# A COMPUTERIZED FARM BUSINESS SIMULATOR FOR RESEARCH AND FARM PLANNING

Thesis for the Degree of Ph. D.

MICHIGAN STATE UNIVERSITY
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ABSTRACT

# A COMPUTERIZED FARM BUSINESS SIMULATOR FOR RESEARCH AND FARM PLANNING

By

Eddy Lorain LaDue

The scientific industrialization of Agriculture is evolving a commercial farming sector made up of individual units of ever increasing size and complexity. This complexity involves the effects of size itself, a rapidly increasing level of technical knowledge and an increased interdependence and interaction of farm firms with input supplies, product processors and retailers. As well as its effects on complexity, expanding size significantly increases the capital levels involved in most management decisions.

Although techniques such as budgeting, comparative analysis and linear programming have been developed to assist managers in decision making, the increased complexity of the management function provides a need for even more sophisticated and sensative tools of analysis. Farmers, farm advisors and researchers all need tools to aid them in understanding the relationships and interrelationships that occur in the commercial farming sector.

This study involved the development and testing of a computerized dairy farm business analysis model for use in both research and farm planning. The model was conceived within a systems framework with the farm business viewed as a set of acting and interacting systems. Simulation was selected as the most appropriate modeling technique to be used.

The major focus of model construction was development of a model which could realistically simulate the important physical and financial characteristics of individual farm businesses. The model developed can handle either a dairy-crop farm or a crop farm with only those crop enterprises usually found on dairy farms. Additional characteristics of the model include (1) a monthly time unit interval with variable values specific to both month and year, (2) a deterministic mode for all except the dairy herd itself, (3) choice of either a calendar or fiscal year basis, (4) focus on "simulation for management" as opposed to "simulation of management," (5) 87 different specific dairy, crop grow or crop harvest systems, and (6) user defined systems which can be used to represent systems not specified by the model.

Model coefficients are divided into two groups. The first group includes those variables which represent the characteristics of the specific situation to be simulated. These coefficients must be input for every alternative simulated. The second group includes all other coefficients used in the model. These coefficients are assigned initial values by the model. Alternative values are input by exception.

Control of the action of the model through a multi-year simulation occurs via coefficient change and management decision entries. These are coded input lines (cards) which instruct the model to carry out the appropriate transactions required to change a coefficient value, buy or sell land, livestock or machinery, or construct buildings. Each instruction is dated as to month and year of occurrance.

Output of the model includes any combination of eleven reports which vary as to data included and degree of detail. Report formats correspond to electronic farm accounting reports to the degree possible. Specification of the reports to be printed at the end of each year is controlled by the user.

The simulator (FABS) is written in Fortran IV for the CDC 3600 computer in a batch processing mode. Simulator operation requires approximately 25 to 35 seconds of CPU time per year simulated for typical situations.

Use of the model on hypothetical situations designed to test the operationability of the user defined systems indicated that the underlying logic was sound and that systems not defined within the model could be simulated. A stanchion-parlor dairy system and eight-row cropping systems were used.

The model was used on two actual farm planning problems to illustrate its extension application. Three different alternatives were simulated for each situation. The general results indicated that specific farm situations could be simulated and that the generated data could be useful in making management decisions.

A small research problem was conducted using the FABS model as the primary research tool. Although insufficient background research on the problem was conducted to provide an acceptable foundation for drawing conclusions from the data generated, the results did indicate that the model had sufficient flexibility to be useful to researchers for certain types of problems.

# A COMPUTERIZED FARM BUSINESS SIMULATOR FOR RESEARCH AND FARM PLANNING

By

Eddy Lorain LaDue

A THESIS

Submitted to

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DEDICATION

To my father

George J. LaDue

My first and foremost teacher in both

Economics and Agriculture

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# INTRODUCTION

The scientific industrialization of Agriculture[1] is evolving a commercial farming sector made up of individual units of ever increasing size and complexity. This complexity involves the effects of size itself, a rapidly increasing level of technical knowledge and an increased interdependence and interaction of farm firms with input suppliers, product processors and retailers. As well as its effects on complexity, expanding size significantly increases the amount of money involved in most management decisions.

This changing situation is particularly true in the dairy subsector where farmers are presently evaluating dairy system investments which frequently involve $40,000 to well over $100,000 for progressive dairymen[2] and a minimum of $5,000 to $35,000 for average

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[1] Shaffer, James D., "The Scientific Industrialization of the U.S. Food and Fiber Sector, Background for Market Policy," in Agricultural Organization in The Modern Industrial Economy, NCR-20-68, Department of Agricultural Economics, The Ohio State University, Columbus, Ohio, 1968.

[2] Hoglund, C. R., J. S. Boyd and J. A. Speicher, Free Stall Dairy Housing Systems, Research Report 91, Michigan State University Agricultural Experiment Station, East Lansing, Michigan, 1969.

dairymen.[3] The large array of combinations of technologies[4] and the herd expansion that often accompanies the change make investment evaluation very complex.

Because of the technological and capital-labor substitution characteristics of industrialization and the apparent financial incentives for increased size of farm units[5] it appears that farm decision making will be subject to increasing complexity. As pointed out by Babb and Eisgruber, "Not only is the complexity of business management problems growing, the nature and environment within which the problems have to be analyzed are changing at an ever increasing rate."[6]

Although techniques such as budgeting, comparative analysis and linear programming have been developed to assist managers in decision making, there is a further need for even more sophisticated and sensative tools of analysis. Farmers and farm advisors need

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[3] Hoglund, C. R., Characteristics of Newly Built Cold-Covered and Warm-Enclosed Dairy Housing Systems, Agricultural Economics Report 129, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, May, 1969.

[4] Buxton, Boyd M., Alternative Dairy Technologies, A Comparison of Unit Cost, Net Return and Investment, Station Bulletin 490, Agricultural Experiment Station, University of Minnesota, 1968.

[5] Krause, K. R. and L. R. Kyle, Economics Factors Underlying The Incidence of Large Farming Units, The Current Situation and Probable Trends, Agricultural Economics Report 12, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, May, 1969.

[6] Babb, E. M. and L. M. Eisgruber, Management Games for Teaching and Research, Educational Methods Inc., Chicago, Illinois, 1966.

more powerful tools to assist them in coping with the multifacited problems of larger, more complex businesses. Researchers need tools to aid them in understanding the relationships and interrelationships that occur in the commercial farming sector. The power of the tools of analysis must increase with the magnitude of the problems being considered.

## Objectives

The primary objective of this study is to develop and validate a total farm business analysis model which can be used to deal with an array of research and farm planning problems. This model is to be a tool which can be used by farm managers and farm management advisors to assist them in coping with the complex decision situations which farm managers face. The model should also offer promise to researchers interested in evaluating current or expected changes either within farm firms or in the environment within which the farm firms operate.

More specifically, the primary objectives are to:

(1) develop a dairy farm business analysis model which

- (a) can reasonably represent Michigan dairy farms.
- (b) can be adjusted by the user to evaluate individual farm situations.
- (c) is flexible enough to assist in the design and evaluation of systems not now in operation.
- (d) is designed to minimize difficulties in expanding or adapting the model to include other farm enterprises.

(e) will offer flexibility in use by offering a range in output options with a corresponding range in input requirements.

and (2) generate evidence as to the degree to which this model may be useful as a tool for research and farm planning.

Although it was presumed at the outset that the model developed would be a simulator designed such that management was viewed in a systems context, it was deemed necessary to critically examine that position. In line with this, secondary objectives of the study were set forth. These secondary objectives were to (1) review systems theory and its relationship to the management function and (2) evaluate the simulation method as a potential tool for total business analysis.

## Methodology

The methodology used in this study included an extensive review and evaluation of systems and simulation literature followed by design and development of a total farm business computer simulation model. The actual process used can be delineated as five steps: (1) problem identification, (2) establishment of a theoretical framework for model development, (3) specification of the model, (4) satisfaction of data requirements and (5) model testing and application.[7]

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[7] The approach to and process of model development follows closely Manetsch, T. J., Design, Development and Use of Simulation Models for Systems Planning and Management, Paper presented at the North Central Regional Farm Management Extension and Research Conference, Michigan State University, October 13-16, 1969.

As previously indicated, the environment in which farmers are and will be making decisions is becoming increasingly complex. The investment and disinvestment decisions being made almost daily involve large capital investments and cash flows of previously unheard of magnitudes. The rapid rate of technological progress provides new crop varieties, machinery systems and building systems at such a fast pace that a number of different methods of carrying out any one function exist at the same time, each with a different investment requirement, technical capacity and degree of obsolesence or potential obsolesence. Increased specialization makes the various parts of an individual business more interdependent and increases the importance of specific technical relationships used by the farm business.

The resultant high level of technical detail required to realistically handle any particular farm situation led to restriction of the problem to development of a model of analysis which would handle only one type of farm businesses.

Because of the author's prior interest and experience in the dairy industry and the fact that dairy farming is the most predominant type of farming in Michigan, the type of farm business chosen was dairy. To develop a model which included more enterprises would have required either more time than was available for the present study and larger computer than was available on a reliable basis or a reduction in the technical detail and thus the realism of the model developed.

Dairy farm managers are currently facing the problems involved in changing to new types of housing and ways of handling cows. In addition, new more efficient and more specialized crop growing and

handling machinery is continually becoming available. Young men starting in farming frequently must evaluate alternative methods of developing a viable business which may involve expansion of the home farm business or formation of an entirely new business. The debt levels caused by these and other changes make investment analyses and cash flow estimation necessary parts of financial management. Older farmers must evaluate the effects of various business reorganization plans (bringing in a partner, reduction of the livestock enterprise) required to meet their changing financial needs and physical abilities.

For these reasons, the problem was defined as a need to develop a business analysis model which would allow analysis of investment, disinvestment and reorganization alternatives for Michigan dairy farms. The model must have sufficient technical relationships built into it so that changes which effect labor requirements, cash flow requirements and other technical input-output coefficients can be evaluated. Further, the model must contain all of the enterprises, livestock and crop, normally found on dairy farms so that the interrelationships between these enterprises can be included in the model.

As defined, the problem focuses on the individual farm business and its problems. It is assumed that data input requirements must be such that any investment, disinvestment or reorganization problem is evaluated with respect to a specific farm situation rather than being generally valid for most situations.

Viewed from a different perspective the problem may be defined as development of "laboratory," for the scientist, farm business manager and farm advisor, to be used in analyzing alternative

investment, disinvestment and organizational strategies. The physical and financial impossibility of experimenting with an actual farm business to answer the problems of specific farm business situations leaves these people with few alternative methods of business analysis. The problem is to design a model which makes use of the capabilities of the digital computer to provide the experimental abilities required to evaluate potential changes in individual businesses.

Although any list of examples is necessarily incomplete, the types of problems which the model must be able to address can be indicated. In addition to those indicated above, examples include: (1) income and cash flow analysis of changing dairy housing systems, (2) comparison of marketing systems with different timing, prices and farm storage requirements, (3) analysis of different growth strategies (both production system and financing system strategies) and (4) comparison of different strategies for increasing business size to include a son. The model need not have the capacity of selecting an optimum ration or determining an optimum fertilizer program.

Following problem identification a theoretical framework for model development was establised. The observation or assumption that the interrelationships between the various parts of a business are of paramount importance led to an in-depth review of systems theory and the systems approach as a basic theoretical foundation for a whole farm business model. Closely associated with this was an analysis and literature review of the simulation method as to its

compatibility with a systems approach to management and economic theory, and as a technique for individual firm representation.

After establishment of a theoretical framework the model was specified in detail and the parameter data collected. Model specification was essentially a heuristic process of trying to develop ways to simulate the physical and financial characteristics of a farm business. Simfarm I[8] and other simulation models developed and being developed by the Department of Agricultural Economics Farm Management staff provided ideas and guidelines for model design. Parameter data was collected from Michigan Telfarm records, DHIC records, Agricultural Economics research reports, Agricultural Experiment station bulletins, Department of Agricultural Economics publications from other states (particularly Minnesota, Illinois and New York) and from faculty members in the Department of Agricultural Economics and other departments in the College of Agriculture and Natural Resources.

The model was then programmed in Fortran IV for Michigan State University's CDC 3600 computer. Computer programs were written by the author and Department of Agricultural Economics computer programmers.

The final phase of model development involved testing and application of the model. This phase included three different activities. First, test farm situations were used to check out all of the user defined systems. Then, two actual farm planning situations were

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[8] Vincent, W. H., Agricultural Economics Report 164, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, in process.

simulated with opportunity for repeated feedback from each of the farm planners. And finally, a small research project was conducted using the model as the primary research tool.

## Plan of Future Chapters

The objective of this chapter has been to provide a general overview of the study by outlining its justification, objectives and methodology. Future chapters present the study and its results in detail. Chapters two and three provide the theoretical framework and background for the model with chapter two covering the general systems theory framework and previous research within which the model is developed and chapter three specifying the general characteristics of the model within that theoretical framework.

In chapter four the model constructed is outlined followed by a discussion of the theoretical basis or justification for certain important model relationships and their method of representation within the model. The final section of this chapter includes directions for use of the model.

Chapter five includes a discussion of the general problems of validation plus an enumeration of the testing and application of the model which was carried out. In chapter six estimates of development and operating costs are made and the problems and costs involved in model maintenance over time discussed.

Possible extensions or modifications of the model are discussed in chapter seven. Chapter eight includes the traditional summary and conclusions of the study.

Three appendices are included. Appendix A is a copy of the user manual and input forms required for use of the model. Appendix B contains a complete description of the model in detail. These appendices should be referred to for all questions about the exact operation of the model or the method of representing system characteristics. Appendix C lists the data sources for the coefficients used in the model.

# CHAPTER II

## PREVIOUS RESEARCH AND EVALUATION OF THE SIMULATION METHOD

An appropriate theoretical framework for a management oriented business analysis model must contain both a suitable implicit view of management and the desired focus on important aspects of the business. The belief that the model must contain the complete farm business, and the observation that the interactions between the various enterprises within the business are of paramount importance in evaluating alternatives, lead one to conclude that use of basic economic concepts within a general systems framework may provide the best theoretical basis for model development. The actual viability of such a combination of economic theory and systems theory, however, depends on the usefulness of the system approach as a basis for a theoretical framework and the existence of a technique which allows incorporation of economic concepts as well as viewing management in a systems context.

One technique which appears to meet these criteria is simulation. Although rapidly expanding use of this technique in business speaks well for its potential application to farm business management, it is necessary to investigate that potential. In an attempt to evaluate systems theory and the simulation method the following discussion explores systems theory as it presently exists, investigates the

relationships between systems theory and simulation, looks at the theoretical economic implications of simulation, compares simulation and linear programming and reviews previous simulation research.

