may aid in explaining what information is being requested.

The disadvantage other than developmental cost of providing this base plan information is that it may bias the entries provided by the user. The benefit is that a reliable example is provided for each data entry. These example entries have been evaluated by several professional personnel of the various agricultural disciplines and should provide a useful benchmark for the farmer-user. Another benefit in allowing farmers to use the provided figures is that it

reduces the amount of their time invested in determining the coefficients and filling-out the form. It appears desirable to minimize the time and frustration involved in filling-out an input form in order to increase participation and use of the model.

2. Description of the Input Form

The input form consists of an introduction which indicates the model's purpose and the decisions that can be rendered, followed by four (4) sections used to gather the data. These four (4) sections may be outlined as follows:

I. Resources Available

- A. Land
- B. Labor
- C. Capital Goods; e.g., machinery and storage facilities used for forage
- D. Cash-on-hand and debt situation

II. Resources Required

- A. Machine-hour requirements for Forage Harvesting
- B. Man-hour requirements for Forage Harvesting
- C. Man-hour requirements for care and feeding of Beef Animals
- D. Feed requirements for Beef Animals

III. Beef Systems

- A. Production Levels and Efficiency Factors
- B. Factors to describe 'beef cow-calf systems'; e.g., herd replacement policies, calving months, Marketing policies, etc.

C. Factors to describe 'purchase calf-sell yearling' systems

IV. Price and Cost Information

A. Beef Price Expectations

B. Custom Rates for hiring-in machine services.

This form requests approximately 1000 entries. Many of these potential entries will not be required if the user prefers to utilize the base-plan figures.

The complete input form is presented in Appendix G.

B. The Data/Matrix Generator

The purpose of the matrix generator is to transform and arrange in MPS format the data collected in the input form. Modelling the seven (7) year planning horizon into a one (1) period model requires that the flow of income and expenses for each activity be compacted into one value - a c_j for each activity. This compaction is achieved by discounting the monetary flow from each activity into a 'present value'.

Physical supply and demand coefficients are also collected and transformed. For example, the supply and demand for forages can occur in each of the nine (9) seasonal time periods modelled; i.e., April - November plus a winter period. The generator using the source data collected in the input form calculates: (1) the forage demanded in each seasonal time period by each beef activity; and (2) the forage supplied in each seasonal time period by each forage/land activity. Similar calculations are performed for the supply and demand for labor.

Upon completion of all calculations to determine the values for each c_j, a_{ij}, and RHS; these coefficients are arranged into a programming matrix. The particular arrangement is known as MPS and consists of arranging all data in column order. That is, column 1 is entered and read in toto before proceeding to column 2, etc. The integerized activities must be the first columns on the left-hand side of the matrix. The right-hand sides are entered as the last column on the right-hand side of the matrix. The particular arrangement of the beef/forage enterprise is presented in Chapter IV. A more detailed discussion of the data/matrix generator is presented in Appendix B.

C. The Algorithm

A mixed-integer linear programming code was used to determine the optimal mix of activities in the beef/forage enterprise. This particular code allows consideration of discontinuous, integerized activities, e.g., capital investments in machinery. Such activities enter the solution code at either the zero or one level. That is, either the activities are not in solution or the entire activity is in solution at its specified level.

The algorithm receives the programming matrix that was prepared by the matrix generator. Via an iterative revised simplex solving procedure, the optimal mix and level of activities is determined and presented in an 'answer matrix' format. This answer matrix is then sent to the report writer

for interpretation and organization. This step is discussed in the following section.

D. The Report Writer

The 'answer matrix' as generated by the algorithm would have little or no meaning to the man-in-the-field who uses the beef/forage model. By reinterpreting and organizing the information contained in the answer matrix, the report writer bridges the gap between the user and the algorithm.

The decisions rendered by the algorithm and the financial results therefrom are presented in five (5) tables: (1) the Farm Plan, (2) Cash Flow Summary, (3) Net Income - Profit & Loss - Statement, (4) Value of Additional Resources, and (5) Labor Requirements. It is intended that these tables be self-administered; i.e., that the information presented is readily understandable to the farmer with nominal aid of extension personnel.

Each statement prepared by the report writer will now be presented and discussed. For a more detailed account of how the report writer operates, see Appendix D.

1. Farm Plan

The farm plan conveys the decisions relevant to the actual physical operation of the farm. Presented herein are the details on proposed cow-calf and calf-yearling enterprises. Information on land utilization, forage handling systems, and additional capital investments is also

presented. Table 5.1 illustrates the information contained in the Farm Plan. Subroutine PLAN (source listing presented in model documentation) is the routine that organizes the Farm Plan table.

a. Beef Enterprise Information. Section A of the Farm Plan table contains the pertinent information identifying the nature of the beef operations brought into solution. If a cow-calf operation is currently conducted on the farm and if this particular operation enters the optimal solution, it is identified under the heading 'Continued Operations'. New cow-calf operations in the optimal plan are indicated under the heading 'Added Cow-Calf Systems'. The labels on the columns are to provide additional information on the actual beef management system and are intended to be self-explanatory to the farmer. The cow-calf system number in these reports is identical to that same numbered system described in the input form. In the event that the optimal solution contains the activities of buying calves and selling yearlings, such activities will be identified under the heading 'Buying Calves-Selling Yearlings'.

b. Land Utilization. Section B of the Farm Plan table delineates the forages to be produced on each particular soil management category, and the acreage amount of each forage-land combination. In addition, information is provided as to whether the forage is harvested via grazing or by mechanical means. Any land available but not used for

Table 5.1. Farm Plan.

Section A. Cow-Calf Systems	No. Cows	Calving Month	Age Calf at Sale	Percent Replacement Stock: Raised	Purchased: Open	Purchased: Bred	Purchased: Cow+Calf
Continued Operations System 1	25	April	7	1.0	0.0	0.0	0.0
Added cow-calf systems System 3	17	May	12	1.0	0.0	0.0	0.0

Buying calves-selling Yearlings

No. Calves	Purchase Month	Purchase Weight	No. months on hand	Sale Weight
None				

Section B. Land Utilization

	Land Type	Acres Owned	Acres Rented	Acres Total
Forages Produced For Grazing				
Clover/Gs	Bottomland	6.7	0.0	6.7
CS-Grazed	Bottomland	50.0	0.0	50.0
Native GS	Hillsides	59.6	0.0	59.6
CS-Grazed	Hillsides	10.4	0.0	10.4
Native GS	Upland	55.0	0.0	55.0
Forages Mechanically Harvested				
Alfalfa/GS	Bottomland	9.4	0.0	9.4
Clover/GS	Bottomland	8.9	0.0	8.9
Acres Not Used By Beef/Forage Enterprise				
	Bottomland	0.0		
	Hillsides	0.0		
	Upland	0.0		

Section C. Forage Harvesting Systems

	Tons DM harvested
First Cutting STCK Loose	46.1
Second and/or Third Cutting STCK Loose	30.5

Section D. Forage Winter Feeding Systems

Type of Hay Package	Feeding Method	Tons DM Fed During Winter
COMP Stack	Limit-RACK	76.58

Section E. New Investments

Breeding Cattle Investments (Year 1)

	No. Units	Purchase Month	Investment Cost
Open Heifers	17	July	$5397.65

Machinery Investments

None

the beef/forage enterprise is also specified.

c. Forage Harvesting Systems. Section C of the Farm Plan table indicates the method of mechanical forage harvest, and the tonnage harvested during each of two (2) harvest periods.

d. Winter Feeding Systems. Section D of the Farm Plan table specifies the method used to feed the cattle during the winter period. Also indicated is the quantity of winter forage required to maintain the proposed number of cattle determined in the optimal solution.

e. New Investments. Section E of the Farm Plan table delineates the capital investments for year one of the planning horizon. Breeding cattle purchased for replacement stock or for additional beef systems are included whereas the purchase of calves for resale is classified as an expense and is not included as a capital investment. Other capital investments that may occur are the purchase of machinery or the construction of buildings intended for use in the beef/forage enterprise.

2. Cash Flow

To determine the financial feasibility of proposed operating and capital budgets, a financial statement that gathers information on the sources (supply) and uses (demand) of funds is required. In the event that the uses of funds are greater than the funds available, funds must be borrowed in order to maintain a going business.

The sources or supply of funds consist of the initial cash-on-hand, gross revenue generated within the accounting period by the beef/forage activities, plus funds borrowed from outside the business. Depreciation is not classified herein as an operating expense item and thus there is no depreciation add-in as a source of funds.

The uses or demand of funds consist of all cash outlays incurred in the operation of the beef/forage enterprise. Such uses as specified in this model are the cash operating expenses, capital investments, principal payments on all credit obligations, and interest payments.

The cash flow summary developed for the beef/forage enterprise is presented in Table 5.2. This statement summarizes for year one the supply and demand for funds by the beef/forage enterprise. The supply of funds available for this enterprise is indicated by the row labeled 'Total Available Dollars'. The demand for funds is indicated by 'Total Outlay of Dollars'. The 'Cash Balance at End of Year One' is the item that balances the supply and demand of funds. This pro forma (anticipatory) statement should aid the farmer in establishing the need for and the securing of funds for the beef/forage enterprise.

The organization and calculation of the cash flow summary statement occurs in subroutine NETINC. See the documentation for a source listing of this routine.

Table 5.2. Cash Flow Summary.

Beginning Cash on Hand	2500.00
Total Cash Income	4246.66
Money Borrowed for Machinery Investment	0.00
Money Borrowed for Building Investment	0.00
Money Borrowed for Cattle Purchases	2897.66
TOTAL AVAILABLE DOLLARS	9644.33
Total Cash Expenses	1848.57
Total Capital Asset Purchases	5397.65
Total Principal Payments on New Credit	413.95
Total Principal Payments on Old Credit	250.00
Interest Payment on Previous Borrowings	47.50
TOTAL OUTLAY OF DOLLARS	7957.68
CASH BALANCE AT END OF YEAR 1	1686.65

3. Net Income Statement

The pro forma annual Net Income Statement - also known as Profit and Loss Statement for an example farm is presented in Table 5.3.

All anticipated cash flows are delineated in the net income statement. The cash inflows from the beef/forage enterprise are obtained via the sale of beef animals and from the renting-out of available land not used for the beef/forage enterprise. This income is summarized in the row labeled 'Total Cash Income'.

The cash outflows are composed of the variable costs incurred in the production and harvesting of forages, the buying of livestock for purposes of resale, plus any finance charges for additional credit secured. The forage production costs are delineated for each forage-land activity that

Table 5.3. Net Income - Profit and Loss - Statement.

CASH INCOME	No. of Units	Next Year (year 1)	Average Year (years 2-7)
Livestock Operations			
From Cows on Hand			
Cow-calf System 1	25	$4246.66	$2865.92
From Cows to be Purchased			
Cow-calf System 3	17	0.0	2915.01
Buy calves - sell yearlings	None		
Total Beef Cash Receipts		4246.66	5780.93
Total Cash Income		$4246.66	$5780.93
CASH EXPENSES	**No. of Units**	**Next Year**	**Average Year**
Forage Production Expenses			
On Owned Land			
Forages Graces	(acres)		
Clover/GS on Bottomland	6.7	217.04	217.04
CS-grazed on Bottomland	50.0	25.00	25.00
Native GS on Bottomland	59.6	29.82	29.82
CS-grazed on Hillsides	10.4	5.18	5.18
Native GS on Upland	55.0	27.50	27.50
Forages Mechanically Harvested			
Alfalfa/GS on Bottomland	9.4	482.93	482.93
Clover/GS on Bottomland	8.9	290.87	290.87
On Rented Land			
Forages Grazed	(acres) None		
Forages Mechanically Harvested	(acres) None		
Total Forage Production Expense		$1078.34	$1078.34
Forage Harvesting Expenses			
First Cutting	(Tons DM)		
STCK Loose	46.1	94.20	94.20
Second and/or Third Cutting	(Tons DM)		
STCK Loose	30.5	62.42	62.42
Custom-Hired-In Services	(Hours)		
For First Cutting			
STCK WGN	7.6	212.20	212.20
For second and/or third cutting			
STACK WGN	5.0	140.62	140.62
Total Forage Production and Harvesting Expenses		$1587.78	$1587.78
Additional Hired Labor Expense	(Hours) None		
Cost of Purchasing Calves	None		
Interest Expense on Beef/Forage Debts For Beef Animals	$2897.66	260.79	223.53
Total Cash Expenses		1848.57	1811.31
Net Cash Operating Income		2398.09	3969.62
MINUS -- Depreciation on Old Machinery		900.00	900.00
Value of Increased Beef Cow Inventory		1003.03	0.00
Net Farm Profit Before Taxes		$2501.13	$3069.62

enters the optimal solution. The total forage production cost is presented in the row entitled 'Total Forage Production Expenses'. The forage harvesting costs include the variable cost for operating one's own machinery plus any cost incurred for the hiring-in of custom machine services.

The hiring-in of additional labor over and above the presently available labor supply is a variable cost that must be covered by revenue from the beef/forage enterprise. The securing of calves for purposes of resale is classified as a cash expense. The final cash expense included is for the outside financing of machinery, building, or beef animal purchases.

The difference between Total Cash Income and Total Cash Expenses is labeled 'Net Cash Operating Income'. This item is analogous to the 'Gross Margin' concept. Such a measure readily indicates the combined effects of alternative beef/forage systems from the vantage of both variable costs and revenues. For the beef/forage enterprise to be a going business, this amount must be sufficient to cover the annual fixed costs of this enterprise.

By adjusting the net cash operating income for changes in the value of machinery, building, and beef inventories, the 'net farm profit before taxes' is derived. This amount represents the return to unpaid labor, own capital and management.

4. Value of Additional Resources

By definition, the value of an additional resource unit (MVP) is equal to the change in the objective function value; e.g., net income (NI) due to the influence of one more resource unit. That is $MVP_{X_i} = \partial NI/\partial X_i$ where X_i represents the ith resource.

In accordance with the Kuhn-Tucker conditions, it is known that a solution to a maximization problem must satisfy the following condition: $MVP_{X_i} \cdot X_i = 0$ for each resource $i = 1...m$.

Simply interpreted, this condition states that if a resource is constraining, implying available $X_i = 0$, then such a resource has a marginal value; i.e., additional units of the ith resource could increase the value of the objective function. However, if units of X_i are left over once the solution is determined, the value of an additional unit of such a resource is zero.

For purposes of increasing the net income of the beef/forage enterprise, the farmer should be interested in determining those resources which are limiting the level of his beef/forage operation. In accordance with the above explanation, a search is conducted for those resources which are exhausted implying that such a resource has a positive marginal value product.

Subroutine MVP in the report writer conducts the search for those resources that are effective constraints on the

beef/forage enterprise. Due to the nature of the objective function, the MVP's calculated by the algorithm cannot be simply picked-out and presented as the value of an additional resource unit. Remembering that each C_j represents a discounted flow of dollars that occur throughout the planning horizon, the MVP's as initially calculated also represent the discounted marginal valuation for the particular resource used during the planning horizon. Thus, assuming single-valued prices on all resources during the planning horizon, each initially calculated MVP_{x_i} must be adjusted (multiplied) by the factor XX.[1/] Such an adjustment of the MVP_{x_i} derives the marginal value product of the ith resource for use in the average year.

Table 5.4 presents the value of the additional resources for a sample farm. If a particular resource could be secured at the price indicated in Table 5.4., there would be no change in the net worth of the beef/forage enterprise. By the same token, if any particular resource listed in Table 5.4 could be obtained and used at zero cost, the net income from the beef/forage enterprise would increase by the indicated amount. Interpretation of this table by the farmer will probably require some explanatory assistance.

[1/] $XX = R/(1. - (1./((1. + R)^N)))$
Where R = discount rate
N = planning horizon length in years.

Table 5.4. Value of Additional Resources[1/].

Value per Hour for Own Machinery	
Sq Baler for One Hour - First Cutting	$ 16.55
Sq Baler + ACM for One Hour - First Cutting	2.44
Sq Baler + THR for One Hour - First Cutting	12.31
Stack Wagon for One Hour - First Cutting	27.97
Sm Rd Baler for One Hour - First Cutting	4.09
Lg Rd Baler for One Hour - First Cutting	24.24
Blower-Slo for One Hour - First Cutting	1.08
Sq Baler for One Hour - 2nd/3rd Cutting	16.55
Sq Baler + ACM for One Hour - 2nd/3rd Cutting	2.44
Sq Baler + THR for One Hour - 2nd/3rd Cutting	12.31
Stack Wagon for One Hour - 2nd/3rd Cutting	27.97
Sm Rd Baler for One Hour - 2nd/3rd Cutting	4.09
Lg Rd Baler for One Hour - 2nd/3rd Cutting	24.24
Blower-Slo for One Hour - 2nd/3rd Cutting	1.08
Silo Storage Space for 1 Ton DM	64.18
Value of 1 Ton DM in Inventory	81.10
Owned Land-Annual Breakeven Variable Cost/Acre	
For Bottomland	7.08
For Upland	5.14
Rented Land-Annual Breakeven Variable Cost/Acre	
Native GS on Bottomland	3.52
Trefoil on Bottomland	4.72
Alfalfa/GS on Bottomland	6.79
Clover/GS on Bottomland	6.79
Grain Stub on Bottomland	2.96
CS-Grazed on Bottomland	8.28
CS-Harvest on Bottomland	14.74
Grain Stub on Hillsides	.56
CS-Grazed on Hillsides	6.21
CS-Harvest on Hillsides	11.22
Native GS on Upland	4.85
Trefoil on Upland	.47
Clover/GS on Upland	.69
Grain Stub on Upland	2.38
CS-Grazed on Upland	6.21
CS-Harvest on Upland	11.22
Value per Ton Forage DM	
For Forage Growth During April	55.29
For Forage Growth During May	41.06

(continued)

Table 5.4. Value of Additional Resources (Continued)

For Forage Growth During June	$ 43.22
For Forage Growth During July	57.63
For Forage Growth During August	72.04
For Forage Growth During September	29.36
For Forage Growth During October	34.54
For Forage Growth During November	49.34
For Forage Growth From December-March	89.70
For 1st Cut Standing in Field-Fed in Winter	49.23
For Harvested Forages to be Fed in Winter	89.70
For Forage Fed to Beef in Winter	102.55
For 2-3 Cut Standing in Field-Fed in Winter	49.23
Annual Breakeven Value per Cow	
Beef Herd Management System 1	62.23
Value/Hr for Cornstalk Stacker in November	15.82

1/ The values presented indicate the value of one additional unit for each respective resource.

5. Labor Requirements

To aid the farmer in determining his anticipated labor needs, Table 5.5 indicates the amount of labor required in each time period. The organization of this table is accomplished in subroutine MVP (source listing presented in model documentation).

Table 5.5. Labor Requirements

		Own Hours	Hired Labor	Total Labor Hours
April	Hours	63.1	0.0	63.1
May	Hours	71.0	0.0	71.0
June	Hours	71.0	0.0	71.0
July	Hours	45.2	0.0	45.2
August	Hours	45.2	0.0	45.2
September	Hours	45.2	0.0	45.2
October	Hours	51.6	0.0	51.6
November	Hours	40.9	0.0	40.9
Winter	Hours	228.7	0.0	228.7

E. Use of the Model in Farm Decision-Making

The major inpetus for this study was to develop a decision-making model that is applicable to farm firms considering a beef/forage enterprise.

The beef/forage model is capable of providing (suggesting) answers to the following questions and related issues: for a given structural farm; i.e., given the resources available, costs and prices expected, and the production transformations and beef management levels specified; "Is the production of beef via conversion of forage; a viable, economically feasible enterprise for my farm situation?" If the answer is 'no', the farm resources should be employed in their best alternative use as evaluated by the specified objective function. If the answer is 'yes', the following issues are relevant.

1. Beef Production Issues

a. What Type of Beef Enterprise? A major dichotomy is employment of resources via a cow-calf operation vis-a-vis buying weaner calves and selling yearlings.

b. How Many Beef Cow Units are to be Handled Under Each Particular Management System? Parameters which vary and serve to identify the beef cow-calf management systems are calving-weaning efficiencies, creep feeding of calves, herd replacement policies, calving schedule, calf marketing policies, and bull stocking rate.

c. How Many Buy Calf-Sell Yearling Units are to be Managed Under Each Particular System? Each management system may vary by either the month of purchase and/or the length of time which the calves are maintained on forage.

2. Forage Production Issues

a. How many tons of forage dry matter are required to support the amount of livestock in the optimal beef/forage plan?

b. Which forage varieties are to be grown and in what amounts?

c. How many forage acres and which soil management groups are to be employed by the beef/forage enterprise? The choice of the soil management groups is dependent upon the opportunity cost of the various land classes, forage yields, and respective forage production costs.

d. What forage improvement and renovation practices should be followed?

3. Forage Harvesting Issues

a. What is the amount and mix of the various forage varieties that are harvested via cattle grazing vis-a-vis mechanical harvest techniques?

b. Which mechanical harvesting techniques are to be practiced?

Each harvesting technique may be conducted with either one's present machinery, if available; with new machinery if

own machinery is not currently available (implying capital investment is required); or via custom-hiring the machine services.

4. Forage Storage and Winter Feeding Issues

a. What storage and feeding practices should be followed? Basically, the forage may be stored inside a structure (shed, barn, or silo) or outside. The forage may be fed with any one of four (4) alternatives modelled. Each forage storage-feeding combination has particular forage storage and feeding losses. The evaluation of these alternatives and selection of the optimal feeding method considers these forage losses in a tradeoff with the respective costs of feeding; i.e., labor requirements and any monetary costs.

F. Summary

This chapter has followed the flow of information as it is processed by the beef/forage model. Special attention was given to the model's output as prepared by the report writer. The information presented in these physical and financial reports constitutes the decisions and the results therefrom as rendered by the model. Chapter V closes with some suggestions of the type of questions for which the beef/forage model may provide an answer.

The following chapter will develop farm plans for example farms with the explicit purposes of validating the beef/forage model.

CHAPTER VI

TESTING AND VALIDATION OF MODEL

This chapter opens with a discussion of model validation and the testing technique used to validate the beef/forage model. A structural farm situation is defined to provide a framework in which the sensitivity of the model can be established. The chapter closes with an interpretation of the results generated by the beef/forage model.

A. Validation

To verify or validate a model requires evidence of the model's ability to perform in an adequate fashion in the real world. This performance may involve *a priori* forecasting as in an econometric model. Or, it may involve the ability of the model to generate and evaluate alternatives in a decision-making context as in a mathematical programming approach. Evaluation of a model's adequacy revolves about the question of how well the model serves its intended purpose.

Naylor and Finger present three (3) philosophically different approaches to the problem of validation.[1] These

[1] Naylor, Thomas H. and J. M. Finger. "Verification of Computer Simulation Model." *Management Science*, Vol 14, No. 2, pp. B92-B101. October 1967.

position approaches are rationalism (synthetic a priorism), empiricism (logical positivism), and positive economics. Also suggested is a combination approach labeled multi-stage verification. The procedural steps in this approach are:

1. Form a set of postulates or hypotheses describing the behavior of the system of interest.

This formation requires specification of the dependent and independent variables as well as the functional relationship between these two sets of variables.

2. Verify the postulates on which the model is based subject to limitations of existing statistical tests.

3. Test the model's ability to predict behavior of the system.

Validation in the manner just described can be conducted in a laboratory environment. However, it should be noted that the real test of a prescriptive model such as the one built herein rests with its ability to aid decision-makers in solving their own unique problems. Validation in this context can only be conducted over time as more people use the model and complete the feedback loop to those concerned with building and evolving such models.

In the problem being addressed, there is no historical series of data with which the model's predictions can be compared. Thus the classical goodness of fit tests are inappropriate.

However, a performance function can be conceived and data can be generated via the model in order to observe the response of the dependent variable. Thus, in accordance with the multi-stage verification process described earlier, the following steps were conducted:

1. Specification of a General Response Function

$Y = f(X_1, X_2, X_3)$

Where Y - dependent variable: the change in net worth of the beef/forage enterprise

X_i - independent variables

2. Identification of Independent Variables

a. Variable X_1 - Beef Price Index. The model utilizes beef prices for six (6) different categories of beef animals. Two (2) sets of price data are used in generating each observation. That is, the model utilizes expected prices for year one of the planning horizon plus an additional set of prices for years two - seven of the planning horizon. The actual prices used by the model to generate the observations of the dependent variable are presented in Appendix E, Table E.1.

b. Variable X_2 - Beef Managerial Index. Two (2) variables were specified to define the measure of beef managerial efficiency. These defined variables are: (1) the calf weaning percentage for each month of the year, and (2) the rate of gain for weaner calves during the warm grazing months

and during the winter. The actual level of these variables is presented in Appendix E, Table E.2.

c. Variable X_3 - Forage Yield Index. Combining the three (3) soil management groups with the ten (10) alternative forage varieties creates 30 forage-land combinations. Each such combination has an associated forage yield. It is these 30 forage yields which are varied in the simulated model runs. In determination of the performance function, these yields are collapsed into one forage yield index for each observation of the dependent variable. The actual level of these forage yields as grown on bottomland, hillsides, and upland are presented in Appendix E, Tables E.3, E.4, and E.5 respectively.

3. Formation of Hypotheses in a Regression Framework

For the function $Y = b_0 \pm b_1X_1 \pm b_2X_2 \pm b_3X_3$

The hypotheses are:

$$H_{o_1} : b_1 = 0$$

$$H_{A_1} : b_1 > 0$$

$$H_{o_2} : b_2 = 0$$

$$H_{A_2} : b_2 > 0$$

$$H_{o_3} : b_3 = 0$$

$$H_{A_3} : b_3 > 0$$

The *a priori* expectations are to reject null hypotheses H_{o_1}, H_{o_2}, and H_{o_3}.

4. Formal Experimental Testing of the Model

(to be discussed in the following section)

It should be noted that subjective evaluation can be advantageously combined with the statistically-based evaluation procedure. In the construction and development of this model, multi-disciplinary professional personnel were used to evaluate the validity of the structural parameters and the structural relationships between these parameters and other variables. Such subjective evaluation should enhance the face validity of the model.

B. Experimental Design

By definition, experimental design can be described as a means for collecting data relevant to the system or problem being studied. In particular, investigation of the response surface is desired. That is, the concern is with the response of the dependent variable Y to a change in factor X_i. For the relationship $Y = f(X_1, X_2 \ldots X_k)$, experimental design techniques can be used to locate X_{iu}; i.e., the uth observation of factor X_i, in an effort to determine the response surface, f.

Experimental design techniques can be used for the following purposes:[2/]

[2/] Hunter, J. S. and T. H. Naylor. "Experimental Designs for Computer Simulation Experiments", Management Science, pp. 422-434. March 1970.

1. To investigate and explain the response surface. The underlying relationships between the dependent variable and the delineated factors can be studied.

2. To determine the optimum combination of factor levels, ceteris paribus for the problem structure and all other variables.

3. To minimize the number of trial runs required to specify the response surface.

4. To provide an analytical structure for the researcher of the problem.

Discussion in this section is premised upon the assumption that the problem area being studied has been or can be modelled in some form; e.g., production function, simulator, or an analytic math program. Another pertinent premise is that the researcher can determine and delineate the important X_i variables affecting the defined response variable, Y.

C. Experimental Design Chosen

The experimental design used is that of central composite. (See Appendix E for a discussion of this and other alternative experimental design techniques.) As the model being analyzed is based upon a linear programming model 'β' - a specified distance from the benchmark parameter values - was selected so as to preserve orthogonality in the dependent variables. In this manner, the implied assumptions of a

linear model are preserved.[3/] For the three (3) factor case, a necessary but not sufficient condition to obtain orthogonality is that the 'β' value must be 1.215.[4/]

The experiment is conducted for a given structural arrangement; i.e., the resource base is constant, and all other variable and equational relationships are held at their present level and form. For the K = 3 factor case, the total number of runs is $2^K + 2K + 1 = 15$.

The central composite design is presented in Table 6.1.

D. Defining the Representative Farms

This section presents the structure of two (2) farms used to test the beef/forage model. Both farm situations are identical with respect to (1) the land and labor resources available, and (2) the activities being evaluated. The main differentiating factors are that farm situation #1 specifies the forage-land usages and has forage-harvesting machinery available. Farm situation #2 is not locked into these particular production practices. All such alternatives are

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[3/] The assumption being referenced is that a matrix (X) dimensioned by the number of observations and number of independent variables + 1 has full rank. That is, there are no exact linear relationships among the independent (exogenous) variables. The orthogonality assumption carries this a bit further to assume that there is no relationship among exogenous variables - the variables have the property of independence.

[4/] Heady, Earl O. and John L. Dillon. Agricultural Production Functions. Iowa State University Press, Ames, p. 172. 1961.

Table 6.1. The Central Composite Experimental Design.

Observation[1/] Number		Independent (Controlled) Variables		
		Beef Price Index	Beef Managerial Efficiency Index	Forage Yield Index
1.	222	110	110	110
2.	224	110	110	90
3.	242	110	90	110
4.	244	110	90	90
5.	422	90	110	110
6.	424	90	110	90
7.	442	90	90	110
8.	444	90	90	90
9.	333	100	100	100
10.	133	121.5	100	100
11.	533	78.5	100	100
12.	313	100	121.5	100
13.	353	100	78.5	100
14.	331	100	100	121.5
15.	335	100	100	78.5

[1/] The first 8 observations represent the 2^K runs in the cube portion of the design. The 'α' distance is ± 10% from the base value of 100.

The #9 observation is the benchmark run with the base period data. This experimental run can be thought as being at the center of the cubical design.

The #10 - 15 observations represent the 2^K runs on the 'star' portion of the design at a distance ± 'β' = ± 21.5% from the center of the design.

left 'open'. This arrangement allows the computer to select this aspect of the farm plan vis-a-vis the farmer determining the mix of forage production and harvesting practices.

It is intended that these test farms be a realistic proxy representative of a multitude of farms that can feasibly - in an economic sense - employ their resources in a beef/forage enterprise. The basic resources, price relationships, productivity levels, investment opportunities, forage and beef production systems are outlined herein to provide the reader an understanding of the situation being analyzed. The resources available for the beef/forage enterprise are to be those farm resources remaining after consideration for those resources required for other farm enterprises that are definitely to be included in the farm plan. This approach suggests the view that the beef/forage enterprise is considered to be - at least initially - a supplemental enterprise.

The remainder of the discussion in this section follows the format of the input form that was developed and is presented in Appendix G.

1. Farm Situation #1

a. Resources Available.

(1) Land Resource. The test farm is assumed to be of the owner-operator type. This farm encompasses 200 acres that are available for the beef/forage enterprise. This acreage consists of 75 bottom-land acres, 70 hillside acres,

and 55 acres of upland. The current usage disposition of these acres is as follows:

50 bottomland acres in corn which can provide cornstalk refuse for beef;

15 bottomland acres in native unimproved pasture;

10 bottomland acres available for forage - legume or grass;

60 hillside acres in native unimproved pasture;

10 hillside acres available for forage - legumes or grasses;

45 upland acres in native unimproved pasture; and

10 upland acres available for forage - legumes or grasses.

The forage that can be produced from the owned acres, the anticipated cost of production, and the opportunity costs of using these acres for the beef/forage enterprise are presented in Table 6.2.

With respect to the general harvesting alternatives associated with this forage produced, all forages may be grazed. In addition, the forage varieties of orchard grass, tall fescue, alfalfa/grass, and red clover/grass may be mechanically harvested and preserved for winter feeding. Cornstalks may also be mechanically harvested and fed in the winter period.

Specifically for this representative farm, the orchard grass grown on bottomland and hillsides has the first cutting

Table 6.2. Forage Yields and Associated Costs/Acre.

Land Type	Forage Yield (Tons DM/acre)	Annual Variable Cost/acre ($/acre)	Opportunity Cost per acre ($/acre
1. Bottomland			
a) Native Pasture	1.5	.50	5.25
b) Korean Lespedeza	3.0	20.00	5.25
c) Birdsfoot Trefoil	3.5	25.00	5.25
d) Available for New Seeding	1.0	0.00	5.25
e) Orchard Grass	4.0	25.00	5.25
f) Tall Fescue	3.0	20.00	5.25
g) Alfalfa/grass	5.5	35.00	5.25
h) Red clover/grass	4.2	17.50	5.25
i) Small-grain aftermath	0.9	0.25	1.35
j) Cornstalk refuse	1.2	0.50	1.35
2. Hillsides			
a) Native Pasture	1.0	0.50	5.25
b) Korean Lespedeza	2.25	20.00	5.25
c) Birdsfoot Trefoil	2.5	25.00	5.25
d) Available for New Seeding	0.8	0.00	5.25
e) Orchard Grass	2.5	25.00	5.25
f) Tall Fescue	2.25	20.00	5.25
g) Alfalfa/grass	3.5	35.00	5.25
h) Red clover/grass	3.0	17.50	5.25
i) Small grain aftermath	0.5	.25	1.35
j) Cornstalk refuse	1.0	.50	1.35
3. Upland			
a) Native Pasture	1.5	.50	5.25
b) Korean Lespedeza	2.5	20.00	5.25
c) Birdsfoot Trefoil	2.8	25.00	5.25
d) Available for New Seeding	1.0	0.00	5.25
e) Orchard Grass	3.2	25.00	5.25
f) Tall Fescue	3.0	17.00	5.25
g) Alfalfa/grass	4.0	35.00	5.25
h) Red Clover/grass	3.4	17.50	5.25
i) Small grain aftermath	0.8	.25	1.35
j) Cornstalk refuse	1.0	.50	1.35

mechanically harvested with the remainder of the growth available for summer-fall grazing. Orchard grass grown on the upland has the first two cuttings mechanically harvested with the remainder of the forage growth available for fall grazing. The tall fescue grown on bottomland has the first and second cuttings mechanically harvested with the remainder of the growth available for fall grazing. Tall fescue grown on hillsides and upland acres has the first cutting mechanically harvested with the remainder of the growth available for summer-fall grazing. All alfalfa/grass and red clover/grass mixtures are 100 percent mechanically harvested. All forage used by beef is to be grown on the farm - on owned or rented acres. Currently, no provision is allowed for the buying or selling of harvested forages.

The annual distribution of growth for all forages and their respective TDN composition during the year is presented in Appendix F, Table F.1 and Table F.2, respectively.

(2) Labor Resources. The representative farm is assumed to have 80 hours per month of own labor available. This labor component may be comprised of the entrepreneur's own labor and/or any family labor available, and/or any permanent hired labor currently employed on the farm. The labor available is that labor remaining after provision is made for other farm enterprises which are to be definitely included in the farm plan.

Additional hired labor may also be included in the labor resources available. The hourly cost and maximum quantity of

these labor hours that can be procured are specified by the user of the model. The labor situation for the representative farm is presented in Table 6.3.

Table 6.3. Labor Available for Beef/Forage Enterprise.