## General Systems Theory

The development of a systems theory for management, or even for the biological sciences, is still in its embryonic stage.[1] At this point there is not even agreement as to what is meant by the term "system." Various authors have defined system in different though somewhat similar ways. Examples of these definitions include (1) "A set of objectives together with relationships between the objects and between their interrelationships,"[2] (2) "An aggregation or assemblage of objects jointed in some regular interaction or interdependence,"[3] (3) "A set of elements so interrelated and integrated that the whole displays unique attributes,"[4] (4) "A set

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1 Hopeman, Richard J., Systems Analysis and Operations Management, Charles E. Merrill Publishing Co., Columbus, Ohio, 1969.

2 McMillan, Claude and Richard Gonzalez, Systems Analysis, A Computer Approach to Decision Models, Richard D. Irwin, Inc., Homewood, Illinois, 1968.

3 Gordon, Geoffrey, System Simulation, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1969.

4 Timms, Howard L., The Production Function in Business, Richard D. Irwin, Inc., Homewood, Illinois, 1966.

of interrelated parts"[5] and many others.[6] Whether "a" definition of system will evolve or not is questionable. A wide variety of disciplines are using the concept with each approaching problems and defining the term in such a way as to meet the needs of the particular discipline. Even those interested in systems from a management point of view have some differences in opinion as illustrated by the above definitions.

Although there is not complete agreement as to the definition of the term system, the definitions all contain the concept of interaction.[7] Other words, such as interdependence or interrelationships, are often used but it appears to be the interaction among a group of components and their attributes which make them a system. Illustrations of the forms that interaction can take include feedback mechanisms, catalysts, inhibitors and joint causality.

There is, however, less agreement as to whether a system must have an objective or not. Kennedy states that the concept of a

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5 Tilles, Seymour, "The Managers Job - A Systems Approach," Harvard Business Review, Vol. 41, No. 1, p. 74, January - February, 1963.

6 For examples, see Hare, Vancourt, Jr., Systems Analysis: A Diagnostic Approach, Harcourt, Brace and World Inc., New York, New York, 1967, and Forrester, Jay, Industrial Dynamics, M.I.T. Press, Cambridge, Massachusetts, 1961.

7 Deutsch, Ralph, System Analysis Techniques, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1969.

system "implies a goal or purpose."[8] Wilson and Wilson[9] indicate that the components of a system must be arranged to perform some wanted operation. Others[10] take a much more theoretical approach and are concerned with general systematic relationships, or the black box to which Boulding[11] refers. Businesses do have objectives and they are important in the design of systems. Whether the systems themselves have objectives is still a moot question. This author contends that business systems should be used to meet the objectives of management.

As previously stated, a general systems theory is just beginning to evolve. The basic idea of a general systems theory stems from the "Gestalt" theory of psychology developed by Wertheimer, Koffka and Kohler.[12] The basic philosophy of this theory is that the whole is more than just the sum of the parts.[13] Thus one must consider the

---

8 Kennedy, John L., "Psychology and System Development" in Psychological Principles in System Development, edited by Robert M. Gagne, Holt, Rinehart and Winston, New York, New York, 1966.

9 Wilson, Ira G. and Marthann E. Wilson, Information, Computers and System Design, John Wiley and Sons, Inc., New York, New York, 1965.

10 Johnson, Richard A., Fremont E. Kast and James E. Rosenzweig, "Systems Theory and Management," Management Science, Vol. 10, No. 3, p. 367, January, 1964.

11 Boulding, Kenneth E., "General Systems as a Point of View," in Views on General Systems Theory, edited by Mihajlo D. Mesarovic, John Wiley and Sons, New York, 1964.

12 Kohler, Wolfgang, Gestalt Psychology, New York, 1929.

13 Ruch, Floyd L., Psychology and Life, Scott, Foresman and Co., Chicago, Illinois, 1963.

whole as an interrelated system and study the individual parts as they effect and are effected by the system.[14]

The real force which gave birth to a general systems theory, however, was the desire to develop a unitary theory of science or as Boulding calls it a "Skeleton of Science."[15] The name and the foundations for a general systems theory were first published in a series of articles in the late 1940's and early 1950's by Ludwig von Bertalanffy.[16] Von Bertalanffy was trying to develop a general theory to explain what he viewed as the parallel evolution and isomorphic laws in science. A set of system principles or characteristics were set forth. These included:

(1) Growth; A system grows as measured by certain attributes of the system. Growth may be either positive or negative and is often typified by proportional, expoential or logistic change.

(2) Wholeness; The system behaves as a whole, the parts are interdependent and often codetermined.

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[14] Petermann, Bruno, The Gestalt Theory, Routledge and Kegan Paul, Ltd., London, 1932.

[15] Boulding, Kenneth E., "General Systems Theory - The Skeleton of Science," Management Science, Vol. 2, No. 3, April, 1956.

[16] The two most commonly quoted which are in English are: von Bertalanffy, Ludwig, "An Outline of General System Theory," The British Journal for the Philosophy of Science, Vol. 1, p. 134, 1950-51, and von Bertalanffy, Ludwig, "General Systems Theory: A New Approach to Unity of Science," Human Biology, Vol. 23, No. 4, p. 301, 1951.

(3) Independence or Physical Summativity; Variation in the complex equals the sum of the variation of the individual elements. Although this is the opposite of wholeness above, its presence only points out that both characteristics can and do appear.

(4) Centralization; Certain elements of a system may have more effect than others. Some elements may have little or no effect. The variables with the most influence may change and the order and procedure of that change may be predictable or consistent.

(5) Competition; There may be competition among the various parts of the system for the resources and the intermediate products of the system. There may be competition between the various parts of the system to determine the specific role to be carried out be each part.

(6) Hierarchical Order; The many system components are themselves systems of the next lower order.

(7) Finality; Systems are seen as approaching three possible final states or solutions with the passage of time. Systems may asymptotically attain a stable stationary state; they may never attain a stable stationary state; or they enter a state of periodic oscillations.

If one defines a theory, as Websters[17] does, as "a systematic statement of principles involved" or as a "formulation of apparent relationships or underlying principles of certain observed phenomena which has been verified to some degree," then von Bertalanffy's above set of principles is the closest approximation to a statement of a general systems theory that is presently available. However, Boulding[18] indicates that the development of a general field theory of the dynamics of action and interaction which would be involved in a general systems theory is a long way ahead. Instead, he proposes a second possible approach to general systems theory which involves construction of a hierarchy of systems.

This hierarchy roughly corresponds to the complexity of the individuals of the various empirical fields. Thus, each field or discipline has its own hierarchy of systems parallel to the hierarchy of other fields or disciplines. The various system levels as proposed by Boulding are listed below.

(1) Frameworks: This is the level of the static structure and includes the geography of the Universe, the mapping of the earth and the pattern of atoms in a molecular formula.

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17 _____: Websters New World Dictionary of the American Language, The World Publishing Company, Cleveland and New York, 1956.

18 Boulding, op. cit., p. 202.

(2) Clockworks; The simple dynamic system with predetermined, necessary motions. This includes the great clock of the universe, the solar system. The greater part of economic theory falls in this category.

(3) Thermostat; This level is that of the control mechanism or cybernetic system. The transmission and interpretation of information is an essential part of the system. The system will move toward any given equilibrium within limits. Initial conditions do not necessarily determine the final state. The essential variable is the difference between the "observed" and the "ideal" level.

(4) Open systems; Self-maintaining structures typify this level. At this level life begins to differentiate itself from non-life. Self-reproduction and self-maintenance in the midst of a throughput of material which originates outside the system and is returned outside the system are salient features.

(5) Plant systems; There is a division of labor among differentiated and mutually dependent parts. There is a difference between genotype and phenotype.

(6) Animal systems; This level is characterized by mobility, teleological behavior and self-awareness. More developed systems at this level have specialized information-receptors leading to an enormous intake of information and a brain which allows response to "image" as well as physical stimulus.

(7) Human systems; At this level the individual human being is considered as a system. This level includes self-consciousness in addition to self-awareness, realization of knowing as well as knowing and an ability to absorb symbols as well as signs.

(8) Social organization systems; This is the level of "roles" tied together with communication. This involves interaction of groups of the next lower set of systems and the development of a set of value systems and a historical record.

(9) Transcendental systems; This is essentially the level of ultimates, absolutes and the inescapable unknowables.

This, of course, is only a listing of a hierarchy of systems or an attempt at constructing a system of systems. It is not a set of principles that could assist one in predicting the outcome of the action of certain actors or conditions within a system and thus be called a theory. The principles of production theory in micro-economics assist one in evaluating the results of producing under certain conditions or having certain conditions change. This hierarchy of systems does not provide a parallel set of principles for a theory of systems.

That there is not at the present time a body of principles and ideas that could be called a systems theory is supported by Ansoff and Slevin. In their search of the systems literature with particular

emphasis on Industrial Dynamics they found no "statements which even begin to describe ID as a theory."[19]

What the work of Boulding and von Bertalanffy has provided is a basis for the development of a heuristic base which serves as the intellectual framework for systems analysis. The most important part of that heuristic base is what may be called the systems concept. This is not another definition of system. It is a theoretical construct which allows elucidation of the skeletal framework of a system.

Modern management organizations and businesses are generally accepted as being systems of the level of Boulding's open systems. They are self-maintaining structures which receive material from and return material to their environment. "The business organization is a man-made system which has dynamic interplay with its environment-customers, competitors, labor organizations, supplies, government and many other agencies."[20]

Within the open system context, the basic concept of a system can be illustrated as shown below.

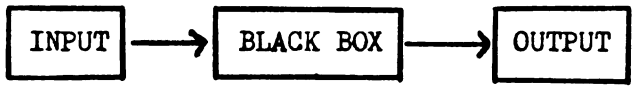



Figure 2.1 Basic Input-Output System

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19 Ansoff, H. Igor and Dennis P. Slevin, "An Appreciation of Industrial Dynamics," Management Science, Vol. 14, No. 7, March, 1968.

20 Johnson, Kast and Rosenzweig, op. cit.

Input consists of information or materials required by the system or imposed on the system for its operation. It is the raw product and the energy sources of the system. Output is the information and material which represents the results of operation of the system. Output consists of both logically required output which the system must or routinely does pass into the environment and imposed output which is a desired or required result of the system.[21]

Input and output are generally assumed to be measurable and dated. Dating provides a basis for viewing a system as a process of a more or less continuous nature and is a very valuable characteristic of input and output when one is attempting to discern attributes of systems.

What is labeled "Black Box" is the system itself. The term "black box" is used to represent a system in which the inputs and outputs are measurable although the process of conversion is not always observable or known.[22] Other names used in place of black box include Control Apparatus,[23] Operations,[24] Organization as

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21 Glans, Thomas B., Grad Burton, David Holstein, William E. Meyers and Richard N. Schmidt, Management Systems, Holt, Rinehart and Winston, Inc., New York, New York, p. 16, 1968.

22 Goetz, Billy E., Quantitative Methods: A Survey and Guide for Managers, McGraw-Hill Book Company, New York, New York, 1965.

23 von Bertalanffy, Ludwig, "General Systems Theory - A Critical Review," in Modern Systems Research for the Behavioral Scientist by Walter Buckley (ed.), Aldine Publishing Co., Chicago, Illinois, 1968.

24 Glans, Burton, Halstein, Meyers and Schmidt, op. cit.

Process [25] or Transformer.[26] However, these names also may have slightly different meaning. The basic difference is the degree to which the contents of the black box is known or knowable. If the black box is viewed as a complete system it is obvious that the major aim of systems analysis is to learn the contents of the black box. Viewed in this light black box is a somewhat misleading term.

Viewed as a basic building block of systems, however, the term black box seems quite appropriate. This is the approach used by Hare who defines the black box as a representation of a grouping of detail. The detail is so grouped because "we do not choose to deal with further detail, or because we are unable to penetrate the black box boundary."[27] The example is given that a dog's owner may be quite satisfied with the black box approach to how and why the dog wags his tail. For the owner it is sufficient to know that: "My dog wags his tail when I give him a bone."

It appears that the best way to resolve the difference between these two views of the black box is to accept them both and interpret them as parts of a continuum. In cases where the black box represents something which is to remain unknown, the input-black box-output unit can represent the most basic unit of the system.

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[25] Young, Stanley, "Organization as a Total System," in Systems, Organization, Analysis, Management: A Book of Readings by David I. Cleland and William R. King (eds.), McGraw Hill Book Co., New York, New York, 1969.

[26] Hare, op. cit., p. 28.

[27] Ibid., p. 29.

In cases where a broader view of a system is being taken the black box will represent a grouping of detail which one would like to know, understand or at least predict. In this case it might be better to use the input-organization as process-output or input-operations output descriptions. For cases between these two, there will be details which are to remain unknown and details which are the object of study.

Another important feature of a system is the feedback loop.[28] The feedback loop provides for the sending of a message from one element in the system to another where it is evaluated for possible action to modify the system. Feedback may be either positive or negative and usually indicates a result of system operation or a deviation of output results from some standard.[29] Although the feedback loop is a feature of the Cybernetic or thermostat level of systems, it is not limited to that level.

The importance of the feedback loop is indicated by two developments. The first is the development of the science of Cybernetics which is the study of adaptive closed loop systems.[30] The feedback loop provides "the adaptive capability of the closed system. The

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28 Hare, Ibid., p. 41.

29 Forrester, Jay W., "Industrial Dynamics - After the First Decade," Management Science, Vol. 14, No. 7, p. 398, March, 1968.

30 George, Frank, "Cybernetics: The New Science of Management," Management Decision, Quarterly Review of Management Technology, Vol. 3, No. 1, Spring, 1969.

second is the development of Industrial Dynamics,[31] which is described as the science of feedback behavior in social systems.

A third basic feature of systems as put forth by Hare[32] is the decision block. This is a decision point within a system where the action taken depends on the values of certain variables. The decision block appears to be particularly useful when systems are viewed as a combination of elemental parts consisting of decision points, feedback loops and input-black box-output units where the black box is assumed to be an unknown group of detail.

Discussion and use of the systems concept has evolved a set of terms with particular meaning in a systems setting which are now widely used in systems literature. For a given system, the environment is "the set of all objects outside the system: (1) a change in whose attributes effect the system and (2) whose attributes are changed by the behavior of the system."[33] Every system has an environment and many systems are the environment or part of the environment of other systems.

A subsystem is a system of lower hierarchical order which is part of another system. Most systems can be thought of as being composed of a set of subsystems. This is analagous to the "wheels within wheels" nature of the average cost curve in economics.

Noise is random fluctuation. When the values of variables cannot be determined with mathematical equations because of random

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31 Forrester, op. cit., 1961.

32 Hare, op. cit., p. 28.

33 Hall, Arthur D., A Methodology for Systems Engineering, D. Van Nostrand Co., Inc., Princeton, New Jersey, 1962.

fluctuation there is noise in the system. The weather, the purchasing agent's vacation or the production manager's illness are all sources of noise. In some cases this can be handled by knowing the distribution of these random elements. In other cases the elements are unknown or unexpected.

Lags are delays, either between input and output or between the source of information in feedback loops and the arrival of the information at its destination. Lags are numerous in agriculture. Most of the inputs (from mans point of view) enter the system in the spring for a corn crop that cannot be used until late fall.

In addition to the systems concept, the heuristic base of systems analysis includes what might be called a "systems perspective." This is a mental framework which allows one to approach problems and to see organizations from a systems point of view. Each person who analyzes problems or assists in the decision making of organizations has a basic framework or mind set which influences his approach to and method of solution of problems. The systems perspective allows one to see "things" as systems and to approach solutions as methods of improving, adjusting, replacing or repairing systems.

What this heuristic base provides is an angle of perception or a method of viewing problems which may be superior to any previously developed method for certain problems. As Boulding points out,[34] "Perhaps one of the most valuable uses of the above (hierarchical) scheme is to prevent us from accepting as final a level of theoretical

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[34] Ibid., p. 207.

analysis which is below the level of the empirical world which we are investigating" and "Its emphasis on communication systems and organizational structure, on principles of homeostasis and growth, on decision processes under uncertainty, is carrying us far beyond the simple models of maximizing behavior of even ten years ago." Viewing the hierarchy of systems as the essential basis for a systems approach or systems analysis has been widely accepted.[35]

Although there is essential agreement that the heuristic base outlined above provides a basis for systems analysis an agreed upon definition for systems analysis has not been found. The unsettled nature of the definition of systems analysis can be illustrated by quoting from two texts with the word "systems analysis" in their title. McMillan and Gonzalez[36] very candidly admit that "To be frank the authors are not certain what is meant by systems analysis." At a much different extreme Hare[37] states that "The scientific method of inquiry, which demands such relevant and dependable relationships for its results, is systems analysis in its broadest sense."

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[35] For examples, see Johnson, R. A., F. E. Kast and J. E. Rosenzweig, The Theory and Management of Systems, McGraw-Hill Book Company, Inc., New York, 1963. Hall, Arthur D., A Methodology for Systems Engineering, D. Van Nostrand Company, Inc., Princeton, New Jersey, 1962. Vincent, Warren H. and Larry J. Connor, "An Orientation for Future Farm Planning and Information Systems," Ag. Econ. Misc., 1968 - 5, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, 1968.

[36] McMillan and Gonzalez, op. cit.

[37] Hare, Van Court Jr., Systems Analysis: A Diagnostic Approach, Harcourt, Brace and World Inc., New York, New York, p. 1, 1967.

At this point in time it appears that systems analysis can best be defined as a method of analysis in which the interaction of the various components of a system are considered of paramount importance. What is called systems analysis will depend upon the specific area of interest and level of focus being considered and the types of analysis historically carried out in that field. For example if a certain field of study had considered price to be a linear function of a certain demand shifter, an analysis which considered price to be the result of the interaction of the forces of demand and supply would be considered as systems analysis. On the other hand, in areas where systems are a historical method of analysis, systems analysis is said to occur only when even greater emphasis is given to the interaction of components.[38]

Using the broad definition systems analysis in economics might be viewed as a change from evaluating the effect of a variable by holding all other variables constant to an attempt to discern the effect of varying the variable when all other variables are allowed to vary in their normal way. This would provide the advantage of allowing observation of the variable under more realistic conditions but the disadvantage that the specific conditions of observation are more difficult to quantify.

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[38] The author is indebted to J. B. Holtman, Departments of Agricultural Engineering and Systems Science, Michigan State University for his assistance in clarifying this point.

Within the field of management Young[39] states that what appears to be occurring with acceptance of systems analysis is that our "concept of the organization is changing from one of structure to one of process." That is, organizations are viewed as a set of flows of information, men, materials and behavior, with time and change the critical aspects. Young feels that this new approach will prove to be more productive.

The relative importance of particular advantages cited for systems analysis may depend on the specific system of concern. However, a general list of advantages is presented below.

(1) Systems analysis allows determination of "better" solutions to problems for which an optimum does not exist or can not be found with optimizing methods.[40]

(2) A larger number of heterogenous variables can be handled in a consistent manner.

(3) Systems analysis allows explicit treatment of uncertainty and can handle different types of uncertainty simultaneously. This is particularly important for long-range planning.

(4) Systems analysis may be conducive to the invention of new systems.

(5) The criteria of analysis or the decision criteria can be broadened or increased in number.

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39 Young, Stanley, Management: A Decision-Making Approach, Dickenson Publishing Company, Inc., Belmont, California, 1968.

40 Hitch, Charles, "An Appreciation of System Analysis," Operations Research, Vol. 3, No. 4, November, 1955.

(6) The complex interrelationships between problem elements and the objectives of numerous functional units may necessitate the use of objective analysis of decision problems.[41]

(7) It provides a method of reducing complex relationships to paper. A manager is able to see the various parts of a business in a more realistic perspective. It provides a basis for "putting it all together."[42]

In the field of management there is wide variation in the level at which systems analysis is applied. In many cases the uninitiated reader is essentially led to believe that this level is the level at which systems analysis applies. Ewell[43] includes an entire large corporation and its subsidiaries as his system for analysis. Neuschel[44] views the various functional units of a business, such as the production control systems, as the appropriate level for systems analysis. To Even[45] systems analysis involves the study of

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[41] Cleland, David I., and William R. King, Systems Analysis and Project Management, McGraw-Hill Book Co., New York, New York, 1968.

[42] King, William R., "The Systems Concept in Management," Journal of Industrial Engineering, Vol. 18, No. 5, May, 1967.

[43] Ewell, James M., "The Total Systems Concept and How to Organize for It," Computers and Automation, Vol. 10, No. 9, September, 1961.

[44] Neuschel, Richard F., Management by System, McGraw-Hill Book Company, Inc., New York, New York, 1960.

[45] Even, Arthur D., The Role of the Industrial Engineer in Systems Design and Improvement," The Journal of Industrial Engineering, Vol. 8, No. 6, p. 370, November - December, 1957.

the system of engineering records and data processing or the management information system. At what may appear to be an extreme, Clippinger[46] views systems analysis as applying only to the configuration of computers and computer related equipment that is used by a firm. Others[47] assume a more general view of systems analysis and allow the problem situation to determine the appropriate level at which systems analysis is to be applied.

Systems analysis has been used, is being used and has been proposed for use in approaching a wide variety of problems, some of which have resisted solution by other methods. Although any short list of examples will leave out far more than it includes, a few examples are presented below.

Dror[48] suggests that systems analysis has potential for assisting in modernization decisions and the solution of certain development problems of developing countries. It has been suggested that systems analysis may provide a superior approach for certain social decisions where there are important externalities and the decision is made by

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[46] Clippinger, R. F., "Systems Implications of Hardware Trends," Systems and Procedures Journal, Vol. 18, No. 3, May - June, 1967.

[47] Optner, Stanford L., Systems Analysis for Business Decisions, Second Edition, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1968. De Masi, Ronald J., An Introduction to Business Systems Analysis, Addison-Wesley Publishing Company, Reading, Massachusetts, 1969. Ellis, David O. and Fred J. Ludwig, Systems Philosophy, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1962.

[48] Dror, Yehezkel, "Systems Analysis and National Modernization Decisions," Academy of Management Journal, Vol. 13, No. 2, June, 1970.

individuals or groups.[49] Although care must be exercised in the use of computers for social decisions,[50] a systems approach to information for social decisions should improve the decision process.[51] Systems analysis is presently being used by the government in support of the PPBS program and increased use is "likely to lead to a higher order of rational decision-making and efficiency on the part of government."[52] Systems analysis has been used on a wide variety of problems in the behavioral sciences.[53] The Institute of Electrical Engineers have initiated publication of a Journal with major focus on systems analysis.[54]

There has been very little use of systems analysis per se in management in agriculture. It has been proposed as a useful approach for farm planning and is covered in a limited way in at least one

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[49] Bower, Joseph L., "Systems Analysis for Social Decisions," Computers and Automation, Vol. 19, No. 3, March, 1970.

[50] Foster, David F., "Computers and Social Change: Uses - and Misuses," Computers and Automation, Vol. 19, No. 8, August, 1970.

[51] Gavin, James M., "The Social Impact of Information Systems," Computers and Automation, Vol. 18, No. 8, July, 1969.

[52] Black, Guy, "Systems Analysis in Government," Business Economics, Vol. 2, No. 2, Spring, 1967.

[53] Buckley, Walter (ed.), Modern Systems Research for the Behavioral Scientist, Aldine Publishing Company, Chicago, Illinois, 1968.

[54] _____, Systems Science and Cybernetics, The Institute of Electrical and Electronic Engineers Inc., New York, New York.

advanced farm management course.[55] However, it has not appeared elsewhere in the literature. It should, of course, be noted that the general systems approach idea has been used by farm operators and researchers for a long period of time. However, this could normally be characterized by a farm operator who observes a certain technical research result and says "yes, but there are other things that you have to take into consideration as well." This is an informal recognition of a concept that has only recently undergone formalization.

## Simulation and Systems Analysis

In a general sense, simulation means a representation of reality. As Chorafas defines it, "Simulation is essentially a working analogy. ... it involves the construction of a working mathematical or physical model presenting similarity of properties or relationships with the natural or technological system under study."[56] Viewed in this manner simulation includes almost any simplified representation of the real world.

In this study we will be concerned only with mathematical models which make use of the computer. The difference between a

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[55] See Vincent, Warren H. and Larry J. Connor, "An Orientation for Future Farm Planning and Information Systems," Agricultural Economics Mimeo, 1968 - 5, Michigan State University. These authors also teach an advanced farm management course which covers some of systems analysis.

[56] Chorafas, Dimitris N., Systems and Simulation, Academic Press, New York, New York, p. 15, 1965.

mathematical model and a physical model can be illustrated by considering the difference between placing a physical model of an aircraft in a wind tunnel and developing a mathematical model of the aero dynamics involved. Simulating a model on a computer consists of using a digital or analog computer to trace numerically or graphically the time paths of all endogenous variables generated by the model.[57]

Given this more limited scope, simulation might be defined as dynamic representation of a system achieved by building a model and moving it through time.[58] This closely corresponds to the definition of computer simulation offered by Naylor, et. al: "A numberical technique for conducting experiments on a digital computer, which involves certain types of mathematical and logical models that describe the behavior of a business or economic system (or some component thereof) over extended periods of real time."[59]

Given the above definition it is obvious that computer simulation is a technique which may be used in systems study or systems analysis. Because of the dynamic characteristics of simulation one

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57 Cohen, Kalman J., "Simulation of the Firm," The American Economic Review, Vol. 50, No. 2, p. 534, May, 1960.

58 Arthur, William, "To Simulate or Not to Simulate: That is the Question," Educational Data Processing Newsletter, Vol. 2, No. 4, p. 9.

59 Naylor, Thomas H., Joseph L. Balintfy, Donald S. Burdeck and Kong Chu, Computer Simulation Techniques, John Wiley and Sons, New York, p. 3, 1968.

might say that any simulation study is systems analysis to some degree, whether it is recognized or not. However, the use of systems analysis does not require the use of simulation as a technique of study. Other techniques and methods of analysis are widely used in systems analysis.[60]

There are, however, several characteristics of systems which make computer simulation a good and often the best technique to use in systems analysis. These include:

1. It may be impossible or extremely costly to observe certain systems in the real world. Examples include determination of the effects of space flight on man prior to the first manned space flight and determination of the United States Gross National Product for the next five years.[61]
2. The system may be so complex, that is so large in terms of the number of variables, parameters, relationships, and events to which the system is responsive, that it is very difficult if not impossible to analyze mathematically.[62]
3. The system may contain relationships between system entities and attributes which are not well behaved or not mathematically tractable. A solution to the model cannot be obtained

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[60] See Optner, op. cit., and Lazzaro, Victor, Systems and Procedures, Second edition, Prentice-Hall Publishing Co., Englewood Cliffs, New Jersey, 1968.

[61] Naylor, et. al. op. cit., p. 5.

[62] McMillan and Gonzalez, op. cit., p. 26.

with straightforward mathematical techniques. This may be caused by either the inherent nature of the system or data limitations forced on the systems analyst.

4. There may be insufficient numerical data about a system available to allow verification of a mathematical model and its solution. Or, such data may be extremely costly to obtain.
5. There are many systems, particularly social systems, which cannot be manipulated or experimented with to determine the impact of changes in the system or its environment. In this case simulation can serve as a systems laboratory. Even in cases where manipulation of the system is possible simulation may be much less expensive.
6. Most systems contain random variables, which are difficult or impossible to handle expeditiously with other types of mathematical models.
7. Real time for many systems may be either too slow or too fast to allow meaningful analysis of the system. Simulation allows one to expand or compress time to the analysts' specifications.

The presence of any one of these characteristics in a system may provide sufficient justification for using simulation as the method of analysis. It should be recognized, however, that combinations of simulation and other research techniques may prove more useful in answering certain system questions than either method alone.

Strickland[63] found combining simulation and linear programming to be a useful approach to studying questions of farm firm growth.

Simulation can be used to analyze systems from several different perspectives.[64] One common perspective is to use simulation as a method of describing the action and interaction of the system to assist in developing an understanding of the system itself. The process of modeling a simulated system requires detailed observation of the real world system which in itself may provide valuable new insights about the system being simulated.

Second, simulation may be used to analyze the behavior of the system. In cases where it is impossible to observe the behavior of the system, a properly validated simulation model may be used to generate data about the system. This is particularly useful for evaluating hypothetical changes in a system and for projecting or predicting the behavior of a system into the future. The simulation model can be developed and validated based on past and present functioning of the system and then used to evaluate changes or projections into the future.

Third, simulation may be applied in the design of systems. In many cases systems must be assembled and purchased as a unit for an essentially unique situation. Commitment to any one system may represent a large fixed investment. The nature of the system and

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63 Strickland, Roger, Combining Simulation and Linear Programming in Studying Farm Firm Growth, Unpublished Ph.D. Thesis, Department of Agricultural Economics, Michigan State University, 1970.

64 This section is based, in part, on Vincent and Connor, op. cit., p. 29.

the cost of the components may be such that no physical evaluation of possible systems is possible. In this case simulation of possible alternative systems may allow discovery of an efficient and acceptable system with minimum cost. In most cases where simulation has been used in the design of systems, decision makers have used a "satisficing" criteria. The system selected was the best of those tested in meeting certain critical criteria.

Fourth, simulation may be used to evaluate the operator of the system. This may be done in two ways. The first is analagous to placing a pilot at the controls of a simulated plane as a means of evaluating his apparent ability to fly. If what constitutes desirable output or behavior of the system is known it is possible to place a manager at the controls of a simulated system and evaluate the results of his decisions. Similarly, the reactions of managers to particular new or unusual situations can be determined.

On the other hand, the performance of operators of systems may be evaluated by simulating the results of system operation if decisions and decision rules other than those used by the operator had been used. This approach is useful when the desirable behavior or output for a system are not known.