Calendar Period	Own, Family, and Permanent Labor Hours Available	Wage/Hour for Additional Hired Labor	Maximum Number of Additional Labor Hours Which May Be Hired
	(man-hours)	($/hour)	(man-hours)
April	80.	3.00	160.
May	80.	3.00	160.
June	80.	3.00	160.
July	80.	3.00	160.
August	80.	3.00	160.
September	80.	3.00	160.
October	80.	3.00	160.
Winter	320.	3.00	160.

(3) Financial Resources. The representative farm has a limited amount of own liquid capital available. The current beef enterprise is almost free of debts. A limited additional debt load may be incurred. Debt limits are placed on the amount of credit that may be obtained for the purposes of investing in machinery, livestock, and buildings. The financial situation is presented in Table 6.4.

Table 6.4. Financial Situation for Representative Farm.

Capital Available for beef/forage enterprise			$2500.
Current Indebtedness of beef/forage enterprise:			
	Amount Outstanding ($)	Interest Rate Charged/year (%)	Remaining Years Indebtedness (years)
Short-term debts	500.	9.5	2.
Long-term debts	0.	6.5	0.
Potential New Borrowings:			
	Amount ($)	Interest Rate Charged/year (%)	Length of Loan (years)
Machinery Loan	25000.	9.	5.
Livestock Loan	10000.	8.5	7.
Building Loan	20000.	9.0	15.

(4) Machinery Resources. The representative farm is defined to have a complement of machinery available for forage harvesting. The machinery resources available are presented in Table 6.5.

The capital value of this machinery complement is assumed to be $4500.00.[5/] The remaining expected useful lifetime for

[5/] Machinery Capital Value Charged against beef/forage enterprise = $\sum_{j=1}^{n}$ Machine Value$_j$. PCTMCH$_j$; j = 1...n machines. For financial accounting purposes, the beef/forage enterprise is to be charged that portion of the machine depreciation for which it uses. That portion for each jth machine is specified by PCTMCH$_j$.

this machinery was set at five (5) years.

Table 6.5. Machine Resources Available for Beef/Forage Enterprise.

Machine	Hours Available for 1st Cutting in Spring (machine-hours)	Hours Available for 2nd/3rd Cuttings in Summer/Fall (machine-hours)	Proportion of Annual Machine Time Charged to Beef/Forage (PCTMCH)
50 HP tractor	50.	75.	.50
100 HP tractor	40.	75.	.25
Mower	150.	200.	1.00
Conditioner	150.	200.	1.00
Rake	150.	200.	1.00
Small Round Baler	112.	140.	1.00

(5) Stored Forage Inventory and Storage Facilities. The end of winter hay inventory is specified to be five (5) tons of hay on hand, no haylage, or corn silage.

The available forage storage facilities consist of a structure that can house fifty (50) tons of forage dry matter. No silos are currently available for storage of either haylage or corn silage. The option is provided for capital investment in additional storage facilities. As defined for the representative farm, building consideration is given to construction of a barn or shed that can hold 100 tons forage DM at an investment cost of $4000.00. As the barn is to be

utilized entirely for the beef enterprise, 100 percent of this cost is to be charged against the beef enterprise.

Also considered for construction is a concrete tower silo. The silo is defined to hold 600 tons of corn silage. The cost of this silo plus unloader is placed at $8000.00. As only 50 percent of this silo's capacity is to be used for the beef enterprise, a similar percent of the silo's cost is charged against the beef enterprise in the event that such a structure is built.

(6) Cattle Inventory. Twenty-five (25) beef cows are currently being run on the representative farm. These cows calve during the month of April and are managed under beef system #1 as defined in Appendix F, Table F.10.

b. Resource Requirements.

(1) Resource Requirements for Forage Harvesting. The machine and man-hours required to mechanically harvest and store forage via the forage harvest systems previously described in Chapter III are calculated from the source data presented in Appendix F, Table F.7. It is recognized that these requested resource requirements are a function of the machinery size, forage yields and hauling distances to be traveled. By allowing each user to enter his own data, the uniqueness of each farm situation may be indicated.

(2) Resource Requirements for Beef Animals. Feed and labor requirements for each category of beef animal may be specified for each unique farm situation. The specifications

for the representative farm are presented in Appendix F, Table F.9. The feed requirement is in terms of pounds of TDN required per day per animal while the labor requirements request is in terms of man-hours required per month per animal.

With respect to the winter feeding systems, some labor is required for the handling of each ton of forage fed. The labor required is unique to each feed handling system. The base plan coefficients for this requirement are presented in Appendix F, Table F.11. Forage conversion efficiencies from forage fed to actual forage consumed for nutritional requirements are also presented in this same table.

c. Beef Systems. Information in this section identifies the particular cow-calf and 'buy calf-sell yearling' activities which are considered in the base plan. The beef production efficiency measures are also presented.

The six (6) calving months considered were March, April, May, June, July, and August. Each calving month was assumed to have an 85 percent calf weaning rate - expressed as the number of calves weaned relative to number of cows exposed to bull. These six (6) calving months combined with the five (5) beef management systems delineated in Appendix F, Table F.10 provide the thirty (30) cow-calf activities evaluated in the base plan.

The 205-day old average weight of calves born in March is assumed to be 375 pounds. If creep feeding occurs this

weight is adjusted by the factor of 1.09. In addition for those calves born in April, May, June, July, or August; seasonal weight adjustment indexes of 1.00, .98, .98, .95, and .95 respectively are used to reflect calf weaning weight differentials attributable to calving time.

The expected weight gain per month by weaner calves is assumed to be 45 pounds for the warm grazing months, and 30 pounds for the winter months. Heifers being retained for replacement stock are assumed to gain 30 pounds per month during pregnancy. The weight of a cull cow at sale time is declared to be 900 pounds.

No 'buy calf-sell yearling' systems were considered in the base plan evaluation.

d. Price and Cost Information. The base plan beef prices, price seasonality adjustment factors, and machine custom hire costs are presented in this section. Separate beef price expectations are requested for year one (current year) of the planning horizon and for years two-seven of the planning horizon. Both price series requests are in terms of the average price expected to exist during the respective time period. The forecasted prices used in the base plan are presented in Table 6.6. The price seasonality factors are presented in Appendix F, Table F.12.

With respect to the cost for machine services hired-in, the label on this request is in terms of dollars per machine hour. However, as this machine cost is often quoted in terms

of cost per unit processed such a figure may be used and then converted to cost per hour. This procedure and the associated data are presented in Appendix F, Table F.13.

Table 6.6. Beef Price Expectations.

Item	Expected Average Annual Price for Year 1	Expected Average Price for Next 6 Years (Years 2-7)
Stock Cow and New Calf	450.00/head	350.00/head
Cull Cow	.30/lb	.25/lb
Open Heifer	.45/lb	.37/lb
Bred Heifer	.50/lb	.40/lb
205 Day-old Calf	.56/lb	.43/lb
750 Lb Calf	.49/lb	.38/lb

2. Farm Situation #2

With respect to the farm situation #1, farm situation #2 differs in the following aspects:

1. Except for the 50 acres of bottomland in corn, no land usages were specified. This implies that the decision on use of the remaining 150 acres of the initial 200 acres is made by the model.

2. No forage packaging machine is included in the base resource set of machinery. This omission forces the model to choose the optimum forage harvesting system.

3. The cost of producing forages was increased. This cost is based upon 120 percent of the expected nutrient

removal by each respective forage variety as produced on each soil management group. (See Appendix F, Tables F.3, F.4, F.5, and F.8.)

4. The mechanical forage harvest practice for the red clover/grass sward was changed to harvesting the first two cuttings with the remaining growth being available for fall grazing.

5. The miscellaneous cost of maintaining a cow was increased from $3.00 to $7.00 to reflect depreciation of the bull attributable to each cow unit.

E. Testing the Model

The discussion in this chapter has proceeded from the model validation questions, to experimental design techniques, and to structuring a representative farm. The intent of this section is to now link these components together in an analytical scheme.

1. Analytical Procedure

The analysis process involves four basic steps:

a. Defining the levels of the parameters specified in section VI. A. 2. as the independent variables.

b. Sensitivity analysis; i.e., actually running the model for each observation of the dependent variable as a functional response of the independent variables. The alternative levels of these independent variables are delineated by the experimental design technique discussed in section VI. C.

c. Derivation of a performance function to indicate the functional relationship between the dependent variable - the change in net worth - and the independent parameters being varied; i.e., beef price measure, beef managerial efficiency measure, and the forage yield measure.

d. Testing the hypotheses that were specified a priori.

2. Defining Levels of the Independent Variables

Three (3) variables were delineated as being of great importance in determining the success or failure of the beef/forage enterprise. Each delineated variable assumes a defined base level plus four (4) alternative levels as specified by the central composite design. The actual values for this experimental design are presented in Appendix E, Tables E.1, E.2, E.3, and E.4.

For purposes of determining the performance function, each set of independent variables is collapsed into an index as indicated by each respective column heading in Appendix E, Table E.1 - Table E.4. Via this approach, fewer runs and observations of the independent variables are required in order to preserve sufficient degrees of freedom to test the response coefficient for each parameter being varied.

3. Sensitivity Analysis

Two sets of 15 observations were collected. The first set consists of those observations generated within the structural framework of farm situation #1 as specified in

section D. The second set of 15 observations were generated for farm situation #2.

The generated observations are presented in Tables 6.7 and 6.8.

Table 6.7. Numerical Results for Farm Situation #1.

Observation Number	Dependent Variable Change in Net Worth ($)	Independent Variable Beef Price Index X_1	Beef Managerial Index X_2	Forage Yield Index X_3
1	25151.90	1.1	1.1	1.1
2	22345.91	1.1	1.1	.9
3	21593.49	1.1	.9	1.1
4	19311.97	1.1	.9	.9
5	19995.44	.9	1.1	1.1
6	17730.98	.9	1.1	.9
7	17144.60	.9	.9	1.1
8	15409.64	.9	.9	.9
9	19850.56	1.0	1.0	1.0
10	24824.89	1.215	1.0	1.0
11	15051.98	.785	1.0	1.0
12	22385.64	1.0	1.215	1.0
13	16593.48	1.0	.785	1.0
14	22203.15	1.0	1.0	1.215
15	17382.11	1.0	1.0	.785

Table 6.8. Numerical Results for Farm Situation #2.

Observation Number	Dependent Variable: Change in Net Worth ($)	Independent Variable: Beef Price Index X_1	Beef Management Index X_2	Forage Yield Index X_3
1	27945.19	1.1	1.1	1.1
2	22929.50	1.1	1.1	.9
3	22159.25	1.1	.9	1.1
4	18824.63	1.1	.9	.9
5	20527.05	.9	1.1	1.1
6	17148.72	.9	1.1	.9
7	16538.04	.9	.9	1.1
8	14088.88	.9	.9	.9
9	19944.30	1.0	1.0	1.0
10	26706.46	1.215	1.0	1.0
11	13950.32	.785	1.0	1.0
12	23779.68	1.0	1.215	1.0
13	15317.91	1.0	.785	1.0
14	23653.56	1.0	1.0	1.215
15	16331.33	1.0	1.0	.785

4. Derivation and Use of Performance Functions

To derive a performance function, the independent variables and their respective range of values were specified. Observations of the dependent variable as a function of these independent variables, ceteris paribus, were collected. The task is to now specify and estimate the particular form of this response function.

It may be recalled that the 'β' distance was chosen to make the experimental design orthogonal. To take advantage of

this orthogonality, a second-order polynomial - quadratic equation - must be fitted; e.g., $Y = B_0 \pm B_1X_1 \pm B_2X_2 \pm B_3X_3 \pm B_{11}X_{11} \pm B_{22}X_{22} \pm B_{33}X_{33} \pm B_{12}X_1X_2 \pm B_{13}X_1X_3 \pm B_{23}X_2X_3$.

However, as the algorithm used - mixed-integer linear programming - is premised upon linear production processes; and assuming independent processes, the implied aggregated production function (objective function) should be linear in the independent variables (parameters - X_1,X_2, and X_3). This suggests that the second-order terms in the polynomial expression should not be significant in influencing the dependent variable. Thus to simplify the performance function being estimated and to alleviate potential multi-correlation difficulties, the second-order terms and the first-order interaction terms were discarded.

The resultant expression that was estimated is:

$$Y = B_0 \pm B_1X_1 \pm B_2X_2 \pm B_3X_3.$$

To obtain the elasticity of the dependent response variable as a function of X_1, X_2, and X_3, the above expression was estimated via linear least squares in double log-base e-format. It was felt that this estimation technique would be relatively more helpful in imputing an economic meaning to the estimated coefficients.

The performance function may be used to:[6/]

[6/] Candler, Wilfred and Wayne Cartwright. "Estimation of Performance Functions for Budgeting and Simulation Studies." AJAE, Vol 51, No. 1, pp. 159-169. February 1969.

1. estimate response of dependent variable as a function of alternative values of the independent variables;

2. measure change in dependent variable for marginal changes in the independent variable;

3. locate break-even points; i.e., combinations of the variables that result in a dependent variable level of zero.

Thus the performance function as estimated herein can be used to directly assess the effect of a change in beef prices, a change in beef managerial efficiency, and/or a shift in ability to produce forages. The effect, ceteris paribus, of altering any or all of these factors upon the change in net worth can be directly estimated via the performance function. This technique eliminates the need of additional model runs in order to assess the response of the dependent variable. Caution should be exercised with respect to the parameter values used. Only values within the range of those parameters originally used to estimate the performance function should be allowed. Extrapolation of these parametric values may or may not yield realistic values of the response function depending upon whether the linear model bounds up with any one of the constraints placed upon the model.

It should also be recognized and remembered that the independent factors used in estimating the performance function are themselves a conglomeration of a number of factors. Thus changing the forage yield index, for example, implies

that each and every forage yield changes by this same percentage amount. This occurrence is an unrealistic possibility. However, the usefulness of the technique should be apparent in that some potentially productive areas of research can be identified via high elasticity of response to a particular category of factors. For example, based on the representative farm observations, a one (1) percent increase in the beef managerial index measure would give a positive .71 percent increase in net income (see Table 6.9). Relative comparisons of this type with other factors which can be identified as influencing the success of the beef/forage enterprise should aid in ranking project priorities for research in the beef/forage area.

The estimated performance function is particular to each problem structure from which the observations were collected. That the response coefficients will vary with the problem structure is illustrated in the response functions generated for farm situations #1 and #2.

Table 6.9. Estimation Results for Farm Situation #1.

	Intercept	Beef Price Index	Beef Management Index	Forage Yield Index
b_i Value	4.297311	1.143393	.712398	.562983
Standard Deviation	.000834	.017011	.017011	.017011
T Value	5153.328572	67.213925	41.878042	33.094712

a. Farm Situation #1. Data presented in Table 6.7 were used to estimate the performance function for farm situation #1.[7] The resultant regression coefficients, their standard deviation and T value are presented in Table 6.9. The regression coefficients may be interpreted as the elasticity of the performance function with respect to each respective independent variable.

The testing of hypotheses, via T test, regarding the response of the change in net worth to beef prices, to beef managerial efficiency measure, and to forage yields all support the *a priori* expectations. Each b_i is significant at the one percent level. The R^2, coefficient of multiple determination, is .9986. Care must be exercised in interpreting this value. It must be remembered that least squares technique assumes existance of an error term that possesses homeocedasticy, i.e., equal variances. As the performance function developed here is generated via a deterministic model, there is no error term. An R^2 of less than one simply indicates lack of fit. This R^2 - as used herein - is interpreted as a measure of the adequacy of the polynomial in approximating the shape of the actual function.[8] Based on

[7] To help ensure that the X'X inverse exists; i.e., that the matrix of independent coefficients presented in Table 6.7 has full rank, observation #9 at the center point and observation #8 were omitted.

[8] *Op. Cit.*

the calculated R^2 for this first set of data from the representative farm, it may be said that the first degree polynomial fits quite well the beef/forage enterprise model.

b. Farm Situation #2. Data presented in Table 6.8 were used to estimate the performance function for farm situation #2. Table 6.10 presents the statistical results for farm situation #2. The discussion presented on the estimation method and interpretation of the performance function remains applicable.

The R^2 of .9978 indicates that the estimated first-order polynomial fits quite well the responses of the model. The F value of 1333.4285 indicates that a significant amount of variation of the dependent variable was accounted for by the exogenous variables. Again, each b_i for the independent variables is highly significant and has the expected sign. The absolute level of each b_i is higher relative to those for the initially specified representative farm. By allowing our hypothetical farmer a wider range of alternatives, the expected payoff for greater efficiencies in beef or forage production has increased.

Farm situation #2 is not as constrained as the initially specified representative farm. As suggested earlier, this respecification allows the model to select the optimal forage production combination and the optimal forage harvesting policy. In addition, beef management systems 3, 4, and 5 were slightly altered in that the selling age of the calf was

changed from 7 months to 8, 10, and 12 months, respectively. This change allows the model a greater reaction or response to the beef managerial efficiency measure, in particular.

Due to this opening-up of the alternatives available for selection in the optimal plan, it was expected ex ante that the model would exhibit greater responses to the parametric changes for farm situation #2. That this is indeed the case is illustrated by a comparison of the b_i coefficients in Table 6.9 with those in Table 6.10.

Table 6.10. Estimation Results for Farm Situation #2.

	Intercept	Beef Price Index	Beef Management Index	Forage Yield Index
b_i Value	4.298872	1.484802	1.036889	.863635
Standard Deviation	.001460	.029873	.029873	.029873
T Value	2943.988803	49.703713	34.709846	28.910168

F. Interpretation of Results

Section E. of this chapter discussed the technique used and results derived in testing the beef/forage model. This section will imputate some practical meaning to these test results. The following discussion will pertain to the 15 runs for farm situation #2.

Table 6.11 presents some comparative measures for the 15 observations on farm situation #2. It is stressed that the measures calculated and shown in Table 6.11 are particular

Table 6.11. Beef/Forage Measures Calculated for Farm Situation #2.

Observation Number	Cow Number (#)	Acres/ Herd Unit (#)	Average Gross Returns/ Herd Unit ($)	Average Gross Margin/ Herd Unit ($)	Average Gross Margin/ Acre[1/] ($)	Annual Forage Production Costs (variable costs only) ($)	Variable Cost for Forage/ Herd Unit ($)	Annual Hay Cost ($)	Cost/ Ton Hay ($)	Cost Hay/ Herd Unit ($)	Tons Hay in Winter /Herd Unit[2/] (Tons)
1	51	2.94	186.59	119.02	40.47	2521.78	49.45	1668.04	16.16	32.70	2.02
2	42	3.57	179.25	108.63	30.42	2391.43	56.94	1519.19	18.28	36.17	1.97
3	49	3.06	147.75	97.20	31.75	1656.22	33.80	1349.85	15.84	27.53	1.74
4	38	3.95	139.45	93.21	23.61	1517.95	39.95	1118.89	17.43	29.44	1.68
5	44	3.40	146.73	95.52	28.01	1716.21	39.00	1375.31	15.86	32.26	1.97
6	34	4.41	136.76	90.38	20.48	1330.37	39.12	1122.23	17.43	33.01	1.89
7	45	3.33	119.96	76.90	23.07	1260.64	30.24	1211.06	15.49	26.91	1.74
8	36	4.16	112.85	71.84	17.24	1169.71	32.49	1078.11	17.79	29.95	1.68
9	42	3.57	144.64	94.51	26.46	1587.78	37.80	1283.24	16.75	30.55	1.82
10	50	3.00	182.70	114.77	38.26	2466.88	49.33	1542.21	16.54	30.84	1.86
11	38	3.94	111.00	70.09	17.76	1230.56	32.38	1139.33	16.63	29.98	1.80
12	55	2.72	146.18	88.98	32.63	2454.68	44.63	1542.71	16.55	28.05	1.69
13	43	3.48	114.49	72.69	20.84	1231.58	28.64	1139.94	16.71	26.51	1.58
14	57	2.63	153.7[illegible]	95.11	36.14	2276.31	39.99	1630.23	15.18	28.60	1.88
15	31	4.83	133.82	87.18	18.01	1229.08	39.64	1036.23	18.98	33.43	1.76

1/ This measure represents the net returns after all variable expenses have been covered. It may be viewed as the returns to unpaid resources, e.g., management, labor, and investment.

2/ In addition to the indicated hay consumed during winter, each of the 15 observations had at least 50 acres of cornstalks available for winter consumption.

to the structure of the representative farm and the associated data; i.e., prices, costs, resource levels, and efficiency measures used therein. With respect to these calculated figures, emphasis should be placed - not on whether these figures are transferable and appropriate to each and every beef/forage producer - but rather within the context that these numbers are calculated, does the concept and structure of the developed beef/forage model provide correct information for this particular farm?

1. Beef Systems

a. Current Cow-calf Systems. In each of the 15 observations, the current cow-calf operation came into solution at its present level. Resources were sufficient in all instances to maintain the 25-cow herd. Assuming that beef activities were to enter the solution, *ex ante* expectations would be that the present operation would be the first to enter. This result simply reflects the fact that the current beef systems do not have to incur the investment cost of procuring beef cow stock. Additional beef systems must obtain breeding stock, which *ceteris paribus* must result in relatively lower net returns. However, for expansion of the beef cow herd and for an insight on possible advantageous changes to the current operation, the additional beef systems brought into solution should be checked.

b. Additional Cow-calf Systems. For each of the 15 observations, the cow-calf system added was number five. The major distinguishing differential factor of this system is that the calves are fed on forage for a longer period - until 12 months of age - than are the calves in any of the alternative systems. Calving occurred in May with sale of calves 12 months later.

The fact that the same additional cow-calf system was selected under varying price and production relationships was cause for initiating concern on the model's sensitivity. However, after evaluation via marginal analysis of the most adverse beef alternative available - with respect to forage conversion efficiency to beef and for forage production costs, the solution is indeed optimal with respect to these alternatives.[9/]

[9/] An economically feasible change requires that:

Marginal Value Product $\geq$ Marginal Factor Cost

That is, $\frac{\partial \text{ Total Revenue}}{\partial \text{ Input}} \geq \frac{\partial \text{ Total Cost}}{\partial \text{ Input}}$

$$\frac{\partial \text{ Total Revenue}}{\partial \text{ Total Cost}} \geq 1.$$

Therefore, Δ Output $\cdot$ Price/output unit $\geq$ Δ Input $\cdot$ Cost/input unit

164.85 lbs beef $\cdot$ \$.4069 $\geq$ 2295 lbs forage $\cdot$ \$.00949

\$67.08 $\geq$ \$20.78

An alternative approach: Marginal Rate of Transformation $\geq$ Inverse Price Ratio

$$\frac{164.85 \text{ lbs beef}}{2295 \text{ lbs forage}} \geq \frac{\$.00949/\text{lb forage}}{\$.4069/\text{lb beef}}$$

$$.0718 \geq .0233$$

(continued...)

9/ (Continued)
For this data set, one must conclude that forage conversion to beef is profitable.

2. Forage Systems

a. Forage Production. Ranking in descending order the 15 observations on the value of the objective function and a similar ranking for the forage variable cost/herd unit indicates a positive relationship between these variables. (See Tables 6.8 and 6.11). That is, the achievement of a higher net income is positively associated with a higher cost for forage consumed by the beef-cow herd unit. The relatively higher costs for forage can be attributed to pasture improvement practices. This suggests that fertilization and renovation of unimproved native pastures may make a positive contribution to the success of the beef enterprise. However, by stratifying this ranking of the 15 net income observations into three strata of five observations each, it is seen that of the five (5) instances (observations 1, 3, 5, 7, and 14) when forage yields were high relative to the base or center point; two are in the first strata, two in the second, and one in the third and lowest strata. This observation provides an even stronger suggestion that the achievement of high forage yields is certainly not a sufficient condition to ensure success of the beef enterprise.

To pictorially illustrate the findings on pasture improvement practices, Figure 6.1 is presented. The vertical axis represents the percentage of pasture that is cultivated under

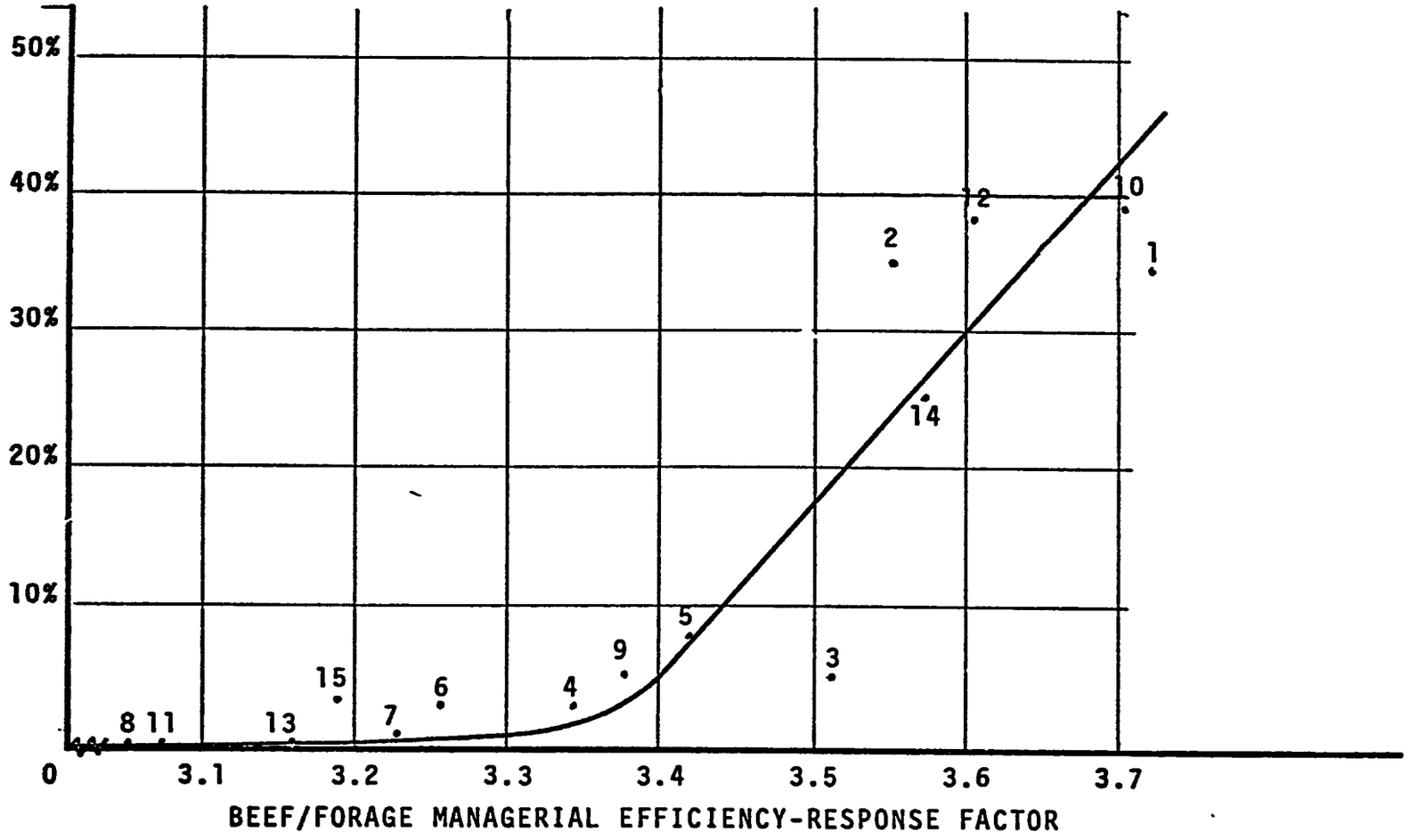

Figure 6.1. Percentage of Pasture Renovated and/or Fertilized.

improved management practices; i.e., renovation and/or fertilization. The horizontal axis is a measure of the production and marketing management efficiency as determined by the response of the objective function to the various indexed factor levels.[10/] It is seen that the optimal policy on pasture management for two-thirds of the situations on the representative farm recommends limited (<10%) or no pasture improvement. Pasture-improvement practices enter the optimal solution only when the manager excels (121.5% of base plan values) in any particular area or when he has the ability to combine above-average (110% of base plan) managerial talents in marketing and beef production. The point to be made is that blanket recommendations on pasture renovation and fertilization ought not to be made without knowledge of the forage response function and with consideration of the associated costs and resultant increases in revenue. Each farm situation is unique. Our goal should be to develop a model that is sufficiently flexible and general to evaluate these varied

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10/ Management efficiency-response measure = $\sum_{i=1}^{3} b_i X_i$

where: b_i - elasticity of objective function with respect to factor X_i

X_i - independent factors; e.g.

X_1 - Price Index - a measure of marketing efficiency

X_2 - Beef Managerial Index - a measure of beef production efficiency

X_3 - Forage Yield Index - a measure of forage production efficiency.

situations and consequently provide specific recommendations. General recommendations risk being misleading if not wrong. A model which can provide specific recommendations for specific problem situations should be more helpful to the farm clientele.

With respect to the particular forages recommended for pasture improvement on farm situation #2, birdsfoot trefoil dominates. Red clover/orchard grass is the forage most frequently mentioned for mechanical harvest and/or grazing. Such results should not be construed as a recommendation for these specific forages. But rather these results are a reflection of the forage data for this particular farm. The alfalfa/grass mixture - although having a higher yield/acre - compares generally less favorable to the red clover/grass mixtures due to higher fertilization recommendations and because of the specified necessity of spraying for the alfalfa weevil. Straight grasses for pasture compare less favorably relative to legumes and/or legume/grass mixtures due to the specified requirements of nitrogen fertilization for the grasses.

The point to be stressed is not that of recommending particular forages for production and conversion to beef. The important issue is whether or not the model correctly evaluates the alternatives presented for consideration.

b. Forage Harvesting-Storage and Feeding Systems. The optimal forage harvesting systems for each of the 15

observations recommends the custom hiring-in of the stack system. It will be recalled that this system involves compressing loose hay into wagon-sized (1.5 ton) stacks. Apparently, the volume of hay required for the various cattle numbers (always ≤57 beef cow-herd units and ≤110 tons of hay/year) was never sufficient to justify investment in any of the hay-packaging machines. This result is again particular to this unique farm and associated cost data but does suggest that, assuming such services are available, custom-machine hire may be a viable alternative to machine investment for the small beef cow herds. Due to the nature of this hay harvesting system, the only storage alternative considered is storage in the field. The recommended feeding system was always limit feeding in racks which was most efficient in usage of hay and relatively more demanding of labor. This result appears logical as forage was always the input that constrained the level of beef activities. Thus the algorithm chose that feeding technique which was most efficient in usage of the most limiting resource.

3. Financial Considerations

Major problems associated with the beef/forage enterprise concern the financial relationships. These financial problems may be delineated as: (a) the liquidity problem,[11/]

[11/] The liquidity concept is identical to the cash balance as calculated in Table 5.2 - the Cash Flow Summary.

(b) high investment cost, and (c) low volume of dollar production.

The cash flow from a cow-calf enterprise is slow relative to many other farm enterprises. A gestation period of nine months limits the production of each cow unit to one calf per year. This pattern of cash income may create cash flow difficulties in allocating funds to cover the stream of expenses that occur throughout the year.

A cow-calf enterprise requires a substantial investment relative to the funds generated from such an investment. Beef stock cows and land to supply the feedstuffs must be provided for such an enterprise. Depending upon the time and place of purchase, the investment can be substantial.

The income produced per unit of size is low relative to that which may be produced from other enterprises. Measures of dollar returns per herd unit, and per acre are presented in Table 6.11.

To provide some insight into these problem areas, the results for farm situation #2 were analyzed. The relationship between liquidity and net worth is illustrated for year 1 and year 4 in Figures 6.2 and 6.3, respectively. Each problem situation was initially endowed with $2500.00 plus the net profit from the 25-cow beef herd. The differential factors are the levels for beef prices, for beef managerial factors, and for forage yields. The interaction of these factors on the same structural farm provides for the differing

levels of the additional cow-calf systems initiated.

The relationship in year one between liquidity and net worth has inverse characteristics; i.e., the higher the change in net worth, the lower is the liquidity. This phenomenon can be explained and attributed to the purchase of additional beef stock which generated no income in the initial purchase year. The net worth of the beef enterprise increases due to the maturing and increase in value of the purchased open heifers. For the 15 observations, the higher net worth figures belong to those runs that purchased the relatively greater number of beef stock. However, liquidity in year one is higher for those situations which invested in relatively fewer beef stock.

This inverse relationship persists in year two. By the third year the relationship does not appear strong as the liquidity-net worth observations are well scattered. Year four indicates that the relationship has reversed itself as the change in net worth and the cash-on-hand are now positively related. Again this relationship is unique to this structural situation and the associated data used. For example, a downward trend in the price of beef was assumed; i.e., beef stock were purchased in a period of high prices while their resultant products were marketed during years of relatively lower prices. In addition, all beef investment requirements greater than $2500.00 were financed at 9 percent interest rate. An upward price trend and/or a lower finance

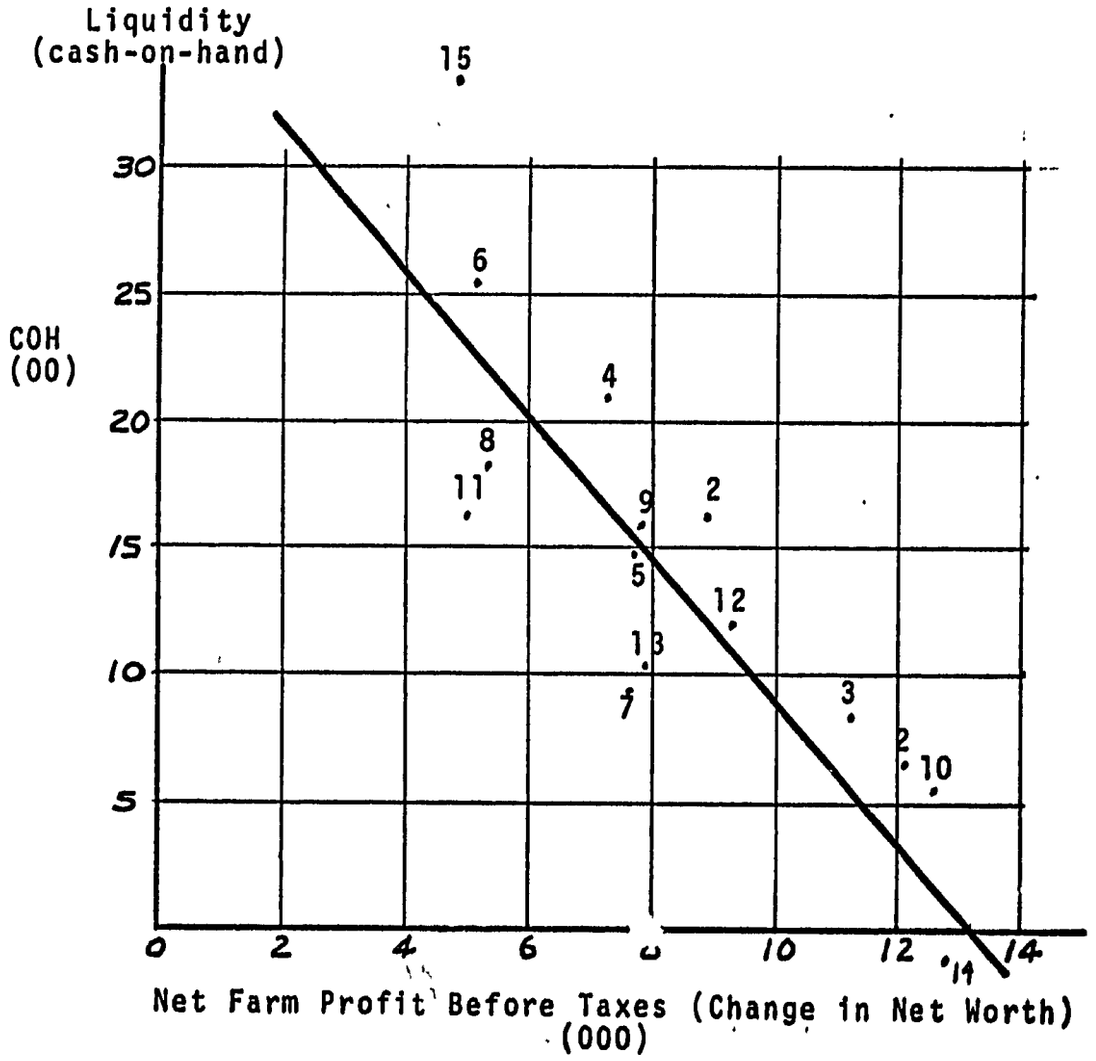

Figure 6.2. Relationship Between Liquidity and Change in Net Worth for Year 1.