## Simulation vs. Linear Programming

Another technique which has received wide use in management both in Agricultural Economics and Business is linear programming. In addition to its previous wide usage this technique has the advantage that it can be used on nearly any computer via canned programs. This means that computer programmer time for use of

this technique is very low and the computer time required for any one program is quite reasonable. For these reasons a comparison of simulation and linear programming is made to insure that the most appropriate technique is used.

Linear programming has been defined as the operations research technique which "deals with the problem of allocating limited resources among competitive activities in an optimal manner,"[65] and has been used in a wide variety of research projects both in agriculture[66] and other fields.[67] Although this might lead one to assume that linear programming could be used to solve practically all problems, simulation appears to have several advantages for a large class of problems.

It should be recognized in any comparison of linear programming and simulation that linear programming can be and has been viewed as a simulation model. Although dynamic linear programming does not violate any assumptions or necessary major features of simulation, it is at most a very restrictive simulation model. Simulation as defined here refers to a much freer form of computer modeling without apriori software restrictions. As is pointed out below under previous

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65 Hillier, Frederick S. and Gerald J. Lieberman, Introduction to Operations Research, Holden-Day, Inc., San Francisco, 1967.

66 For examples see Hutton, Robert F., "Operations Research Techniques in Farm Management: Survey and Appraisal," Journal of Farm Economics, Vol. 47, No. 5, December, 1965, p. 1400, and Shapley, Allen E., Alternatives in Dairy Farm Technology with Special Emphasis on Labor, Unpublished Ph.D. Thesis, Department of Agricultural Economics, Michigan State University, 1968.

67 Dorfman R., P. Samuelson and R. Solow, Linear Programming and Economic Analysis, McGraw-Hill Book Co., New York, 1958.

research, linear programming and simulation have been combined for certain applications; both as co-equals and with a linear programming model as a part of a simulation model.

One advantage of simulation is the ease with which it handles multiple goals. The single parameter nature of the objective function of simple linear programming forces maximization or minimization of one variable subject to certain constraints. Thus, a single goal is implied: optimization with respect to one variable. Although it may be argued that a properly designed linear programming model can reflect several goals through the use of restrictions, this is only partly true. To the degree that goals can be reflected by the use of minimums, maximums or linear tie-in relationships they can be included by using restrictions. If one has a maximum debt level which is not to be exceeded under any conditions, this can be reflected in linear programming. Or, if the maximum debt level is a linear function of income, this can also be reflected.

However, if the variables within the multiple objective function are not linerally related, representation in a linear programming model becomes difficult and at best a step function approximation. Further, if there is a significant number of variables involved, a great deal of ingenuity is required to get the appropriate relationships entered and a large proportion of each model will consist of restrictions and dummy activities. The largest problem, however, is not the difficulty of entering these relationships, but the fact that different farm operators will have different variables and relationships in their objective

function and thus the model may have to be reformulated for each situation.

Another problem is the lack of a common denominator for variables in the objective function. If an objective function includes the probability of going bankrupt, the satisfaction of having the highest producing herd in the county and the level of monetary income, finding a common denominator, or common denominators, may be impossible apriori. In order to include relationships between variables of this type common denominators must be found, at least between successive pairs of variable, because all the relationships must be endogenous to the model.

Associated with an ability to handle multiple goals is an ability to handle sequential decisions within the planning period, using different criteria.[68] A logical progression of decisions and decision criteria can be built into a simulation model and is an assumed feature of many models.

Simulation, on the other hand, handles multiple goals in two ways. First, the decision rules within the model can depend on a number of variables each of which may reflect different goals. For example, the simulator may borrow money for a certain operation only if the expected income exceeded a certain level with that level itself dependent upon the current equity situation. In this case income and debt-equity goals are reflected in the decision rule.

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[68] Irwin, George D., "A Comparative Review of Some Firm Growth Models," Agricultural Economics Research, Vol. 20, No. 3, p. 82, July, 1968.

Second, the values of any number of variables can be printed out. Thus, for each policy or alternative being considered the variables to be used in the objective function or as decision criteria are made available to the decision maker. One might view this as a menu of alternatives and the expected results of choosing those alternatives printed out for the decision maker to select from. The objective function or decision criteria are exogenous to the model. This allows any type of decision criteria to be used and does not require that the criteria be either determined prior to simulation or capable of being stated in mathematically tractable form.

Possibly the most important advantage of simulation is that any type of function or relationship can be included in the model. It does not require that relationships be continuous or linear. Step functions, conditional relationships, qualitative variables and indivisibilities, as well as continuous and/or linear equations can be included in any combination. It is likely that few real world relationships, particularly economic relationships, are actually linear. Linear programming becomes useful only for those cases where a linear approximation is acceptable or as good as the data being used.

Associated with the ability of simulation to handle any sort of relationship is its ability to handle stochastic variables. In cases where only the probability distribution of a variable is known or where a stochastic relationship is considered a better representation of a variable, a random variable can be used. This

feature also allows development of completely stochastic models which can be used in Monte Carlo simulation of alternatives.

When more than one time period is used, dynamic linear programming must be used. If recursive programming is used it is possible that short run optimization may lock out optimum long run alternatives. Optimization in early time periods may cause purchase or sale of durable assets which use up limited credit and/or become fixed assets in later time periods. This may not be in the longer run interest of the firm and may preclude optimal long run decisions. In this case proper selection of alternatives may allow a simulation model to provide better information as to the optimum long run alternative than would be provided by an optimizing linear programming model. It should be pointed out, however, that in cases where polyperiod programming can be used this criticism becomes invalid.

Given the data problems involved in developing a linear programming matrix and the sensitivity of many linear programming solutions to slight changes in the matrix there is a question as to the degree to which these solutions are optimum in any real sense. What is set forth as the optimal solution may be practically no more "optimal" than a number of other solutions, some of which may be much more acceptable. In comparison of simulation and recursive programming Lins found that although linear programming solutions often generated a higher net worth, some "mathematically optimum" solutions were in fact not "logical optimums."[69]

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69 Lins, David A., "An Empirical Comparison of Simulation and Recursive Linear Programming Firm Growth Models," Agricultural Economics Research, Vol. 21, No. 1, p. 7, January, 1969.

Simulation, of course, also has large data requirements and thus data amassing problems similar to those of linear programming. However, simulation takes a less ambitious approach and does not attempt to optimize or put forth an answer which is to be interpreted as the optimum.

A final advantage of simulation is that it tells "how to get there from here." A simple linear programming solution usually presents an optimal organization and allocation of resources but without indication of how the firm gets to that organization or even if it is possible. Even a poly-period model only presents a number of optimum points along the path. Appropriate restrictions will insure that any of the points is possible but a great deal of the detail of "how to get there from here" is ommitted.

A simulation model moves through time a step at a time and the values of the variables at each step can be printed out so that the decision maker knows how the final organization and allocation configuration is reached.

## Simulation and Economic Theory

A cursory review of the literature indicates that simulation is an analytical method which may be used either to formulate and test economic theory or to apply economic theory to the solution of real world problems. As pointed out by Shubik[70] there are many aspects of economic theory that are very incompletely developed or not developed at all. Examples include oligopoly, multiple product

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70 Shubik, p. 415, 1970

firms, welfare economics and marketing. The economics profession is continually attempting to develop or improve theories in these and many other areas. Shubik, Naylor et. al.[71] and Cyert and March[72] all indicate that simulation is a tool which has great potential for assisting economists in developing the required new theory.

The primary advantage of simulation is that it can be used in both the formulation and validation of more complex theories.[73] Traditional verbal, graphical and mathematical models used by economists have often been called "unrealistic" when applied to complex problems. This lack of realism has meant that theory is often limited to the less complex situations or complex situations significantly reduced in scope by a number of assumptions.

The simulation method forces very few restrictions on the form of the model. By using large computers, large numbers of variables and relationships of any kind and combination can be handled. This frees research workers of many problems related to adequacy of representation.[74] Many of the previously required assumptions can be relaxed.

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[71] Naylor et. al., p. 189, 1968.

[72] Cyert, Richard M., and James G. March, A Behavioral Theory of the Firm, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1963.

[73] Shubik, Martin, "Simulation of the Industry and the Firm," The American Economic Review, Vol. 50, No. 5, p. 918, December, 1960.

[74] Orcutt, Guy H., "Simulation of Economic Systems," The American Economic Review, Vol. 50, No. 5, p. 900, December, 1960.

A primary advantage of simulation over traditional econometric models is the ability of simulation to handle lagged variables endogenously. Econometric models are usually interpreted as one-period-change models. The lagged values of endogenous variables are "assumed to be predetermined by outside forces rather than by earlier applications of the mechanisms specified in the model."[75] To determine the values of endogenous variables for future time periods new values must be assigned to the lagged endogenous variables for each period. "...it is assumed that each period any errors resulting from the "determination" of last periods' endogenous variables are corrected, so that there is a tendency for the one-period-change model to be kept on course by the fact that it always has a correct starting place."[76]

Computer simulation allows development of process models where the values of lagged endogenous variables are calculated within the model with no corrections for error. "The equations of the model, together with the observed time paths of the exogenous variables, are treated as a closed dynamic system; each period, the values of the predetermined endogenous variables are the values generated by the model, not the known or actually observed values."[77]

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[75] Cohen, Kalman J. and Richard M. Cyert, "Computer Models in Dynamic Economics," Quarterly Journal of Economics, Vol. 75, No. 1, February, 1961.

[76] Cohen, Kalman J., Computer Models of the Shoe, Leather, Hide Sequence, Prentice-Hall, Englewood Cliffs, New Jersey, 1960.

[77] Ibid., p. 13.

Computer simulation provides a laboratory for the study of economic systems which has not been previously available. In cases where considerable information is available concerning the components of a system, the system can be synthesized for study. When little is known about a system, a set of relations can be derived which will exhibit the observed characteristics of the system. This model can then be analyzed to "determine whether or not the behavior of the model corresponds with the observed behavior of the total system."[78]

A simulation model of an economic system allows detailed analysis of a representation of that system which can provide a basis for the development of theories about the system. Theories thus developed can be evaluated with respect to real world data. On the other hand, theories can be tested or validated by using a simulation model to calculate the expected reactions of the system to stimuli relevant to the theory.

Although one must guard against a temptation to both develop and validate a particular theory with a single simulation model, a variety of models combined with the available real world data may allow both development and validation of theories via simulation. Use of only one model could provide a basis for refutation of more naive theories and would provide the first phase of validation for more sound theories.

For the purposes of this study the most important relationship between simulation and economic theory is that economic theory can

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[78] Cohen and Cyert, op. cit. p. 118.

be used in the development of simulation models designed to address particular questions and represent specific systems. The theory indicates many of the relationships required within the model. The theory may indicate the kinds of relationships involved, the relative magnitude of the relationships or the factors to consider in developing model interrelationships. Numerous examples of the use of economic theory in computer simulation models appear in the review of literature below.

## Previous Simulation Research

A review of all the simulation literature is a task beyond the scope of this work. As indicated by such titles as Simulation in Social Science,[79] Simulation of the Dynamics of Fluid Systems,[80] Simulation in Systems Engineering[81] and A Simulation Model of a Saturated Medical System,[82] simulation has been used in a number of (indeed most) fields outside of Business, Economics and Agriculture. However, what is presented below is a brief review of some of the uses

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79 Guetzkow, Harold (ed.), Simulation in Social Science, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1962.

80 Clymer, A. B., Simulation of The Dynamics of Fluid Systems, Eastern Simulation Council Meeting, Philadelphia, Pennsylvania, May, 1961.

81 Smith, E. C., Jr., "Simulation in Systems Engineering," IBM Systems Journal, p. 33, September, 1962.

82 Calley, John L., J. B. Hallan and A. H. Packer, "A Simulation Model of a Saturated Medical System," American Institute of Industrial Engineers Eighteenth Annual Institute Conference and Convention Proceedings, p. 138, 1967.

of simulation in business and economics and a somewhat more detailed review of the use of simulation in Agriculture. Although any demarkation between these fields is necessarily arbitrary, the material is presented under three headings for expository purposes.

In Economics

Except for a little work by Yule[83] and Orcutt[84] on time series which possibly could have been called Monte Carlo simulation, there is essentially no use of simulation by economists prior to 1950. Since that time the use of simulation by economists has grown with the advancement of computer technology.[85] A comparison of the number of economic models presented in Shubik's[86] 1960 bibliography and Naylor's[87] 1969 bibliography on simulation provide an indication of the rate of growth. A sampling is presented below.

Simulation studies in economics have been focused at three different levels, the firm, the industry and the economy. At the

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83 Yule, G., "Why Do We Sometimes Get Nonsense Correlations Between Time Series?" Journal of the Royal Statistical Society, Vol. 89, 1926.

84 Orcutt, Guy, "A Study of the Autoregressive Nature of the Time Series Used for Tinbergen's Model of the Economic System of the United States, 1919-1932, Journal of the Royal Statistical Society, Series B, Vol. 10, 1948.

85 Orcutt, op. cit., 1960.

86 Shubik, Martin, "Bibliography on Simulation, Gaming, Artificial Intelligence and Allied Topics," Journal of The American Statistical Association, Vol. 55, No. 292, p. 736, December, 1960.

87 Naylor, Thomas H., "Bibliography 19., Simulation and Gaming," Computing Reviews, p. 61, January, 1969.

level of the firm Chu and Naylor[88] developed a dynamic model of the firm using the model presented in Value and Capital by J. R. Hicks as the point of departure. Cyert and March[89] rejected a major part of classical theory and used simulation to develop a behavioral theory of the firm. Their model is an oligopoly model with a number of quite realistic attributes. Naylor et. al.[90] present three variations of the well known Cobweb Model; a stochastic model, a learning model and a model with stocks.

A characteristic of many of the more comprehensive models of the firm is the inclusion of important theory from a number of discipline besides economics. For example, Bonini[91] included theory from accounting, organization theory and behavioral science. Cyert and March use behavioral science, psychology, sociology and organization theory as well as economics. This apparent trend may spell the beginning of a multi-disciplinary theory of the firm.

At the industry level Bladerston[92] and Hoggatt carried out a simulation study of the United States West Coast lumber industry in

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88 Chu, Kong and Thomas H. Naylor, "A Dynamic Model of the Firm," Management Science, Vol. 11, No. 7, May, 1965.

89 Cyert and March, op. cit.

90 Naylor et. al., op. cit., p. 192.

91 Bonini, Charles P., Simulation of Information and Decision Systems in the Firm, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1963.

92 Bladerston, F. E. and Austin C. Hoggatt, Simulation of Market Processes, Institute of Business and Economic Research, Berkeley, California, 1962.

an attempt to determine the affect of economic forces on institutional alignments, decentralization of market decisions and limits on market information. Cohen[93] developed a model of the hide-leather industry including tanners, shoe manufacturers and shoe retailers. The time paths of variables generated by a simulation or "process model" where compared with actual values for the 1930 to 1940 decade. A very close correspondence was found between simulated time paths and actual time paths.