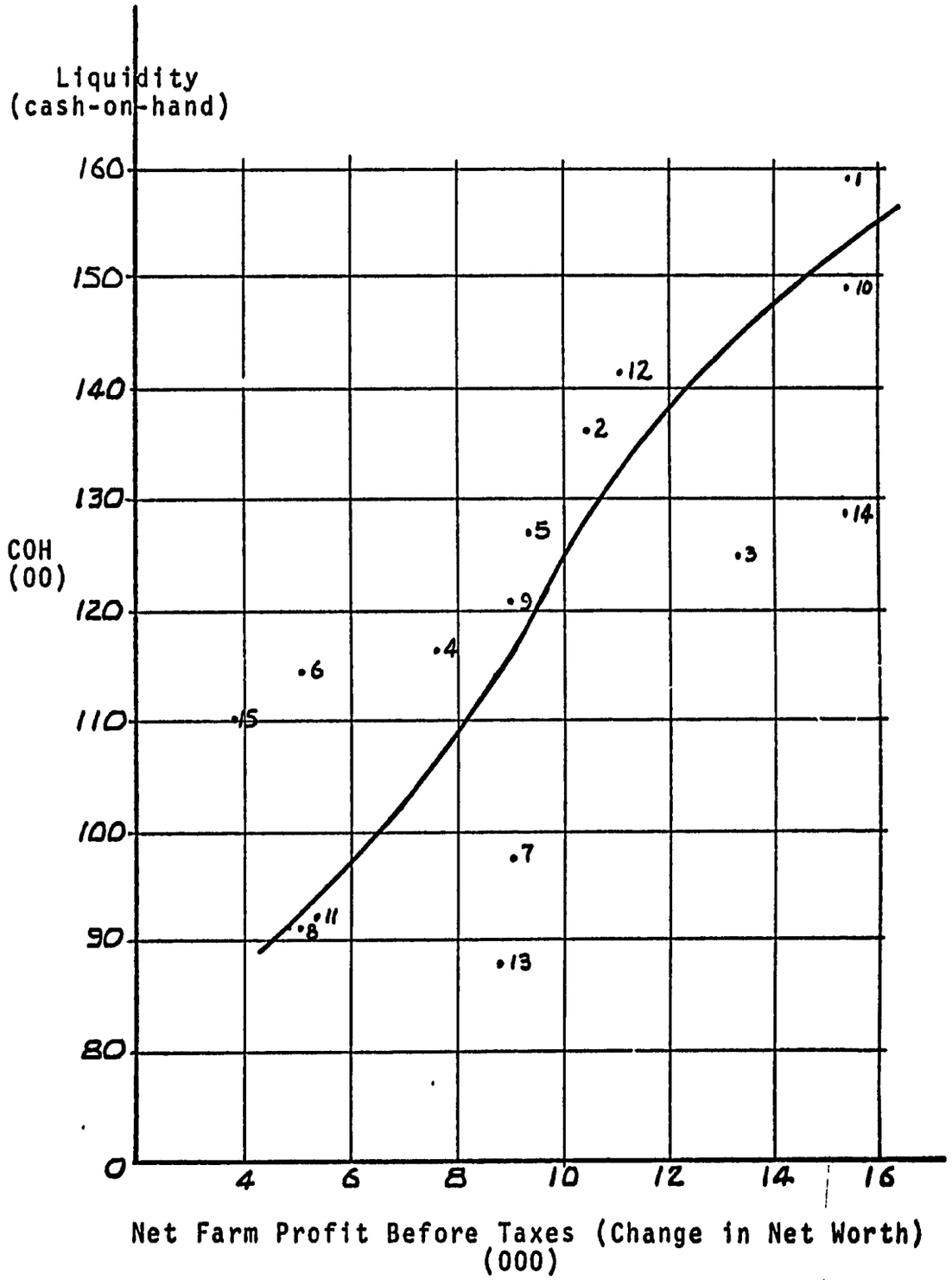

Figure 6.3. Relationship Between Liquidity and Change in Net Worth for Year 4.

rate or amount borrowed would shorten the period required to establish a positive relationship between change in net worth and liquidity.

G. Summary

This chapter has presented the technique used to validate the beef/forage model. An experimental design was used to specify the number and location of the observation points for the representative farms as defined in this chapter. Observations of the dependent variable were collected and an interpretation of the results presented.

The next and last chapter of this thesis will sketch and summarize the beef/forage model. The thesis closes with some suggestions and observations on the application, refinements, and associated needs of the beef/forage model.

CHAPTER VII

SUMMARY AND SUGGESTIONS

A. Objectives of Study

The primary objective of this effort was to develop a prototype model that conceptualizes, interrelates, and evaluates alternative beef/forage production systems. It was desired that this decision-making model have sufficient flexibility to analyze a multitude of alternative farm situations. Such situations may vary with respect to their objectives, management abilities, resource structure, price expectations, and beef/forage alternatives that are to be evaluated.

B. The Model

1. Informational Flow of the Model

A format was developed to gather the information unique to each farm situation. This information flows into a computer routine that transforms, generates, and arranges the data into a format suitable for the problem-solving algorithm. The resultant answers are then transformed and arranged into a format that is self-decipherable to the farm audience.

2. Modelling Considerations

a. Objective Function. The specified objective function is a one-dimensional function concerned with maximizing the change in net worth of the beef/forage enterprise. The financial considerations pointed out in Chapter VI imply that a one-dimensional objective function leaves wanting the consideration of very real elements that may affect the decision-making process. The indicated tradeoff between liquidity and net worth that occurs in the early years of initiating a beef/forage enterprise suggests that opportunity should be provided in the objective function for a differential weighting of net worth in the form of cash vis-a-vis in the form of capital assets. Human beings are complicated beings who may have multi-dimensional objectives. The allowance of such possibilities should be considered in further development of all decision-making models.

b. Identification of Activities and Constraints. The activities modelled consider the gamut of all major decisions required in initiating and/or operating a beef/forage enterprise. All such activities are interlocked in a series of biological and economic relationships.

Alternative beef cow-calf and calf-yearling activities compete for the resources of labor, machine-time, finances, and the forage/land supply. Activities to supply forage; i.e., forage production, harvesting, storage, and feeding activities, were modelled. In addition to the actual

beef/forage production decisions, provision was incorporated to enlarge the resource base; e.g., hiring of labor, renting of land, borrowing of funds, and investing in beef stock cows, machinery and buildings.

To delineate the issues surrounding the beef/forage complex; animal scientists, agronomists, agricultural engineers, and agricultural economists worked together in a multi-disciplinary effort. Disciplines were called upon to make a contribution as the need arose. Such multi-disciplinary interaction seemed to have complementary effects as each discipline could profit and increase its problem-awareness by listening to others. In addition, the man in the field - both farmers and extension personnel - were asked to participate. Only via such interaction could the relevant activities and potential constraints for the beef/forage enterprise be identified.

c. Planning Horizon. The specified planning horizon used in the model was seven (7) years. Capital investment decisions should be made with an awareness of the resultant flow of income and expenses that occur in future years because of the initial investment decision. The difficulty was in establishing the proper length of the planning horizon for an enterprise that can contain a multitude of possible capital investments - some of which will vary with respect to their anticipated productive lifetime. The planning horizon as defined and used in this model is premised upon the

anticipated productive lifetime of a beef-cow unit; i.e., seven years.

d. Treatment of Time. Time was considered via usage of the present-value formulation. Each dollar value (c_j) in the model's objective function represents a discounted stream of funds that occurs throughout the planning horizon.

The basic price data are gathered via the input form. This price information is then used in the data generator to calculate costs and returns for each particular activity for each year of the planning horizon. These values are then discounted and summed to provide a one-value measure for each alternative activity considered in the model. Thus the decision on the optimal mix of activities to be brought into solution for the beef/forage enterprise is partially based upon these one-value measures for each specific activity. Once the optimal activity set is determined, this information is reinterpreted via a report writer. This reinterpretation involves a reverse reciprocal calculation of the initial present value technique that was used. In this manner, cost and returns for each activity in solution can be specified for each year of the planning horizon.

e. Treatment of Risk and Uncertainty. Some literature on the treatment of risk and uncertainty as it relates to operation research techniques was perused and is presented in Appendix A. Although being cognizant of the possibly great potential impact of price and technical variability upon the

optimal decision set, this area was not incorporated into the model. The resultant model is thus deterministic.

f. Treatment of Investment. Investment in a capital asset is an all or none type decision and should be treated as such. Via use of a mixed-integer algorithm, investments in machinery and building structures are treated as discrete units. The investment cost in buildings and machinery which may be used in other enterprises is reduced by the percentage of asset time employed by the other enterprises.

All beef activities are treated as being infinitely divisible. Due to the number of beef activities and the fact that each cow-calf activity is a composite of a number of beef animal categories, the investment in beef activities is treated in the algorithm as continuous. The intergerizing of the beef numbers is accomplished via truncation in the report writer.

g. Treatment of Tax-related Issues. Decisions on capital asset investments are premised upon c_j's which represent the present value of the total cost of each respective investment. The investment cost for each asset is reduced by the discounted value of the asset *per se* (discounted salvage value) at the end of the planning horizon. The recognition of investment credit and tax-deductible depreciation has not been incorporated in this model.

The beef activities do not at the present time consider the effects of income taxation - capital gains provision - on

the c_j for beef activities. Each such c_j is simply the present value of the net cash flow plus a salvage value for the beef stock cow evaluated at the end of the planning horizon. Although this treatment should not affect the resource-allocation decision for beef, it does understate the cash outflow in that income tax payments are neglected. The result is that the cash-on-hand presented in the cash flow summary is biased upward.

h. Cost/Benefits of Modelling. Building a prototype decision-making model for a farm problem requires substantial developmental costs. Once the model is developed, several phases of testing and refinement subsequently occur over time. This entire process requires a substantial amount of professional staff and computer time. Such costs can be easily documented. More difficult to ascertain is the benefit of such an effort. The initial presumption must be that the expected payoff is greater than the expected costs. For this presumption to be true, the model must have correctly defined and solved a problem that is common to many farmers.

3. The Input Form

An input form was developed to collect from the farmer the data unique to each problem situation. Attempts were made to ensure that the input form is clear and communicable to the farmer. Base plan data are provided - not only for example purposes - but to suggest realistic coefficients to the user.

The danger here is that the data entries may be biased towards the 'base plan' data.

4. The Data Generator

The data generator serves a liaison function between the farmer's data on the input form and the problem-solving algorithm. The purpose of this generator is to transform and arrange the data into the MPS format required by the algorithm. The calculation and placement of each objective function value (c_j), each transformation coefficient (a_{ij}), and each right hand side (RHS_i) is accomplished via the data generator.

5. Programming Matrix

The programming matrix developed by the data generator and used by the algorithm is a one-period model. Each c_j has incorporated via the present value - discounting technique, cost and revenue flows which occur for that respective activity throughout the planning horizon. Via modelling in this manner, all resource-allocation decisions consider the resultant flow of funds. This modelling technique is also much more efficient with respect to use of computer core memory space and computer solution time.

6. The Algorithm

The algorithm selected for the problem solution is a zero-one mixed integer programming code (MIPZ1). All activities specified as being discrete may enter the solution code

at either the zero or one level. Activities specified as being continuous are treated as being infinitely divisible. The algorithm solves via the revised simplex technique. As no bounding routine is currently incorporated in the algorithm, each bound must be entered as a row constraint.

7. The Report Writer

The report writer serves a liaison function between the algorithm and the farmer. The purpose of the report writer is to present the decisions rendered by the model and the results therefrom in a format that is meaningful and understandable to the farmer. Due to the nature of the c_j's; i.e., their being a discounted present value, the report writer also serves to reinterpret these values to an annual concept.

It is desired that the physical and financial reports which are organized by the report writer will be those which prove quite helpful to the farmer in solving his defined problem.

C. Model Validation

Validation of the model involved two phases. One phase was concerned with increasing the face validity of the model. This approach uses 'scrutiny by experts' from several academic disciplines to ascertain: (1) that relevant alternatives are included for consideration; (2) that the associated value and physical data are appropriate; and (3) that the model is internally consistent.

The second phase was concerned with determining the response and sensitivity of the model to particular factors thought to be of major significance in determining the success of the beef/forage enterprise. Several computer runs were conducted with data that varied as suggested by an experimental design technique - central composite design. A priori hypotheses were formed concerning the model's anticipated response to the changes of the specified factors. Regression equations were fitted to each set of observations. The hypotheses testing was conducted and the anticipated results upheld.

D. Research Applications of the Beef/Forage Model

The beef/forage model can be used to indicate possible research areas in the agricultural disciplines. Via scrutiny of Table 5.4, the value of additional resources, as evaluated in a particular structural situation, suggests possible research areas. For example, the high shadow price on forage fed to beef during winter indicates relatively high rewards to farmers who can find a more efficient technique to feed forage and thus conserve this valuable forage resource.

The value of additional forages produced during the growing season is a mirror image of the forage production-distribution pattern. That is, for a given demand for forages, forage becomes more valuable as it becomes less available and vice versa. This is a problem recognized by farmers who run

low on forage during the hotter-dryer months of summer and early fall. Analysis of the shadow prices on forage growth indicate a high value for forages which can start their growth early in the spring and/or produce during July and August. This suggests a payoff for research that can develop forages which can produce during these times and also a payoff for forages which can carryover - store 'on the stump' - and not lose feeding value.

Due to dormancy of forage growth during the winter season, a payoff incentive appears for a technique to transfer cornstalks and crop refuse for feeding availability during this winter period.

Other suggested research areas that can be studied via this model are:

1. Economies of Size

Increased beef herd size should result in decreased labor requirements per beef cow herd unit. Via multiple runs, this interaction and its effect upon the objective function and associated financial situation can be determined.

2. Machinery and Building Investments

Sensitivity analyses can determine the volume of operation required to economically justify purchase of new equipment for forage handling.

3. Fertilization and Pasture Renovation

Via entering alternative forage production yields as a function of fertilization and/or renovation; the payoff in terms of increased forage production as marketed through a beef enterprise can be determined.

4. Beef Managerial Factors

The following list suggests additional areas that may be studied via this model:

Creep feeding of baby calves,
varied calf weaning efficiencies,
alternative rate of gain for calves,
alternative calf marketing policies,
alternative calving schedules,
alternative herd-replacement policies.

5. Price Trends

The direction and magnitude of price trends directly affect the ability and rapidity of the beef cow to pay for itself. Such phenomena can be studied via this model.

6. Growth of the Beef/Forage Enterprise

By running the model in a recursive manner, the growth path of the beef/forage enterprise for a particular initial structural situation could be established. With this technique the decisions and resultant effects in period one provide the respecified resource levels for year two. This

cycle could be continued throughout the planning horizon to establish the growth path for a particular firm.

E. Extension Applications of the Model

The problem addressed by this model concerns the potential production and utilization of forages by some type of a beef enterprise. The alternative type of beef enterprises to be considered are specified by the user of the model. In the event that some type of beef activities are economically feasible, the model will determine the optimal forage production, harvesting, storage, and winter feeding systems. This model is strictly a forage utilization model by beef. It does not consider feedlot operations. For farmers who wish to investigate a problem in any or all of the facets of a beef/forage system, this model is appropriate.

At least two (2) alternative approaches can be used to convey the benefits of this model to the potential audience in the field. The most obvious approach is to implement this model as an extension package and make it available to the farm clientele. One method of delivery could be via a workshop presented by university professional staff. An alternative mode is submission of individual farm problems by the extension personnel in the field.

An alternative second approach to deliver this model is to conduct extensive parametric sensitivity analysis for the representative farm. The variable interactions and their effect upon the optimal activity mix and resultant flow of

funds could be published and presented in the form of extension bulletins, magazine articles, etc.

These two approaches are not mutually exclusive. In fact, it appears that usage of the second technique to gain farmer cognizance of the model and its abilities should enhance delivery via the workshop-field extension approach.

F. Research Needs for the Beef/Forage Model

To further develop and refine the capabilities of the beef/forage model, it is imperative that the following areas be given consideration.

1. Primary Data Base

An updated library of primary data that accurately reflects costs, returns, and technical coefficients for those activities involved in the beef/forage area needs to be established. An attempt has been made in this study to gather relevant figures which are used as the suggested 'base plan' data. However, in need of further study are the areas discussed below.

The labor requirements area appears to be in dire need of some type of time study. Information needs to be gathered on the labor required for beef animals by size of herd and for forage harvesting and winter handling of forage by alternative systems.

Many studies have been conducted on the nutritional requirements for beef animals. Yet there not only remains a

question of nutritional quantities required, but how best to measure this quantity. For example, some institutions suggest that the best one unit measure to establish beef feed requirements is based upon total digestible nutrients. The other suggested route is to use estimated net energy. This issue still leaves begging the question of the balanced ration.

Forage response functions to fertilization by different forage varieties need to be developed. Independent variables that ought to be included in such a functional relationship are climatological data, and fertility and tilth qualities of the respective soils.

2. Mixed-integer Programming Codes

The mixed-integer program used in this study was limited as to the maximum dimensions of the programming matrix that could be analyzed. The development of a bounding code would eliminate the necessity of row constraints to indicate the limits of bounded activities. The development of workable mixed-integer programming codes is in its infancy. Further refinement is required to make these codes more efficient in their use of computer time.

3. Refinements of the Beef/Forage Model

a. The summary cash flow as presented in Table 5.2 needs to be refined and extended into the future. The refinement should involve the calculation of an after-tax cash balance

at the end of each time period. This after-tax cash balance more acurately reflects the estimated cash balance that would be available in the subsequent time period. The cash-flow summary is currently calculated for the first year only. It might prove helpful to extend the cash flow into the second year. However, a caveat should be issued that such a cash flow is premised upon forecasted price relationships. A reliable ability in the long-range forecasting area has yet to be demonstrated.

b. Risk and uncertainty. The beef/forage model is deterministic; real world expectations are not. Each risk event has an associated probability distribution. It would appear desirable to establish these distributions to indicate the probability of particular events. Much work in the operations research treatment of risk is needed to increase the realism of decision-making models.

G. Extension Needs

The benefits from developing an applied problem-solving model are not realized unless problems are submitted for consideration. To enhance the use of applied problem-solving models, the following suggestions are submitted.

1. The first prerequisite is the development of reliable models to solve decision-making problems that are common to many farmers. The initial phase of the model development should involve participation by multi-disciplinary professional personnel and also the man in the field who is confronted with the problem.

2. To facilitate wider applicability of the model, the model should be sufficiently flexible to consider a wide variety of structural situations with respect to resources available, technical coefficients, and price expectations.

3. To facilitate easier use of the model, clear, easily understood input and output forms should be developed and made available. Documentation of the model should be accomplished and made available for those desiring to understand and use the model. Model documentation will have different meaning to different audiences.[1/] From an extension view, the documentation should indicate the model's capabilities and the means to access the particular model.

4. The infrastructure of the professional university staff person and the extension professional in the field should be combined to work with the computer hardware and software. Capabilities should be made available to submit jobs via batch or on-line.

5. Of great importance to the success of any extension program is the delivery system produced by the extension personnel in the field. To provide incentive for their active participation and promotion of a model, extension personnel should be involved in the various stages of developing the

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[1/] Schmidt, John R. "Documentation of EDP Programs for Extension." A paper presented at the North Central Farm Management Extension Workshop, Michigan State University, May 23, 1973.

model. In this manner, the model may be viewed as being an integral part of their program vis-a-vis an imposition upon their program.

H. Summary

This chapter has summarized the objectives, modelling considerations, applications, and needs of the beef/forage model developed in this study.

An attempt has been made to incorporate within this model the entire beef/forage system. This model is quite flexible with respect to the resource structure, preferences, and price and production expectations which may be analyzed. It is desired that this model be a useful tool in helping farmers to evaluate the alternatives involved in the beef/forage enterprise.

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APPENDICES

APPENDIX A

APPENDIX A

MODELLING ALTERNATIVES AND ALGORITHMS AVAILABLE

For discussion purposes, it may prove helpful to utilize a classification scheme to delineate the modelling alternatives available. Models can generally be categorized according to their treatment of time and certainty of knowledge.

A. Static Deterministic Models

Models within this classification do not consider the passage of time and assume perfect knowledge of all events i.e., there is no error term associated with each element of data. Such models have relatively more assumptions than models in other categories and as such are much simpler. Examples of models within this category are production function analysis, budgeting, and unembellished linear programming. Such models have experienced a wide range of use in solving micro-oriented problems. The relatively quick acceptance and use of these models is hypothesized to be positively correlated with the relatively well-developed state of static micro-economic theory.

Production function analysis is an optimization technique based upon the marginality conditions of neo-classical

economics. Research using this technique can determine the optimum level of output and the optimal mix of inputs for given elasticities of production and marginal rates of technical substitution. The shortcoming of this technique is that multi-product functions are not easily handled.

Multi-product situations can be handled by either budgeting or linear programming. Via budgeting, the best of the considered alternatives may be chosen after a complete evaluation of each possibility. This process is quite time-consuming but has wide practical usage in evaluation of limited planning changes. Linear programming is an optimization technique whereby a linear objective function is optimized subject to linear constraints. Via an interactive technique, the LP solution will select - from all processes considered - the global mix of activities. Unembellished linear programming is widely used as a pedagogical tool. For research purposes, extensions of linear programming *per se* are used.

To recognize the limitations of both budgeting and ordinary linear programming, one should be cognizant of their underlying assumptions.

1. Linearity of the Objective function $z = \sum_{j=1}^{n} c_j x_j$

To assume a linear objective function implies that the values, c_j's, of the activities, x_j's, are single-valued and

thus non-stochastic. This implies a perfectly elastic demand curve at the non-fluctuating market price which in turn implies that the subject firm is operating in a world approaching perfect competition.

2. Additivity of Resources and Activities

An accounting of the ith resource used in 'j' real activities states that the total amount of the ith resource used plus that amount left over (in slack activities) must equal the total amount of the ith resource available. This condition may be expressed as $\sum_{j=1}^{n} a_{ij} \leq b_i$ where a_{ij} = technical input-output coefficient for jth activity as limited by the ith resource availability

b_i = amount of ith resource available

n = the number of j activities.

This assumption eliminates the possibility of any interaction among the activities and the resources used per unit of activity. Such an assumption implies a relationship of proportionality and constant resource productivity. In other words, linear programming assumes constant returns to scale in the activities.

3. Convexity

A solution space containing x_j activities is said to be convex if and only if for all x_j in solution, any point x on the straight line joining two (2) x_j's is also in the solution space. Another was of stating this assumption is:

$x = (1 - \lambda)x_{j1} + \lambda(x_{j2})$ where λ is a scalar between zero (0) and one (1).

The convexity assumption implies the commonly discussed notions of divisibility and continuity. To satisfy this assumption, each activity and resource can be in solution at any non-negative level. Such an assumption allows the unreal possibility of such events as .562 of a machine and .125 of a cow to enter the solution for the farm plan.

The relaxation of the continuity assumption can be handled via a modification of the linear programming constraint set. This modification known as integer or discrete programming will be discussed later in this chapter. The budgeting technique is usually discrete and thus does not assume convexity.

4. Non-negativity

All activities to be considered must be greater than or equal to zero. This assumption can be expressed as $x_j \geq 0$ for $j = 1...n$.

B. Dynamic Deterministic Models

Models in this category continue to assume perfect knowledge but do allow consideration for the passage of time. Some approaches which may be classified in this category are multi-period linear programming, recursive programming, and dynamic programming.

1. Multi-period Linear Programming

Multi or poly-period programming is an optimization technique that recognizes the interdependence over time between decisions made in the current period and those to be made in future periods. Such an approach is helpful in studying growth paths over time. The assumptions of linear programming also pertain to this approach.

The modelling technique is that of block-diagonal with the upper left-hand block pertaining to the current period; and the lower right-hand block representing the last period in the planning horizon. Each block represents the activities to be considered for a particular time period. Transfer equations (rows) are modelled such that the output for period 't' becomes the input or resource base for period '$t^{+}1$', etc.

Boussard delineates three (3) main problem areas associated with this approach.[1/]

(1) The Objective Function. The objective function requires an expression of how future plans and the values of such plans are to influence current decisions. The problem here is a weighting or evaluation of current income (consumption) versus current saving-investment which enables a higher level of future income (consumption).

[1/] Boussard, Jean-Marc, "Time Horizon, Objective Function, and Uncertainty in a Multi-period Model of Firm Growth." AJAE, Vol 53, No. 3, p. 467. August 1971.

(2) The Matrix Size Problem - The 'Curse of Dimensionality'. This problem stems from the necessity of having a sub-matrix or block of activities for each period in the planning horizon. An additional requirement is the provision of transfer rows between periods.

Once a multi-period problem is modelled, the matrix may be of too large a size to efficiently solve. Continued refinement of computer capabilities and modelling techniques should reduce this difficulty.

(3) Imperfect Knowledge. Although this problem is characteristic of all approaches studying in a biological-economic environment, it may be even more serious here. The reason is that this approach requires not only data about the current situation but also requires forecasted data for each period in the planning horizon. Considering the general reliability of our forecasting techniques, this problem may suggest that either the planning horizon be quite short and/or that the multi-period model need be solved for only the activities in the first period.

A paper by Irwin surveys some growth modelling studies utilizing multi-period linear programming.[2/]

2. Recursive Programming

By definition, recursive programming is an optimization technique to solve "a sequence of mathematical programming

[2/] Irwin, George D. "A comparative Review of Some Firm Growth Models," Agricultural Economics Research, Vol 20, No. 3, pp. 84-91. August 1968.

problems in which the parameters of a given problem are functionally related to the optimal variables of preceding problems of the sequence."[3/] However, this algorithm does not render optimal rules which lead to optimal policies over the planning horizon. Instead, each separate period is optimally solved in sequence with the optimum solution for period 't' providing the resources or right-hand sides for period 't+1'; the 't+1' solution provides inputs for period 't+2', etc.

The concept is similar to multi-period programming. The difference is that multi-period programming simultaneously solves the problem for the entire planning horizon whereas recursive programming solves one period 't', then period 't+1', etc, in a sequential manner.

Heidhues has used recursive programming to investigate the farm growth process in Germany.[4/]

3. Dynamic Programming (DP)

Dynamic programming is an analytical approach to problems involving sequential decisions. The objective in DP is to find an optimal policy of allocating resources at each stage of a multi-stage decision process. This approach provides an alternative way to view problems but it is not

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[3/] Day, Richard H. Recursive Programming and Production Response, Amsterdam: North-Holland, 1963.

[4/] Heidhues, Theodor. "A Recursive Programming Model of Farm Growth in Northern Germany." JFE, Vol 48, No. 3, pp. 668-684. August 1966.

an algorithm or a particular mathematical model.

Dynamic programming is based upon Bellman's "Principle of Optimality". This principle states that "an optimal policy has the property that whatever the initial states and decision are, the remaining decisions must constitute an optimal policy with regard to the state resulting from the first decision." The critical assumption of this approach is that of recursiveness; i.e. that the decision problem can be broken down into sequential - not simultaneous - calculations. This premise allows decisions to be made one at a time.

Dynamic programming techniques can be applied to problems characterized by a sequential nature. Examples of such problems are equipment replacement, livestock herd replacement and culling practices, feedlot scheduling, range refurbishment, feed inventory, allocation of irrigation water, and transportation cost minimization. O. Burt (7) has used this approach in studying range management policies. Meyer and Newett (37) used DP to study feedlot optimization.

Usage of this model has been impaired by the dimensions of real world decision problems which can not be defined by a few state variables in a multi-stage setting. In addition as DP is an approach - not an algorithm - usage of DP requires that each unique problem be formulated in the DP logic and translated to a computer language. These factors suggest that DP usage may be subject to substantial

developmental costs and to lengthy computational time. A basic advantage is that DP is not restricted to linear objective functions and linear constraints, nor to deterministic processes. The approach is completely flexible with respect to the nature of the functions.

C. Static Stochastic Models

Models within this category do not recognize the passage of time but do give consideration to imperfect knowledge. The crux is that coefficients in the objective function, the technical coefficients, or the resource availabilities now have an associated probability distribution other than one.

1. Discrete Stochastic Linear Programming

As was noted in the discussion in Chapter II under variability of coefficients, there are two (2) basic approaches to handling their stochastic nature.

(1) Passive Approach. With this approach, the statistical distribution of the optimum values of the objective function is estimated based on the knowledge of the probability distribution of the stochastic elements.

The problem may be formulated as follows:[5/]

1. Maximize $E(U) = f(\sigma)$

   subject to:

[5/] This schematic is based upon my interpretation and summarization of: Rae, Allan N. "Stochastic Programming, Utility, and Sequential Decision Problems in Farm Management." AJAE, Vol 53, No. 3, pp. 448-460. August 1971.

2. $\sum_{j=1}^{n} A_{e,qj}\ 8j \leq b_{e,qj}$ for each bth resource

3. $\sum_{j=1}^{n} I\ X_{e,kj} \leqq 0$.

4. $\sum_{j=1}^{n} -c_{jk}\ x_{kj} + \sigma = 0$

where E(U) is expected utility

σ is some set of activities that transforms payoffs into the appropriate utility levels

x_{kj} - the jth activity that is continued into stage k; k = 1 ... q

$A_{e,qj}$ - the technical coefficients should event e occur for the jth activity at the qth stage

Equation 3 is a type of mutually exclusive constraint which determines the decision branches which can be followed as predestined by each previous decision. I is an identity matrix.

Equation 4 is an accounting row to collect the payoffs, c_j's, from each jth activity at each stage.

The solution of such a problem assumes that the decision-maker can express his preferences between probability distributions of outcomes. He must be able to determine his own subjective function. Such a function does permit the reflection of alternative risk preferences upon the optimal decision plan. With this approach, a deterministic program for each of the environments can be solved. The objective function value can then be determined via a probability distribution of the underlying e's.

(2) Active Approach. With this approach, an attempt is made to recognize the source of the stochastic nature of the objective function. One such source of variation is in resource availabilities. The formulation of such a problem is now presented.

1. Maximize $z = \sum_{j=1}^{n} c_j x_j$

subject to:

2. $\sum_{j=1}^{n} a_{ij} x_j \leq b_i U_{ij}$ for all $i = 1 \ldots m$ resources

3. $x_j \geq 0 \quad j=1, 2 \ldots n$

4. $\sum_{j-1}^{n} U_{ij} = 1$

5. $U_{ij} \geq 0$

where c_j = payoff from x_jth activity

b_i = total potential amount of ith resource available

u_{ij} = allocation matrix for use of ith resource in jth activity

n = number of activities or processes

This active programming approach can be extended to the situation where each resource has to be allocated in advance of the technical coefficient values becoming known for each activity. Subsequent maximization is subject to both the

resource prior allocation and the eventuating coefficient values.

2. Quadratic Programming (QP)

Quadratic programming is applicable to situations where the objective function is non-linear. It may be used with objective functions which have one turning point; i.e., a function with one variable raised to the exponential power of two. This approach may be used to maximize a concave function or to minimize a convex function, subject to linear constraints. Such a situation could arise when either price is a function of output or the c_j is stochastic with a known probability distribution.

This approach may be formulated as follows:

1. maximize $z = \sum_{j=1}^{n} c_j x_j + \sum_{j=1}^{n} \sum_{k=1}^{n} c_{jk} x_j x_k$

   subject to:

2. $\sum_{j=1}^{n} a_{ij} x_j \leq b_i$ for $1 = 1 \ldots m$

3. $x_j \geq 0$

z, c_j, x_j, b_i, and a_{ij} are as defined previously. c_{jk} is the covariance term when $j \neq k$ and is the variance term when $j = k$. For a maximization problem, the matrix of this quadratic form must be negative semi-definite; i.e., $X'CX$ 0 for all X. This condition insures that the objective function is, in fact, concave from the origin.

With respect to firm management problems, quadratic programming is applicable to situations where product price is a function of demand, or to risky investment (capital budgeting) situations where the probability distribution of the stochastic element(s) is known and risk is measured via the variance term. In such an instance, the objective function could be to minimize risk subject to a required output level. Another possibility is to formulate the objective function in terms of an expected value as expressed via a function of the mean and variance of the outcomes. QP can handle problems involving income variability subject to linear resource constraints. Problems involving stochastic resource constraints constitute a QP problem but can not be handled by presently available algorithms. Problems involving stochastic technical constraints can be handled via the general problem format presented. This does require, however, that this variability be reflected in the objective function resulting in a stochastic objective function.

Quadratic programming has had rather limited use in firm management issues. This fact may be partially attributed to insufficient development of working algorithms tailored to the present level of computer capacities. The primary advantage of QP is that it recognizes the stochastic nature of the real world. The single-valued assumption of LP can be relaxed to recognize the variability of prices. QP continues to assume additivity of the resources.

D. Dynamic Stochastic Models

Models in this category not only relax the assumption of perfect knowledge but also consider the passage of time. Such modelling conditions more nearly approach the conditions of the real world.

1. Sequential Programming Under Uncertainty

Much of the work on this approach is based on Dantzig's model which combined the merits of linear programming and sequential programming. As with deterministic multi-period models, this technique is troubled by the large dimensions of the basic matrix when several periods are considered. A paper by Yaron and Horowitz illustrates and extends Dantzig's idea of breaking the planning model into short-run plans and a long-run plan.[6/] For each period, several optimal short-run plans are determined for different situations. Each short-run solution gives a production plan for that period as limited by the available fixed assets and equity. The actual net return is then determined by the optimal plan value plus effect of a random event. These short-run plans then serve as activities in the long-run plan. In this manner some compactness of the long-run matrix is achieved.

[6/] Yaron, D. and U. Horowitz, "A Sequential Programming Model of Growth and Capital Accumulation of a Farm Under Uncertainty." AJAE, Vol 54, No. 3, pp. 441-451. August 1972.

The model may be formulated as follows:

Short-run plans: (a deterministic situation)

Maximize $z_t^i = P_t Y_t^i$

subject to: $G_t Y_t^i \leq B_t^i \quad t = 1,2...T$

$Y_t^i \geq 0 \quad i = 1,2...I$

where P_t = vector of net returns per activity unit in period t

Y_t = the ith vector of activity levels in period t

G_t = matrix of input-output coefficients in period t

B_t^i = vector of resources for ith level of activity in period t

Then, the short-run net revenue for period t is $r_t^{i,e}$ is equal to $z_t^i + v_t^i | \theta_t^e$

where $v_t^i | \theta_t^e$ = net returns from other activities not considered above given that event θ_t^e has occurred in period t.

Long-run plan: (a stochastic situation)

Maximize $z = \sum_{k=1}^{n} \rho_e C_k X_k$

subject to: $A_{sk} X_s \leq B_s$ for (k,s = 1,2....# of situations considered)

$X_k \geq 0$

where ρ_e = probability of event e occurring

C_k = vector of net returns for situation k

X_k = vector of activity levels in situation k

A_{sk} = matrices of input-output coefficients

B_s = the vector of resources available for situation s

Dantzig shows that the solution to this problem is in fact optimal.[7]

2. Simulation

Naylor defines simulation as "a numerical technique for conducting experiments with certain types of mathematical models which describe the behavior of a complex system on a digital computer over extended periods of time."[8]

Simulation is an approach - not an algorithm *per se*. In contrast to the mathematical programming alternatives as discussed in this chapter which are analytic; i.e., guarantee an optimum, a simulation model is non-analytic. That is, simulation does not guarantee an optimum. However if the solution space has a broad plateau, the lack of an optimal solution may not be much of a shortcoming. In such a situation, it may be said with a certain level of probability that the solution is in the top 'X' per cent.[9] The question in need of an *a priori* answer is the flatness of the n-dimensional (activity) solution space.

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[7] Dantzig, George B. "Linear Programming under Uncertainty," *Management Science*, Vol 1, No. 3-4, pp. 197-206. 1955.

[8] Naylor, Thomas H. *Computer Simulation Experiments with Models of Economic Systems*, John Wiley & Sons, Inc., New York. 1971.

[9] Candler, Wilfred, Wayne Cartwright, and J. B. Penn, "The Substitution of Analytic for Simulation Algorithms: An Example." *AJAE*, Vol 55, No. 2, pp. 235-239. May 1973.

Simulation may be an appropriate technique for solving defined problems whose conditions do not meet the assumptions for the analytic algorithms. Examples of such intractable conditions are indivisibilities, a non-linear objective function, multiple goals, and stochastic situations.

The process of simulating can be viewed in four (4) stages:

1. As with all approaches, the problem must first be defined.
2. Formulate the mathematical model to reflect all relevant relationships.
3. Express the relationships in a computer program.
4. Validate and test the model.

Trebeck (62) used simulation to determine the benefits of spatial diversification of a beef cow herd over rangeland and irrigated land. His objective function consisted of increasing the entrepreneur's utility as measured by expected income and the associated risk as indicated by the variance of the expected income.

At Purdue University, Lee (34) conceived and prototyped a swine simulator. Sonntag (59) further developed this model with Lines (35) providing additional refinement. This model is used as a normative growth model to indicate profitable changes for a swine enterprise over a 5-year period. The objective is to increase the terminal net worth of the farm firm as constrained by production capacity, physical resource

supply, capital availability, and personal consumption requirements. This model considers alternative farrowing systems, housing systems, annual scheduling, and row crop production systems.

The main advantage of simulation appears to be its flexibility. Simulation is not limited to any particular structure. It can contain as many relationships, variables, or decision rules as required to realistically structure the problem situation.

Some disadvantages associated with simulation are the substantial developmental costs with respect to the problem formulation in the computer logic, lengthy computer-run times, large memory-core requirements, need of specifying heuristics, solution evaluation, and the question of verifying the model. In contrast to the analytic algorithms which can be used for a multitude of different problems, the simulator lacks this aspect of flexibility as it is usually written with the purpose of solving one specific problem.

APPENDIX B

APPENDIX B

THE DATA/MATRIX GENERATOR

As the data gathered by the input form is not in a format suitable for the solution algorithm, it is necessary to have liaison routines between the gathered data and the algorithm. This liaison activity is fulfilled by computer routines which transform and generate the data into the required format. The nine (9) routines which were written make calculations to provide the following: (1) feed requirements for beef systems - (Program TDNR), (2) labor requirements for beef systems - (Program LABOR), (3) the net value over time of beef systems - (Program PVBEEF), (4) man and machinery resources required for various forage harvesting systems - (Program FORHR), (5) amount of forage availability throughout the year - (Program FORAGE), (6) the net cost over time of land required for forage production - (Program PVLAND), (7) forage storage facilities and the associated costs over time - (Program STORAGE), (8) financial situation and winter feeding system coefficeints - (Program MISC), and (9) placement of the calculated coefficients in the proper cell of the matrix - (Program LABEL). Examples of the primary data used are presented in Appendices F and G - i.e., the input form with its Base Plan data.

A. Program TDNR

Program TDNR calculates the total digestible nutrients (TDN) required for the beef 'cow-calf' systems and for the 'purchase calf-sell yearling' systems. The feed requirements are based on pounds of TDN required to grow and maintain animals in the various stages of their life cycle.[1/] The ration provided is not nutritionally balanced *per se*, but some additional supplementation is built into the routine.

For the 'purchase calf-sell yearling' activities, the TDN requirements are figured on a per calf basis. These TDN requirements are a function of the size of animal. The actual functional form to calculate TDN required per animal and the associated coefficients may be determined by the feed requirement data provided by the user of the model. Default values for this function are obtained from the National Research Council's (NRC) published work combined with that by Purdue's Animal Science department. The time of year serves as an intercept shifter of the functional form.

For the 'cow-calf' systems, the TDN requirements are figured on a beef cow-herd-unit basis. A beef cow-herd-unit is defined as:

$$\left(\frac{1 \text{ beef}}{\text{cow}} \cdot \frac{1 \text{ beef cow-herd-unit}}{\text{per beef cow}}\right) + \left(\frac{\text{No. weaner calves}}{\text{No. stock cows}} \cdot \frac{1 \text{ cow}}{1 \text{ calf}}\right) +$$

[1/] TDN is defined as the summation of all the digestible organic nutrients; i.e., % protein, % fiber, % nitrogen-fred extract, plus 2.25 times the % fat.
Morrison, Frank B. Feeds and Feeding, p. 40.

$$\left(\frac{\text{No. stock replacement units}}{\text{No. stock cows}} \cdot \frac{1 \text{ cow}}{1 \text{ stock replacement}}\right) + \left(\frac{\text{No. bulls}}{\text{No. cows}} \cdot \frac{1 \text{ cow}}{1 \text{ bull}}\right).$$

This definition simply states that a beef cow-herd-unit consists of a base stock cow plus a share of the calves, a share of the replacement stock, and a share of the bull. The share of calves is determined by the weaning percentage. The share of herd replacement stock is determined by the herd replacement policy; i.e., what is the culling rate and how are these cull cows to be replaced. The share of the bull is simply determined by how many cows are serviced by each bull. It is thus evident that the TDN requirement for a beef cow-herd-unit per time period is a function of the calving-weaning efficiency, calf marketing policy, herd replacement policy, and the bull stocking rate. Input coefficients gathered by the input form allow the user to reflect the effect of calf size, cow size, and lactation upon the feed requirements for these animals. These TDN requirements should be positively related to size of animal and to the milk flow. The time of year serves as an intercept shifter of the functional form determining TDN requirements as a function of the beef animal's size and type.

The basic calculation consists of determining the amount of TDN required for each animal category for each time period. Each of these figures is then multiplied by a percentage indicating the portion of this animal category represented

in one beef cow-herd-unit. These answers are then summed to determine the TDN required for one (1) beef cow-herd-unit for each time period.

The basic equations involved in calculating the total digestible nutrients (TDN) required per beef cow-herd-unit per time period are as follows:[2/]

(a) BCR(L,J,KT) = PBC · RTDN(J,1)

where PBC = (1. - WP(I)) · PB

(b) CWCR(L,J,KT) = RTDN(J,1) · ((1. - PB) · (1. - WP(I)))

(c) PCR(L,J,KT) = RTDN(J,2) · WP(I)

(d) CCR(L,J,KT) = RTDN(I,3) · (WP(I) + PRCCB)

where PRCCB = PRCCB/PL

(e) CR(L,J,KT) = RTDN(JC,JCR) · (WP(I) + PRCCB)

(f) ROHB(L,J,KT) = RTDN(J,JOHR) · (PROHB · RR)

where RR = 1/expected productive life of brood cow

(g) RBHB(L,J,KT) = RTDN(J,JBHR) · (PRBHB · RR)

(h) RRH(L,J,KT) = RTDN(J,JRH) · (PRHR · RR)

(i) BULL(L,J,KT) = RTDN(J,21) · BR

[2/] The following 10 dependent variables are expressed in matrix form which is dimensioned by L = 6 calving periods, J = 13 time periods in the year, and KT = 5 sets of parameters to describe the KTth beef management system. The 13 time periods consist of the 12 months of the year plus a winter period which summarizes the data for the months of December through March.

(j) TTDNR(L,J,KT) = BCR(L,J,KT) + CWCR(L,J,KT) + PCR(L,J,KT) + CCR(L,J,KT) + CR(L,J,KT) + ROHG(L,J,KT) + RBHB(L,J,KT) + RRH(L,J,KT) + BULL(L,J,KT)

where: BCR = TDN requirements for barren cow

BR = bull ratio; i.e. (1./(# of cows/bull))

BULL = TDN requirements for bull

CCR = TDN requirements for cow with calf

CR = TDN requirements for weaner calf

CWCR = TDN requirements for cow which looses her calf

PB = proportion of cows which do not conceive

PCR = TDN requirements for pregnant cow

PRBHB = proportion of replacement stock purchased as bred heifers

PRCCB = proportion of replacement stock purchased as cow with calf

PROHB = proportion of replacement stock purchased as open heifers

RBHB = TDN requirements for purchased bred heifer

ROHB = TDN requirements for purchased open heifer

RR = culling rate for stock cows

RRH = TDN requirements for raised replacement heifer

RTDN - required TDN for each livestock category

TTDNR = total TDN required for a beef cow-herd-unit

WP(I) = weaning percentage of the Ith calving month; expressed as the number of calves weaned per number of cows exposed to bull.

The TDN requirement calculations for the 'buy calf-sell yearling' systems involve equations of type 'e' above.

B. Program LABOR

This program calculates the man hours of labor required for the beef 'cow-calf' systems and the 'purchase calf-sell yearling' systems. As with Program TDNR, the calculations for the 'cow-calf' system are based on the beef cow-herd-unit whereas the coefficients for the 'purchase calf-sell yearling' systems are figured on a per calf basis.

The labor required for each beef cow-herd-unit will be a function of the calving-weaning percentage, the calf marketing policy, the herd replacement policy, seasonal time of year, and stage of development for each animal category. The basic equations involved in Program LABOR calculations are analogous to those in Program TDNR and consist of determining the amount of man hours required for each animal category during the nine time periods of the year. Each man-hour requirement/time period for each animal category is multiplied by a percentage indicating the portion of this animal category represented in one beef cow-herd-unit. These

answers are then summed to determine the labor required for one beef-cow-herd unit for each time period.

The basic equations used in Program LABOR are as follows:[3/]

(a) BCR(L,J,KT) = RQL(1) · PBC

(b) CWCR(L,J,KT) = RQL(1) · ((1. - PB) · (1. - WP(I)))

(c) PCR (L,J,KT) = RQL(2) · WP(I)

(d) CCR(L,J,KT) = RQL(3) · WP(I)

(e) CR(L,J,KT) = RQL(10) · WP(I)

(f) ROHB(L,J,KT) = RQL(JOHR) · (PROHB · RR)

(g) RBHB(L,J,KT) = RQL(JBHR) · (PRBHB · RR)

(h) RRH(L,J,KT) = RQL(JRH) · (PRHR · RR)

(i) BULL(L,J,KT) = RQL(21) · BR

(j) TLABR(L,J,KT) = BCR(L,J,KT) + CWCR(L,J,KT) + PCR):.K,LT) + CCR)L,J,KT) + CR}L,J,KT) + ROHB(L,J,KT) + RBHB(L,J,KT) + RRH(L,J,KT) + BULL(L,J,KT)

Additional provisions were built into the computer program to allow for increased labor needs during the calving month, for creep feeding purposes, for calf preparations, e.g., vaccination, dehorning, etc.; and during the winter period.

[3/] RQL(21) is an array listing amount of man hours required per month for 21 different beef animal cetegories.

The remainder of the matrices and coefficients have meanings similar to that defined in Program TDNR on pages 186-188 except that the concern is now with labor requirements, not TDN requirements.

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3/ (continued)
The dimensions for the matrices are as explained in footnote 2/.

C. Program PVBEEF

This program calculates the contribution to overhead and profit-c_j- for the various beef system activities. Other than the opportunity cost activities for land, the beef system activities are the only positive revenue producing processes. Included in the beef system is the complex of 'cow-calf' activities plus the 'purchase calf-sell yearling' activities.

The net value of each beef activity is composed of the total discounted revenues and costs generated during the 7-year planning horizon. In calculating each c_j, the costs incurred do not include the charge for land and forage. The forage-land activities provide feed for the beef systems and are modelled separately. The cost items included are a standard cost per cow for veterinary expense, supplementary nutrients, marketing costs, and a charge for breeding services. The costs which vary significantly among beef cow systems are the replacement cow costs. Revenue is produced by the sale of calves and cull cows. Also included in revenue is an estimated salvage value for the base beef cow at the end of the planning horizon. Prices received and costs incurred are in part determined by the base price expectations provided by the user. These prices are then adjusted by a seasonal index and are also a function of the weight of the animal

which is, in turn, affected by a seasonality provision. In summary, the c_j for each beef activity can be stated as a function of the beef production and marketing policies.

The general formula used to calculate the c_j for the jth beef activity is as follows:

$$c_j = \left[\sum_{i=1}^{n} ((P_j \cdot W_j) - A_j)/(1+R)^i \right] + S_j/(1+R)^n$$

where: c_j = present value of the jth beef activity which has generated revenues and costs over lifetime of animal

P_j = price per pound for jth product sold

W_j = weight of jth product sold

A_j = production and replacement costs for jth beef activity

S_j = salvage value of stock cow

R = discount factor

n = expected productive life of cow.

For calf revenue the price per pound, P_j, is determined as follows: $P_j = (BP \cdot PI) \pm ((\Delta P/\Delta W) \cdot \Delta W_j)$

where: BP = base price given for weaner calf

PI = seasonal price index

ΔP = price differential between weaner calf and yearling

ΔW = weight differential between weaner calf and yearling

ΔW_j = weight differential between calf sold and yearling.

This formula simply states that the base price provided by the user is adjusted for seasonality and weight of the product. If the product for sale weighs more than the base product, the price received is determined by a downward linear adjustment of price and vice versa. In a similar fashion, the price of cull cows sold and of replacement stock purchased is determined.

The basic equations involved in calculating the returns for each beef activity are now presented.

For each 'buy calf-sell yearling' activity, the objective function value is calculated via:

a. CJCLF(I,J) = REVCLF(I,J) + ARVCLF(I,J) - CLFCST(I,J) - ACLFCT(I,J)

where REVCLF(I,J) = (PRYS · SWTCLF)

ARVCLF(I,J) = (APRYS · SWTCLF)/(1.+R)^J

CLFCST(I,J) = (WTCALF · PRCB) + VET

ACLFCT(I,J) = ((WTCALF · APRCB) + VET)/(1.+R)^J

where PRYS = (PRYS · WCPRI(0)) + (((PRWC-PRYC)/(750.-CALFW1)) · (750.-SWTCLF))

or[4/]

PRYS = (PRYC · WCPRI(0)) - (((PRWC-PRYC)/(750.-CALFW1)) · (SWTCLF - 750.)))

[4/] These formulas calculate the price per pound for calves. The given price is adjusted for a monthly price variation about the average and for the difference in weight from benchmark weights. The change in price is assumed to be

(continued...)

4/ (continued)
an inverse linear function of the change in weight. Thus, as the weight of the calf increases above the benchmark weight, the price is lowered and vice versa.

APRYS = (APRYC · WCPRI(0)) + (((APRWC - APRYC)/ (750. - CALFWI)) · (750.-SWTCLF))

or4/

APRYS = (APRYC · WCPRI(0)) - (((APRWC - APRYC)/ (750.-CALFW1)) · (SWTCLF - 750.))

PRCB = (PRWC · WCPRI(0)) + (((PRWC - PRYC)/ (750.-CALFW1)) · (CALFW1 - WTCALF))

or4/

PRCB = (PRWC · WCPRI(0)) - (((APRWC - PRYC)/ (750. - CALFW1)) · (WTCALF - CALFW1))

APRCB = (APRWC · WCPRI(0)) + (((APRWC - APRYC)/ (750. - CALFW1)) · (CALFW1 - WTCALF))

or

APRCB = (APRWC · WCPRI(0)) - (((APRWC - APRYC)/ (750.-CALFW1)) · (WTCALF - CALFW1)

GSUM = WTPM(1) · TIME (I)

GWTR = WTPM(2) · TIME(II)

SWTCLF = WTCALF + GSUM + GWTR.

A verbal description of the terms in the above equations is as follows:

APRCB - average price per pound for calf purchased in years 2 - 7

APRYS - average price per pound for yearling calf sold in years 2 - 7

ACLFCT - discounted total purchase cost plus veterinary cost for each calf purchased in each of years 2 - 7

ARVCLF - discounted total revenue from purchase and sale of calves in each of years 2 - 7

CALFW1 - weight of calf at 205 days of age

CLFCST - total of purchase cost plus veterinary cost for each calf bought in year 1

CJCLF - the present value of the discounted stream of revenue and costs for the process of buying calves-selling yearlings in each year of a 7-year planning horizon

GSUM - the total pounds gained per calf during warm months

GWTR - the total pounds gained per calf during winter months

PRCB - price per pound of calf purchased in year 1

PRYS - price per pound of yearling calf sold in year 1

PRWC - given price per pound for 205 day old calf

PRYC - given price per pound for 750 pound yearling calf

SWTCLF - weight of calf sold

WTCALF - weight of calf purchased

WCPRI - monthly price index for calves

WTPM(1)- average pounds gained by calf in each of the eight warmest months of the year

WTPM(2)- average pounds gained by calf in each of the four coldest months of the year

VET - annual veterinary cost per calf.

For the beef cow-calf activities, the returns, purchase costs and miscellaneous costs are handled in an analogous manner. The difference being that these activities require a breeding stock unit. Fow cow-calf systems presently in inventory, some replacement stock must be procured in each year. For new additional cow-calf systems, all breeding stock must be purchased, and replacement stock procured in years 2 - 7. The user specifies the type of replacement stock to be purchased; i.e., open heifer, bred heifer, or cow with calf. As an alternative, the replacement stock may be raised on the farm.

For each cow-calf activity, the objective function value is calculated via:

a. BRETRN(L,KT) = CALFRE(L,KT) + COWRET(L,KT) - COSTOH(L,KT) + SALVGE

where: CALFRE(L,KT) is the total discounted returns from calf sales. These returns are calculated in a fashion similar to (REVCLF(I,J) + ARVCLF(I,J)) as described earlier in this

section. The difference is that the number of calves sold must reflect both the weaning percentage and the heifers saved back for replacement stock; e.g.,

1. CALFRE(L,KT) = (CALFWT(I) · ((PRWC · WCPRI(0)) - ((PRWC-PRYC)/(750. - CALFW1)) · (CALFWT(I) - CALFW1))) · (WP(I) + ((PRCCB - PRHR) · (1./PL))) - CRCOST - VETCOW.

This value is calculated for each year in the planning horizon. The discounted sum of these figures indicates the present value earned from calf sales via each respective cow-calf activity.

2. COWRET(L,KT) = (COWWT · (PRCULL · SCPRI(0))) · (((1. - WP(I)) · PB))

3. COSTOH(L,KT) = ((PROH · SCPRI(0)) · (1000. - (WTPMH · TIME(I))) · (PROHB · 1/PL) + ((PRBH · SCPRI(J)) · (1000. - (WTPMH · TIME(II))) · (PRBHB · 1/PL) + ((PRCC · SCPRI(IJ)) · (PRCCB · 1/PL)

4. SALVGE = (COWWT · (APRCUL · SCPRI(9))) · $1/(1+R)^7$

A verbal description of the new terms in these relationships is as follows:

BRETRN(L,KT) - the discounted present value of the returns earned by a beef cow-calf activity during the planning horizon.

COWRET(L,KT) - the discounted present value of dollars earned during the planning horizon via the sale of cull cows. The formula presented above calculates these returns from sale of barren cows. A similar formula calculates an additional component for the sale of cows which lose their calves.

COSTOH(L,KT) - the discounted present value for the cost of procuring initial and replacement breeding stock. The formula presented above calculates the cost of securing replacement stock in year 1. A similar formula without the constant (1/PL) calculates cost of the initial breeding stock.

SALVGE - the discounted salvage value of the beef cow at end of the seven-year planning horizon.

CRCOST - cost of creep feed for calves.

CALFWT(I) - weight of calf raised.

COWWT - average weight of cull cow.

PB - proportion of cows-without-calves attributed to barreness.

PL - productive life in years of the stock cow.

PROH - price per pound for open heifer in current year.

PRBH - price per pound for bred heifer in current year.

PRCC - price per cow-calf unit in current year.

SCPRI(I) - stock cow price index by month

VETCOW - annual veterinary, supplemental feed, and miscellaneous costs per cow and weaner calf.

D. Program FORHR

This program is concerned with developing the coefficients for the intergerized (discrete) activities of investing in machinery and for the non-intergerized (continuous) forage harvesting activities. Determined in this program are the present machinery resources available, machine resources required for the various forage harvesting systems, investment cost for additional machine resources, and the amount of associated machine-hours provided by the respective investment. Also calculated are the objective function coefficients indicating the discounted total net cost for the investment in machinery; and the discounted variable costs incurred for the forage harvesting systems during the planning period; and costs for custom-hiring of machinery.

1. Machine Investment

Investment in a machine item constitutes a lumpiness problem in that, barring partnership arrangements or other such agreements, purchase of a machine is an all or none decision. Such an investment process violates the linear programming assumption pertaining to divisibility of processes. To accommodate this consideration, these activities are considered as zero-one variables in a mixed integer programming model. If the activity does not enter the solution, it remains at the zero level. If the activity does enter the solution set, it comes in in its entirety.

The objective function coefficients, c_j's, for the machine investment activities consist of the negative contribution of each machine purchase to the net worth of the beef enterprise. This coefficient is determined as follows:

$$c_j = (DEP(J) - SALVGE(J)) \cdot PCTMCH_J$$

where: $PCTMCH_J$ - the percentage of machine working time that is to be employed by and thus charged to the beef enterprise

DEP(J) - the present value of the stream of the depreciation discounted over the planning horizon

SALVGE(J) - the present value of the jth asset's salvage value at end of the planning horizon.

These machine investment activities provide machine-hour resources which can then be employed by the beef/forage enterprise. The level of these activities is either zero or one and the number of such activities that can be brought into solution is constrained by the liquid capital available for machine investments.

2. Forage Harvesting Systems

Eight (8) forage harvesting systems are developed for consideration. These systems are:

(1) regular square bale - manually stacked in shed

(2) regular square bale - manually stacked outside

(3) regular square bale - mechanically stacked outside

(4) small square bale, handled via bale thrower into wagons and dumped in shed

(5) mechanical stack system of compressing loose hay into small stacks

(6) small round bales - left in field and picked up during slack time

(7) large round bale - left in field

(8) haylage via chopper and stored in silo.

These forage harvesting systems are constrained by the man-hours of labor available for the first cutting and for the second-third cuttings; and by the hours of machine-time available in these same respective time periods. The a_{ij}'s for the jth forage harvesting system as constrained by the ith labor resource available and by the hours available for

the ith machine are calculated in this routine from data gathered via the input form. For example:

for the Ith machine used in the Jth forage harvesting system, the a_{ij} = HRMCH(I);

for the man-hours required by the Jth forage harvesting system, the a_{ij} = HRMAN(I);

where: HRMCH(I) - number of hours required for the Ith machine to process 1 ton of forage TDN

HRMAN(I) - total number of man-hours required to harvest and store 1 ton of forage TDN via the Jth forage harvesting system.

Tractor horsepower requirements were also given consideration in this routine. Each pulled implement requires a certain amount of horsepower. This total horsepower requirement for each machine consists of a drawbar component plus a power-takeoff component. If presently available tractor horsepower is not sufficient to power a particular implement involved in a forage harvesting system being considered, it will be necessary to invest in a larger tractor.

The c_j for each forage harvesting system is based on the cost per ton TDN to harvest forage via the particular system being considered. Each forage system is composed of various machine combinations with an associated requirement of man-hours to handle each machine.

The general formula used in calculating the c_j's for each forage harvesting system is as follows:

$$c_j = \sum_{i-1}^{n} \left(\sum_{ii=1}^{m} (HRMCH_{ii} \cdot OCOST_{ii}) \right) / (1+R)^i$$

where: ii - the different machines used in the jth forage harvesting system

n - the planning horizon of seven (7) years

$HRMCH_{ii}$ - the machine hours required for the iith machine to process one ton TDN of forage

$OCOST_{ii}$ - the operating cost per hour for the iith machine; this operating cost includes the variable cost for both the pulled machine and the tractor to power it.[5/]

3. Machine Custom Hire

Machine custom-hire services are provided as an alternative to investing in machinery. Such services may be hired in either one or both of the two (2) forage harvesting periods. The c_j for these activities consists of the variable cost per hour for hiring-in these services during the planning horizon. The ten (10) alternative machine-services

[5/] The actual operating costs used are presented in Appendix G, page 17 of the input form.

considered for hire are: (1) mowing, (2) conditioning, (3) raking, (4) regular square baler, (5) square baler with accumulator and stacker, (6) square baler with bale thrower plus wagons, (7) mechanical stack system for loose hay, (8) small round baler, (9) large round baler, and (10) forage chopper and wagons. The cost/hour for these services rendered is to include allowance for a tractor and man to operate the machine.

The general formula used to determine the c_j to reflect the cost of these services is: $c_j = \sum_{i=1}^{n} X_j/(1+R)^i$

where: X_j = cost/hour for the jth machine service

n = planning horizon in years

R = discount rate.

The basic equations involved in calculating the coefficients for machinery investment, forage harvesting systems, and custom hire of machine services are now presented.

<u>(1) Machinery Purchases</u>. The cost charged against the beef enterprise for purchase of a machine is determined by the following equation.

a. CJMCH(I) = DEP(I) - SALVGE(I)

where: $\text{DEP(I)} = \sum_{j-1}^{7} (\text{IVCOST(I)}/7.) / (1.+R)^J$

DEP(I) - the present value of the depreciation on the Ith machine which is incurred during the planning horizon. Assumed is the straight-line method of calculating depreciation.

SALVGE(I) = (IVCOST(I) - (TDEP(I) · 7)/(1+R)^7

SALVGE(I) - the present value of the depreciated machine at the end of the 7-year planning horizon.

TDEP(I) - annual depreciation on the Ith machine.

IVCOST(I) = COST(I) · PCTMCH(I)

IVCOST(I) - the cost of the Ith machine which is to be charged against the beef/forage enterprise.

COST(I) - the actual dollar cost of purchasing the Ith machine.

PCTMCH(I) - the proportion of the Ith machine's time that is to be employed by the beef/forage enterprise. This figure indicates that portion of the fixed investment cost for the Ith machine which is allocated to the beef/forage enterprise.

CJMCH(I) - the ownership costs incurred for the Ith machine.

(2) Forage Harvesting Considerations. Eight (8) alternative forage harvesting systems have been modelled for each of two (2) forage harvesting periods. The variable cost (c_j) of harvesting one (1) ton of total digestible nutrients (TDN) from forage via a particular harvesting system is calculated by the following:

a. TCSTAC(I) = C + COSTAC(II) + COSTAC(III) + QTWINE

where: $C = \sum_{J=1}^{3} COSTAC(J)$

C - the operating costs to mow, condition and rake one ton of forage TDN

COSTAC(II) - operating costs to package one ton of forage TDN

COSTAC(III) - operating costs to haul, handle, and store one ton of forage TDN

QTWINE - cost per ton forage TDN for twine to wrap and secure the hay package

TCSTAC(I) - the total variable cost to harvest one ton of forage TDN. The annual cost is summed and discounted over the planning horizon to provide the c_j for each harvesting activity.

The following sections - b, c, d, and e calculate the a_{ij}'s for the forage harvesting systems.

b. HAYHR(I) - X + HRMAN(II) + HRMAN(III)

where X = HRMAN(I)

X - man-hours of labor required to mow, condition, and rake one ton of forage TDN

HRMAN(II) - man-hours of labor required to package one ton of forage TDN

HRMAN(III) - man-hours of labor required to handle, haul, and/or store one ton of forage TDN

HAYER(I) - total man-hours of labor required to harvest one ton of TDN from forage via the Ith harvesting system.

c. HRMCH(JJ) = ((1./ACHR(JJ)) /2.025) · 1.96

where HRMCH(JJ) - the hours required for the JJth machine to process one ton of forage TDN

ACHR(JJ) - the acreage per hour that can be processed by the JJth machine

The number 2.025 represents an assumed forage dry matter yield in tons. This yield is that amount which is assumed produced by a forage variety from either the first cutting or the second plus third cuttings.

The number 1.96 represents the dry matter tonnage required to produce one ton of forage total digestible nutrients.

d. TTRHR(I) = (HRMCH(JM) · TOHP(JM) + ((Y + HRMCH(JMM)) · 40.)

where Y = HRMCH(J)

Y - machine hours required to mow, condition, and rake one ton of forage TDN

The number 40 represents the assumed horsepower required to power a mower, conditioner, or rake.

TOHP(JM) = DBHPJ(JM) + (PTOHP(JM) · 1.5)

TOHP(JM) - the horsepower required to power the JMth implement

where DBHP(JM) = ((SIZE(II) · COEF) · SPEED(JM) / (375. · .96 · .8)

DBHP(JM) - drawbar horsepower in power-takeoff (PTO) equivalents

SIZE(II) - size in pounds of implement being towed and powered

COEF - coefficient of rolling resistance; i.e., the friction of implement with ground surface

SPEED(JM) - speed of operation in miles per hour

The number 375 is the standard for horsepower equivalents.

The numbers .96 and .8 represent tractive efficiency rates; i.e., the ratio (drawbar horsepower/axle horsepower)

PTOHP(JM) = UNITHR(JM) · PTOHP(JM)

PTOHP(JM) - the standard of horsepower-hours required to process one unit; e.g., a ton of hay

UNITHR(JM) - the rate of units processed per hour; e.g., tons/hour.

e. Each mechanical forage harvesting activity has an associated forage conversion efficiency, i.e., of the forage available in the field, what proportion is actually harvested? The forage conversion efficiencies are calculated externally to this model and are simply read in by Program LABEL.

(3) Custom Hire of Machine Services. The actual cost to the user of custom hired services is determined by the outright variable cost of hiring these services minus those variable costs for operating one's own machinery. These own operating costs must be subtracted to avoid double-counting of such expenses.

$$HIRE(I) = \sum_{J=1}^{7} (CUHIRE(I) - OCOST(I))/(1+R)^{J}$$

CUHIRE(I) - the cost for hiring one hour of the Ith machine service complete with man and power unit

OCOST(I) - variable cost per hour to operate the Ith machine

HIRE(I) - the actual cost to the user for the Ith machine service. This figure is the present value of hiring one hour of this service in each year of the planning horizon.

E. Program FORAGE

This program calculates the forage available and the amount of each forage variety that can be made available for

each of the nine (9) time periods during the year. Although the forages that are considered herein have names peculiar to the midwest and Indiana in particular, these forage varieties could be replaced with those varieties of another geographic area. For such needs, alternative forage yields, their respective distribution of growth during the year, and their TDN composition would have to be entered. The forages used in our test data were: (1) native pasture, (2) korean lespedeza, (3) birdsfoot trefoil, (4) new seeding, (5) orchard grass, (6) tall fescue, (7) alfalfa/grass mixture, (8) red clover/grass mixture. (9) aftermath from small grains and/or soybeans, and (10) cornstalk refuse. In addition, one (1) activity was provided for the provision of corn silage.

Each of the listed ten (10) forages can be grown on three (3) different soil management groupings (bottomland, hillsides and upland) operated under two (2) forms of land control (ownership and cash rental). The input form requests expected yields for each of the forage varieties grown under these alternative conditions. The label on this request is in tons of dry matter (DM) per acre.

Each forage yield is multipled by a particular array representing the anticipated distribution of growth for that respective forage during the year. Such an array for orchard grass is pictured in Figure B.1. Similar arrays for each forage are grouped into a matrix entitled PFPT(I,JJ). The use of this matrix in the data generator is shown in the equations of this section.

The array of forage yields, FYM(I,JJ), is then multiplied by its respective percentage composition of total digestible nutrients, PTDN(I,JJ). The end result represents the tons of TDN available from an acre of each particular forage during each specified time period. The TDN percentage composition for orchard grass is shown in Figure B.2. Figure B.3 indicates the end result; i.e., the TDN amount available - expressed as a percent of the total.

With respect to the harvesting of these forages, features were built into the generator to recognize that 100 percent of the forage produced cannot be harvested. For grazing, a 'grazing waste' coefficient is included to recognize tramping of forage and other conversion inefficiencies associated with cattle grazing on land.

For mechanical harvest of forages, four (4) forage varieties can be so harvested. These varieties are orchard grass, tall fescue, alfalfa/grass, and red clover/grass. Each of these forages may be cut one, two, or three times or any combination thereof. Forages which are mechanically harvested are then made available for stored feeding during the winter period. Forage grown but not mechanically harvested is available for grazing.