Several computer models have been developed for simulating a number of subindustries within the textile industry. Zymelman[94] developed a model of the cotton-textile gray-goods industry for the U.S. Department of commerce. Models have also been developed for the tufted textile industry and the ladies seamless hosiery industry.[95]

Although Orcutt[96] in 1960 and more explicitly in 1961[97] stated that simulation may be useful in alleviating some of the aggregation problems that have been plaguing economists for years, no general industry level models of a nature similar to the general firm models outlined above appear to have been constructed. Orcutt suggested that simulated micro level representative consumer or producer units

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93 Cohen, op. cit., 1960.

94 Zymelman, Manuel, "A Stabilization Policy for the Cotton Textile Cycle," Management Science, Vol. 11, No. 7, March, 1965.

95 U.S. Department of Commerce, Civilian Industrial Technology Program in Textiles, Textile Industry Behavioral Information, Washington, D.C., March, 1965.

96 Orcutt, op. cit., 1960.

97 Orcutt, Greenberger, Korbel and Revlin, op. cit.

could be added up directly and thus avoid the intermediate phase of specifying how the behavioral relationships are to be added. There is the problem that variables exogenous to the firm may not be exogenous to the industry[98] which could require involved feedback effects or a sort of iterative solution involving resimulation of the micro units if the aggregate industry level variables were inconsistent with the levels assumed in the exogenous micro level simulation. However, even recognizing this problem, it is surprising that a general industry model has not been developed.

Many of the popularly known economy level or macroeconomic models are econometric or one-period-change models. Given the values of lagged endogenous variables for periods t-1, t-2 etc., the model can calculate values for t. Values for t+1 cannot be calculated until values for period t are available. Included in this group are Klein's model,[99] Christ's model[100] and the Klein-Goldberger models.[101]

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98 Manderscheid, Lester V. and Glenn L. Nelson, "A Framework for Viewing Simulation," Canadian Journal of Agricultural Economics, Vol. 17, No. 1, p. 39, February, 1969.

99 Klein, Lawrence, Economic Fluctuations in the United States, 1921 - 1941, Cowles Commission for Research in Economics Monograph No. 11, John Wiley and Sons, New York, 1950.

100 Christ, C. F., "A Test of an Econometric Model for the United States," Conference on Business Cycles, National Bureau of Economic Research, New York, 1951.

101 Klein, L., and A. S. Goldberger, An Econometric Model of the United States, 1929 - 1952, North-Holland Publishing Co., Amsterdam, 1955.

Simulation models of the economy are more recent and fewer in number. The Duesenberry, Eckstein and Fromm[102] model focused on the impact of alternative time patterns of decline of fixed investment and government purchases on national income when automatic stabilizers are put in a realistic macroeconomic setting. The Brookings - SSRC Quarterly Econometric Model of the United States is likely the most elaborate model of an economic system in existence. This model is aimed at both understanding and predicting the United States economic system. Other macro level simulation studies include the Orcutt et. al.[103] demographic model of the United States household sector and Holland and Gillespie's[104] model of the Indian Economy.

At an applied or specific problem oriented level economists have made numerous uses of the simulation method. Kain and Meyer[105] indicate that simulation is particularly appealing when evaluating "public investments characterized by important externalities, broad social objectives and durable installations." They cite computer simulation studies of regional and urban problems including regional

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102 Duesenberry, James S., Otto Eckstein and Gary Fromm, "A Simulation of the United States Economy in Recession," Econometrica, Vol. 28, No. 4, p. 749-809, October, 1960.

103 Orcutt, et. al., op. cit., 1961.

104 Holland, Edward P. and Robert W. Gillespie, Experiments on a Simulated Underdeveloped Economy: Development Plans and Balance of Payments Policies, The M.I.T. Press, Cambridge, 1963.

105 Kain, John F. and John R. Meyer, "Computer Simulations, Physio-Economic Systems, and Intraregional Models," American Economic Review, Vol. 58, No. 2, p. 171, May, 1968.

analysis, metropolitan growth, community renewal and river basin development. Taylor[106] used simulation to develop hypotheses relative to development patterns. The impact of war on defense spending patterns was studied by Galper.[107]

In Business

The use of simulation in business has had two major foci. It has been used, both to develop and train managers and as a tool of management to assist in decision making. The role of simulation in the development and training of managers has occurred through the creation and use of management games.

The term "game" may be unfortunate. Although participation in the use of management games is often enjoyable, the primary objective is to educate. The name management "laboratory" has been suggested as a substitute. However, considering the long reign of the term "game" it appears likely to stay.

Management games are the computerized descendents of the war-chess games of the seventeenth and eighteenth centuries.[108] The first games were played on a board with pieces to represent the military items. In 1798 George Venturini introduced a game ("New Kriegspiel") which replaced the board with a map. The map had a

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106 Taylor, Lance J., "Development Patterns: A Simulation Study," Quarterly Journal of Economics, Vol. 83, No. 2, p. 220, May, 1969.

107 Galper, Harvey, "The Impacts of the Vietnam War on Defense Spending," Journal of Business, Vol. 42, No. 4, p. 401, October, 1969.

108 Longworth, John W., "From War-Chess to Farm Management Games," Canadian Journal of Agricultural Economics, Vol. 18, No. 2, p. 1, July, 1970.

grid of 3600 squares and there were 60 pages of rules. In 1811, von Reisswitz, a Prussian Army officer, developed the first war game played in a sand box. This eventually received wide acceptance and war gaming gradually spread throughout Europe and North America. Efforts were made to make the games more realistic and include probability distributions. By the end of World War I, war games had developed into operational tools, being used to rehearse campaigns as well as for training. The German spring offensive in 1918 was planned and tested in a war game, as were the invasion of France in 1940 and the invasion of the Ukraine in 1941.[109]

The publication of von Neumann and Morgenstern's classic book[110] in 1944 placed new emphasis on war games and, more importantly, aroused interest in the subject of decision making under uncertainty. This area had been neglected by most researchers[111] up to that point because it was considered to be an art and thus the "exclusive province of men of 'experience'."[112]

In 1955 the Rand Corporation developed for the Air Force what was to become the forerunner of business management games. This game called "monopologs," was a simulation of the Air Force supply

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109 Thomas, Clayton J., "Military Gaming," Progress in Operations Research, Russell L. Ackoff, Editor, John Wiley and Sons, Inc., New York, p. 421, 1961.

110 von Neumann, J. and O. Morgenstern, Theory of Games and Economic Behavior, Princeton University Press, Princeton, New Jersey, 1944.

111 Notable exceptions would include Knight and Hart.

112 Luce, R. D. and H. Raiffa, Games and Decisions: Introduction and Critical Survey, John Wiley and Sons, p. 3, New York, 1957.

system and was primarily concerned with the management of inventory in the face of uncertain demand. After observing this game the American Management Association developed their Top Management Decision Game. This was the first fully computerized business management game. In October, 1957, this game was used in a course on decision making for business executives at the Academy of Advanced Management.

A facilitating factor in the development of war games and business games during the 1950's was the development of the digital and analog computers. This was essentially the period of takeoff in the development of computer technology. The ability of computers to rapidly handle large quantities of data provided researchers with a capability that previously did not exist. This capability may have been a prerequisite for the development of realistic business games that were rapid enough and inexpensive enough for widespread business use.

Although a number of non-computerized games were developed during this same period,[113] even advocates of non-computer games stressed the advantages of computerized games.[114]

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[113] For examples see Vance, S., Management Decision Simulation: A Non-Computer Business Game, McGraw Hill Book Co., Inc., New York, 1960, or Green, J. R., and R. L. Sisson, Dynamic Management Decision Games, John Wiley and Sons, New York, 1959.

[114] Andlinger, G. R., "Business Games-Play One!" Harvard Business Review, Vol. 36, No. 2, p. 115, March-April, 1958.

Three broad and often overlapping classes of business management games have evolved.[115] The first class is aimed at general executive development and focuses attention on all aspects of the business at the upper-middle or top management level. The principles are assumed to apply for any particular type of firm. These are total enterprise games and are often quite complex. A number of games that would fall in this general class have been designed primarily for college instruction. Manuals for such games are often designed with classroom limitations in mind.[116]

The second class is industry or industry specific games. These games incorporate much of the language and institutional framework of the industry concerned. Industry games are usually developed by people directly involved in the industry and are aimed at in-service training rather than general management education. An example is the insurance game.[117]

Functional games usually focus on decision making within one specific area, while taking cognisance of the remaining aspects of the firm, or on illustration of a particular management technique. Games included in this third class are usually devised to provide a particular experience within a very specific area.

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115 Longworth, op. cit., 1970.

116 For examples see Smith, W. Nye, Elmer E. Estey and Ellsworth F. Vines, Integrated Simulation, South-Western Publishing Co., Cincinnati, Ohio, 1968, or Darden, Bill R. and William H. Lucas, The Decision Making Game, Appleton-Century-Crofts, New York, 1969.

117 McGuiness, J. S., "A Managerial Game for an Insurance Company," Operations Research, Vol. 8, No. 2, p. 196, March-April, 1960.

The number of business games was estimated in 1960 to exceed one hundred.[118] Any cursory review of the literature indicates that the rate of development and use of business games has been continually increasing throughout the last decade.[119]

The primary use of all management games has been to assist in management education. They often stimulate interest and make learning more palitable, but this is of secondary importance. Although there are undoubtedly cases where games have been used to address specific problems, business games are generally designed to be most useful for teaching management skills.

The second major use of simulation in business has been as a tool of analysis to assist in decision making. This might be characterized as use of simulation as a decision aiding technique. Although a few decision making simulation models have been developed, other procedures such as linear programming and inventory control models appear to be more applicable for this type of problem.[120]

As of approximately 1950 simulation was a "technical curiosity which some prophesied would be a panacea for systems-analysis studies, and others viewed as a sort of mathematicians sedative, which held no technical promise, but consumed all too large a share of available

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118 Richards, M. D., and F. W. Kniffin, "Business Decision Games - A New Management Tool," Pennsylvania Business Survey, Bureau of Business Research, Pennsylvania State University, p. 7, June-July, 1960.

119 Graham, Robert C., and Clifford F. Gray, Business Games Handbook, American Management Association, Inc., 1969.

120 Sisson, Roger L., "Simulation: Uses," in Progress in Operations Research, Vol. III, Julius S. Aronofsky, (ed.), John Wiley and Sons, Inc., New York, p. 19, 1969.

time, manpower, and money."[121] Since then there have been thousands of applications of simulation for the purpose of aiding decision making.[122] Many of these applications have been reported in the literature. The principal sources of these reports are Management Science, Operations Research, Behavioral Science, The Journal of the Association of Computing Machinery. Although it tends to emphasize engineering applications of computer simulation, the magazine Simulation publishes the results of simulation studies as well as technical research on simulation itself. A new Journal called Simulation and Games emphasizes simulation in the social sciences and may become an important source of simulation literature applicable to business.

Simulation has been applied to a number of specific and relatively separate management or problem areas. One of these areas is the design of communication and data-handling systems. Research and discussion in this area has concentrated on the development of management information systems. The principal purpose of management information systems is to provide economically the information needed for planning, direction, evaluation, coordination, and control of the firm.[123] This essentially amounts to the development of a system

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121 Morgenthaler, George W., "The Theory and Application of Simulation in Operations Research," in Progress in Operations Research, Vol. I, Russell L. Ackoff, (ed.), John Wiley and Sons, Inc., New York p. 363, 1961.

122 Sisson, op. cit., p. 30.

123 Beged-Dov, Aharon G., "An Overview of Management Science and Information Systems," Management Science, Vol. 13, No. 12, p. B-817, August, 1967.

of decision aiding techniques. As indicated above simulation may be one of these decision aiding techniques. However, simulation can also be used in the development and evaluation of information systems for specific problem situations.[124]

A second use of simulation has been in the design and evaluation of the management system per se. This involves simulation of the firm from the perspective of where decisions and policies are made and what factors are important in decision making at decision points. For example, in the simulation of a vertically integrated firm, Roberts et. al.[125] found that the particular performance measures used to monitor the progress of the firm strongly influenced the decisions made by managers of the various segments of the firm.

Simulation is also used for capital allocation or investment problems. In this case simulation is used to develop information as to the expected results of various investment alternatives or combinations of alternatives. The manager can then select the portfolio he desires.[126] As pointed out by Clarke,[127] the primary advantages of

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[124] Vazonyi, Andrew, "Automated Information Systems in Planning Control and Command," Management Science, Vol. 11, No. 4, p. B-2, February, 1965.

[125] Roberts, Edward B., Dan I. Abrams, and Henry B. Weil, "A Systems Study of Policy Formulation in a Vertically - Integrated Firm," Management Science, Vol. 14, No. 12, p. B-674, August, 1968.

[126] Salazar, Rodolfo C., and Subrata K. Sen, "A Simulation Model of Capital Budgeting Under Uncertainty," Management Science, Vol. 14, No. 4, p. B-675, December, 1968.

[127] Clarke, Lawrence J., "Simulation in Capital Investment Decisions," The Journal of Industrial Engineering, Vol. 19, No. 10, p. 495, October, 1968.

simulation in handling the risk and uncertainty involved in investment are (1) the forecast density function of the decision parameters do not have to meet any particular shape or mathematical equation, (2) the full range of data relative to each parameter is used and (3) management can evaluate the risks involved in alternative investments and select the portfolio which is closest to its personal risk-return preference without attempting to communicate its risk-return preference to others. Economos[128] found that the data generated in using simulation as a method of analyzing the risk of entering a certain business line is also useful for management control in handling the investment if accepted.

Simulation has also been useful in the design and analysis of facility layout. The primary advantage of this fourth use of simulation is the ability to evaluate facility layouts without incurring the actual cost of the physical facilities themselves. Examples include simulation of warehouse locations for large-scale, multi-plant firms[129] and an iterative model for determining the optimum location of a firm's facilities by selecting successively better sub-optimal solutions.[130]

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128 Economos, A. M., "A Financial Simulation for Risk Analysis of a Proposed Subsidiary," Management Science, Vol. 15, No. 12, p. B-675, August, 1968.

129 Kuehn, Alfred A., and Michael J. Hamburger, "A Heuristic Program for Locating Warehouses," Management Science, p. 643, 1962.

130 Armour, Gordon C. and Elwood S. Buffa, "A Heuristic Algorithm and Simulation Approach to Relative Location of Facilities," Management Science, Vol. 9, No. 2, p. 294, January, 1963.

Use of simulation in personnel selection has occurred primarily through the use of management games as a method of evaluating a potential employee's ability under certain specified management situations. Data from game play is evaluated along with other more conventional sources of information. In a somewhat more comprehensive approach Smith and Greenlaw[131] developed a simulation model of the complete decision process of the personnel officer.