Mechanical forage harvesting efficiencies are modelled as structural parameters and are straightforwardly written into the matrix. This assignment occurs in Program LABEL but will now be discussed. Recalling that eight (8) forage

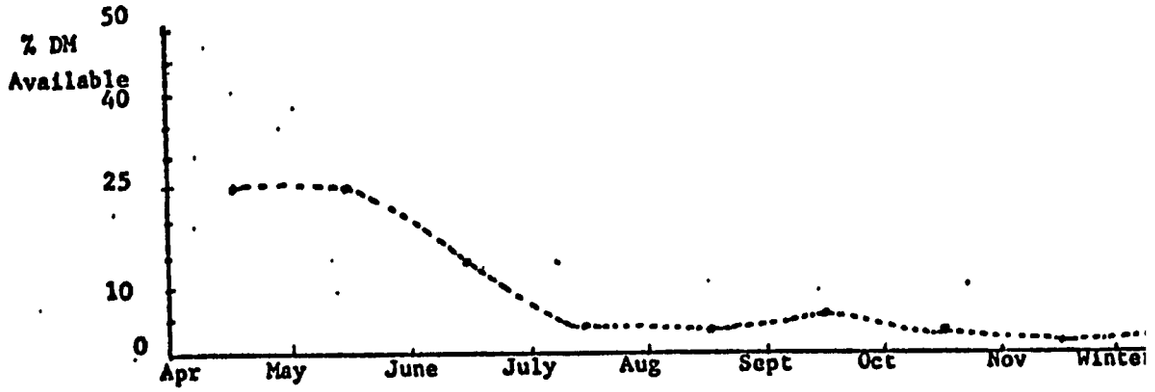

Figure B.1. Availability of Dry Matter from Orchard Grass.

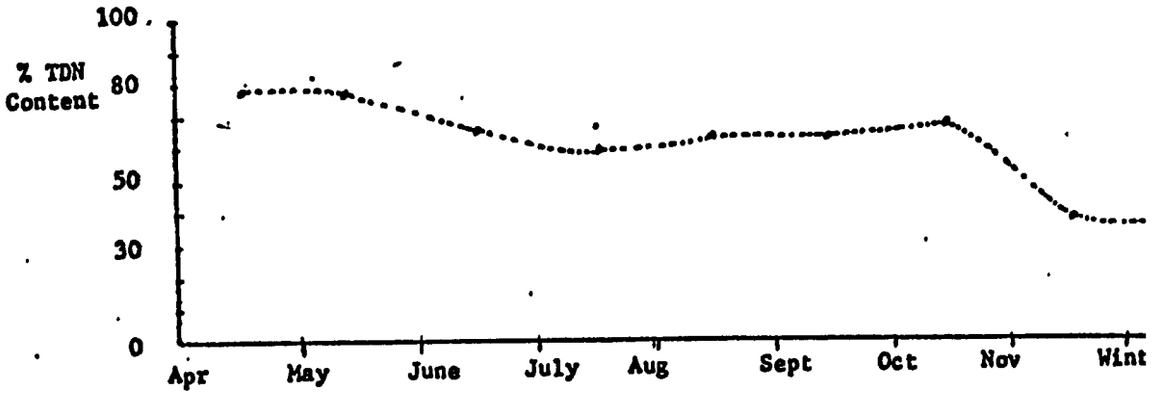

Figure B.2. Total Digestible Nutrient (TDN) Content of Orchard Grass.

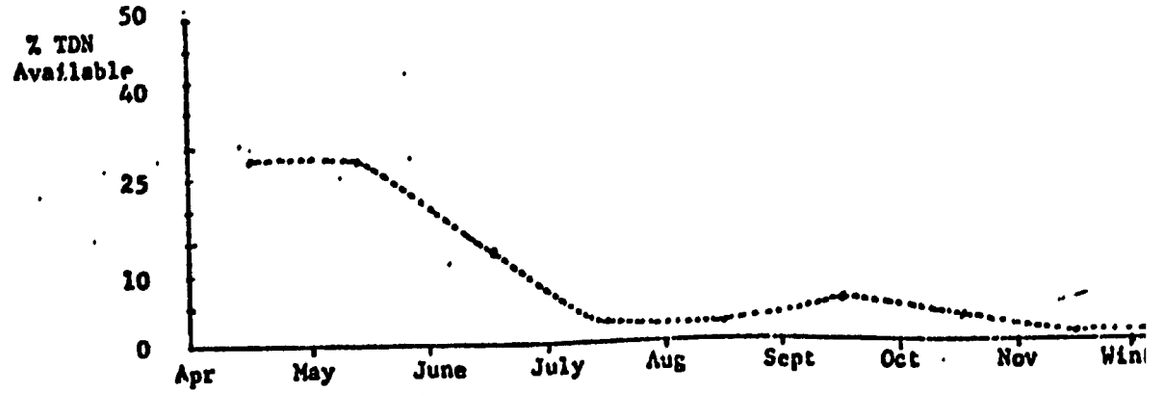

Figure B.3. TDN Available from Orchard Grass.

harvesting systems were modelled, as discussed in section D.2, Program FORHR of this chapter, each such system has an associated harvesting and storage loss. These forage losses occur during the processes of mowing, conditioning, raking, packaging, and storing of the forage. Such losses may be conceptually pictured as in Figure B.4 which presents these losses for a particular forage being harvested at the recommended machine specifications. In addition to the forage losses due to moisture considerations as suggested in Figure B.1, there are weather-storage losses for those systems which store the forage outside. It is this combination of forage-storage losses which are taken as structural parameters herein with the recognition that these considerations are in need of more study.

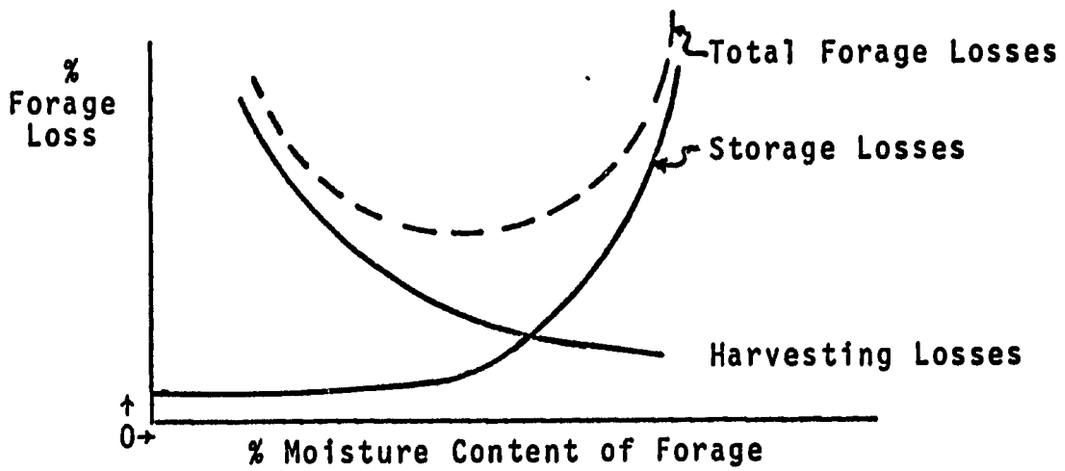

Figure B.4. Forage Conversion Losses.

The general formula used in Program FORAGE is as follows:

$$HTDNM(I,JJ) = FY(I) \cdot HPFPT(I,JJ) \cdot PTDN(I,JJ)$$

where

HTDNM(I,JJ) - the tons of forage TDN available from an acre of the Ith forage during the JJth time period

FY(I) - the annual forage dry matter yield per acre from the Ith forage

For grazing of forage, HPFPT(I,JJ) = PFPT(I,JJ) · GW

For mechanical harvest of forage, HPFPT(I,JJ) = PFPT(I,JJ)

PFPT(I,JJ) - the distribution of growth factor; i.e., the percentage of the annual Ith forage yield that is produced and made available during the JJth time period

GW - a grazing waste factor to indicate that grazing cannot harvest 100% of the forage produced. Such grazing wastes may be attributed to tramping and manure droppage

PTDN(I,JJ) - the total digestible nutrient factor; i.e., the percentage of the Ith forage dry matter produced during the JJth time period that is totally digestible.

F. Program PVLAND

This program calculates the c_j for all land activities providing forage. This c_j will have a negative contribution to overhead and profit. Also calculated are c_j's to reflect the opportunity cost of land being considered for employment by a beef enterprise. This c_j has a positive contribution to

to the objective function and represents what the user feels to be the most profitable alternative net return for use of the land in an employment other than the beef/forage enterprise.

The general formula used in calculation is as follows:

$$c_j = \sum_{i=1}^{n} X_j/(1 + R)^i$$

where: n = years of planning horizon

R = discount rate

For activities representing the opportunity cost of land, X_j is the annual net income from the next best alternative employment of the jth land type.

For activities representing land used to provide forage, X_j is the annual net charge for variable production costs incurred in the operation of the jth forage-land combination.

For owned land, this annual variable cost/acre should consist of costs expected to be incurred for maintenance and/or establishment of the seeding. This cost should include such items as fertilizer, lime, herbicide, and their cost of application. Also to be included are the cost of new seed, fencing, water provision, brush clearance, pesticides, and any other cash expenditures incurred in the establishment and/or maintenance of a forage acre. Forage harvesting costs are not to be included as these costs are incorporated in the

c_j for the activities representing the forage harvesting systems. For rented land, the annual variable cost/acre includes those costs analogous to the ones encountered for owned land plus the cost/acre for cash rental. All c_j's represent the present value of this stream of expenses and/or revenue as discounted over the planning horizon. Example forage production cost budgets are presented in Appendix F, Tables F.3, F.4, and F.5.

The specific formulas used in Program PVLAND are as follows:

$$PVLDCH(I) = \sum_{J=1}^{7} LANDCH(I)/(1+R)^J$$

$$PVLDIN(I) = \sum_{J=1}^{7} LANDIN(I)/(1+R)^J$$

$$COSTLD(I) = \sum_{J=1}^{7} CRENT(I)/(1+R)^J$$

where PVLDCH(I) - The C_i for using owned land in forage production. This figure represents the present valuc of the discounted stream of variable production expenses encountered during the 7-year planning horizon.

LANDCH(I) - The annual variable production expenses encountered per acre for the Ith forage-land combination; e.g., producing alfalfa on hillsides.

PVLDIN(I) - The C_j for using owned land in the best alternative employment other than forage produced for beef animals.

LANDIN(I) - The annual net income per acre that can be expected from the best alternative use of the Ith land cetegory.

COSTLD(I) - The C_j for obtaining use of an acre of rented land.

CRENT(I) - The annual variable cost to obtain the rented land and produce forage in the Ith forage-land combination.

G. Program STORAGE

This program records and calculates data pertinent to the forage storage facilities available, increases in storage capacity, and the amount of forage currently in storage.

The c_j's for the intergerized activities of building more forage storage facilities consider the initial investment cost, annual fixed and variable costs of this new storage, and the salvage value of this asset. The general formula used is:

$$c_j = (DEP_j - SVG_j + CST_j) \cdot PCT_j$$

where: c_j - present value of the net contribution to overhead and profit encountered over 7 years from investment in the jth structure

DEP_j - the present value of the stream of depreciation on the jth structure discounted over the planning horizon

SVG_j - the present value of the salvage worth of the jth structure at end of planning horizon

PCT_j - the percent of the jth structure that is to be employed by and thus charged to the beef enterprise

CST_j - the present value of the stream of annual expenses encountered in owning the jth storage structure; this cost may include an interest cost, repair cost, and a property tax charge.

These investment activities are constrained by available finances. The a_{ij}'s for this situation are simply the investment cost. Suggested investment costs are presented in an information table contained in the input form. These investment costs are calculated via Program Silo (available from the author) and include the base silo and unloader costs. Figures are provided for the annual storage cost per ton of silage saved for each of the various types and sizes of silos.

The specific formulas used in Program STORAGE are as follows:

CJBRN = (DEPBRN = BRNSVG) · PCTBRN) + BRNCST

CJSLO = (DEPSLO = SLOSVG) · PCTSLO) + SLOCST

where CJBRN - the (negative) contribution to net worth for building a barn

CJSLO - the (negative) contribution to net worth for building a silo

BRNIVT - total cost for constructing a specific barn size

$$DEPBRN = \sum_{J=1}^{7} ((BRNIVT \cdot BRNDEP)/(1+R)^{J}$$

DEPBRN - the amount of total depreciation on the barn. DEPBRN represents the present value of this stream of depreciation expenses.

BRNDEP - the annual percentage rate of depreciation on the barn

PCTBRN - the percentage of barn space and time that is to be utilized by and thus charged to the beef/forage enterprise.

$$BRNSVG = (BRNIVT - BRNIVT \cdot BRNDEP \cdot 7.))/(1+R)^{7}$$

BRNSVG - the salvage value of the barn as evaluated at the end of the 7-year planning horizon.

$$BRNCST = \sum_{J=1}^{7} (BRNIVT \cdot (BRNINT + BRNREP + BRNTAX)) \cdot PCTBRN/(1+R)^{J}$$

BRNCST - the present value of the stream of annual costs encountered in ownership of the barn.

BRNINT - annual percentage interest charge on money invested in barn

BRNREP - annual percentage repair charge required to maintain the barn

BRNTAX - annual percentage property tax charge on barn structure.

The calculations and interpretation of the costs encountered in building a silo are exactly analogous to those explained above for the barn.

H. Program MISC

This program gives consideration to labor availability, the cost of hiring additional labor, debt situation and interest costs, and alternative winter feeding systems.

1. Labor Situation

The amount of labor available is provided by the input form. These figures provide the right hand side (RHS) for the labor constraints. The hiring-in of additional labor is considered if it is so desired. This labor has an associated cost and should have a limitation on quantity available. The cost is simply the wage rate per hour summed and discounted over the planning horizon. This figure provides the c_j for the labor-hiring activities. These activities will be constrained by the maximum amounts of labor which can be hired.

The c_j for hiring labor is determined by the following calculation:

$$WAGE(I) = \sum_{J=1}^{7} XWAGE(I)/(1+R)^J$$

where WAGE(I) - the discounted present value for hiring one hour of labor during the Ith time period in each year of the planning horizon

XWAGE(I) - the dollar wage paid for each hour of hired labor.

2. Debt Situation

Included in this section are requests on the present amount of debt incurred, the maximum limitations on debts, and the interest charged for borrowing money. This interest cost provides the negative c_j's for the three (3) activities of borrowing money for livestock, for machinery, and for buildings. The maximum limits on these three (3) types of debt provide the RHS value for the three (3) constraints limiting the amount of debt which can be incurred by each of these borrowing activities.

3. Winter Feeding Systems

Four (4) feeding systems are considered for getting the stored forage to the cattle during the winter period. The systems as specified are:

(1) Ad libitum feeding; feed placed on ground surface

(2) Limit feeding; feed placed on ground surface

(3) Ad libitum feeding; feed placed in feed bunks or racks

(4) Limit feeding; feed placed in feed bunks or racks.

Each system has an associated labor requirement and an efficiency of feed conversion. The tradeoff between the use of these two (2) resources - labor and forage - compared with the resource limitations will determine which feeding system allows the most cow-herd-units for a particular beef system and thus determine the most profitable way to handle the winter feeding chore.

To convert the forage wastage index as requested in the input form to the forage efficiency index of conversion used in the programming tableau, the following equation was used:

FD(IT,JJ) = -1./(1. + FEED(I)).

I. Program LABEL

This program uniquely labels each value coefficient (c_j), production transformation coefficients (a_{ij}), and the right hand side values (RHS). Each value is then placed into the proper location of the initial linear programming tableau. All columns and rows have a unique identity in order to correctly identify each separate coefficient in the programming tableau. Many of these coefficients were calculated in the eight (8) previous programs explained in this chapter. Program LABEL then arranges these coefficients into the MPS format necessary for the solution algorithm. The proper format consists of the coefficients being taken in column order;

i.e., the first column is read in its entirety, then the second column, etc., with the integerized activities necessarily being the first set of columns.

The labeling code consists of row and column identifications plus placing the correct sign; i.e., positive or negative, on each coefficient.[1/]

The general technique used is to generate small block components or submatrices of the initial programming tableau. Such blocks reflect the interactions within each section of activities. Once these blocks have been generated, these blocks are placed in the proper arrangement to reflect the interactions between the component blocks.

The Label routine also reads in the transformation efficiencies for the forage carryover and the mechanical forage harvesting activities.

With respect to the forage carryover activities, the month-to-month carryover efficiencies are as follows:

April - May	.95
May - June	.95

[1/] With respect to coefficient signs:

for the a_{ij}'s - positive (+) indicates a demand for the Ith resource by the Jth activity
- negative (-) indicates a supply of the Ith resource by the Jth activity

for the C_j - positive (+) indicates a positive contribution to the change in net worth of the beef/forage enterprise by the Jth activity
- negative (-) indicates a negative contribution to the change in net worth of the beef/forage enterprise by the Jth activity.

June - July	.75
July - August	.80
August - September	.85
September - October	.85
October - November	.70
November - Winter	.55

APPENDIX C

CODE FOR LINEAR PROGRAMMING MATRIX

This appendix provides the means to decode the row and column identifiers used in the linear programming tableau. Each identifier must be unique to its particular row or column. In this manner, each cell in the matrix has a unique identity.

The code used is a five (5)-digited numeral. The first number for each identifier is a one (1), two (2), or three (3) and indicates an activity (column), the objective function (row), and constraints (rows) respectively. The second and third numbers in each numeric code indicate the category being referenced. The fourth and fifth numbers signify particular processes within this basic category.

A. Activity Codes

There are 34 general categories of activities. The discussion proceeds in ascending order; i.e., those activities with the lowest numeric codes are discussed first.

1. Integerized Activities

(1) Machinery Investments (Categorical Code 10). There are twenty-one (21) alternative machine investments. Thus the code for this category of activities ranges from 11001 -

11021. The first ten (10) activities are for the purchase of tractors ranging from the 40 horsepower size to the 140 horsepower size. The eleventh through twenty-first activities are for the purchase of the following machine implements:

11011 - mower

11012 - conditioner

11013 - rake

11014 - square baler

11015 - square baler with accumulator and stacker

11016 - square baler with bale thrower

11017 - stack wagon which compresses loose hay

11018 - small round baler

11019 - large round baler

11020 - forage chopper and wagon(s)

11021 - blower for chopped forage

(2) Building Investment (Categorical Code 28). There are two (2) building activities and one (1) finance activity within this category. These activities are coded as follows:

12801 - building investment in barn

12802 - building investment in silo

12803 - outside credit (borrowing money) to finance the building structure

2. Divisible Input/Output Activities

(1) Finance Machinery Investment (Categorical Codes 15 and 16).

11501 - beginning cash on hand that is invested in machinery

11601 - outside credit (borrowing money) to finance the machinery investment

(2) Forage Harvesting Activities (Categorical Codes 25 and 26). Code 25 indicates the first cutting harvested during May-June. Code 26 indicates the second and/or third cuttings harvested in the period July, August, and September.

The fourth and fifth numbers in the code signify the particular forage harvest activity. Their meanings are as follows:

01 - regular square bale - manually stacked in shed

02 - regular square bale - manually stacked outside

03 - regular square bale - gathered in a bale accumulator and mechanically stacked outside

04 - small square bale - handled via bale thrower into wagons and dumped in shed

05 - mechanical stack system of compressed 'loose' hay - stacks left outside

06 - small round bale - left in field and picked up during slack time

07 - large round bale - left in field and moved during slack time

08 - haylage via forage chopper - stored in silo

Unique number codes are created by combining the harvest period indicator with the code for the particular harvest

activity. Thus, the code 12508 indicates the first cutting of forage harvested via the chopper during the May-June time period.

The forage harvest activity codes range from:

12501 - 12508 -- first cutting of forage

12601 - 12608 -- second and/or third cutting of forage

(3) Custom-hire Activities (Categorical Codes 24 and 27). The twenty (20) activities (12401 - 12410 and 12701 - 12710) modeled in this section provide an alternative to ownership of forage harvesting implements. The second and third numbers indicate the time period; e.g., 27 - first cutting in May-June, 24 - second and/or third cutting in July, August, or September. The fourth and fifth numbers indicate the particular machine: e.g.,

01 - hiring-in tractor, man, and mower

02 - hiring-in tractor, man, and conditioner

03 - hiring-in tractor, man, and rake

04 - hiring-in tractor, man, and regular square baler

05 - hiring-in tractor, man, and square baler with bale accumulator and mechanical stacker

06 - hiring-in tractor, man, and square baler with bale thrower plus wagons

07 - hiring-in tractor, man, and mechanical stacker which compresses loose hay into wagon-sized stacks

08 - hiring-in tractor, man, and small round baler

09 - hiring-in tractor, man, and large round baler

10 - hiring-in tractor, man, and forage chopper with wagons

An activity code of 12701 indicates the hiring-in of the mowing process for the first forage cutting during the May-June time period. Activity code 12401 indicates hiring-in of this same process for the second and/or third cutting.

(4) Forage Inventory (Categorical Code 29).

12901 - beginning hay inventory (tons TON)

12902 - beginning haylage inventory (tons TON)

12903 - beginning corn silage inventory (tons TON)

12904 - total beginning inventory of forages (tons TON)

(5) Land Opportunity Cost Activities (Categorical Codes 30, 31, and 32). There are a total of thirty-three (33) forage-land combinations which may be employed in an alternative other than by the beef enterprise. Codes 30, 31, and 32 indicate owned bottomland, hillsides, and upland respectively. Each land category can produce the following forages:

01 - permanent pasture
02 - korean lespedeza
03 - birdsfoot trefoil
04 - new seeding
05 - orchard grass
06 - tall fescue
07 - alfalfa/grass
08 - red clover/grass
09 - aftermath from small grain and soybean acres
10 - cornstalks available for grazing
11 - cornstalks which must be mechanically harvested if this aftermath is to be utilized

Unique numeric codes are created by combining the categorical code with each of these forage identifiers. Thus, the activity 13007 indicates bottom-land which could produce alfalfa for beef utilization but will, instead, be employed in its best alternative use.

The code for land opportunity cost activities can be summarized as follows:

13001 - 13011 - opportunity cost activities on bottomland

13101 - 13111 - opportunity cost activities on hillsides

13201 - 13211 - opportunity cost activities on upland

(6) Intermediate Activities.

a. Forages produced on owned land and harvested via grazing (categorical codes 33, 34, and 35)

Codes 33, 34, and 35 refer to owned acres of bottomland, hillsides, and upland respectively. Combining these codes with the forage identifiers (presented in section 2.(5)) results in 33 unique codes identifying the various forage-land combinations. For example, code 13401 refers to the grazing of permanent pasture that is grown on the hillsides.

The range for these codes is as follows:

13301 - 13311 - grazing of bottomland forages; owned land

13401 - 13411 - grazing of hillside forages; owned land

13501 - 13511 - grazing of upland forages; owned land

b. Forages produced on cash-rented land and harvested via grazing (categorical codes 36, 37, and 38).

Codes 36, 37, and 38 refer to rented acres of bottomland, hillsides, and upland respectively. Combining these

codes with the forage identifiers results in 33 unique codes identifying the various forage-land combinations. For example, code 13806 refers to the grazing of tall fescue on the upland.

The range for these codes is as follows:

13601 - 13611 - grazing of bottomland forages; cash-rented land

13701 - 13711 - grazing of hillside forages; cash-rented land

13801 - 13811 - grazing of upland forages; cash-rented land

c. Forages produced on owned land and harvested via grazing and/or mechanical means (categorical codes 39, 40, 41, and 45).

Codes 39, 40, and 41 refer to owned acres of bottomland, hillsides, and upland respectively. Forage acres in this category may be harvested by a mix of mechanical harvest and grazing techniques (as specified by the user-participant). Four (4) forages are included for consideration. Combining the land and forage indicators results in twelve (12) forage-land activities which are eligible for mechanical harvest.

The range for these activities is:

13901 - 13904 - mechanical harvest/grazing of forages produced on bottomland; owned acres

14001 - 14004 - mechanical harvest/grazing of forages produced on hillsides; owned acres

14101 - 14104 - mechanical harvest/grazing of forages produced on upland; owned acres

where the forage indicators are:

01 - orchard grass

02 - tall fescue

03 - alfalfa/grass

04 - red clover/grass.

In addition activity 14501 signifies the production and harvesting of corn silage on owned land.

d. Forages produced on cash-rented land and harvested via grazing and/or mechanical means (categorical codes 42, 43, and 44)

Codes 42, 43, and 44 refer to cash-rented acres of bottomland, hillsides, and upland respectively. Combining these three (3) land categories with the four (4) forages, as given in section 6c above, results in twelve (12) forage-land combinations which can be mechanically harvested.

The range for these activities is:

14201 - 14204 - mechanical harvest/grazing of forages produced on bottomland; cash-rented acres

14301 - 14304 - mechanical harvest/grazing of forages produced on hillsides; cash-rented acres

14401 - 14404 - mechanical harvest/grazing of forages produced on upland; cash-rented acres.

<u>(7) Carryover Activities</u> (Categorical Code 48). There is a carryover activity for each of the eight (8) time

intervals between the nine (9) separate time periods modelled. These time intervals are coded as follows:

01 - April to May

02 - May to June

03 - June to July

04 - July to August

05 - August to September

06 - September to October

07 - October to November

08 - November to Winter

The code of 14808 can be interpreted as the means of carrying forage produced but not consumed in November to the next time period - winter.

(8) Winter Feeding Activities (Categorical Code 49). These twenty (20) activities provide the means during the winter time period of feeding stored forage to cattle. These activities are the combinations of five (5) types of forage packages, two (2) levels of feeding, and two (2) methods of the cattle accessing the forage package.

14901 - *ad libitum* feeding on ground surface of small bales stored inside

14902 - limit feeding on ground surface of small bales stored inside

14903 - *ad libitum* feeding in feed bunks or racks of small bales stored inside

14904 - limit feeding in feed bunks or racks of small bales stored inside

14905 - ad libitum feeding on ground surface of small bales stored outside

14906 - limit feeding on ground surface of small bales stored outside

14907 - ad libitum feeding in feed bunks or racks of small bales stored outside

14908 - limit feeding in feed bunks or racks of small bales stored outside

14909 - ad libitum feeding on ground surface of compressed stacks

14910 - limit feeding on ground surface of compressed stacks

14911 - ad libitum feeding in feed bunks or racks of compressed stacks

14912 - limit feeding in feed bunks or racks of compressed stacks

14913 - ad libitum feeding on ground surface of large round bales

14914 - limit feeding on ground surface of large round bales

14915 - ad libitum feeding in feed bunks or racks of large round bales

14916 - limit feeding in feed bunks or racks of large round bales

14917 - ad libitum feeding on ground surface of haylage

14918 - limit feeding on ground surface of haylage

14919 - ad libitum feeding in feed bunks or racks of haylage

14920 - limit feeding in feed bunks or racks of haylage

(9) Cow-Calf Activities (Categorical Code 50). The thirty (30) cow-calf activities in this section result from a combination of six (6) alternative calving months and five (5) sets of parameters that describe the alternative beef management policies. All input information for these activities may be dictated by the user.

The code for these activities may be presented in a summary fashion as follows:

15001 - 15006 - Beef Management Policy #1 combined with the calving months

15007 - 15012 - Beef Management Policy #2 combined with the calving months

15013 - 15018 - Beef Management Policy #3 combined with the calving months

15019 - 15024 - Beef Management Policy #4 combined with the calving months

15025 - 15030 - Beef Management Policy #5 combined with the calving months.

(10) 'Buy Calf-Sell Yearling' Activities (Categorical code 55). The twenty (20) activities coded in this section result from the user specifying four (4) alternative months

in which to buy calves and five (5) different lengths of time for which these calves may be kept on forage.

The code is summarily explained as follows:

15501 - 15505 - calves purchased in first month specified and fed for the alternative time periods specified

15506 - 15510 - calves purchased in second month specified and fed for the alternative time periods specified

15511 - 15515 - calves purchased in third month specified and fed for the alternative time periods specified

15516 - 15520 - calves purchased in fourth month specified and fed for the alternative time periods specified.

(11) Present Cow-Calf Activities (Categorical Code 56).

15601 - Beef Management Policy #1 and calving in specified month

15602 - Beef Management Policy #2 and calving in specified month.

(12) Financial Activities (Categorical Codes 61, 62, and 63).

16101 - outside finance (borrowing money) to invest in cattle

16201 - beginning cash on hand that is invested in building structures

16301 - beginning cash on hand that is invested in cattle.

(13) Forage Transfer Activities (Categorical Code 99).

19909 - transfer a carryover to the winter period of forage available but not consumed in November

19910 - transfer of mechanically harvested forages to desired carryover inventory for next year.

B. Objective Function

The numeric identifier for the objective function is 20000.

C. Constraints

There are 26 general categories of constraints. These limitations upon the forage-beef enterprise will be discussed in an ascending categorical order.

1. Financial Considerations (Categorical Code 10)

31001 - financial accounting for investment in machinery

31002 - limitation on amount of cash-on-hand

31003 - limitation on amount of capital that can be borrowed for investment in machinery

2. Tractor Horsepower-Hours (Categorical Code 11)

31101 - limit on availability of tractor horsepower-hours for first cutting of forage

31102 - limit on availability of tractor horsepower-hours during periods for 2nd and 3rd cuttings of forage.

3. Machine-hour Availability (Categorical Code 12 and 13)

Code 12 indicates machine-hours available for first cutting of forage; and code 13 indicates available machine-hours during periods for second and third cuttings of forage. The machine implements used in the forage harvesting process are coded as follows:

01 - mower

02 - conditioner

03 - rake

04 - square baler

05 - square baler with accumulator and stacker

06 - square baler with bale thrower

07 - stack wagon to compress loose hay

08 - small round baler

09 - large round baler

10 - forage chopper

11 - blower

For example 31209 is an accounting row concerned with the availability of a large round baler during the May - June time period.

4. Financial Considerations for Building Investments (Categorical Code 20)

32001 - financial accounting for investments in buildings

32002 - limit on amount of capital that can be borrowed for investments in buildings

5. Forage Storage
(Categorical Code 23)

32301 - available barn storage space (tons DM) for hay

32302 - available silo storage space (tons DM) for haylage and silage

6. Forage Inventory
(Categorical Code 24)

32401 - tons hay DM on hand at beginning of year

32402 - tons haylage DM on hand at beginning of year

32403 - tons corn silage DM on hand at beginning of year

32404 - accounting for total forage inventory on hand at beginning of year.

7. Owned Land
(Categorical Codes 30, 31, 32, 33, 34, 35, and 36)

33001 - owned acres of bottomland available for beef/forage enterprise

33101 - owned acres of hillsides available for beef/forage enterprise

33201 - owned acres of upland available for beef/forage enterprise

33301 - accounting of total acres of owned land available for beef/forage enterprise.

Other constraints in this section are concerned with the accounting of forage-land combinations. The forage varieties considered are as coded and discussed in section A.2 5 of this appendix. These accounting relationships can be summarized as follows:

33401 - 33411 - forage accounts on acres of owned bottomland

33501 - 33511 - forage accounts on acres of owned hillsides

33601 - 33611 - forage accounts on acres of owned upland.

For example, 33501 accounts for utilization of owned hillside acres by permanent pasture.

8. Cash-rented Land
(Categorical Codes 37, 38, and 39)

The accounting constraints considered in this section are analogous to those just discussed in the previous section. The difference being that these constraints are concerned with cash-rented land - not owned land. These accounting relationships for rented land can be summarized as follows:

33701 - 33711 - forage accounts on acres of cash-rented bottomland

33801 - 33811 - forage accounts on acres of cash-rented hillsides

33901 - 33911 - forage accounts on acres of cash-rented upland.

For example, 33903 accounts for utilization of cash-rented upland acres by birdsfoot trefoil.

9. Total Digestible Nutrients (TDN)
(Categorical Code 40)

Rows in this section account for supply-demand of TDN during each period and transfer unused forages between periods.

34001 - TDN account for April

34002 - TDN account for May

34003 - TDN account for June

34004 - TDN account for July

34005 - TDN account for August

34006 - TDN account for September

34007 - TDN account for October

34008 - TDN account for November

34009 - TDN availability during winter from growing forages

34010 - TDN availability derived from first cutting of forage

34011 - transfer of forage in field to stored forage via mechanical harvest system

34012 - transfer of stored forages to cattle via winter feeding systems

34013 - TDN availability derived from second and third cuttings of forage.

10. Corn Consideration
(Categorical Codes 41 and 42)

34101 - acres of land available which can produce corn for silage

34102 - accounting for hours of chopper time available during September to chop corn silage

34201 - accounting for hours of compressed stack wagon time available during November to 'harvest' cornstalks.

11. Labor Considerations (Categorical Code 45)

Rows in this section account for the hours of own labor used in each time period. This account insures that the supply of labor is greater than the demand for labor in each time period.

34501 - man-hours of labor account for April

34502 - man-hours of labor account for May

34503 - man-hours of labor account for June

34504 - man-hours of labor account for July

34505 - man-hours of labor account for August

34506 - man-hours of labor account for September

34507 - man-hours of labor account for October

34508 - man-hours of labor account for November

34509 - man-hours of labor account for Winter.

12. Beef Finance (Categorical Code 46)

34601 - financial accounting for investment in beef animals

34602 - limitation on amount of capital that can be borrowed for investment in beef animals.

13. Present Beef Cow Inventory (Categorical Code 47)

34701 - upper limit on number of beef cows on hand that are handled via beef management policy #1 and calving in specified month

34702 - upper limit on number of beef cows on hand that are handled via beef management policy #2 and calving in specified month

14. Coordination of Forage Harvest and Winter Feeding Activities (Categorical Code 49)

Constraints in this section are of the mutually exclusive type. Such constraints insure that if the forage is harvested and packaged in large round bales; then large round bales are the package that must be fed during the winter period.

34901 - harvest and feeding of small bales that were stored in barn or shed

34902 - harvest and feeding of small bales that were stored outside

34903 - harvest and feeding of compressed loose hay stacks that were stored outside

34904 - harvest and feeding of large round bales that were stored outside

34905 - harvest and feeding of haylage that was stored in silo.

15. Hired Labor (Categorical Code 60)

These constraints provide an upper limit to the man-hours of labor which can be hired in each of the nine (9) time periods modelled.

The coded range for these activities is 36001 - 36009. For example, 36002 indicates the man-hour limit of labor which can be hired during May.

16. Desired Forage Inventory
(Categorical Code 99)

39909 - a lower limit to the tons of forage dry matter which is to remain after completion of the winter feeding period.

APPENDIX C

APPENDIX D

APPENDIX D

THE REPORT WRITER

The purpose of the report writer is to interpret and organize into table format that data prepared by the algorithm. Prepared by the report writer are five (5) tables that summarize the physical resource allocations and the associated financial results. The report writer consists of a main program and four (4) subroutines. The function of each program will now be discussed. Due to the length of the report writer, the source program listing is not included in this text. The model documentation can be consulted for such a listing.

A. Program REPORT

The primary function of Program Report is to decode and strip the 'Answer Matrix' - i.e., the 'columns report' and the 'rows report' - that was prepared by the solution algorithm, (MIPZ1).

The program proceeds iteratively through the 'columns report'. All activities that are in solution are picked out and placed in a matrix labeled ANSW(100,4). Each row of this matrix consists of an activity in solution. Columns 1 - 4 serve to identify the activity, determine its value - c_j,

determine its level or amount in solution, and specify the penalty cost, respectively.