A large variety of production management problems have been approached via simulation. One of the more famous early applications was the simulation of job-shop sequencing. Study of job-shop problems led to the development of the Simscript programming language. One of the more recently developed job-shop simulators is designed to determine the optimum sequence of jobs for the next shift. At the beginning of each shift the model provides the foreman of each section with the priority of jobs currently in his section.[132]

Simulation has also received wide application in marketing. In a comprehensive review of marketing simulations, Kotler and Schultz[133] point out four usages of simulation in marketing. These are:
(1) Imitation of the essential behavioral characteristics of a system.

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131 Smith, Robert D. and Paul S. Greenlaw, "Simulation of a Psychological Decision Process in Personnel Selection," Management Science, Vol. 13, No. 8, p. B-409, April, 1967.

132 Bulkin, Michael H., John L. Colley and Harry W. Steinhoff, Jr., "Load Forecasting Priority Sequencing and Simulation in a Job Shop Control System," Management Science, Vol. 13, No. 2, p. B-29, October, 1966.

133 Kotler, Philip and Randall L. Schultz, "Marketing Simulations: Review and Prospects," The Journal of Business, Vol. 43, No. 3, p. 237, July, 1970.

This would include simulators such as the model of a market for frequently purchased packaged goods developed by Lavington,[134] (2) as a method of introducing and handling uncertainty, (3) as a computational technique for measuring parametric sensitivity and (4) as a heuristic technique for finding approximately optimal solutions. The high level of uncertainty and complexity involved in marketing management decisions has also precipitated attempts to simulate decision making in the marketing area.[135]

In Agriculture

Previous use of simulation in Agriculture has concentrated primarily on business management games and simulators designed for specific problems. The first simulator in the agricultural field was a cheese plant simulator developed in the early 1960's by Glickstein et. al. at Purdue University.[136] Since that time interest in simulation has expanded rapidly.

Interest in management games has spanned the entire period of interest in simulators in general. Prior to the development of agricultural games, non-agricultural business management games were

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134 Lavington, Michael R., "A Practical Microsimulation Model for Consumer Marketing," Operations Research Quarterly, Vol. 21, No. 1, p. 25, March, 1970.

135 Robertson, Gary N., C Geoffrey E. Fernald, and John G. Myers, "Decision Making and Learning: A Simulated Marketing Manager," Behavioral Science, Vol. 15, No. 4, July, 1970.

136 Glickstein, Aaron, E. M. Babb, C. E. French and J. H. Green, Simulation Procedures for Production Control in an Indiana Cheese Plant, Agricultural Experiment Station Research Bulletin 757, Purdue University, December, 1962.

used in some agricultural economics classes.[137] The first computerized management game was the Purdue Farm Management Game developed by Eisgruber[138] at Purdue University. This game is a model of a central Indiana mixed enterprise farm and has been widely used both in and outside of Indiana. Fuller used this game as a prototype for developing a Northeast Farm Management Game[139] and a Poultry Farm Management Game.[140]

The farm management game, Simfarm, developed by Warren Vincent[141] at Michigan State has been used extensively in classroom teaching and has received some research application.[142] Two other farm management games are the California Farm Management Game[143] and a game developed by Hutton in Pennsylvania. This latter game has

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137 Garoian, Leon, "Review of Management Games for Teaching and Research by E. M. Babb and L. M. Eisgruber," Journal of Farm Economics, Vol. 49, No. 3, p. 765, August, 1967.

138 Eisgruber, L. M., Farm Operation Simulator and Farm Management Decision Exercise, Agricultural Experiment Station Research Progress Report 162, Purdue University, February, 1965.

139 Fuller, E. I., The Use of the Northeast Farm Management Game in Massachusetts, Mimeograph, Department of Agricultural and Food Economics, University of Massachusetts, March, 1968.

140 Fuller, E. I., Massachusetts Poultry Farm Management Game, Players Information, Mimeograph, Department of Agricultural and Food Economics, University of Massachusetts, Amherst, Massachusetts, August, 1968.

141 Vincent, op. cit.

142 Strickland, op. cit.

143 Faris, J. E. and J. Wildermuth, The California Farm Management Game, Southern San Joaquin Valley Farms, Participants' Manual, Giannini Foundation of Agricultural Economics, University of California, Berkely, California, October, 1966.

been extensively used in a comparison with four methods of teaching farm business analysis to high school and adult students.[144]

All of the farm management games developed have a number of similarities. First, all models create uncertainty by incorporation of stochastic elements. Second, participating teams may, and usually do, consist of one person. Third, the situation is constructed such that the teams are pitted against the real world uncertainties of the model rather than the actions of each other. Fourth, the models all have a decision period of one year.

In a game recently developed by Longworth,[145] a monthly decision period is used. Although the author indicated that this contributed to the games ability to provide a valuable "exercise in the full managerial process" involving both "technical and institutional aspects," the limited storage capacity of the computer used did not allow complete monthly interaction of variables.

At approximately the same time the Purdue Farm Management Game was developed, three other agri-business games were developed at Purdue University.[146] These include a farm supply business game, a supermarket game and a dairy processing game. The farm supply business management game attempts to duplicate the environment of a farm supply business selling feed and fertilizer. The supermarket game simulates

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[144] Curtis, S. M., "The Use of a Business Game for Teaching Farm Business Analysis to High School and Adult Students," American Journal of Agricultural Economics, Vol. 58, No. 4, p. 1025, November, 1968.

[145] Longworth, op. cit., 1959.

[146] Babb and Eisgruber, op. cit.

an urban supermarket with four departments and emphasizes marketing decisions. Marketing decisions are also emphasized in the dairy management game. This game involves two to four competing dairies processing and selling wholesale and retail.

A number of simulation models designed to address specific problems have concentrated on the ability of the simulation model to handle uncertainty. In an early study Halter and Dean[147] used simulation in a study of management policies under conditions of weather and price uncertainty. At that time they concluded that "... it appears that simulation is a promising tool of analysis, particularly if uncertainty characterizes the decision-making environment and a large number of time related interrelationships among variables exist."

Eidman et. al.[148] combined simulation and Bayesian decision theory in evaluating uncertainty involved in commercial turkey production contracting. A 1965 study by Zusman and Amiad[149] and a 1968 study by Anderson[150] developed models for evaluation of cropping

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147 Halter, A. N. and G. W. Dean, "Use of Simulation in Evaluating Management Policies Under Uncertainty: Application to a Large Scale Ranch," Journal of Farm Economics, Vol. 47, No. 3, p. 557, August, 1965.

148 Eidman, Vernon R., Gerald Dean and Harold Carter, "An Application of Statistical Decision Theory to Commercial Turkey Production," Journal of Farm Economics, Vol. 49, No. 4, p. 852, November, 1967.

149 Zusman, Pinhas and Amotoz Amiad, "Simulation: A Tool for Farm Planning Under Conditions of Weather Uncertainty," Journal of Farm Economics, Vol. 47, No. 3, p. 754, August, 1965.

150 Anderson, Raymond L., "A Simulation Program to Establish Optimum Crop Patterns on Irrigated Farms Based on Preseason Estimates of Water Supply," American Journal of Agricultural Economics, Vol. 50, No. 5, p. 1586, December, 1968.

patterns under weather uncertainty. Use of simulation to evaluate the combined effect of weather and equipment breakdown uncertainties has been carried out for sugar cane[151] and a model emphasizing the effect of weather uncertainties on the trade-off between harvest machinery investment and crop losses is being developed for corn.[152]

The ability of simulation to handle multiple goals was exploited in a study by Patrick and Eisgruber.[153] Although they attempted to develop a weighting scheme for four defined goals in order to evaluate the satisfactoriness of various growth plans, they point out that "Because of the interaction among controlled variables, decisions made, goals, expectations and outcomes, it is not possible to analyze the effects of controlled variables without also taking into account the relationship between expectations and outcomes and the changes in farmers' goals over the course of time." The time paths of variables are known, whereas in standard linear programming and marginal analysis only the equilibrium positions are known.

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151 Sorenson, Eric E. and James F. Gilheany, "A Simulation Model for Harvest Operations Under Stochastic Conditions," Management Science, Vol. 16, No. 8, p. B-549, April, 1970.

152 Haltman, J. B., K. L. Prickett, D. L. Armstrong and L. J. Connor, Modeling of Corn Production Systems - A New Approach, Paper No. 70-125 presented at the 1970 Annual Meeting of the American Society of Agricultural Engineers, Minneapolis, Minnesota, July, 1970.

153 Patrick, George F. and Ludwig M. Eisgruber, "The Impact of Managerial Ability and Capital Structure on Growth of the Farm Firm," American Journal of Agricultural Economics, Vol. 50, No. 3, p. 491, August, 1968.

Support for the use of simulation in farm firm growth research per se was indicated as early as 1966.[154] Since that time a number of farm firm growth models have been developed at Purdue University. These models have all been modifications of the Purdue Farm Management Game. Harshbarger's model emphasized land purchase strategies and loan limits.[155] A version developed by Harrison focuses on financial leverage and its influence on growth.[156] A number of other unreported versions have been or are being developed.

An interesting feature of some of the Purdue models is an attempt to build in a search routine for selection of superior alternatives. This is accomplished by a sub-program with built in decision rules which assigns probabilities to various activities and then readjusts those probabilities depending on the income generated when alternative combinations of activities are selected. Successive combinations chosen depend upon the updated probabilities connected with each activity.

It has been suggested by a number of farm management researchers that linear programming might be included at a number of sub levels within simulation programs in order to use optimization at certain decision points. Methods of introducing optimality into simulation

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154 Walker, Odell L. and James R. Martin, "Firm Growth Research Opportunities and Techniques," Journal of Farm Economics, Vol. 48, No. 5, p. 1522, December, 1966.

155 Irwin, op. cit., 1968.

156 Harrison, Virden L., Management Strategies for the Growth of Farm Firms, Mimeograph, Department of Agricultural Economics, Purdue University, December, 1968.

models such as these appear to possess the capability of extending the usefulness of simulation models.

Efforts to introduce optimality exogenous to the model by developing response surfaces and methods of selecting optimum points from those have been made in two different studies. In a study by Zusman and Amiad[157] the method of steepest ascent was used to select optimum or near optimum solutions from a surface generated by repeated simulation according to a sample design.

Candler and Cartwright[158] have developed a performance function which is an explicit function of performance statistics generated by a simulation or budgeting model. This has the disadvantage that the functional form must be assumed and, like the Zusman and Amiad method, it requires a large number of simulation runs.

Another group of problems within the field of agriculture to which simulation has been applied includes a group of problems to which optimization essentially does not apply. Vincent[159] in collaboration with Sheppard has developed a poultry integrater simulator which is directed toward the design of equitable egg production

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157 Zusman and Amiad, op. cit.

158 Candler, Wilfred and Wayne Cartwright, "Estimation of Performance Functions for Budgeting and Simulation Studies," American Journal of Agricultural Economics, Vol. 51, No. 1, p. 159, February, 1969.

159 Vincent, Warren H., "Simulation for Problem-Solving in the Poultry Industry," in Agricultural Economics Report 157, Simulation Uses in Agricultural Economics, Department of Agricultural Economics, Michigan State University, February, 1970.

contracts. Tyner and Tweeten[160] in 1968 and Schechter and Heady[161] in 1970 developed simulation models of the farm economy in an attempt to assess the effect of government farm programs on farm prices, farm incomes, output, stock accumulations, efficiency and treasury costs. In each of these cases there was a conflict (producer income vs. integrater income, farm income vs. government costs) which excluded optimization in any realistic sense. The latter study did develop marginal rates of substitution among the response variables which should be useful in policy making.

Upchurch[162] states that the circumstances which presently promote vertical integration provide a situation where simulation and systems analysis "offers the most promising approach for gaining meaningful insights into market performance." The USDA is presently supporting a hog and pork subsector study in which a simulation model of the subsector is a major part.

A major effort to apply simulation to the problems of the agricultural economy of underdeveloped countries is being made by a team of

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160 Tyner, Fred H. and Luther G. Tweeten, "Simulation as a Method of Appraising Farm Programs," American Journal of Agricultural Economics, Vol. 50, No. 1, p. 66, February, 1968.

161 Shechter, Mordechai and Earl D. Heady, "Response Surface Analysis and Simulation Models in Policy Choices," American Journal of Agricultural Economics, Vol. 52, No. 1, p. 41, February, 1970.

162 Upchurch, M. L., Recent Advances in Research Methods in Marketing, Paper presented at XIV International Conference of Agricultural Economists, Moscow, August, 1970.

researchers at Michigan State University.[163] Although they list lack of trained personnel and lack of data in developing countries as limiting factors, the benefits they list include (1) clearer understanding of the economy, (2) acquisition of relevant information in an "instant recall" model, and (3) a diagnostic tool for evaluating policies. In another study, Foster and Yost[164] used simulation in an attempt to evaluate the relationships between population growth, education and income in an underdeveloped economy.

On the domestic rural development front, Edward[165] developed a small two region simulation model of the United States to assess the differential regional effects of various income and population policies.

The potential value of the use of simulation in extension was pointed out as early as 1963. At that time Babb and French[166] indicated that large food processors had their own system simulators and that extension workers could assist decision making in smaller

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163 Hayenga, M. L., T. J. Manetsch, and A. N. Halter, "Computer Simulation as a Planning Tool in Developing Economies," American Journal of Agricultural Economics, Vol. 50, No. 5, p. 1755, December, 1968, and Halter, A. N., M. L. Hayenga, and T. J. Manetsch, "Simulating a Developing Agricultural Economy: Methodology and Planning Capability," American Journal of Agricultural Economics, Vol. 52, No. 2, p. 272, May, 1970.

164 Foster, Phillips and Larry Yost, "A Simulation Study of Population, Education and Income Growth in Uganda," American Journal of Agricultural Economics, Vol. 51, No. 3, p. 576, August, 1969.

165 Edwards, Clark, "A Simple, Two-Region Simulation of Population, Income, and Employment," Agricultural Economics Research, Vol. 22, No. 2, p. 29, April, 1970.

166 Babb, E. M. and C. E. French, "Use of Simulation Procedures," Journal of Farm Economics, November, 1963.

firms by making simulation procedures available. The first applications involved the adaptation and use of games for teaching management.[167] Although they stated a number of requirements for games and in extension, Hammond et. al.[168] were very encouraged with the use of a simplified management game for dairy plant managers.

Extension workers at Purdue University have developed extension oriented simulators which they used in their Top Farmer Corn Workshop in 1969 and their Top Farmer Hog Workshop in 1970. These models were designed for use in group meetings and batch processing. The workshops were conducted as a series of meetings with farmers supplying data on their own operations at one meeting and the extension personnel returning the results at the next meeting. Those involved with this effort were quite enthused with this approach.

Michigan State extension workers have taken a somewhat different approach. They are developing a number of initially smaller programs for use by farmers and extension workers on a demand basis with remote access to computers via touch-tone telephone and teletype. Over fifteen programs have been developed which simulate a wide variety of limited size problems faced by farm managers.

The primary benefit of making simulation models available through extension is to allow firm decision makers to carry out exante

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[167] Babb, E. M., "Business Games as a Marketing Extension Tool," Journal of Farm Economics, p. 1024, December, 1964.

[168] Hammond, David H., J. Robert Strain and C. Phillip Baumel, "Simplifying Management Games for Extension Programs," Journal of Farm Economics, Vol. 48, No. 4, p. 1026, November, 1966.

experimentation with a simulation model rather than forcing them to experiment within their real world environment.[169]

A problem involved in the extension application of simulation is the possibly more demanding requirements of the software developed. Candler et. al.[170] found this to be the case in their recent experience at Purdue.

Except for the above mentioned extension oriented simulation models, it appears that few models have been constructed which are general enough to be useful in approaching any broad spectrum of problems. An important effort to develop general research or farm planning models has been conducted by Hutton of Pennsylvania. His first effort, which was also one of the early simulation models in agriculture, was a model of a dairy enterprise.[171] All important parameters were input by the user. The model stochastically simulated through any number of years desired. Emphasis was on dairy herd characteristics. The primary limitations of this model were the exclusion of all enterprises except the dairy herd and its heavy technical input requirement.

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169 Walker and Martin, op. cit., and Babb and French, op. cit.

170 Candler, Wilfred, Michael Boehlje and Robert Saatoff, "Computer Software for Farm Management Extension," American Journal of Agricultural Economics, Vol. 52, No. 1, February, 1970.

171 Hutton, Robert F., A Simulation Technique for Making Management Decisions in Dairy Farming, Agricultural Economic Report, No. 87, Economic Research Service, United States Department of Agriculture, February, 1966.

More recently, Hutton and Hinman have developed what they call a "General Agricultural Firm Simulator."[172] This model is designed primarily for use in modeling farm firms but can accept and process data on a wide range of type and size of problem situations. This model is designed in a linear programming format. Input data is arranged in tables with column headings indicating activities and row columns indicating inputs required or products produced. Allowance is made for input and product price trend, the introduction of stochastic price and purchase, sale of capital items and development of user defined subroutines. All activities are completely defined by the user. Production functions are linear and independent. This model has been used by one of its authors in a study of finance management practices.[173]

A more general perspective of the usefulness of simulation which appears in the literature is that it may serve as the laboratory of the social scientist. Burt[174] observes that "Simulation can be used to generate observations om complex phenomena much as a

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172 Hutton, R. F. and H. R. Hinman, A General Agricultural Firm Simulator, Agricultural Economics and Rural Sociology Bulletin 72, The Pennsylvania State University, University Park, Pennsylvania, July, 1969.

173 Hinman, H. R., Appraising Results of Alternative Finance Management Practices by Use of Simulation, Unpublished Ph.D. Thesis, Pennsylvania State University, December, 1969, reported in Hinman, H. R. and R. F. Hutton, "A General Simulation Model for Farm Firms," Agricultural Economics Research, Vol. 22, No. 3, July, 1970.

174 Burt, Oscar R., "Operations Research Techniques in Farm Management, Potential Contribution," Journal of Farm Economics, Vol. 47, No. 5, p. 1418, December, 1965.

traditional experiment is used." In a similar vain Irwin[175] states that "It seems to me that simulation is the nearest thing we have to the flexibility of the physical scientists' laboratory." Although this might appear to place simulation in the role of the social scientists' salvation, Irwin goes on to say that "Simulation both encourages and terrifies. It entices with its flexibility but frightens with the realization that we must specify both the kinds and forms of relationships. Our ignorance stands cowering in the spotlight."

This latter statement points out one of the disadvantages cited for simulation. This is the fact that development of simulation models require a large investment of effort and money. The complexity of most models forces a large data collection effort. Software development is time consuming and requires trained personnel. This has led a number of researchers to indicate that other analytic techniques are preferred whenever they can handle the situation.[176]

Two other disadvantages or limitations of simulation appear in the literature.[177] First, most models are so complex that it is difficult to explain all the assumptions. This allows the economist to (either intentionally or unintentionally) build his own biases or

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175 Irwin, George D., "Discussion: Firm Growth Research Opportunities and Techniques," Journal of Farm Economics, Vol. 48, No. 5, p. 1533, December, 1966.

176 Irwin, op. cit., p. 94, 1968.

177 Suttor, R. E. and R. J. Crom, "Computer Models and Simulation." Journal of Farm Economics, Vol. 46, No. 5, p. 1341, December, 1964.

preconceptions into the model. Second, simulation is so well suited to specific problem areas that it may encourage more specialization among economists and they may thus find it harder to keep up with developments outside their field of specialization.

## Final Evaluation

The above discussion leads the author to conclude that simulation is the proper technique to use for the problem being considered. Although the systems approach does not provide the unifying theory that its proponents imply, it does provide a "systems concept" and the basis for a "systems perspective" which focuses on the interactive elements of a system. This appears to allow the desired management focus.

The simulation technique does allow integration of basic economic concepts into a model within a general systems framework. Simulation is, in a sense, a systems approach to modeling. In addition, its ability to include any kind of relationship allows inclusion of theoretical economic concepts as well as concepts from other disciplines.

Although the model will be complex and the development cost high, the investment levels involved in the decisions being considered by farm managers are of such magnitude that a small change in decision making efficiency could easily justify the model development cost. In addition, the existence of sequential decision criteria or goals, the non-linearity of many of the relationships found on most farm firms and the need to be able to evaluate alternatives actually being considered by farm managers make simulation appear to be the technique to use.

# CHAPTER III

## MODEL DESIGN CONSIDERATIONS

After development of an appropriate theoretical framework for model design and selection of a modeling technique, but prior to construction of a specific model, a number of model design characteristics must be considered in detail. These characteristics relate not to the specific relationships to be included in the model but to the type of model to be constructed. They represent a general specification of the model and actually determine its effective design. Decisions relative to these characteristics must be made early in model design so that the appropriate specific relationships will be included in a desirable manner. Further, these general characteristics determine the specific method or approach to be used in reflecting and carrying out the general theoretical framework decided in the previous chapter. Those characteristics which appear to be most important for the model being developed are discussed in this chapter.

### Degree of Generalization

Generalization of a model of the nature considered here can be accomplished in at least three ways. First, a model designed to address a particular problem can be constructed so that the model is

useful in addressing this same problem in other areas or so that the model is capable of addressing a number of different problems in a particular problem area. This can be illustrated by observing that a dairy enterprise model designed to answer questions for a particular farm situation can be generalized to handle either similar dairy enterprise questions on other farms or a much wider scope of dairy enterprise problems than those of initial concern.

Second, a model may be designed to handle a wide variety of enterprise situations such that the model user or the model itself must choose those parts of the model which are appropriate to the problem being considered. A model which contained dairy, beef, swine, poultry, field crop and vegetable crop enterprise alternatives would fit this category. Most applications of such a model would use only a few of the enterprise alternatives.

The third type of generalization involves development of a model in which only the logic or the methods in which variables are used are specified within the model. The user specifies the activities and all the parameters relative to those enterprises. A typical example of this type of generalization is the general agricultural firm model developed by Hutton and Hinman.[1] In this case the activities and the input and output coefficients relative to those activities are specified by the user.

Although these three types of generalization represent a continuum in the sense that the amount and specificity of data contained within

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[1] Hutton and Hinman, op. cit., 1969.

the model continually decreases, their uniqueness in other respects makes the categorization useful.

The model developed in this paper is generalized with respect to the first type of generalization. This model is designed to be useful for a wide variety of dairy farm problems and firm situations. The limited degree of generalization of the second type is indicated by the fact that the model is useful only for dairy farms and crop farms that grow only those crops usually found on dairy farms.

The primary justification for not generalizing the model in the type three sense was a desire to both reduce the burden of user input and make the model as realistic as possible. Realism requires specification of a number of very complex multivariate interrelationships which may be impossible to build into a model containing only the standardized logic required for type three generalization.

## Computer Language

The languages available for use in developing a simulation model include several general purpose languages, such as Fortran, Cobal or Algol, plus over 40 specific simulation languages.[2] Although the general availability of Fortran compilers and computer programmers, a basic knowledge of Fortran on the part of the model designer, and the inherent flexibility of the Fortran language may lead to an apriori decision to choose Fortran over the other general purpose

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[2] Teichroew, Daniel and John F. Lubin, "Computer Simulation-Discussion of the Technique and Comparison of Languages," Communications of the Association for Computing Machinery, Vol. 9, No. 10, pp. 723-739, October, 1966.

languages, the applicability of the specific simulation languages must be considered in greater detail. The specific simulation languages considered potentially useful for the model being developed include only those most frequently used in management and agricultural economics and/or available at the MSU Computing Center. These are DYNAMO, CSMP, FORDYN, GPSS, GASP, SIMSCRIPT and SPURT.

Specific simulation languages are generally designed to handle one of two basic types of simulation models. These are continuous-change models and discrete-change models. Continuous-change models are appropriate when the system to be simulated can be viewed as a continuous flow of information and material rather than a series of discrete events or transferrals. Models of this type are usually represented mathematically by differential or difference equations that describe rates of change of the variables over time. Although analytical or numerical methods are frequently used to solve this type of model, simulation is often required when analytical or numerical methods are either inappropriate or not powerful enough to reach a solution.

Discrete-change models are appropriate when the system can be viewed as a series of discrete events. The discreteness may be caused by actual discrete events, measuring devices or measuring intervals which provide discrete data or intricate functions which can be most easily represented by discrete segments.

Corresponding to the two basic types of models are two classes of simulation languages; continuous-change languages and discrete-change languages. Although a number of continuous-change languages

were investigated in detail there is insufficient basis for selecting a continuous-change language.

In a study of a tufted carpet mill using Dynamo, Yurow[3] concluded that continuous representation is useful for obtaining only qualitative managerial guidelines. He recommended use of discrete models when more precise measurement is required.

Although growth of both plants and animals is certainly a continuous process, and continuous functions may best represent it, financing, debt repayment and crop sales on a specific farm are very discrete activities that could not be easily represented by continuous functions. Further, the intended extension application of the model being constructed requires more than "qualitative managerial guidelines."

The decision between FORTRAN and one of the specific descrete languages rests on the relative advantages and disadvantages of each of the specific simulation languages over Fortran. Fortran has the advantage that: (1) it provides practically complete flexibility, (2) programmers are available, (3) most computer facilities have Fortran compilers and thus the program would be adaptable to other research and farm planning situations, (4) the researcher was familiar with Fortran and (5) MSU's other Forward Farm Planning programs and other research programs which might be used in conjunction with this model are in Fortran.

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[3] Yurow, Jerome A., "Analysis and Computer Simulation of the Production and Distribution Systems of a Tufted Carpet Mill," Journal of Industrial Engineering, Vol. 18, No. 1, January, 1967.

Although languages such as CPSS, GASP and Simscript may help in formulating a simulation problem, they tend to force a certain degree of form on the model which appears inappropriate to the problem being considered.[4] The model could be formulated in these languages. However, they do not appear to provide sufficient advantage to make any of them superior to Fortran for the particular simulator being designed.

Spurt, on the other hand provides some quite useful routines which could have been used in the model developed. The decision not to use Spurt routines was made on a routine by routine basis. In each case another routine either previously developed or developed specifically for the model was considered either superior or easier to use.

## Time Interval

The appropriate basic unit of time for a simulation model depends primarily on the questions the model is being designed to address. Although the data used (both parameters within the model and initialization values) and the output variables are important, they can usually be adjusted to the requirements of the problems being addressed.

The basic unit of time selected for the farm business simulator reported in this paper is one month. Action takes place on a monthly

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[4] For a detailed discussion and comparison of simulation languages see Teichroew and Lubin, op. cit., Krasnow, Howard and Beino Merikallio, "The Past, Present, and Future of General Simulation Languages," Management Science, Vol. 11, No. 2, November, 1964, and other references listed in the bibliography.

basis, coefficients are month specific and output may consist of monthly values. This can be viewed as a state variable approach where the values or states of variables change monthly.

Use of a monthly time unit has several advantages over the annual time period used in most previously developed simulators. More micro or tactical comparisons and analyses can be made. Many important tactical questions which hinge on the timing of operations cannot be handled on an annual basis except by inserting the answer in the model before simulation. A monthly time period may allow one to address problems of this nature with the simulator. In some cases the mere shortening of the time period allows the analysis to be made. In other cases the shorter time period will make an analysis possible but additional data indicating the appropriate values for certain coefficients will also be required.

Cash flows can be handled in a realistic manner on a monthly basis. Handling cash flows on an annual basis essentially forces one to net out many of the real problems. An annual cash flow statement tells little more about liquidity problems than an income statement. The real problems of cash flow usually occur within a year rather than between years.

An advantage associated with cash flows is more realistic handling of credit, particularly short-term credit. Without elaborate credit control procedures an annual model may have non-existent or ineffective credit limitations and/or incorrect interest calculations. For example, an annual model could show a zero short-term credit balance at the beginning and end of the

year but still have implied unlimited use of short-term credit at some point during the year.

A particular advantage of the one month time interval for farm planning is that simulation of a problem can start in any month. A user can input the existing farm situation regardless of the time of year and simulate forward from that point. This feature does, however, have the disadvantage of complicating annual summary and tax calculations.

A further advantage is the fact that interaction of monthly values of variables may improve the accuracy of variables being calculated. In many cases monthly parameter values are the same as annual values or the monthly values are one-twelfth of annual values. Thus, when these values are multiplied by monthly values of other variables which vary by month, the result is a better estimate than would have been generated using annual data.

It should, of course, be recognized that this improvement in accuracy does not always occur. In cases where the value of a variable in one period is dependent on its value in previous periods the effect of an inaccurate parameter will be compounded. That is, if $Y_t = XY_{t-1}$, an inaccurate parameter value for X will make the value of Y more inaccurate if t is in months (and X is set equal to $\frac{X}{12}$) than if t is in years.

An obvious disadvantage of the monthly time unit is the magnitude of the data requirements. Both the model builder and the user experience a many-fold increase in the amount of data required. In

addition to the evident quantity problem is the fact that some relationships may not have been previously specified on a monthly basis.

Thus, certain monthly variable values may be of relatively lower quality than their annual counterparts. It is important to point out however that many monthly variables in a simulator can have no greater error than their annual counterpart and that as pointed out above monthly interaction of variables may in itself reduce error.

A shorter time period also involves more development and computer time and cost. It requires more professional and programmer time to develop a model with a shorter time unit and the resultant larger number of variables. In addition the computer time required for debugging and running such a model is longer. The longer run time increases the cost of using the simulator after it is developed.

Another possible disadvantage is the fact that most summaries of farm operating data has previously been on an annual basis. Record systems such as Telfarm make most calculations on an annual basis.

One alternative time period which could have been used is a quarterly or three month unit. Certainly sufficient precedent has been set by business for use of this time unit. The primary reason for not using a quarterly time period is the paucity of agricultural data on a quarterly basis. Most data which is not annual is monthly, weekly or daily.