Program Report then decodes the 'rows report'. This process consists of reading each row in this section of the 'Answer Matrix'. Each row consists of an accounting or resource constraint. Columns 1 - 4 for each row serve to identify the constraint, determine its initial value (RHS), determine the amount of the resource remaining; i.e., its slack value, and specify its marginal value product, respectively.

B. Subroutine PUT

The function of Program PUT is to segment matrix ANSW (100,4) into several smaller matrices that are organized according to subject matter content. Each category of activities (see Appendix C) is organized into a separate matrix. For example, forage production, forage harvesting, renting of land, cow-calf production activities, etc., are each segregated into separate blocks. These matrices are initially zeroed out. In the event that a particular block of activities does not enter the basis, the respective matrix contains all zero coefficients. All these matrices are dimensioned in blank COMMON and are available for use by each subroutine in the report writer.

An additional function of Program PUT is to reinterpret to an average annual amount those c_j's that are discounted present values. This process is accomplished by multiplying

the specified c_j by factor XX.[1/] In this manner the annual contribution of the activity to the net income of the beef/forage enterprise can be calculated.

C. Subroutine PLAN

The function of Program PLAN is to organize the 'Farm Plan' table. Program PLAN searches through all matrices - as blocked out by Program PUT - that are pertinent to either the employment of forage/land resources, beef production activities, or to capital investment activities. Each matrix is searched via nested 'DO' loops. In the event that a particular block of activities did not enter the basis, the manipulations in that particular loop are skipped. The summing and organization of the data contained in each particular matrix occurs in its respective 'DO' loop. At the completion of each loop, the organized information is written out in the tabular form.

D. Subroutine NETINC

The purpose of Program NETINC is to organize the 'Net Income - Profit and Loss - Statement', and the 'Cash Flow Summary' table.

The Net Income Statement is organized first. The general procedure is similar to that used for the 'Farm Plan' table.

[1/] $XX = R/(1. - (1/(1.+R)^N))$
where R is the discount rate in decimal format
and N is the planning horizon in years.
This factor XX is analogous to the amortization factor used in annuity formulations.

Each matrix containing activities that are capable of generating either income and/or expenses is searched via nested 'DO' loops. If a particular matrix is zeroed out, all manipulations relevant to that matrix are skipped. After completion of each loop, the organized information is written out in tabular form. The entire Net Income Statement is organized and written before proceeding to the 'Cash Flow Summary'.

The 'Cash Flow Summary' table utilizes the summary financial figures calculated for the Net Income Statement. These summary figures plus some financial data obtained from the input form relative to the initial financial situation are used in calculating the 'Cash Flow Summary'.

E. Subroutine MVP

The purpose of Program MVP - marginal value product - is to organize into table format, the information on effective resource constraints.

The table entitled 'Value of Additional Resources' is organized first. The purpose of this table is to indicate those resources that are limiting the size of the beef/forage enterprise. The approach is to search via a 'DO' loop that information contained in the 'rows report'. Each row that has a zero level shadow price, MVP, is skipped. As a zero level shadow price indicates that the respective resource is non-constraining, it is not of current interest to the entrepreneur wishing to increase the size of operation. Each row

that has a positive marginal value product, implying a limitation on the beef/forage enterprise, is pulled out and presented in the table entitled 'Value of Additional Resources'. Before this value is presented, it is reinterpreted to an annual value. As the c_j's for activities are discounted present values, the marginal evaluation for constraining resources also represents a discounted present value. In the same manner that the c_j's were recalculated, i.e., a reversal of the present value calculations by using the annuity formulation, each MVP is reinterpreted to an annual value. Examination of this table indicates the contribution to net income of one additional unit of each specified resource.

A 'Labor Requirements' table is also organized by Program MVP. The procedure is to pull out the coded rows that account for own labor and for additional hired labor employed by the beef/forage enterprise. The own, hired, and total hours of labor used for each time period are presented in this table.

APPENDIX E

APPENDIX E

EXPERIMENTAL DESIGN

A. Alternative Experimental Design Techniques

The design techniques to be discussed are used to fit polynomial type expressions. A first order polynomial contains no exponential powers greater than one but does allow cross-product expressions; e.g., $Y = B_0 + B_1X_1 + B_2X_2 + B_{12}X_1X_2$. A second-order polynomial includes cross-product terms and allows exponential expressions to the power of two; e.g., $Y = B_0 + B_1X_1 + B_2X_2 + B_{11}X_1^2 + B_{22}X_2^2 + B_{12}X_1X_2$. The difficulty in an *a priori* view is that it is not known with certainty whether the response surface is of the first order; i.e., linear in the variables, or of the second order; i.e., a quadratic function of the variables.

1. Full or Complete Factorial Design

The data collection points via this design consist of all possible combinations between factors of the within-factor levels selected for study.[1/] For example, consider a response surface generated between three (3) delineated

[1/] Heady, Earl O. and John L. Dillon. *Agricultural Production Functions*. Iowa State University Press, Ames, p. 164. 1961.

variables each of which can assume five (5) within-factor values. The number of design points required for a full factorial design would be the product of the number of levels for each factor or $n^k = 125$ observations of the dependent variable.[2/]

This approach considers all possible factor combinations. The resultant design points give a symmetric arrangement over the response surface. This is a desirable attribute especially if there exists no a priori knowledge about the response surface to be generated. The more gentle the slope of the response surface and the wider the plateau surrounding the optimal values, the better the fit that the full factorial design will give to the response surface; i.e., the full factorial works best for a first-order polynomial.

However, this high density of observations comes at the cost of research resources required to generate and analyze such a multitude of data. Relative to the number of parameters to be estimated, the complete factorial technique generates more observations than are required for the degrees of freedom consideration in statistical analysis.

2. Fractional Factorial Design

The intent of this design is to lower the required number of observations but to not sacrifice too much information

[2/] n = number of values (levels) within or for each factor
k = number of different factors to be considered

about the response surface. In essence, a fractional factorial design is equivalent to a single block of a confounded complete factorial.[3/]

This design technique excludes the separate effect(s) for the higher-order interaction(s) and confounds such effects into the main effects. Ideally, tne interactions excluded are of negligibly small value. Otherwise, the main parameter estimates will be biased because of the negligence of significant higher-order effects.

Tables of design are available to delineate the particular treatments to be used for correct confounding.

3. Composite Designs

The composite design approach decreases the number of required design points from the n^k amount required by the complete factorial. In addition the parameter estimates provided are statistically at least as good in terms of the degrees of freedom on which the estimates are evaluated.

The central composite design consists of a cube plus star points plus a center point. Such a design is presented in Figure E.1. Th' number of design points are as follows:

2^k points for the cube portion to determine the response surface in the $(\pm\alpha_1 \ldots \pm\alpha_k)$ neighborhood of the original mean values of the 'k' controlled variables.

[3/] op. cit. p. 169.

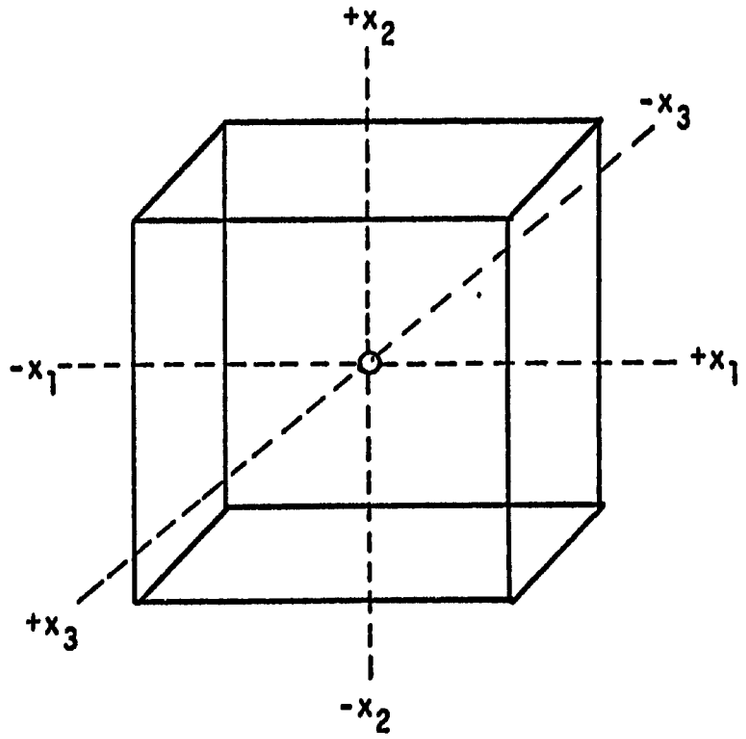

Figure E.1. Central Composite Design.

2k design points to explore responses in the ±b distance along the star rays; i.e., the x_i axes where i = 1....k controlled variables.

1 run for a benchmark response value at the mean level of all controlled variables. This design point is shown by point 0 in Figure E.1.

The 'β' level can be chosen to reflect one's evaluation of the tradeoff between precision and bias of the estimated response coefficients. As the absolute value of 'β' becomes larger, the precision increases but so does the bias if the

true response surface is not of the second order. Or, the 'β' value can be chosen such that the experimental design is orthogonal.

A non-central composite design differs from the central composite in that K supplementary treatments are added to the corner of the cube which exhibits the greatest response of the dependent variable.

4. Rotatable Designs

By definition, a rotatable design is one in which the variability of an estimated response at any point in the factor space depends only on the magnitude of its distance from the center of the design - not on the direction from the center.

The construction of a rotatable design appears similar to that of a central composite design. The difference is in the selection of the 'α' and 'β' distances.

The tables presented on the following pages constitute the parametric values for the specified independent variables. Each independent variable and its associated data are intended to provide relevant, realistic parameters for sensitivity analysis. The 'α' and 'β' distances as specified by the central composite design provide the location for generation of additional observations of the dependent variable.

Table E.1. PRICE DATA.

	Base (1.)		$-\alpha$ (.9)		$+\alpha$ (1.1)		$-\beta$ (.785)		$+\beta$ (1.215)	
	Year 1	Years 2-7	Year 1	Years 2-7	Year 1	Years 2-7	Year 1	Years 2-7	Year 1	Years 2-7
Stock Cow + calf	$450.	350.	405.	315.	495.	385.	353.25	274.75	546.75	425.25
Cull Cow ($/lb)	$ .30	.25	.27	.227	.33	.275	.236	.197	.365	.304
Open Heifer ($/lb)	$ .45	.37	.405	.333	.495	.407	.354	.291	.547	.45
Bred Heifer ($/lb)	$ .50	.40	.45	.36	.55	.44	.393	.314	.608	.486
205 day-old calf ($/lb)	$ .56	.43	.504	.387	.616	.473	.439	.337	.68	.522
750 lb calf ($/lb)	$ .49	.38	.441	.342	.539	.418	.385	.299	.595	.462

Table E.2. BEEF MANAGERIAL EFFICIENCY MEASURES.

	Base	$-\alpha$ (.9)	$+\alpha$ (1.1)	$-\beta$ (.785)	$+\beta$ (1.215)
Weaning Rate					
April	.85	.765	.935	.668	.999
May	.85	.765	.935	.668	.999
June	.85	.765	.935	.668	.999
July	.85	.765	.935	.668	.999
August	.85	.765	.935	.668	.999
September	.85	.765	.935	.668	.999
October	.85	.765	.935	.668	.999
November	.80	.72	.88	.628	.972
December	.80	.72	.88	.628	.972
January	.80	.72	.88	.628	.972
February	.80	.72	.88	.628	.972
March	.85	.765	.935	.668	.999
Warm weather per month rate of gain for calf	45.	40.5	49.5	35.325	54.675
Cold weather rate of gain per month for calf	30.	27.	33.	23.55	36.45

Table E.3. FORAGE YIELDS ON BOTTOMLAND (tons dry matter/acre).

	Base	$-\alpha$ (.9)	$+\alpha$ (1.1)	$-\beta$ (.785)	$+\beta$ (1.215)
Native Pasture	1.5	1.35	1.65	1.178	1.823
Korean Lespedeza	3.0	2.7	3.3	2.355	3.645
Birdsfoot Trefoil	3.5	3.15	3.85	2.748	4.253
New Seeding	1.0	.9	1.1	.785	1.215
Orchard Grass	4.0	3.6	4.4	3.14	4.86
Tall Fescue	3.0	2.7	3.3	2.355	3.645
Alfalfa/Orchard Grass	5.5	4.95	6.05	4.318	6.683
Red Clover/ Orchard Grass	4.2	3.78	4.62	3.297	5.103
Small Grain Aftermath	.9	.81	.99	.707	1.094
Cornstalks	1.2	1.08	1.32	.942	1.458
Corn Silage (tons 30% DM)	18.	16.2	19.8	14.13	21.87

Table E.4. FORAGE YIELDS ON HILLSIDES (tons dry matter/acre).

	Base	$-\alpha$ (.9)	$+\alpha$ (1.1)	$-\beta$ (.785)	$+\beta$ (1.215)
Native Pasture	1.0	.9	1.1	.785	1.215
Korean Lespedeza	2.25	2.025	2.475	1.767	2.734
Birdsfoot Trefoil	2.5	2.25	2.75	1.963	3.038
New Seeding	0.8	.72	.88	.628	.972
Orchard Grass	2.5	2.25	2.75	1.963	3.038
Tall Fescue	2.25	2.025	2.475	1.767	2.734
Alfalfa/Orchard Grass	3.5	3.15	3.85	2.748	4.253
Red Clover/ Orchard Grass	3.0	2.7	3.3	2.355	3.645
Small Grain Aftermath	0.5	.45	.55	.393	.608
Cornstalks	1.0	.9	1.1	.785	1.215

Table E.5. FORAGE YIELDS ON UPLAND (tons dry matter/acre).

	Base	$-\alpha$ (.9)	$+\alpha$ (1.1)	$-\beta$ (.785)	$+\beta$ (1.215)
Native Pasture	1.5	1.35	1.65	1.178	1.823
Korean Lespedeza	2.5	2.25	2.75	1.963	3.038
Birdsfoot Trefoil	2.8	2.52	3.08	2.198	3.402
New Seeding	1.0	.9	1.1	.785	1.215
Orchard Grass	3.2	2.88	3.52	2.512	3.888
Tall Fescue	3.0	2.70	3.30	2.355	3.645
Alfalfa/Orchard Grass	4.0	3.6	4.4	3.14	4.86
Red Clover/ Orchard Grass	3.4	3.06	3.74	2.669	4.131
Small Grain Aftermath	.8	.72	.88	.628	.972
Cornstalks	1.0	.9	1.1	.785	1.215

APPENDIX F

DATA TABLES

Table F.1. PERCENTAGE DISTRIBUTION OF FORAGE GROWTH (during the year)1/.

Forage Variety	April	May	June	July	Aug	Sept	Oct	Nov	Winter
Permanent Pasture	15	30	15	6	7	15	9	3	0
Korean Lespedeza	0	0	5	30	25	25	15	0	0
Birdsfoot Trefoil	20	20	20	15	20	5	0	0	0
New Seeding	0	0	0	0	30	70	0	0	0
Orchard Grass	25	25	15	5	5	8	6	4	7
Tall Fescue	25	25	15	5	5	8	6	4	7
Alfalfa/ grass	15	20	25	15	7	8	0	10	0
Red clover/ grass	0	20	20	20	20	15	5	0	0
Aftermath - straw of soybeans, oats, etc.	0	0	0	20	20	40	20	0	0
Cornstalks	0	0	0	0	0	0	20	60	20

1/Data presented herein is based upon some Purdue Agronomic unpublished data as conveyed by Dr. V.L. Lechtenberg. A zero indicates either that the forage is dormant or a heuristic management practice to insure maintenance of a perennial forage or establishment of a new stand.

Table F.2. TOTAL DIGESTIBLE NUTRIENT (TDN) COMPOSITION OF FORAGES[1/] (in percentage).

Forage Variety	April	May	June	July	Aug	Sept	Oct	Nov	Winter[2]
Permanent Pasture	70	64	60	58	56	57	60	45	45
Korean Lespedeza	83	75	72	67	69	70	73	50	50
Birdsfoot Trefoil	79	76	70	65	66	67	70	48	48
New Seeding	84	75	70	68	70	71	75	50	50
Orchard Grass	79	79	69	63	68	69	72	45	45
Tall Fescue	70	64	60	58	56	57	60	45	45
Alfalfa/ grass	80	75	70	68	70	71	75	51	51
Red clover/ grass	80	75	70	68	70	71	75	51	51
Aftermath - straw of soybeans, oats, etc.	40	40	40	40	40	40	40	40	40
Cornstalks	48	48	48	48	48	48	48	48	48

1/Data presented herein is based upon some Purdue Agronomic data as conveyed by Dr. V.L. Lechtenberg.

2/TDN composition for the winter period is for either hay or dormant forage.

Table F.3. Forage Production Cost Budgets for Bottomland

	Korean Lespedeza	Birdsfoot Trefoil	Orchard Grass	Tall Fescue	Alfalfa/ Orchard Grass	Red Clover/ Orchard Grass
Physical Information						
Seeding Rate (lbs/acre)	15	6	8	20	10 Alfalfa 4 O.G.	8 R.C. 4 O.G.
Seed Cost ($)	95/cwt	210/cst	65/cwt	42/cwt	111/bu Alf	65/bu R.C.
Length of Stand (Years)	5	5	5	5	5	3
Yield (Tons DM/ac)	3.0	3.5	4.0	3.0	5.5	4.2
Composition						
% N	-	-	2.	2.	-	-
% P	.25	.16	.33	.32	.27 Alf	.27 R.C.
% K	3.	3.	3.	3.	2.5 Alf	1.9 R.C.
Lbs Fertilizer	0-18-216	0-144-252	192-31-288	144-23-216	0-37-349	0-28-220
Cost Information						
Seed Cost/yr	2.85	2.52	1.04	1.68	4.74	4.75
Fertilizer Cost						
N	-	-	19.20	14.40	-	-
P	7.20	5.37	12.67	9.22	15.16	11.49
K	15.12	17.64	20.16	15.12	24.42	15.34
Lime	3.00	3.00	3.00	3.00	3.00	3.00
Insecticide	-	-	-	-	6.00	-
Application of Fertilizer	1.00	1.00	1.00	1.00	1.00	1.00
Total Variable Production Cost/acre	29.17	29.53	57.07	44.42	51.32	32.58

Table F.4. Forage Production Cost Budgets for Hillsides.

	Korean Lespedeza	Birdsfoot Trefoil	Orchard Grass	Tall Fescue	Alfalfa/ Orchard Grass	Red Clover/ Orchard Grass
Physical Information						
Seeding Rate (lbs/acre)	15	6	8	20	10 Alfalfa 4 O.G.	8 R.C. 4 O.G.
Seed Cost	95/cwt	210/cwt	65/cwt	42/cwt	111/bu Alf	65/bu R.C.
Length of Stand (yrs)	5	5	5	5	5	3
Yield (Tons DM/ac)	2.25	2.5	2.5	2.25	3.5	3.0
Composition						
% N	-	-	2.	2.	-	-
% P	.25	.16	.33	.32	.27 Alf	.27 R.C.
% K	3.	3.	3.	3.	2.5 Alf	1.9 R.C.
Lbs Fertilizer (elemental form)	0-14-162	0-10-180	120- 20-180	108-17-162	0-24-222	0-21-157
Cost Information						
Seed Cost/yr	2.85	2.52	1.04	1.68	4.74	4.75
Fertilizer Cost						
N	-	-	12.00	10.80	-	-
P	5.40	3.84	7.92	6.91	9.6	8.21
K	11.34	12.60	12.60	11.34	5.03	10.96
Lime	3.00	3.00	3.00	3.00	3.00	3.00
Insecticide	-	-	-	-	6.00	-
Application of Fertilizer	1.00	1.00	1.00	1.00	1.00	1.00
Total Variable Production Cost per acre	23.59	22.96	37.56	34.73	39.93	27.92

Table F.5. Forage Production Cost Budgets for Upland.

	Korean Lespedeza	Birdsfoot Trefoil	Orchard Grass	Tall Fescue	Alfalfa/ Orchard Grass	Red Clover/ Orchard Grass
Physical Information						
Seeding Rate (lbs/acre)	15	6	8	20	10 Alfalfa 4 O.G.	8 R.c. 4 O.G.
Seed Cost ($)	95/cwt	210/cwt	65/cwt	42/cwt	111/bu Alf	65/bu R.C.
Length of Stand (years)	5	5	5	5	5	3
Yield (Tons DM/ac)	2.5	2.8	3.2	3.0	4.0	3.4
Composition						
% N	-	-	2.	2.	-	-
%P	.25	.16	.33	.32	.27 Alf	.27 R.C.
% K	3.	3.	3.	3.	2.5 Alf	1.9 R.C.
Lbs Fertilizer (elemental form)	0-15-180	0-11-202	154-25-230	144-23-216	0-28-255	0-24-177
Cost Information						
Seed Cost/yr	2.85	2.52	1.04	1.68	4.74	4.75
Fertilizer Cost						
N	-	-	15.36	14.40	-	-
P	6.00	4.30	10.14	9.22	11.09	9.30
K	12.60	14.11	16.13	15.12	5.75	12.42
Lime	3.00	3.00	3.00	3.00	3.00	3.00
Insecticide	-	-	-	-	6.00	-
Application of Fertilizer	1.00	1.00	1.00	1.00	1.00	1.00
Total Variable Production Cost per acre	25.45	24.93	46.67	44.42	43.70	30.47

Table F.6. Machine Capacity Coefficients for Varying Ground Speeds and Operation Efficiency Levels.

ACRES PER HOUR FOR MACHINE AT 50 PERCENT EFFICIENCY

SIZE OF MACHINE		GROUND SPEED (MPH) OF MACHINE								
FT	INCHES	2	2.5	3.	3.5	4.	4.5	5.	5.5	6.
5.0	60.0	.60	.75	.90	1.05	1.20	1.35	1.50	1.65	1.80
5.5	66.0	.66	.82	.99	1.15	1.32	1.48	1.65	1.81	1.98
6.0	72.0	.72	.90	1.08	1.26	1.44	1.62	1.80	1.98	2.16
6.5	78.0	.78	.97	1.17	1.36	1.56	1.75	1.95	2.14	2.34
7.0	84.0	.84	1.05	1.26	1.47	1.68	1.89	2.10	2.31	2.52
7.5	90.0	.90	1.13	1.35	1.57	1.80	2.02	2.25	2.47	2.70
8.0	96.0	.96	1.20	1.44	1.68	1.92	2.16	2.40	2.64	2.88
8.5	102.0	1.02	1.27	1.53	1.78	2.04	2.29	2.55	2.80	3.06
9.0	108.0	1.08	1.35	1.62	1.89	2.16	2.43	2.70	2.97	3.24
9.5	114.0	1.14	1.42	1.71	1.99	2.28	2.56	2.85	3.13	3.42
10.0	120.0	1.20	1.50	1.80	2.10	2.40	2.70	3.00	3.30	3.60
10.5	126.0	1.26	1.57	1.89	2.20	2.52	2.83	3.15	3.46	3.78
11.0	132.0	1.32	1.65	1.98	2.31	2.64	2.97	3.30	3.63	3.96
11.5	138.0	1.38	1.72	2.07	2.41	2.76	3.10	3.45	3.79	4.14
12.0	144.0	1.44	1.80	2.16	2.52	2.88	3.24	3.60	3.96	4.32
12.5	150.0	1.50	1.88	2.25	2.63	3.00	3.38	3.75	4.13	4.50
13.0	156.0	1.56	1.95	2.34	2.73	3.12	3.51	3.90	4.29	4.68
13.5	162.0	1.62	2.02	2.43	2.83	3.24	3.64	4.05	4.45	4.86
14.0	168.0	1.68	2.10	2.52	2.94	3.36	3.78	4.20	4.62	5.04

ACRES PER HOUR FOR MACHINE AT 60 PERCENT EFFICIENCY

SIZE OF MACHINE		GROUND SPEED (MPH) OF MACHINE								
FT	INCHES	2	2.5	3.	3.5	4.	4.5	5.	5.5	6.
5.0	60.0	.72	.90	1.08	1.26	1.44	1.62	1.80	1.98	2.16
5.5	66.0	.79	.99	1.19	1.39	1.58	1.78	1.98	2.18	2.38
6.0	72.0	.86	1.08	1.30	1.51	1.73	1.94	2.16	2.38	2.59
6.5	78.0	.94	1.17	1.40	1.64	1.87	2.11	2.34	2.57	2.81
7.0	84.0	1.01	1.26	1.51	1.76	2.02	2.27	2.52	2.77	3.02
7.5	90.0	1.08	1.35	1.62	1.89	2.16	2.43	2.70	2.97	3.24
8.0	96.0	1.15	1.44	1.73	2.02	2.30	2.59	2.88	3.17	3.46
8.5	102.0	1.22	1.53	1.84	2.14	2.45	2.75	3.06	3.37	3.67
9.0	108.0	1.30	1.62	1.94	2.27	2.59	2.92	3.24	3.56	3.89
9.5	114.0	1.37	1.71	2.05	2.39	2.74	3.08	3.42	3.76	4.10
10.0	120.0	1.44	1.80	2.16	2.52	2.88	3.24	3.60	3.96	4.32
10.5	126.0	1.51	1.89	2.27	2.65	3.02	3.40	3.78	4.16	4.54
11.0	132.0	1.58	1.98	2.38	2.77	3.17	3.56	3.96	4.36	4.75
11.5	138.0	1.66	2.07	2.48	2.90	3.31	3.73	4.14	4.55	4.97
12.0	144.0	1.73	2.16	2.59	3.02	3.46	3.89	4.32	4.75	5.18
12.5	150.0	1.80	2.25	2.70	3.15	3.60	4.05	4.50	4.95	5.40
13.0	156.0	1.87	2.34	2.81	3.28	3.74	4.21	4.68	5.15	5.62
13.5	162.0	1.94	2.43	2.92	3.40	3.89	4.37	4.86	5.35	5.83
14.0	168.0	2.02	2.52	3.02	3.53	4.03	4.54	5.04	5.54	6.05

ACRES PER HOUR FOR MACHINE AT 70 PERCENT EFFICIENCY

SIZE OF MACHINE		GROUND SPEED (MPH) OF MACHINE								
FT	INCHES	2	2.5	3.	3.5	4.	4.5	5.	5.5	6.
5.0	60.0	.84	1.05	1.26	1.47	1.68	1.89	2.10	2.31	2.52
5.5	66.0	.92	1.15	1.39	1.62	1.85	2.08	2.31	2.54	2.77
6.0	72.0	1.01	1.26	1.51	1.76	2.02	2.27	2.52	2.77	3.02
6.5	78.0	1.09	1.36	1.64	1.91	2.18	2.46	2.73	3.00	3.28
7.0	84.0	1.18	1.47	1.76	2.06	2.35	2.65	2.94	3.23	3.53
7.5	90.0	1.26	1.57	1.89	2.20	2.52	2.83	3.15	3.46	3.78
8.0	96.0	1.34	1.68	2.02	2.35	2.69	3.02	3.36	3.70	4.03
8.5	102.0	1.43	1.78	2.14	2.50	2.86	3.21	3.57	3.93	4.28
9.0	108.0	1.51	1.89	2.27	2.65	3.02	3.40	3.78	4.16	4.54
9.5	114.0	1.60	1.99	2.39	2.79	3.19	3.59	3.99	4.39	4.79
10.0	120.0	1.68	2.10	2.52	2.94	3.36	3.78	4.20	4.62	5.04
10.5	126.0	1.76	2.20	2.65	3.09	3.53	3.97	4.41	4.85	5.29
11.0	132.0	1.85	2.31	2.77	3.23	3.70	4.16	4.62	5.08	5.54
11.5	138.0	1.93	2.41	2.90	3.38	3.86	4.35	4.83	5.31	5.80
12.0	144.0	2.02	2.52	3.02	3.53	4.03	4.54	5.04	5.54	6.05
12.5	150.0	2.10	2.62	3.15	3.67	4.20	4.72	5.25	5.77	6.30
13.0	156.0	2.18	2.73	3.28	3.82	4.37	4.91	5.46	6.01	6.55
13.5	162.0	2.27	2.83	3.40	3.97	4.54	5.10	5.67	6.24	6.80
14.0	168.0	2.35	2.94	3.53	4.12	4.70	5.29	5.88	6.47	7.06

ACRES PER HOUR FOR MACHINE AT 80 PERCENT EFFICIENCY

SIZE OF MACHINE		GROUND SPEED (MPH) OF MACHINE								
FT	INCHES	2	2.5	3.	3.5	4.	4.5	5.	5.5	6.
5.0	60.0	.96	1.20	1.44	1.68	1.92	2.16	2.40	2.64	2.88
5.5	66.0	1.06	1.32	1.58	1.85	2.11	2.38	2.64	2.90	3.17
6.0	72.0	1.15	1.44	1.73	2.02	2.30	2.59	2.88	3.17	3.46
6.5	78.0	1.25	1.56	1.87	2.18	2.50	2.81	3.12	3.43	3.74
7.0	84.0	1.34	1.68	2.02	2.35	2.69	3.02	3.36	3.70	4.03
7.5	90.0	1.44	1.80	2.16	2.52	2.88	3.24	3.60	3.96	4.32
8.0	96.0	1.54	1.92	2.30	2.69	3.07	3.46	3.84	4.22	4.61
8.5	102.0	1.63	2.04	2.45	2.86	3.26	3.67	4.08	4.49	4.90
9.0	108.0	1.73	2.16	2.59	3.02	3.46	3.89	4.32	4.75	5.18
9.5	114.0	1.82	2.28	2.74	3.19	3.65	4.10	4.56	5.02	5.47
10.0	120.0	1.92	2.40	2.88	3.36	3.84	4.32	4.80	5.28	5.76
10.5	126.0	2.02	2.52	3.02	3.53	4.03	4.54	5.04	5.54	6.05
11.0	132.0	2.11	2.64	3.17	3.70	4.22	4.75	5.28	5.81	6.34
11.5	138.0	2.21	2.76	3.31	3.86	4.42	4.97	5.52	6.07	6.62
12.0	144.0	2.30	2.88	3.46	4.03	4.61	5.18	5.76	6.34	6.91
12.5	150.0	2.40	3.00	3.60	4.20	4.80	5.40	6.00	6.60	7.20
13.0	156.0	2.50	3.12	3.74	4.37	4.99	5.62	6.24	6.86	7.49
13.5	162.0	2.59	3.24	3.89	4.54	5.18	5.83	6.48	7.13	7.78
14.0	168.0	2.69	3.36	4.03	4.70	5.38	6.05	6.72	7.39	8.06

ACRES PER HOUR FOR MACHINE AT 90 PERCENT EFFICIENCY

SIZE OF MACHINE		GROUND SPEED (MPH) OF MACHINE								
FT	INCHES	2	2.5	3.	3.5	4.	4.5	5.	5.5	6.
5.0	60.0	1.08	1.35	1.62	1.89	2.16	2.43	2.70	2.97	3.24
5.5	66.0	1.19	1.48	1.78	2.08	2.38	2.67	2.97	3.27	3.56
6.0	72.0	1.30	1.62	1.94	2.27	2.59	2.92	3.24	3.56	3.89
6.5	78.0	1.40	1.75	2.11	2.46	2.81	3.16	3.51	3.86	4.21
7.0	84.0	1.51	1.89	2.27	2.65	3.02	3.40	3.78	4.16	4.54
7.5	90.0	1.62	2.02	2.43	2.83	3.24	3.64	4.05	4.45	4.86
8.0	96.0	1.73	2.16	2.59	3.02	3.46	3.89	4.32	4.75	5.18
8.5	102.0	1.84	2.29	2.75	3.21	3.67	4.13	4.59	5.05	5.51
9.0	108.0	1.94	2.43	2.92	3.40	3.89	4.37	4.86	5.35	5.83
9.5	114.0	2.05	2.56	3.08	3.59	4.10	4.62	5.13	5.64	6.16
10.0	120.0	2.16	2.70	3.24	3.78	4.32	4.86	5.40	5.94	6.48
10.5	126.0	2.27	2.83	3.40	3.97	4.54	5.10	5.67	6.24	6.80
11.0	132.0	2.38	2.97	3.56	4.16	4.75	5.35	5.94	6.53	7.13
11.5	138.0	2.48	3.10	3.73	4.35	4.97	5.59	6.21	6.83	7.45
12.0	144.0	2.59	3.24	3.89	4.54	5.18	5.83	6.48	7.13	7.78
12.5	150.0	2.70	3.37	4.05	4.72	5.40	6.07	6.75	7.42	8.10
13.0	156.0	2.81	3.51	4.21	4.91	5.62	6.32	7.02	7.72	8.42
13.5	162.0	2.92	3.64	4.37	5.10	5.83	6.56	7.29	8.02	8.75
14.0	168.0	3.02	3.78	4.54	5.29	6.05	6.80	7.56	8.32	9.07

ACRES PER HOUR FOR MACHINE AT100 PERCENT EFFICIENCY

SIZE OF MACHINE		GROUND SPEED (MPH) OF MACHINE								
FT	INCHES	2	2.5	3.	3.5	4.	4.5	5.	5.5	6.
5.0	60.0	1.20	1.50	1.80	2.10	2.40	2.70	3.00	3.30	3.60
5.5	66.0	1.32	1.65	1.98	2.31	2.64	2.97	3.30	3.63	3.96
6.0	72.0	1.44	1.80	2.16	2.52	2.88	3.24	3.60	3.96	4.32
6.5	78.0	1.56	1.95	2.34	2.73	3.12	3.51	3.90	4.29	4.68
7.0	84.0	1.68	2.10	2.52	2.94	3.36	3.78	4.20	4.62	5.04
7.5	90.0	1.80	2.25	2.70	3.15	3.60	4.05	4.50	4.95	5.40
8.0	96.0	1.92	2.40	2.88	3.36	3.84	4.32	4.80	5.28	5.76
8.5	102.0	2.04	2.55	3.06	3.57	4.08	4.59	5.10	5.61	6.12
9.0	108.0	2.16	2.70	3.24	3.78	4.32	4.86	5.40	5.94	6.48
9.5	114.0	2.28	2.85	3.42	3.99	4.56	5.13	5.70	6.27	6.84
10.0	120.0	2.40	3.00	3.60	4.20	4.80	5.40	6.00	6.60	7.20
10.5	126.0	2.52	3.15	3.78	4.41	5.04	5.67	6.30	6.93	7.56
11.0	132.0	2.64	3.30	3.96	4.62	5.28	5.94	6.60	7.26	7.92
11.5	138.0	2.76	3.45	4.14	4.83	5.52	6.21	6.90	7.59	8.28
12.0	144.0	2.88	3.60	4.32	5.04	5.76	6.48	7.20	7.92	8.64
12.5	150.0	3.00	3.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00
13.0	156.0	3.12	3.90	4.68	5.46	6.24	7.02	7.80	8.58	9.36
13.5	162.0	3.24	4.05	4.86	5.67	6.48	7.29	8.10	8.91	9.72
14.0	168.0	3.36	4.20	5.04	5.88	6.72	7.56	8.40	9.24	10.08

Table F.7. Machine and Man-hour Requirements for Forage Harvesting.

Process	# Acres/machine-hr	# acres/man-hour
Mow	2.7	2.5
Condition	2.5	2.0
Rake (windrow)	5.0	4.5
Square baler (drop bales)	2.5	2.2
Square baler with bale accumulator	2.07	1.8
Square baler with bale thrower and wagon	2.07	1.8
Stack system of blowing loose hay into wagon	3.0	2.7
Small round baler	2.0	1.8
Large round baler	3.0	2.7
Chopper & wagon for haylage	3.0	2.7
Tractor & carrier to pick up dropped square bales and stack in barn	2.0	0.8
Tractor & carrier to pick up dropped square bales and stack outside in field	2.5	1.0
Tractor & carrier for accumulated bales to be stacked outside	3.5	1.8
Tractor & wagon to unload bales thrown into wagon	3.0	1.4
Tractor & wagon to carry haylage to silo	3.5	2.8
Chopper & wagon for corn silage	1.4	1.25
Blower	20. tons/hr	20. tons/hr

Table F.8. Forage Yields and Associated Costs/Acre.

Land Type	Forage Yield	Annual Variable Cost/acre	Opportunity Cost Per Acre
	(Tons DM/acre)	($/acre)	($/acre)
1. Bottomland			
(a) Native Pasture	1.5	.50	5.25
(b) Korean Lespedeza	3.0	29.17	5.25
(c) Birdsfoot Trefoil	3.5	29.53	5.25
(d) Available for New Seeding	1.0	3.00	5.25
(e) Orchard Grass	4.0	57.07	5.25
(f) Tall Fescue	3.0	44.42	5.25
(g) Alfalfa/grass	5.5	51.32	5.25
(h) Red Clover/grass	4.2	32.58	5.25
(i) Small-grain aftermath	0.9	.25	1.35
(j) Cornstalk Refuse	1.2	.50	1.35
2. Hillsides			
(a) Native Pasture	1.0	.50	5.25
(b) Korean Lespedeza	2.25	23.59	5.25
(c) Birdsfoot Trefoil	2.5	22.96	5.25
(d) Available for New Seeding	0.8	3.00	5.25
(e) Orchard Grass	2.5	37.56	5.25
(f) Tall Fescue	2.25	34.73	5.25
(g) Alfalfa/grass	3.5	39.93	5.25
(h) Red Clover/grass	3.0	27.92	5.25
(i) Small Grain aftermath	0.5	.25	1.35
(j) Cornstalk Refuse	1.0	.50	1.35
3. Upland			
(a) Native Pasture	1.5	.50	5.25
(b) Korean Lespedeza	2.5	25.45	5.25
(c) Birdsfoot Trefoil	2.8	24.93	5.25
(d) Available for New Seeding	1.0	3.00	5.25
(e) Orchard Grass	3.2	46.67	5.25
(f) Tall Fescue	3.0	44.42	5.25
(g) Alfalfa/grass	4.0	43.70	5.25
(h) Red Clover/grass	3.4	30.47	5.25
(i) Small Grain aftermath	0.8	.25	1.35
(j) Cornstalk Refuse	1.0	.50	1.35

Table F.9. Feed & Labor Requirements for Beef Animals.

Livestock Category	Daily TDN Requirement (pounds)	Monthly Labor Requirement for Grazing Animals (man-hours)
Barren Cow	8.0	0.5
Pregnant Cow	9.0	0.667
Cow with 1-6 month-old calf	17.0	1.0
7 month-old calf	5.0	0.8
8 month-old calf	5.5	0.3
9 month-old calf	6.0	0.3
10 month-old calf	6.4	0.3
11 month-old calf	6.7	0.3
12 month-old calf	7.0	0.3
13 month-old calf	7.4	0.3
14 month-old calf	7.8	0.3
15 month-old calf	8.2	0.3
16 month-old calf	8.6	0.3
17 month-old calf	8.9	0.3
18 month-old calf	9.1	0.3
19 month-old calf	9.3	0.3
20 month-old calf	9.6	0.3
21 month-old calf	9.8	0.3
22 month-old calf	10.1	0.3
23 month-old calf	10.3	0.3
Bull	13.0	1.0

Table F.10. Beef Management System Coefficients.

Management Variables	System #1	System #2	System #3	System #4	System #5
# months before calving that a replacement OPEN heifer would be purchased	10	10	10	10	10
# months before calving that a replacement BRED heifer would be purchased	4	4	4	4	4
Selling Age of Calf (# months of age)	7	7	8	10	12
Weaning Age of Calf (# months of age)	7	7	7	7	7
# months after calving that a barren cow is kept on farm	6	1	1	1	1
# months after calving that a cow which loses its calf is kept on farm	12	1	1	1	1
Percentage of calfless cows due to non-conception (barrenness)	.8	.4	.4	.4	.4
# years of productive life for cow (# calving years)	5.	7.	7.	7.	7.
With respect to Herd Replacement Policies: (express percentages in decimal form)					
Percentage of Replacement stock bought as OPEN heifers	0.	0.	0.	0.	0.
Percentage of Replacement stock bought as BRED heifers	0.	0.	0.	0.	0.
Percentage of Replacement stock raised on farm	1.	1.	1.	1.	1.
Percentage of Replacement stock bought as cows with calves (the total of these last 4 figures must be 1.0 for each column.)	0.	0.	0.	0.	0.
#cows per bull	25.	25.	25.	25.	25.
Creep Feeding enter 0.0 if you do not wish to consider creep feeding enter 1.0 if you do wish to consider creep feeding	0.0	0.0	0.0	0.0	0.0

Table F.11. Winter Feeding Systems

Type of Forage Package	Full Feed on Ground or Free Feed at Stack		Limit Feed on Ground or at Field or Stack		Full Feed in Bunks		Limit Feed in Bunks	
	Man-hrs/ ton DM (hay)[1]	Feed Wastage Index [2]	Man-hrs/ ton DM (hay)	Feed Wastage Index	Man-hrs/ ton DM (hay)	Feed Wastage Index	Man-hrs/ ton DM (hay)	Feed Wastage Index
Conventional Bales stored in barn (shed) (either round or square bales)	2.1	.29	2.1	.04	2.27	.307	2.27	.057
Conventional Bales stored outside in field, stack or pile (either round or square bales)	.03	1.00	1.84	.75	1.40	.307	1.40	.057
Loose Hay compressed into small stacks	.03	.697	.30	.417	1.05	.273	1.05	.023
Large Round Bales	.03	.471	.30	.221	1.05	.273	1.05	.023
Haylage	1.00	.29	1.0	.04	.10	.26	.10	.01

[1] The man-hour requirement per ton of hay will vary with the size of load, the mechanization, the distance between hay storage and feeding site, and the number of gates which must be opened and closed.

[2] The feed wastage index is that percentage of total forage exposed or given to the beef animal that is not necessary for nutritional requirements. For example, the figure of 0.4 indicates that there is 40% more feed demanded (fed) than in nutritionally required due to overeating, tramping, wastage, and some spoilage.

Table F.12. Beef Price Seasonality Indexes.

Time Period	Cow & Heifer Price Index	Weaner Calf Price Index
April	1.063	1.055
May	1.084	1.048
June	1.087	1.035
July	1.024	.976
August	1.019	.977
September	.998	.972
October	.943	.958
November	.897	.946
December	.892	.935
January	.934	1.004
February	1.004	1.033
March	1.047	1.077

Table F.13. Machine Custom Rates

Item	$ Rate/unit	$ Rate/hour
Tractor, man & mower	$3.00/ac 2.69 ac/hr	8.07
Tractor, man & mower-conditioner	$5.15/ac 2.39 ac/hr	12.30
Tractor, man & rake	$2.35/ac 4.61 ac/hr	10.83
Tractor, man & regular square baler	$ .20/bale 100/bales/hr	20.00
Tractor, man & square baler with accumulator plus stacker	$ .35/bale 50. bales/hr	17.50
Tractor, man, square baler with bale thrower plus wagon	$ .25/bale 120. bales/hr	30.00
Tractor, man, & stack system	$10.00/stack 3. stacks/hr	30.00
Tractor, man & small round baler	$ .15/bale 70. bales/hr	10.50
Tractor, man & Large round baler	$8.00/bale 5.00 bales/hr	40.00
Tractor, man, chopper & wagons (for haylage)	$3.15/ton 8.5 ton/hr	26.78

APPENDIX G

THE INPUT FORM

BEEF COW-CALF

PROFIT PLANNING MODEL

By

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INTRODUCTION

The purpose of this beef cow-forage model is to assist farmers in deciding on the profitability and organization of a beef cow-calf enterprise.

This model can assist you in answering questions such as:

Are beef cows profitable?

How many beef cows can be carried on my farm?

Do buy calf · sell yearling systems fit on my farm?

Which forages should I grow?

How much of each specific forage should be grown?

Which harvest system should be used for these forages?

Which forage storage system should be used?

In which month should I calve?

Is creep feeding profitable?

What should be my herd replacement policy?

When should my weaner calves be sold?

Is my available capital going to limit the number of cattle I can carry?

Figure 1 on page three (3) briefly describes the model's purpose, inputs and outputs.

This model emphasizes the best way of utilizing forage acres by a beef cow herd. It does not consider alternative cattle feeding systems.

You will be asked to list your resources, e.g., land, labor, etc., available for a beef cow-calf operation. Enter only the amount of resources which are available for the beef cow-calf enterprise. Tell us only the resources available after allowance for other enterprises such as corn, soybeans, swine, etc., which are to be included in your farm plan.

You will also be asked to list beef production alternatives which you are willing to consider. For example, you will list potential calving months to be considered, weaning percentages for each calving month, herd replacement policies, calf selling policies, feed and labor requirements, expected prices, costs, etc. Where these data entries are required, 'base plan' figures have been listed. If you feel that the 'base plan' figure is adequate, leave the respective blank as is. The computer will then use this listed base value. However, if you feel the base plan to be inappropriate, these figures should be changed to fit your own situation.

Background information, investment costs, feed and labor requirements, machinery work rates, etc., are provided in the accompanying informational booklet.

Using the information from your completed input form, the computer will report the best plan from among your alternatives. The best plan maximizes your net worth at the end of the seven year planning period. The computer output will provide a farm plan for the first year. It will tell you how many cow-calf units you can handle, the forages you need to grow, and the method of harvest.

Also provided will be two financial statements -- the Net Income statement and a Cash Flow statement.

Figure 1. Schematic for Beef Cow-Calf Profit Planning Model.

Model's Purpose: To aid in planning whether to have a beef cow-calf enterprise, age of product to market, choosing the best beef management system and accompanying forage management system.

I. Goal
Maximize net worth at the end of a seven year period

Farm Manager

Given
a. Resources available
b. Management efficiency factors
c. Prices of products & costs of inputs
d. Risk preference

II. Conditions Specified
A. Resources Available
1. Land
2. Labor
3. Cash & debt
4. Livestock inventory
5. Forage storage facilities
6. Machinery & equipment

B. Management-efficiency factors
1. Forage yields
2. Calf weaning rate
3. Weaner calf weight and rate of gain after weaning
4. Labor requirements
5. Feed requirements
6. Machine time requirements

C. Expected Prices
1. Weaner calves
2. Cull cows
3. Breeding stock
4. Corn
5. Corn silage
6. Hay

D. Risk Preferences
1. Maximum debt
2. Livestock debt limits
3. Machinery debt limits

III. Business Organization Alternatives
A. Products to Produce
1. Forages
2. Beef cow-calf or yearlings
3. Calf-feeders

B. Production Scheduling

C. Production Systems
1. Forage Harvest
a. Square baler
b. Small round baler
c. Large round baler
d. Haylage
2. Forage Storage
a. in field
b. in shed, barn
3. Forage Feeding
a. limit feeding in rack (bunk)
b. limit feeding on ground
c. free choice in rack (bunk)
d. free choice on ground

IV. Output
A. Physical Farm Plan
1. Beef Management System
2. Forage Manament System
3. Size & type of enterprise

B. Capital Situation
1. Net Income Statement
2. Assets by type
3. Debts by type

C. Cash Flow Summary

Please enter some identifying information (e.g., farm name, owner's or operator's name, etc.) in the space provided below. (card 214)

Footnotes from Page 5.

1/ Variable cost/acre for owned land consists of an annual average charge for maintenance and/or establishment of the seeding. This cost should include such items as fertilizer, lime, herbicide, and their cost of application. Also to be included are the cost of new seed, fencing, water provision, brush clearance, pesticides and any other cash expenditures incurred in the establishment and/or maintenance of a forage acre. If, for example, you spend $10/acre for alfalfa seed and the established alfalfa is kept for four years; your annual variable costs for alfalfa will be $2.50/acre for seed plus the annual maintenance costs. See the accompanying booklet for some forage production budgets.

If you habitually combine seed from your own hay and pasture land, the net income from this operation and any other such income producing activity should be used to decrease your annual variable cost/acre.

For cornstalk acres, the annual cost/acre may reflect anticipated yield decreases in the following year due to packing of soil, late plowing date, etc.

2/ Entries in this column are used to reflect the possible income you could earn by renting-out your own land.

3/ If you are not tied-in to growing certain acreages of particular forages, you may enter the acreage amount not committed in this entry blank. The computer solution will then provide a selection of the forages to be grown.

4/ This row is used to reflect the necessity of periodical re-establishment of new forage seedings and the associated acreage required. As the cost of establishment is to be distributed over the lifetime of each respective seedling variety; e.g., alfalfa, tall fescue, etc., this cost should reflect only one year's share of the estimated seed cost.

5/ Costs for these dry forages should reflect costs of nutrients removed, anticipated yield decreases in next cropping year due to cattle tramping the soil. These costs may be counterbalanced by a credit for manure dropped by cattle. e.g., for Cornstalks grazed

2000 lbs yield/acre	X .5 grazing coefficient	X .0023	elemental phosphorus content	X $ .40/lb P	= .92/acre
2000 lbs yield/acre	X .5 grazing coefficient	X .0075	elemental nitrogen content	X $ .10/lb N	= .75/acre
2000 lbs yield/acre	X .5 grazing coefficient	X .0179	elemental potassium content	X $ .07/lb K	= 1.25/acre
					$2.92/acre

I. Land, Labor and Capital Available for Beef.

This page requests information pertaining to the acreage, yield, and production costs for forages grown on your OWNED LAND available for the BEEF ENTERPRISE.

If all your land available for beef cows is rented land, turn to page 9.

To accurately describe your own situation, list your own estimates in the appropriate blanks.

If you do not own any "bottomland", enter zeroes in the 'acres' blanks and turn to next page.

Land Type	Acres		Forage Yield (tons DM/ac)		Annual Variable cost/acre[1] ($/acre)		Potential Income per acre from renting out owned land[2]	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
I. Bottomland								
A. Uncommitted to Specific Forage[3]	Card 95-1 25.	___.___	--	--	--	--	--	--
B. Native Pasture	Cards 83,84 0.	___.___	Cards 96,97 1.5	___.___	Cards 173,174 .50	$___.___	Cards 180,181 $ 5.25	$___.___
C. Hay & Rotation Pasture								
1. Korean Lespedeza	0.0	___.___	3.0	___.___	29.88	___.___	5.25	___.___
2. Birdsfoot Trefoil	0.0	___.___	3.5	___.___	30.16	___.___	5.25	___.___
3. Available for New Seeding[4]	0.0	___.___	1.0	___.___	3.00	___.___	5.25	___.___
4. Orchard Grass	0.0	___.___	4.0	___.___	57.33	___.___	5.25	___.___
5. Tall Fescue	0.0	___.___	3.0	___.___	44.84	___.___	5.25	___.___
6. Alfalfa/grass	0.0	___.___	5.5	___.___	55.50	___.___	5.25	___.___
7. Red Clover/grass	0.0	___.___	4.2	___.___	37.96	___.___	5.25	___.___
D. Small grain acres available for grazing aftermath following harvest[5]	0.0	___.___	0.9	___.___	0.25	___.___	1.35	___.___
E. Cornstalks available for grazing[5]	50.0	___.___	1.2	___.___	0.50	___.___	1.35	___.___
F. Cornstalks available for mechanical harvest only[5]	0.0	___.___	1.2	___.___	0.50	___.___	1.35	___.___
Total Owned Bottomland	75.00	___.___	--	--	--	--	--	--

If you do not own any "hillside" acres, enter zeroes in the 'acres' blanks and turn to next page.

Land Type	Acres		Forage Yield (Tons/DM/ac)		Annual Variable cost/acre[1] ($/acre)		Potential Income per acre from renting out owned land[2]	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
II. Hillsides								
A. Uncommitted to Specific Forage[3]	Card 95-2 70.0	___.___	Cards 98,99 --	--	Cards 175,176 --	--	Cards 182,183 --	--
B. Native Pasture	Cards 85,86 0.0	___.___	1.0	___.___	.50	$___.___	$ 5.25	$___.___
C. Hay & Rotation Pasture								
1. Korean Lespedeza	0.0	___.___	2.25	___.___	24.30	___.___	5.25	___.___
2. Birdsfoot Trefoil	0.0	___.___	2.5	___.___	23.59	___.___	5.25	___.___
3. Available for New Seeding[4]	0.0	___.___	0.8	___.___	3.00	___.___	5.25	___.___
4. Orchard Grass	0.0	___.___	2.5	___.___	37.82	___.___	5.25	___.___
5. Tall Fescue	0.0	___.___	2.25	___.___	35.15	___.___	5.25	___.___
6. Alfalfa/grass	0.0	___.___	3.5	___.___	41.11	___.___	5.25	___.___
7. Red clover/grass	0.0	___.___	3.0	___.___	30.30	___.___	5.25	___.___
D. Small grain acres available for grazing aftermath following harvest	0.0	___.___	0.5	___.___	.25	___.___	1.35	___.___
E. Cornstalks available for grazing	0.0	___.___	1.0	___.___	.50	___.___	1.35	___.___
F. Cornstalks available for mechanical harvest only	0.0	___.___	1.0	___.___	.50	___.___	1.35	___.___
Total Owned Hillsides	70.0	.	--	--	--	--	--	--

If you do not own any 'upland' acres, enter zeroes in the 'acres blanks and fill in last two rows on this page.

Land Type	Acres		Forage Yield (Tons DM/ac)		Annual Variable cost/acre[1] ($/acre)		Pontential Income per acre from renting out owned land[2]	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
III. Upland								
A. Uncommitted to Specific Forage[3]	Card 95-3 55.	0.	Cards 100,101 --	--	Cards 177,178 --	--	Cards 184,185 --	--
B. Native Pasture	Cards 87,88	.	1.5	.	.50	$.	$5.25	$.
C. Hay & Rotation Pasture								
1. Korean Lespedeza	0.0	.	2.5	.	29.88	.	5.25	.
2. Birdsfoot Trefoil		.	2.8	.	25.56	.	5.25	.
3. Available for New Seeding[4]		.	1.0	.	3.00	.	5.25	.
4. Orchard Grass	0.0	.	3.2	.	46.93	.	5.25	.
5. Tall Fescue	0.0	.	3.0	.	44.84	.	5.25	.
6. Alfalfa/grass	0.0	.	4.0	.	44.88	.	5.25	.
7. Red clover/grass	0.0	.	3.4	.	32.85	.	5.25	.
D. Small grain acres available for grazing aftermath following harvest	0.0	.	0.8	.	.25	.	1.35	.
E. Cornstalks available for grazing	0.0	.	1.0	.	.50	.	1.35	.
F. Cornstalks available for mechanical harvest only	0.0	.	1.0	.	.50	.	1.35	.
Total Owned Upland	55.	.	-- Card 108	--	Card 179	--	--	--
Corn Silage Acres (Card 82-5	0.0	.	18.0	.	100.00	.	--	--
Total Owned Land	200.0		--	--	--			

3.

Footnotes to pages 9 and 10.

1/ Variable cost/acre for rented land consists of an annual cash rental charge plus the cost for maintenance and/or establishment of the seeding. This cost should include such items as fertilizer, lime, herbicide, and their cost of application. Also to be included are the cost of new seed, fencing, water provision, brush clearance, pesticides and any other cash expenditures incurred in the establishment and/or maintenance of a forage acre. If, for example, you spend $10/acre for alfalfa seed and the established alfalfa is kept for four years' your annual variable costs for alfalfa will be $2.50/acre for seed plus the annual maintenance costs.

If you habitually combine seed from your own hay and pasture land, the net income from this operation and any other such income producing activity should be used to decrease your annual variable cost/acre.

For cornstalk acres, the annual cost/acre may reflect anticipated yield decreases in the following year due to packing of soil, late plowing date, etc.

2/ If you do not wish to consider rental of a particular category of land or if such land is not available for rent, enter zero in the acres for that forage/land category. For land which you have definitely rented or care to consider for rental by the beef/forage enterprise, list the acreage amount and the estimated cost/acre.

3/ This row is used to reflect the necessity of periodical re-establishment of new forage seedings and the associated acreage required. As the cost of establishment is to be distributed over the lifetime of each respective seedling variety; e.g., alfalfa, tall fescue, etc., the cost for this category should be zero.

This page requests information pertaining to the acreage, yield, and production costs for forages grown on your RENTED LAND available for the BEEF ENTERPRISE.

If all your land available for beef cows is owned land, and you do not wish to consider rental of land; turn to page 11.

To accurately describe your own situation, list your own estimates in the appropriate blanks.[1]

Land Type	Acres		Yield (tons DM/acre)		Annual Variable Cost/acre[2]	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
I. Bottomland	Cards 89,90		Cards 102,103		Cards 186,187	
A. Native Pasture	0.0	___.___	1.5	___.___	$10.50	$___.___
B. Hay & Rotation Pasture						
1. Korean Lespedeza	0.0	___.___	3.0	___.___	39.88	___.___
2. Birdsfoot Trefoil	0.0	___.___	3.5	___.___	40.16	___.___
3. Available for New Seeding[3]	0.0	___.___	1.0	___.___	13.00	___.___
4. Orchard Grass	0.0	___.___	4.0	___.___	67.33	___.___
5. Tall Fescue	0.0	___.___	3.0	___.___	54.84	___.___
6. Alfalfa/grass	0.0	___.___	5.5	___.___	65.50	___.___
7. Red clover/grass	0.0	___.___	4.2	___.___	47.96	___.___
C. Small grain acres available for grazing aftermath following harvest	0.0	___.___	0.9	___.___	1.35	___.___
D. Cornstalks available for grazing	0.0	___.___	1.2	___.___	1.35	___.___
E. Cornstalks available for mechanical harvest only	0.0	___.___	1.2	___.___	1.35	___.___
Total Rented Bottomland	0.0	___.___	--	--	--	--
II. Hillsides	Cards 91,92		Cards 104,105		Cards 188,189	
A. Native Pasture	0.0	___.___	1.0	___.___	$10.50	$___.___
B. Hay & Rotation Pasture						
1. Korean Lespedeza	0.0	___.___	2.25	___.___	34.30	___.___
2. Birdsfoot Trefoil	0.0	___.___	2.5	___.___	33.59	___.___
3. Available for New Seeding[3]	0.0	___.___	0.8	___.___	13.00	___.___
4. Orchard Grass	0.0	___.___	2.5	___.___	47.82	___.___
5. Tall Fescue	0.0	___.___	2.25	___.___	45.15	___.___
6. Alfalfa/grass	0.0	___.___	3.5	___.___	51.11	___.___
7. Red clover/grass	0.0	___.___	3.0	___.___	40.30	___.___
C. Small grain acres available for grazing aftermath following harvest	0.0	___.___	0.5	___.___	1.35	___.___
D. Cornstalks available for grazing	0.0	___.___	1.0	___.___	1.35	___.___
E. Cornstalks available for mechanical harvest only	0.0	___.___	1.0	___.___	1.35	___.___
Total Rented Hillsides	0.0	___.___	--	--	--	--

10.

Land Type	Acres		Yield (tons DM/acre)		Annual Variable Cost/acre[2]	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
III. Upland	Cards 93,94		Cards 106,107		Cards 190,191	
A. Native Pasture	0.0	___.___	1.5	___.___	$10.50	$___.___
B. Hay & Rotation Pasture						
1. Korean Lespedeza	0.0	___.___	2.5	___.___	39.88	___.___
2. Birdsfoot Trefoil	0.0	___.___	2.8	___.___	35.56	___.___
3. Available for New Seeding[3]	0.0	___.___	1.0	___.___	13.00	___.___
4. Orchard Grass	0.0	___.___	3.2	___.___	56.93	___.___
5. Tall Fescue	0.0	___.___	3.0	___.___	54.84	___.___
6. Alfalfa/grass	0.0	___.___	4.0	___.___	54.88	___.___
7. Red clover/grass	0.0	___.___	3.4	___.___	42.85	___.___
C. Small grain acres available for grazing aftermath following harvest	0.0	___.___	0.8	___.___	1.35	___.___
D. Cornstalks available for grazing	0.0	___.___	1.0	___.___	1.35	___.___
E. Cornstalks available for mechanical harvest only	0.0	___.___	1.0	___.___	1.35	___.___
Total Rented Upland	0.0	___.___	--	--	--	--

Enter your own estimate of the ANNUAL DISTRIBUTION of FORAGE GROWTH on BOTTOMLAND
If the base plan estimates do not appear appropriate for your conditions.

(If you do not have any 'Bottomland acres', skip to the following page.)

	Native Pasture		Korean Lespedeza		Birdsfoot Trefoil		New Seeding		Orchard Grass		Tall Fescue		Alfalfa/ grass		Red Clover		Aftermath Small Grains		Cornstalks	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
	Card 109		Card 110		Card 111		Card 112		Card 113		Card 114		Card 115		Card 116		Card 117		Card 118	
April	0.15[1]	.__	0.0	.__	0.20	.__	0.0	.__	0.25	.__	0.25	.__	0.15	.__	0.0	.__	0.0	.__	0.0	.__
May	0.30	.__	0.0	.__	0.20	.__	0.0	.__	0.25	.__	0.25	.__	0.20	.__	0.20	.__	0.0	.__	0.0	.__
June	0.15	.__	0.05	.__	0.20	.__	0.0	.__	0.15	.__	0.15	.__	0.25	.__	0.20	.__	0.0	.__	0.0	.__
July	0.06	.__	0.30	.__	0.15	.__	0.0	.__	0.05	.__	0.05	.__	0.20	.__	0.20	.__	0.20	.__	0.0	.__
Aug.	0.07	.__	0.25	.__	0.20	.__	0.3	.__	0.05	.__	0.05	.__	0.20	.__	0.20	.__	0.20	.__	0.0	.__
Sept.	0.15	.__	0.25	.__	0.05	.__	0.7	.__	0.08	.__	0.08	.__	0.08	.__	0.15	.__	0.40	.__	0.0	.__
Oct.	0.09	.__	0.15	.__	0.00	.__	0.0	.__	0.06	.__	0.06	.__	0.00	.__	0.05	.__	0.20	.__	0.20	.__
Nov.	0.03	.__	0.00	.__	0.00	.__	0.0	.__	0.04	.__	0.04	.__	0.10	.__	0.0	.__	0.0	.__	0.40	.__
Wtr.	0.0	.__	0.0	.__	0.0	.__	0.0	.__	0.07	.__	0.07	.__	0.0	.__	0.0	.__	0.0	.__	0.40	.__
Total[2]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

1/ A .15 in the April row in the column entitled Native Pasture indicates that 15% of the aforementioned pasture yield will be available during April. These availability percentages may also reflect forage managerial practices, e.g., to ensure winter hardiness of the perennial - alfalfa - alfalfa in the base plan is not available during October.

2/ Each column total must sum to 1.0 to indicate that the total potential amount available is 100% of the aforementioned forage yield.

Enter your own estimate of the ANNUAL DISTRIBUTION of FORAGE GROWTH on HILLSIDES if the base plan estimates do not appear appropriate for your conditions.

(If you do not have any 'Hillside acres', skip to the following page.)

	Native Pasture		Korean Lespedeza		Birdsfoot Trefoil		New Seeding		Orchard Grass		Tall Fescue		Alfalfa/ grass		Red Clover		Aftermath Small Grains		Cornstalks	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
	Card 119		Card 120		Card 121		Card 122		Card 123		Card 124		Card 125		Card 126		Card 127		Card 128	
April	0.15	.__	0.0	.__	0.20	.__	0.0	.__	0.25	.__	0.25	.__	0.15	.__	0.0	.__	0.0	.__	0.0	.__
May	0.30	.__	0.0	.__	0.20	.__	0.0	.__	0.25	.__	0.25	.__	0.20	.__	0.20	.__	0.0	.__	0.0	.__
June	0.15	.__	0.05	.__	0.20	.__	0.0	.__	0.15	.__	0.15	.__	0.25	.__	0.20	.__	0.0	.__	0.0	.__
July	0.06	.__	0.30	.__	0.15	.__	0.0	.__	0.05	.__	0.05	.__	0.15	.__	0.20	.__	0.20	.__	0.0	.__
Aug.	0.07	.__	0.25	.__	0.20	.__	0.3	.__	0.05	.__	0.05	.__	0.07	.__	0.20	.__	0.20	.__	0.0	.__
Sept.	0.15	.__	0.25	.__	0.05	.__	0.7	.__	0.08	.__	0.08	.__	0.08	.__	0.15	.__	0.40	.__	0.0	.__
Oct.	0.09	.__	0.15	.__	0.00	.__	0.0	.__	0.06	.__	0.06	.__	0.00	.__	0.05	.__	0.20	.__	0.20	.__
Nov.	0.03	.__	0.00	.__	0.0	.__	0.0	.__	0.04	.__	0.04	.__	0.10	.__	0.0	.__	0.0	.__	0.40	.__
Wtr.	0.0	.__	0.0	.__	0.0	.__	0.0	.__	0.07	.__	0.07	.__	0.0	.__	0.0	.__	0.0	.__	0.40	.__
Total[2]	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

1/ A .15 in the April row in the column entitled Native Pasture indicates that 15% of the aforementioned pasture yield will be available during April.

2/ Each column total must sum to 1.0 to indicate that the total potential amount available is 100% of the aforementioned forage yield.

Enter your own estimate of the ANNUAL DISTRIBUTION of FORAGE GROWTH on UPLAND if the base plan estimates do not appear appropriate for your conditions. (If you do not have any 'Upland acres', skip to the following page.)

	Native Pasture		Korean Lespedeza		Birdsfoot Trefoil		New Seeding		Orchard Grass		Tall Fescue		Alfalfa/ grass		Red Clover		Aftermath Small Grains		Cornstalks	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
	Card 129		Card 130		Card 131		Card 132		Card 133		Card 134		Card 135		Card 136		Card 137		Card 138	
April	0.15	.__	0.0	.__	0.20	.__	0.0	.__	0.25	.__	0.25	.__	0.15	.__	0.0	.__	0.0	.__	0.0	.__
May	0.30	.__	0.0	.__	0.20	.__	0.0	.__	0.25	.__	0.25	.__	0.20	.__	0.20	.__	0.0	.__	0.0	.__
June	0.15	.__	0.05	.__	0.20	.__	0.0	.__	0.15	.__	0.15	.__	0.25	.__	0.20	.__	0.0	.__	0.0	.__
July	0.06	.__	0.30	.__	0.15	.__	0.0	.__	0.05	.__	0.05	.__	0.15	.__	0.20	.__	0.20	.__	0.0	.__
Aug.	0.07	.__	0.25	.__	0.20	.__	0.3	.__	0.05	.__	0.05	.__	0.07	.__	0.20	.__	0.20	.__	0.0	.__
Sept.	0.15	.__	0.25	.__	0.05	.__	0.7	.__	0.08	.__	0.08	.__	0.08	.__	0.15	.__	0.40	.__	0.0	.__
Oct.	0.09	.__	0.15	.__	0.00	.__	0.0	.__	0.06	.__	0.06	.__	0.00	.__	0.05	.__	0.20	.__	0.20	.__
Nov.	0.03	.__	0.00	.__	0.0	.__	0.0	.__	0.04	.__	0.04	.__	0.10	.__	0.0	.__	0.0	.__	0.40	.__
Dec.	0.0	.__	0.0	.__	0.0	.__	0.0	.__	0.07	.__	0.07	.__	0.0	.__	0.0	.__	0.0	.__	0.40	.__
Total[2]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	

1/ A .15 in the April row in the column entitled Native Pasture indicates that 15% of the aforementioned pasture yield will be available during April.

2/ Each column total must sum to 1.0 to indicate that the total potential amount available is 100% of the aforementioned forage yield.

14.

Indicate your forage harvesting policies by checking which cuttings you would desire mechanically harvested[1]

	Forage Harvests on OWNED Land						Forage Harvests on RENTED Land					
	Cut #1		Cut #2		Cut #3		Cut #1		Cut #2		Cut #3	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
Bottomland												
Orchard Grass	Card 149 X		X				Card 161 X		X			
Tall Fescue	Card 150 X						Card 162 X					
Alfalfa/grass	Card 151 X		X		X		Card 163 X		X		X	
Red Clover/ grass	Card 152 X		X				Card 164 X		X			
Hillsides												
Orchard Grass	Card 153 X						Card 165 X		X		X	
Tall Fescue	Card 154 X						Card 166 X					
Alfalfa/grass	Card 155 X		X		X		Card 167 X		X		X	
Red Clover/ grass	Card 156 X		X				Card 168 X		X			
Upland												
Orchard Grass	Card 157 X		X				Card 169 X		X			
Tall Fescue	Card 158 X						Card 170 X					
Alfalfa/grass	Card 159 X		X		X		Card 171 X		X		X	
Red Clover/ grass	Card 160 X		X				Card 172 X		X			

[1] A check under any one number indicates mechanical harvest of that particular cutting only and implies that the remainder of this forage grown will be grazed.

A check under #1 and #2 indicates that the first two cuttings will be mechanically harvested. This treatment then allows late summer-fall grazing of this acreage.

A check under #1, #2, and #3 indicates that all growth is to be mechanically harvested. Cut #1 occurs in May-June. Cut #2 occurs in July-August. Cut #3 occurs in September.

15.

List the amount of your LABOR AVAILABLE for the BEEF-FORAGE ENTERPRISE.

Calendar Period	Own, Family, and Permanent Labor Hours available 1/		$ Wage/Hour for additional hired labor 2/		Maximum Number of Additional Labor Hours which can be hired	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
	Cards 200,201		Cards 202,203		Cards 204,205	
April	80.	___.___	$3.00	$___.___	160.	___.___
May	80.	___.___	3.00	___.___	160.	___.___
June	80.	___.___	3.00	___.___	160.	___.___
July	80.	___.___	3.00	___.___	160.	___.___
August	80.	___.___	3.00	___.___	160.	___.___
September	80.	___.___	3.00	___.___	160.	___.___
October	80.	___.___	3.00	___.___	160.	___.___
November	80.	___.___	3.00	___.___	160.	___.___
Winter	320.	___.___	3.00	___.___	160.	___.___

1/ This category includes your own labor, any family labor, and permanent hired labor. Count only those hours available or left over after employment by other enterprises. If you do not know how many hours will be left over for the beef-forage enterprise, suggested labor requirements for various processes in the farm business are presented in the accompanying informational booklet.

2/ If there are seasonal effects on the wage rate paid to additional hired labor, please reflect this fact in the figures you provide.

This page requests information on the capital situation for the beef cow-calf enterprise. Remember that this information pertains to only this enterprise. You should attempt to determine in your own mind just how much debt your present beef cow-calf enterprise carries and how much debt you are willing to incur in the future for such an operation.

For debts incurred in the process of developing an enterprise plan, specify the interest rate to be charged for each type of loan, and length of loan. For current debts of the beef cow-forage enterprise; please specify the amount of debt outstanding, remaining years for payment, and the interest rate charged on these loans.

Financial Considerations

	Base Plan	My Plan
Capital Available for beef cow-forage enterprise: (CAPUSE (1) - Card 197-1)	2500.	____.____

Potential New Borrowings

Purpose of Loan	Length of Loan (yrs) LOANYR(I)		Upper Limits on Credit ($) CAPUSE(2,3,4)		Interest Rate Charged (%) RATE (I)	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
	Card 199-1,2,3		Card 197-2,3,4		Card 206-1,2,3	
Machinery Loan	5.	____.____	25000.	____.____	9.	____.____
Building Loan	15.	____.____	20000.	____.____	8.5	____.____
Livestock Loan	7.	____.____	10000.	____.____	9.	____.____

Current Indebtedness of present beef cow-forage enterprise:

Loan Length	Remaining Years of Indebtedness		Amount Outstanding($) DEBTOS(I)		Interest Rate Charged/yr (%)	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
	Card 199-4,5		Card 198		Card 206-4,5	
Short-term debts	2.	____.____	500	____.____	9.5	____.____
Long-term debts	0.	____.____	0	____.____	6.5	____.____

List the information requested on your MACHINERY AVAILABLE for the BEEF ENTERPRISE.

Item	% of Annual machine-time employed by beef-forage enterprise		Own Machine-Hrs Available for Forage Harvests 1/				Additional Investment in machinery (can be either new or used)						Operating cost/hr. for each machine 2/ ($/hr.)	
			Cut #1		Cuts #2 & #3		Investment cost ($)		Expected Lifetime (years)		Expected Lifetime (hours)			
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
	Cards 57,58,59		Cards 68,69,70		Cards 71,72,73		Cards 45,46,47		Cards 48,49,50		Cards 60,61		Cards 42,43,44	
Tractor - 40 hp	.5	____	0	____	0	____	5000	____	15	____	12000	____	1.62	____
- 50 hp	.5	____	50	____	75	____	7000	____	15	____	12000	____	2.05	____
- 60 hp	.5	____	0	____	0	____	9000	____	10	____	12000	____	2.00	____
- 70 hp	.5	____	0	____	0	____	10500	____	10	____	12000	____	2.25	____
- 80 hp	.5	____	0	____	0	____	12800	____	10	____	12000	____	2.50	____
- 90 hp	.5	____	0	____	0	____	13700	____	10	____	12000	____	2.75	____
-100 hp	.25	____	50	____	75	____	14400	____	10	____	12000	____	2.97	____
-110 hp	.25	____	0	____	0	____	15100	____	10	____	12000	____	3.15	____
-120 hp	.25	____	0	____	0	____	15800	____	10	____	12000	____	3.25	____
-140 hp	.25	____	0	____	0	____	17000	____	10	____	12000	____	3.50	____
Mower	1.	____	150	____	200	____	800	____	10	____	--	--	.40	____
Conditioner	1.	____	50	____	200	____	3000	____	10	____	--	--	.35	____
Rake	1.	____	150	____	200	____	910	____	20	____	--	--	.33	____
Square Baler	1.	____	0	____	0	____	3000	____	10	____	--	--	1.22	____
Square Baler with accumulator plus stacker	1.	____	0	____	0	____	21500	____	10	____	--	--	1.35	____
Square Baler with bale thrower	1.	____	0	____	0	____	3650	____	10	____	--	--	1.35	____
Stack System	1.	____	0	____	0	____	13650	____	10	____	--	--	2.03	____
Small Round Baler	1.	____	112	____	140	____	2500	____	15	____	--	--	1.00	____
Large Round Baler	1.	____	0	____	0	____	4500	____	10	____	--	--	1.00	____
Forage Chopper & Wagons	1.	____	0	____	0	____	7000	____	10	____	--	--	1.60	____
Blower	1.	____	0	____	0	____	925	____	15	____	--	--	2.50	____

1/,2/ See footnotes on page 18.

Worksheet to Calculate Estimated Machine Time Available for Forage Enterprise. (It is not necessary to fill in this page if you can otherwise provide a good estimate of your available machine-time for forage harvesting.)

Item	Good Week Days in Period	X	Hrs/day	=	Total potential field hrs	Machine-hrs required for other processes 3/	Machine hrs available for forage 4/
Tractor 40 hp	_____	X	_____		_____	_____	_____
50 hp	_____	X	_____		_____	_____	_____
60 hp	_____	X	_____		_____	_____	_____
70 hp	_____	X	_____		_____	_____	_____
80 hp	_____	X	_____		_____	_____	_____
90 hp	_____	X	_____		_____	_____	_____
100 hp	_____	X	_____		_____	_____	_____
110 hp	_____	X	_____		_____	_____	_____
120 hp	_____	X	_____		_____	_____	_____
140 hp	_____	X	_____		_____	_____	_____
Mower	_____	X	_____		_____	_____	_____
Mower conditioner	_____	X	_____		_____	_____	_____
Rake	_____	X	_____		_____	_____	_____
Square baler	_____	X	_____		_____	_____	_____
Hesston System	_____	X	_____		_____	_____	_____
Small Round baler	_____	X	_____		_____	_____	_____
Large Round baler	_____	X	_____		_____	_____	_____
Forage Chopper & wagons	_____	X	_____		_____	_____	_____

1/ If you do not possess a particular machine, your available machine-hours will be zero for that machine. See this page for method and worksheet to calculate machine-hours available for first cutting of forage.

2/ Include costs for repairs, maintenance, lubrication, fuel, oil and oil filter. Suggested figures are in the accompanying informational booklet.

For all machines except the blower, the operating cost/machine-hour is for that machine only. However for the blower, the operating cost should include the tractor operating cost also.

3/ This deduction of machine-hours is required for only those machines which may be used in this same time period but for a purpose other than the beef-forage enterprise. If this machinery is used for only the beef-forage engerprise, then total potential field hours are the same as machine hours available for the forage enterprise.

4/ If you do not possess a particular machine, your available machine-hours will be zero for that machine. The amount of machine hours available will be conditioned by the amount of good working days and the hours/day.

19.

	Base Plan	My Plan
Indicate the number of respective machine harvest-hours available for:		
Forage Chopper hours available in September (SLGHR) (Card 82-2)	0.	___.
Stack System hours available in November (PSHRNV) (Card 82-1)	0.	___.
Estimate the following values:		
Total dollar value of the machinery available for beef-forage enterprise (machines which are only partially employed by this enterprise should have a value reflecting this part-time employment) (VALUOM) Card 213-1	$4500.	___.
An average of the approximate remaining useful lifetime of this machinery (in years) (ELIFEM) Card 213-2	5.	___.
Your anticipated TAX bracket (rate in percent) (Card 6-1)	22.	___.
Discount Rate; i.e., your desired rate of return on total investment (rate in percent) (Card 6-2)	10.	___.
Veterinary mineral supplement, and Miscellaneous costs (e.g., herd bull depreciation)/year for:		
Cow with calf (Card 41-1) VETCOW	$ 7.	___.
Feeder calf (Card 41-2) VET	$ 2.	___.

COSTS FOR SILOS BY SIZE AND TYPE

SILO TYPE AND SIZE	SILO CAPACITY (TONS) CORN SILAGE	SILO CAPACITY (TONS) HAYLAGE (.50 DM)	INVESTMENT COST ($) SILO	INVESTMENT COST ($) UNLOADER	INVESTMENT COST/TON CORN SILAGE	INVESTMENT COST/TON HAYLAGE	ANNUAL COST	ANNUAL COST/TON CORN SILAGE	ANNUAL COST/TON HAYLAGE
CONCRETE STAVE									
16 X 40	177.0	106.2	2250	1300	20.06	33.43	659.32	3.88	6.47
16 X 50	238.0	142.8	2900	1300	17.65	29.41	770.93	3.37	5.62
18 X 40	224.0	134.4	2750	1500	18.97	31.62	787.17	3.66	6.10
18 X 50	302.0	181.2	3500	1500	16.56	27.59	915.95	3.16	5.27
18 X 60	387.0	232.2	4250	1500	14.86	24.76	1044.72	2.81	4.69
20 X 50	373.0	223.8	4000	1600	15.01	25.02	1022.80	2.86	4.76
20 X 60	478.0	286.8	5000	1600	13.81	23.01	1194.50	2.60	4.34
22 X 50	452.0	271.2	4750	1900	14.71	24.52	1214.57	2.80	4.67
22 X 60	579.0	347.4	5750	1900	13.21	22.02	1386.27	2.49	4.16
24 X 50	538.0	322.8	5500	2500	14.87	24.78	1469.35	2.84	4.74
24 X 60	689.0	413.4	6500	2500	13.06	21.77	1641.05	2.48	4.14
24 X 70	852.0	511.2	7500	2500	11.74	19.56	1812.75	2.22	3.69
26 X 60	807.0	484.2	7650	2800	12.95	21.58	1901.50	2.45	4.09
26 X 70	1000.0	600.0	8800	2800	11.60	19.33	2098.96	2.19	3.64
28 X 60	940.0	564.0	8750	3150	12.66	21.10	2163.87	2.40	4.00
28 X 70	1159.0	695.4	10000	3150	11.35	18.91	2378.50	2.14	3.56
30 X 60	1076.0	645.6	10000	3500	12.55	20.91	2452.00	2.37	3.96
30 X 70	1332.0	799.2	11200	3500	11.04	18.39	2658.04	2.08	3.46
GAS TIGHT									
20 X 50	373.0	223.8	11200	2800	37.53	62.56	2268.00	6.83	11.39
20 X 60	478.0	286.8	13200	2800	33.47	55.79	2568.00	6.04	10.06
25 X 65	840.0	504.0	21500	4000	30.36	50.60	4065.00	5.44	9.06
BUNKER									
500 T	500.0	300.0	3300	0	6.60	11.00	660.00	1.57	2.62
800 T	800.0	480.0	4600	0	5.75	9.58	920.00	1.37	2.28
1200 T	1200.0	720.0	6600	0	5.50	9.17	1320.00	1.31	2.18
2500 T	2500.0	1500.0	12500	0	5.00	8.33	2500.00	1.19	1.98
5000 T	5000.0	3000.0	22500	0	4.50	7.50	4500.00	1.07	1.79

4/ Annual Cost/year = (Investment Cost of Silo X annual percentage cost for ownership and operation) + investment cost of unloader X annual percentage cost for ownership and operation).

5/ Annual cost/year/ton of silage saved = (annual cost/year)/tons of silage in silo) X 1/(1 - percent storage loss).

(assumes one complete filling per year)

This page is used to indicate your present forage inventory, your available forage storage facilities, and your willingness to increase this forage storage capacity.

Normal INVENTORY of FORAGES on hand at end of winter (March):

(Card 194)

Hay in barn or shed	_____	tons 90% DM
Haylage in silo	_____	tons 50% DM
Corn Silage in silo	_____	tons 30% DM

PRESENT STORAGE FACILITIES:

(Card 195)

Hay Storage Barns	_____	tons 90% DM
Silos	_____	tons 30% DM

NEW STORAGE FACILITIES:

Would you consider building new forage storage facilities which may be completely or partially used by the beef-forage enterprise?

(Card 196)

_____ Yes (1)
_____ No (0)

If your answer is yes, please fill in the remaining blanks on this page.

If No is your answer, turn to the following page.

	BARN Card 192	SILO[2] Card 193
Size of Structure desired	____.__ tons 90% Dm[1]	____.__ tons 30% DM
Estimated Investment Cost for New Forage Storage Facilities[1]	____.__	$____.__
Percent of facility to be used for beef cow-forage enterprise (express the percent in decimal form)	____.__	____.__
Annual ownership costs as percent of investment costs[3]	____.__	____.__
Depreciation	____.__	____.__
Interest	____.__	____.__
Repairs	____.__	____.__
Taxes, Insurance	____.__	____.__

1/ You may either think in terms of rectangular size of a building or of storage capacity for the facility. Rectangular size gives square footage which if multiplied by average height of the facility gives cubic feet available for storage. At approximately 250-330 cu ft/ton of hay, dimensions of a building can easily be converted to storage capacity; e.g., a shed 100 ft long, 25 ft wide, and 20 ft high gives 50,000 cu ft. At 250 cu ft required/ton of hay, this building can hold 200 tons of hay or approximately 8000 50-lb bales.

Estimated investment costs for a pole shed are $16/ton of baled hay or $1.50/sq ft.

2/ See opposite page for suggested size and cost figures for different types of silos.

3/ Suggested 'ballpark' figures (in percentages)

	Gas Tight	Concrete Stave	Bunker	Unloader
Depreciation	5.	6.67	10.	10.
Interest	8.	8.	8.	8.
Repairs	1.	1.5	1.5	2.0
Taxes, Insurance	1.	1.	0.5	1.0

II. Resource Requirements

MACHINE and MAN-HOUR REQUIREMENTS
for FORAGE HARVESTING
(See the opposite page for a worksheet to aid in determining required machine-hrs/acre.)

Process	# acres/machine-hour that can normally be processed[1] ACHR(17)		# acres/man-hour that can normally be processed[2] HRMAN (17)	
	Base Plan	My Plan	Base Plan	My Plan
	Cards 76,77,78		Cards 79,80,81	
1. Mow	2.7	___	2.5	___
2. Condition[3]	2.4	___	2.0	___
3. Rake (windrow)	5.0	___	4.5	___
4. Square baler (drop bales)	2.5	___	2.2	___
5. Square baler with bale accumulator	2.07	___	1.8	___
6. Square baler with bale thrower and wagon	2.07	___	1.8	___
7. Stack system of blowing loose hay into wagon	3.0	___	2.7	___
8. Small round baler	2.0	___	1.8	___
9. Large round baler	3.0	___	2.7	___
10. Chopper & wagon for haylage	3.0	___	2.7	___
11. Tractor & carrier to pick up dropped square bales and stack in barn	2.0	___	0.8	___
12. Tractor & carrier to pick up dropped square bales and stack outside in field	2.5	___	1.0	___
13. Tractor & carrier for accumulated bales to be stacked outside	3.5	___	1.8	___
14. Tractor & wagon to unload bales thrown into wagon	3.0	___	1.4	___
15. Tractor & wagon to carry haylage to silo	3.5	___	2.8	___
16. Chopper & wagon for corn silage	1.4	___	1.25	___
17. Blower	20.0 T/hr	___ T/hr	20.0 T/man-hr	___ T/man-hr

1/ The number of acres per hour will depend upon the size of your machinery, the anticipated average yield for each cutting, and for harvesting activities--the hauling distance.

2/ Normally this figure will be no greater and probably less than the corresponding acres/machine hour. The rationale is to reflect tractor and machine preparation time or the fact that more than 1 man is required for this activity; e.g., picking up dropped hay bales requires at least 2 men -- 1 tractor driver and 1 loader.

3/ If you mow, condition and/or windrow in one operation, enter zeroes in the row (5) for the condition and/or raking processes.

Worksheet for Figuring Machine Hour Requirements for Forage Harvesting

(It is not necessary that this page be filled out if you can otherwise provide a good estimate for machine hours required/acre.)

Process	$\frac{1}{100}$	Swath Width of machine (in inches)	X	Operating Speed (in mph)	X	Field Efficiency (%)	=	Acres per Machine-hour
_____	$\frac{1}{100}$	_____ in.	X	_____ mph	X	____.____	=	_____ acres/hour
_____	$\frac{1}{100}$	_____ in.	X	_____ mph	X	____.____	=	_____ acres/hour
_____	$\frac{1}{100}$	_____ in.	X	_____ mph	X	____.____	=	_____ acres/hour
_____	$\frac{1}{100}$	_____ in.	X	_____ mph	X	____.____	=	_____ acres/hour
_____	$\frac{1}{100}$	_____ in.	X	_____ mph	X	____.____	=	_____ acres/hour
_____	$\frac{1}{100}$	_____ in.	X	_____ mph	X	____.____	=	_____ acres/hour

Examples:

Mow	$\frac{1}{100}$	84 in.	X	4.0 mph	X	.80	=	2.69	acres/hour
Mow-condition	$\frac{1}{100}$	84 in.	X	3.8 mph	X	.75	=	2.39	acres/hour
Windrow	$\frac{1}{100}$	84 in.	X	4.0 mph	X	.80	=	4.69	acres/hour
Square baler (drop bales)	$\frac{1}{100}$	84 in.	X	4.0 mph	X	.75	=	2.52	acres/hour
Square baler with bale thrower	$\frac{1}{100}$	84 in.	X	3.8 mph	X	.65	=	2.07	acres/hour

See the accompanying informational booklet for some additional completed calculations for machine-hours required/acre for the various harvesting processes at selected speeds and field efficiency rates.

FEED and Labor Requirements for BEEF ANIMALS

TDN Requirements Index (TDNI) (Card 7-1) (To adjust all base plan TDN figures by the same amount, enter an index other than 1.0) The entries in the column entitled 'Daily TDN Requirement' may then be omitted.)	Base Index 1.0 My Index ___.___
Labor Requirements Index (ESIZE) (Card 24-2) (to adjust all base plan labor figures by the same amount, enter an index other than 1.0. The entries in the column entitled 'Monthly Labor Requirement' may then be omitted.)	Base Index 1.0 My Index ___.___

Livestock Category	Daily TDN Requirement (pounds)		Monthly Labor Requirement for grazing animals (man-hours)	
	Base Plan	My Plan	Base Plan	My Plan
	Cards 8,9,10		Cards 25,26,27	
Barren Cow	9.0	___.___	.5	___.___
Pregnant Cow	9.0	___.___	.667	___.___
Cow with 1				
6-month old calf	14.0	___.___	1.0	___.___
7-month old calf	5.0	___.___	0.8	___.___
8-month old calf	5.5	___.___	0.3	___.___
9-month old calf	6.0	___.___	0.3	___.___
10-month old calf	6.4	___.___	0.3	___.___
11-month old calf	6.7	___.___	0.3	___.___
12-month old calf	7.0	___.___	0.3	___.___
13-month old calf	7.4	___.___	0.3	___.___
14-month old calf	7.8	___.___	0.3	___.___
15-month old calf	8.2	___.___	0.3	___.___
16-month old calf	8.6	___.___	0.3	___.___
17-month old calf	8.9	___.___	0.3	___.___
18-month old calf	9.1	___.___	0.3	___.___
19-month old yearling	9.3	___.___	0.3	___.___
20-month old yearling	9.6	___.___	0.3	___.___
21-month old yearling	9.8	___.___	0.3	___.___
22-month old yearling	10.1	___.___	0.3	___.___
23-month old yearling	10.3	___.___	0.3	___.___
Bull	12.0	___.___	1.0	___.___

Index to reflect increased TDN needs during winter	(WTRI) Card 7-2 1.2		(WTRLI) Card 24-1 1.5	___.___
Index to reflect increased labor needs	---	---	(CMCLI) Card 24-3 2.0	___.___
Index to reflect increased labor needs for cow & calf if creep feed	---	---	(CCRFI) Card 24-4 1.08	___.___

WINTER FEEDING SYSTEMS

	Full Feed on Ground or Free Feed at Stack				Limit Feed on Ground or at Field Stack				Full Feed in bunks				Limit Feed in bunks			
	Man-hrs/ ton DM (hay)1/		Feed Wastage Index2/		Man-hrs/ ton DM (hay)		Feed Wastage Index		Man-hrs/ ton DM (hay)		Feed Wastage Index		Man-hrs/ ton DM (hay)		Feed Wastage Index	
	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan	Base Plan	My Plan
Conventional Bales stored in barn (shed) (either round or square bales)	Card 210-1 2.1		Card 207-1 .29		Card 210-2 2.1		Card 207-2 .04		Card 210-3 2.27		Card 207-3 .307		Card 210-4 2.27		Card 207-4 .057	
Conventional Bales stored outside in pasture, stack or pile (either round or square bales)	Card 210-5 .03		Card 207-5 1.		Card 210-6 1.84		Card 207-6 .75		Card 210-7 1.40		Card 207-7 .307		Card 210-8 1.40		Card 207-8 .057	
Loose hay stack system	Card 211-1 .03		Card 208-1 .667		Card 211-2 .30		Card 208-2 .417		Card 211-3 1.05		Card 208-3 .273		Card 211-4 1.05		Card 208-4 .023	
Large Bales	Card 211-5 .03		Card 208-5 .471		Card 211-6 .30		Card 208-6 .221		Card 211-7 1.05		Card 208-7 .273		Card 211-8 1.05		Card 208-8 .023	
Haylage	Card 212-1 1.0		Card 209-1 .29		Card 212-2 1.0		Card 209-2 .04		Card 212-3 .1		Card 209-3 .125		Card 212-4 .1		Card 209-4 .01	

1/ This figure requests your estimate of how much time would be required at your farm to feed one ton of dry matter. This man-hour requirement per ton of hay will vary with the size of loads, the mechanization, the distance between hay storage and feeding site, and the number of gates which must be opened and closed.

2/ The feed wastage index is that percentage of total forage exposed or given to the beef animal that is not necessary for nutritional requirements. For example, the figure of 0.4 indicates that there is 40% more feed demanded (fed) than is nutritionally required due to overeating, tramping, wastage, and some spoilage.

III. BEEF SYSTEMS

The purpose of this section is to specify various beef management systems which you want considered for your farm operation.

On this page, please list your present cow inventory, calf and cow weights, plus the expected weight gains for young stock.

Item	Base Plan	My Plan
Number of Beef Cows on hand calving in month of _____ (list the intended calving month, e.g., April - use system #1 on page 27 to describe this beef management system.)[1]	Card 31-1,2 25.0	_____
Number of Beef Cows on hand calving in month of_____(list the intended calving month - use system #2 on page 27 to describe this beef management system)[1]	0.0	_____
Cull Cow's Average Weight (COWWT)	Card 30-2 1000.	_____
Average Weight Gain per Month by Heifer (WTPMH)	Card 30-3 30.	_____
Expected Average Weight at 205 days of age for calves born in March (mix of calves is half steers and half heifers; assume no creep feeding (CALFW1)	Card 13-2 445.0 lbs.	_____
For calves born in other months of the year, give their expected 205-day wt. as a percentage of the March calf wt. (express the percentage as a decimal; e.g., if you feed a May calf to weigh 5% more than the March calf, enter 1.05 in the May blank.) (PCTWT(12)	Cards 28,29	
March	1.00	_____
April	1.00	_____
May	.98	_____
June	.98	_____
July	.95	_____
August	.95	_____
September	.96	_____
October	.96	_____
November	.94	_____
December	.94	_____
January	.96	_____
February	.96	_____
Expected percentage increase in weaning calf weight due to creep feeding (PCTCRP)	Card 30-1 1.09	_____
Expected monthly increase in calf weight for weaner calves carried on forage over the warm months (WTPM(1)	Card 32-1,2 45.00 lbs	_____
over the cold months (WTPM(2)	30.00 lbs	_____

[1] If you do not have any beef cows at present, enter zero in the "My Plan" column and leave this calving month entry blank.

The entries on this page identify the types of BEEF MANAGEMENT SYSTEMS you wish to consider. If you now have a beef cow herd, use system #1 to describe your present operation. If your beef cow herd is split into t (2) different management systems, use system #2 to describe your second system.

If you do not now have a beef cow herd, each column is to be used to describe an alternative beef management system. Each beef management system being considered should be different from every other system.

BEEF MANAGEMENT SYSTEM COEFFICIENTS

Management Variables	Base Plan	System #1	System #2	System #3	System #4	System #5
		Card 14	Card 16	Card 18	Card 20	Card 22
# months before calving that a replacement OPEN heifer would be purchased	10	____	____	____	____	____
# months before calving that a replacement BRED heifer would be purchased	4	____	____	____	____	____
Selling Age of Calf (#months of age)	10	____	____	____	____	____
Weaning Age of Calf (#months of age)	7	____	____	____	____	____
# months after calving a barren cow is kept on farm	0	____	____	____	____	____
# months after calving that a cow which loses its calf is kept	12	____	____	____	____	____
		Card 15	Card 17	Card 19	Card 21	Card 23
Proportion of calfless cows due to non-conception (barrenness)	0.4	____	____	____	____	____
#years of productive life for cow (#calving years)	7.	____	____	____	____	____
With respect to Herd Replacement Policies:						
Proportion of Replacement stock bought as OPEN heifers	0.0	____	____	____	____	____
Proportion of Replacement stock bought as BRED heifers	0.0	____	____	____	____	____
Proportion of Replacement stock raised on farm	0.9	____	____	____	____	____
Proportion of Replacement stock bought as cows with calves (the total of these last 4 figures must be 1.0 for each column)	0.1	____	____	____	____	____
#cows per bull	30.	____	____	____	____	____
Creep Feeding Enter 0.0 if you do not wish to consider creep feeding Enter 1.0 if you do wish to consider creep feeding	0.0	____	____	____	____	____

The entries on this page indicate the potential calving months you wish to consider. A maximum of six (6) calving months can be considered.

Beneath the column heading 'Weaning Percentage', give your estimate for expected percentage of calves weaned as a percent of the number of cows exposed to the bull. You need only list a weaning percentage for those months you wish to consider for calving purposes.

CALVING SYSTEMS				
Calving Months	(Check months to be considered for calving) 1/		Weaning Percentage (expressed as percent of cows exposed to bull which wean a calf)	
	Base Plan	My Plan	Base Plan	My Plan
	Card 1		Cards 4,5	
April	2		.85	
May	X		.85	
June			.85	
July			.85	
August			.85	
September			.85	
October	X		.85	
November			.80	
December			.80	
January	X		.80	
February	X		.80	
March	X		.85	

1/ If on page 26 you indicated that you currently have some beef cows, enter a 2 in the entry month blank for when those cows described in system 1 are to calve. If you currently have two beef cow herds managed under a system different from system #1 and you so indicated on page 26, please enter a 3 for the intended calving month of the second beef herd.

Calf-Yearling Systems

Do you wish to consider buying calves, carrying the calves on forage, and selling yearlings. Card 11-5

1. Yes_____(1)
2. No_____(0)

If your answer is No, skip to the next page.

	Base Plan	My Plan
Initial Weight of Calves which are to be purchased and carried on forage (WTCALF)	Card 13-1 500	_____lbs.
Check four (4) possible months for buying calves: (BUYCLF (5))	Card 11-1,2,3,4	
1. April	X	_____
2. May	X	_____
3. June		_____
4. July		_____
5. August		_____
6. September	X	_____
7. October	X	_____
8. November		_____
9. December		_____
10. January		_____
11. February		_____
12. March		_____
Check five (5) possible lengths of time (in months) for which the purchased calves would be carried on forage: (SELCLF (5))	Card 12	
1 Month		1._____
2 Months		2._____
3 Months		3._____
4 Months	X	4._____
5 Months		5._____
6 Months	X	6._____
7 Months		7._____
8 Months	X	8._____
9 Months		9._____
10 Months	X	10._____
11 Months		11._____
12 Months	X	12._____

IV. Price and Cost Information

This page requests your expectations on prices of beef cattle and feed. The bottom half of the page is used to reflect the seasonality of beef prices.

PRICE EXPECTATIONS

Item	Expected Average annual price for current year		Expected Average price for next 6 years	
	Base Plan	My Plan	Base Plan	My Plan
	Cards 33,34		Cards 35,36	
Stock Cow & new calf	$500. /hd	$___.___/hd	$350. /hd	$___.___/hd
Cull cow	.25/lb	___.___/lb	.20/lb	___.___/lb
Open Heifer	.50/lb	___.___/lb	.40/lb	___.___/lb
Bred Heifer	.55/lb	___.___/lb	.50/lb	___.___/lb
205 day-old weaner calf	.60/lb	___.___/lb	.50/lb	___.___/lb
750 lb yearling calf	.50/lb	___.___/lb	.40/lb	___.___/lb
Corn	2.00/bu	___.___/bu	1.50/bu	___.___/bu
Corn Silage	15.00/ton	___.___/ton	12.00/ton	___.___/ton
Hay	35.00/ton	___.___/ton	35.00/ton	___.___/ton

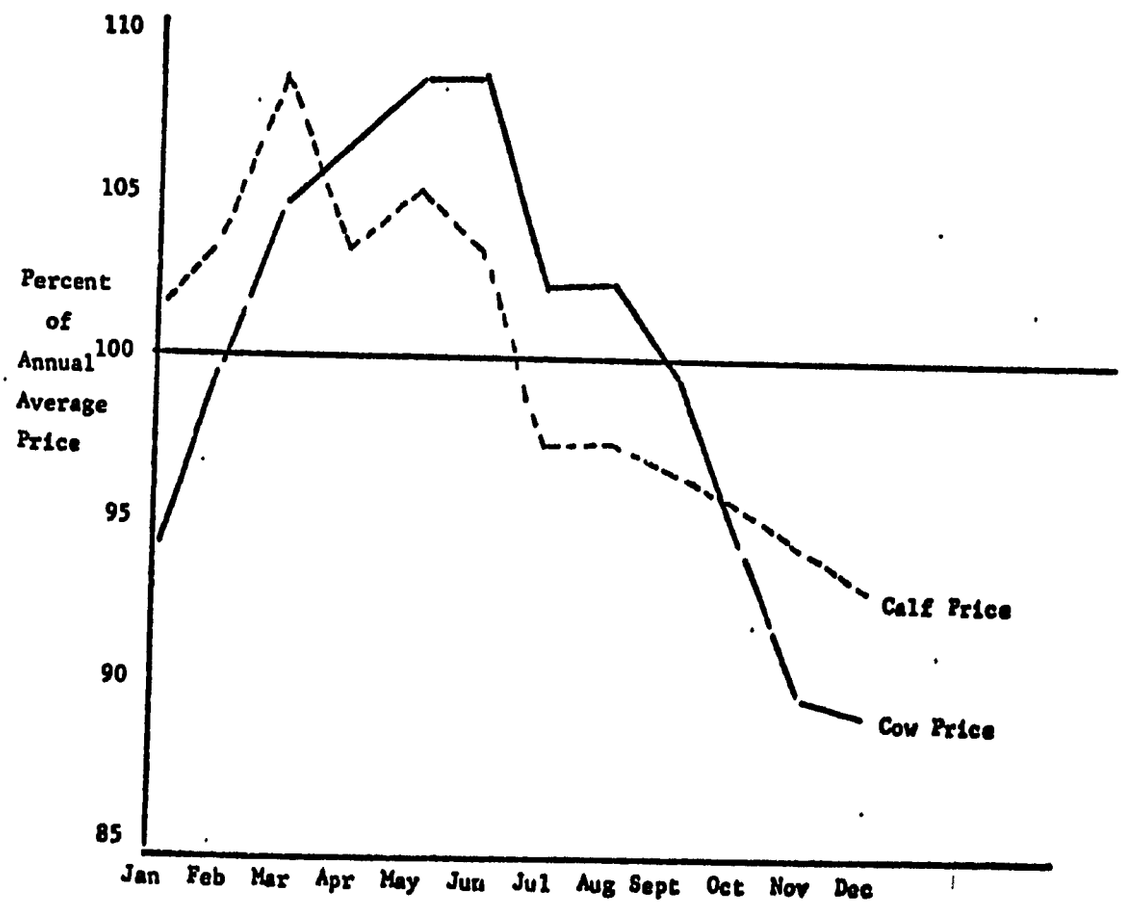
Below, you may indicate the price seasonality of breeding stock and calves; e.g., if you feel the April price for calves to be 3.2% higher than the price you listed above, enter 1.032 in the April blank beneath the column entitled 'weaner calves - my plan'.

Month	Cows & Heifers		Weaner Calves	
	Base Plan	My Plan	Base Plan	My Plan
	Cards 37,38		Cards 39,40	
April	1.063	___.___	1.055	___.___
May	1.084	___.___	1.048	___.___
June	1.087	___.___	1.035	___.___
July	1.024	___.___	.976	___.___
August	1.019	___.___	.977	___.___
September	.998	___.___	.972	___.___
October	.943	___.___	.958	___.___
November	.897	___.___	.946	___.___
December	.892	___.___	.935	___.___
January	.934	___.___	1.004	___.___
February	1.004	___.___	1.033	___.___
March	1.047	___.___	1.077	___.___

Average Prices in Indiana for Feeder Calves and Cows

Year	Calves	Cows
1962	26.0	14.3
1963	25.0	13.5
1964	22.5	11.9
1965	23.4	13.7
1966	28.1	16.6
1967	28.6	16.1
1968	29.0	17.1
1969	32.4	19.2
1970	34.4	20.0
1971	36.0	20.4
1972	43.4	23.9

Seasonal Variation for Feeder Calf and Cow Prices (based on Indiana Prices for Years 1962-1971).



This page requests information on your anticipated cost for hiring-in custom work. Some suggested rates are provided on this page with additional rates provided in the accompanying informational booklet. It is necessary to fill in only the cost per hour blank.

CUSTOM RATES		
Item	Base Plan	My Plan
	Cards 74,75	
Tractor, man & mower	$3.00/ac 2.69 ac/hr 8.07/hr	____ . /hr
Tractor, man & Mower-conditioner	$5.15/ac 2.39 ac/hr $12.30 /hr	____ . /hr
Tractor, man & rake	$2.35/ac 4.61 ac/hr $10.83/hr	____ . /hr
Tractor, man & regular square baler	$ .20/bale 100 bales/hr $20.00/hr	____ . /hr
Tractor, man, & square baler with accumulator plus stacker	$ .35/bale 50 bales/hr 17.50/hr	____ . /hr
Tractor, man, square baler with bale thrower plus wagon	$ .25/bale 120 bales/hr $30.00/hr	____ . /hr
Tractor, man & Stack System	$10.00/stacks 3/stack/hr $30.00 /hr	____ . /hr
Tractor, man & small round baler	$ .15/bale 70 bales/ $10.50/hr	____ . /hr
Tractor, man & large round baler	$ 8.00/bale 5 bales/hr $40.00/hr	____ . /hr
Tractor, man, chopper & wagons (for haylage)	$ 3.15/ton 8.5 ton/hr $26.78/hr	____ . /hr

VITA

VITA

Gerald D. Schwab

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Master of Science, Michigan State University, Department of Agricultural Economics, East Lansing, Michigan, August 1969. Thesis title: Soil, Fertilities, and Management Ralationships Affecting Economic Choices of Corn Silage and Alfalfa on Dairy Farms. Major Professor: C. R. Hoglund.

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