All in all, it appears to the author that the quarterly time unit offers insufficient gain over an annual time unit to make it worthwhile.

## Farm Planning vs. Research Emphasis

As indicated in the title of this publication, the simulator being developed is designed for both research and farm planning. It is indeed anticipated that the model will be of genuine use for both applications.

Nearly all model characteristics needed for research coincide with those of farm planning. However, conflict between these two applications does occur at times. The most important case of conflict for the present model occurred in the development of output forms. Whenever such conflict has arisen in the development of the present model, the farm planning application has received prior consideration.

The primary justification for giving farm planning prior consideration is an effort to avoid any model deficiencies which might occur as the result of attempting to do two jobs and ending up doing neither well. Justification is not based on any apriori judgement that either of the intended application areas is of superior worthiness. The farm planning emphasis was chosen because no whole farm simulation models developed primarily for extension application had been constructed and it appeared to the author and others that such a model should be of considerable value.

## Stochastic vs. Deterministic

The primary reason for inclusion of stochastic elements in simulation models is to allow realistic inclusion of variables for which only probability distributions of their values are known or for which the best estimate of their values are represented by estimates of their probability distributions. That is, variables which create

real-world uncertainty can be included in a manner which comes closest to reality and variables for which only limited data is available can be included (at least for study) if reasonable estimates of their density functions can be made.

To be able to include the interactive effect of related random variables is a distinct advantage. Although the expected value of the product of independent variables equals the product of their respective expected values, this is not true where independence cannot be assumed. For any particular firm situation there is good reason to believe that many groups of interacting environmental factors, interacting firm factors or interacting firm and environmental factors are not independent.

The ranges, distributions and expected time paths for the variables resulting from operation of the model can be calculated via Monte-Carlo simulation. For many variables, such as income and debt levels, the possible range of outcomes and variation in time paths may be as or more important than the expected value. An investment alternative which carries with it a ten percent chance of bankruptcy may be preferred over another alternative with a higher expected income but a twenty-five percent chance of bankruptcy.

The primary disadvantages of a stochastic model are the increased programming required, increased computer running time and possibly increased data requirements. Increased programming is caused by (1) the fact that stochastic variables may be somewhat more difficult to handle and thus require more programming statements, particularly in cases when a large number of different distributions are included, (2) the recycling required for Monte-Carlo simulation and (3) the

additional programming necessary for summarization of Monte-Carlo results. In some cases specification of the parameters of a probability distribution for a variable may require more data collection effort than finding an "average" value for the variable.

A deterministic simulation model is in a certain sense a sophisticated budgeting technique which can be used to predict the consequences of various alternatives being considered. Although budgeting a ten year period on a monthly basis would be a monumental task, it could be done and the results would be similar to simulation of that ten year period. The high cost of developing a simulation model and the computer cost involved in the actual simulation require that a deterministic simulator meet one or more of the following conditions:

(1) It is easier to use than hand budgeting. That is use of the simulator must be easier than making the equivalent budgeting calculations.

(2) It is faster than alternative methods of evaluation. Hand budgeting requires a large amount of farmer and often farm advisor time. A significant reduction in this time requirement could save both farmer and extension funds. In cases where decision making time is severely limited a simulator may make complete analysis within the time constraint possible.

(3) It is more reliable than alternative methods. A simulator may include a number of coefficients which the user does not have or would be difficult for him to get. The simulator may provide coefficients which are better estimates than the typical user could develop on his own. If either of these

possibilities are true, the results with the simulator could be better than results generated by other projection methods.

(4) It comes closer to meeting the needs of potential users. A simulator which contains elements such as decision rules or decision branching can develop an alternative as it progresses. This feature is difficult or impossible to duplicate with linear programming and most other methods.

(5) It is cheaper. Substitution of capital, in the form of computer use, for labor may reduce the cost of the analysis required for decision making. Lower cost management analysis could increase the amount of analysis which is profitable and thus provide social benefit of better resource allocation (assuming optimum private and social allocation coincide) as well as the private gain of higher profit.

For extension application a deterministic model has the further advantage of being somewhat more easily understood by farmers and agents. The repeatability (for each run of the model through time) of elements not being manipulated makes comparisons appear more direct. In order to evaluate an alternative, a stochastic model must be run several times and the results summarized. The summarized results of several runs are usually more difficult to understand than a single deterministic run.

This model is deterministic with the exception of certain elements in the dairy herd simulation where the actual animals which are sold, die or are culled depend on a random number generator. This feature has little effect on the model when large herds are simulated except

for always forcing purchase, sale or culling of integer numbers of animals. Small herd simulation is realistic in the sense that integer numbers of animals are purchased, sold or culled but has greater variability from simulation to simulation. The number of random numbers drawn is so small that the law of large numbers is inoperative.

The primary reasons for limiting this model to a deterministic mode are cost and the advantages of a deterministic model for extension applications. Use of a stochastic model would require multiple runs of the present model plus development of a program to summarize the multiple runs. At least ten to twenty runs would be required to generate sufficient data to analyze any specific problem. Thus the computer cost for a stochastic model would be ten to twenty times that for a deterministic model. The advantages of use of a stochastic model for the problems of interest here appear insufficient to offset this cost differential. Given the extension focus of the present problem, the advantages of a deterministic model for extension use cited above provide additional justification for use of a deterministic mode.

Stochastic elements were incorporated into simulation of the dairy herd per se to allow generation of realistic monthly values for the dairy herd. Coefficients such as death rate, involuntary sale rate and culling rate are expressed as percentages of the number of animals in the herd. This creates rounding and timing problems. If the mortality rate is one percent per year, one cow from a one hundred cow herd must die sometime during the year. Use of a one-twelfth of one percent monthly rate will make the effective mortality rate zero. Use of annual calculations would leave the problem of which

month the animal died in. The exact causal factors determining the specific month in which the animal dies are unknown and even if they were known would likely be too detailed for inclusion in the model. To handle problems of this nature probability density functions were inserted to provide the required linkage between the percentage parameters and actual numbers of animals.

## User - Simulator Interaction

"At Last: Real Computer Power for Decision Makers." This title of a recent article in Harvard Business Review[5] expresses at least one person's opinion of the usefulness of decision maker-simulator interaction. Two reasons are given for recent interest in and emphasis on interactive systems. First, technological breakthroughs in remote terminals and time sharing have made interaction possible. Second, there has been growing recognition of the iterative exercise of managerial judgement in decision making. Researchers are tending to pull back from the older notion that model builders are going to solve the managers' problems. Decisions will continue to be made by managers - but with the help of computers.

There are several advantages of user-simulator interaction. It allows managers and researchers to use their intuition to develop alternative superior solutions to problems. In many cases these superior solutions may be suggested by "peculiar" or "interesting" results of rather routine solutions.

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5 Jones, Curtis H., "At Last: Real Computer Power for Decision Makers," Harvard Business Review, Vol. 48, No. 5, p. 75, September - October, 1970.

Interaction may allow more efficient evaluation of alternatives. An alternative which violates a credit restraint in month three of a ten year simulation may be discarded or altered within or after the first year. In cases where a succession of decisions are being evaluated, simulation of a few alternative decision series may suggest either the series to be chosen or a number of series that would be unacceptable. This reduces the number of alternatives to be simulated.

Decision maker interaction with the model allows fewer value judgements and goals to be inflexibly imbedded in the computer program. The model may not allow certain situations to occur because of assumed values for model parameters. A decision maker equipped with the ability to ask the simulator for more information on a situation or rerun a particular years data with different parameter values may discover such circumstances.

The decision maker may experience a more intimate working relationship with the simulator and thus be more willing to test new or different ideas. Facilitation of idea testing would usually be expected to improve decision making and overall management.

Interaction of the manager with the simulator may increase the level of confidence in the model and thus encourage further use of the model.

A primary limitation to the development of interactive simulators is the absence of remote access time sharing computer at many computer facilities. However, the importance of this limitation is being rapidly reduced with the installation of new computers.

The important disadvantages include increased programming time required to develop the interactive aspects and the increased computer hook-up time (peripheral processor and phone line time) required for the manager to decide and input decisions.

The simulation model reported in this publication is developed for batch processing and thus no user-simulator interaction. However, the model is to be transferred to a remote access time sharing computer after development. With that in mind, provision for development of a certain level of interaction has been made. At the end of each year a previously selected quantity of output will be printed. At this time the program will ask the user if (1) more data on the past year's simulation is required and (2) the user desires to make changes in the parameter values or decision rules for the next year. The user will input his decisions via teletype.

Determination of an optimal level of user-simulator interaction will have to be made after this model has been in use. At this point in time there are no real guidelines for the appropriate level of interaction except to observe that they depend upon the characteristics of the anticipated users of the system developed.

## Computer Selection

There were essentially two groups of computers available for use in developing this simulation model. One group, at the Michigan State University Computer Center, consisted of a CDC 3600 and CDC 6500. This facility offered batch processing within a close proximity of the research offices. Although the CDC 6500 possess a time sharing capability, the remote access capability had not yet been developed.

This machine had the further limitation that the systems software was still in the process of being developed. Thus down-time was high and turn-around time erratic and often quite long.

The CDC 3600, a considerably slower machine with a smaller core memory, was reliable and turn-around time generally quite reasonable. Given the time constraints within which the model was developed and the programming carried out, this computer was judged to be the better choice of those available at Michigan State University if it was large enough. A preliminary estimate of the memory requirements of the model indicated that the simulator could be developed on this machine although certain core saving techniques might be required.

The second group of available computers included a number of commercial computer facilities that were available via teletype. These included two Detroit based computer services, ACTS and DACC, and the University of Michigan system at Ann Arbor. Each of these systems was presently being used by members of the Department of Agricultural Economics faculty. Each of these services offered time sharing remote access capability via telephone lines to anyplace where the telephone cost was not prohibitive.

A remote access facility offers several advantages. First, it allows development of user-simulator interaction into the model. The simulator can be developed under the assumption that it will be used via remote access which allows user-simulator interaction. The program can be developed and debugged in the mode in which it is to be used.

Second, the model can be realistically tested in actual situations anyplace in the state. An important phase of simulator development is testing or validation of the model. The real test of a model designed as an aid to decision makers would be to subject it to the scrutiny of a real manager under conditions that could be expected to prevail when the model is in general use.

Third, the near instantaneous turn around time and programmer oriented software system make development and debugging of programs faster and more efficient than possible with batch processing.

Fourth, remote access via telephone makes the simulator available to all for which the telephone service is not prohibitive. This effectively makes the computer available to farm advisors and managers throughout the state and possibly throughout a much larger area.

Fifth, any cost of transferring the program from one computer system to another is avoided. If the model is to be used via teletype, developing the model directly on a teletype unit avoids any costs involved in transferring it from a batch processing unit to the remote access unit.

The primary disadvantage of using one of the remote access units indicated above was cost. The commercial rates charged for use of these facilities far exceeded the university rates charged University departments. This cost gap was further widened by the availability of free or non-pay computer time for development of this model. Non-pay computer time arises from the dual pricing policy of the Computer Center which makes a certain amount of free computer time available to each Department for each unit of paid computer time used by that Department. Availability of such computer time made

the estimated costs for developing the model on the University computers less than $200 as opposed to a $6,500 estimate for use of a remote access computer.

The wide difference in computer charges was the primary factor leading to a decision to develop the model on Michigan State University's CDC 3600 computer and then transfer it via paper tape punched by the CDC 3600 to a remote access unit after development. Transfer costs were estimated to be negligible compared to the cost difference. A secondary advantage of developing the model on the CDC 3600 was the fact that the programmers to work on the project had had little experience on the remote access unit and felt they would be more efficient on the home machine.

This procedure should provide a test of the advisability of accepting the approach of development and transfer as a general practice. The procedure may also cause the emergence of two models; one a research and batch processing oriented model on the CDC 3600 and the other an extension oriented farm planning model available by remote access. If this should occur it may increase the value of the present effort.

## Of or For Management

A simulation model may be designed to "simulate the manager" or to "simulate for the manager." A model designed for the study of management or management processes will usually be a model of a manager or possibly a game to be played by management. A number of previously mentioned studies have been designed to simulate the manager. This includes Robertson et. al.'s study of a marketing

manager[6] and Smith and Greenlaw's simulation of a personnel manager.[7] As pointed out by Baker[8] there are a number of conceptual and technical problems involved in simulating a decision maker. The human capacities of self-direction, autocriticism and adaptation are not even well understood. Computerizing them is even farther off. However, many of the less complicated actions of managers can be computerized and this process in itself may assist in the understanding of the process of management.

A model "of management" has limited usefulness to managers without knowledge of what consitutes "good management" or "poor management". Experience has shown that a model which provides the opportunity for the evaluation of management decision can be used in teaching management.

Simulation models designed "for management" span a broad spectrum in both size and topic covered. The primary purpose of these models is to provide managers with information about the firm or its environment which they did not previously possess. These models are generally designed to provide predictive data relative to a question of "what if _____" or descriptive data relative to a question of "what is _____." "What if" questions generally represent a request for information relative to a particular potential action. For

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6 Robertson, Fernald and Myers, op. cit.

7 Smith and Greenlaw, op. cit.

8 Baker, Frank B., "The Internal Organization of Computer Models of Cognitive Behavior," Behavioral Science, Vol. 12, No. 2, p. 156, March, 1967.

example, "what if we construct this building next year?" "What is" questions often related to the probability of an event occurring. For example, "what is the likelihood of being able to harvest this crop with this machine in three weeks?" "What is" questions may also be "what if" questions in disguise; what is the value of this variable if we continue as we are now?

The usefulness of models designed for management resides in their ability to provide information which allows managers to make better decisions or to improve the perspective of management relative to the operation of the business. They do not teach management except to the extent that use of the model reveals principles or relationships to management.

The model developed in this paper is designed in a "what if" context for use by management. It is assumed that the user (farm manager, farm advisor or researcher) has a limited range of alternatives and the decision criteria for determining acceptable alternatives to be critically evaluated are considered exogenous to the model. The simulator is to be used to develop data on the expected consequences of choosing each alternative.

This simulator is neither a positivistic economic model of what managers do nor a normative model of what they should be doing. It is a data and information generator which provides managers with a better basis for deciding what they should be doing. In this sense it might be described as a positivistic model with possible normative consequences.

## Input and Output

The appropriate input forms and data requirements for a simulation model of course depends on the type of system being simulated, the anticipated user of the model and the way the model is to be used. Although the appropriate characteristics of input data for extension oriented farm planning models has not yet been conclusively determined, there are certain apparent desirable attributes. An obviously desirable attribute, particularly for a management clientele noted for its disdain for "bookwork", is brevity. An unnecessarily long input form could be a greater deterrent to its widespread use than a high price. Questions asked and data required must be designed to get as much information per question as possible.

The questions asked must be easily understood by the user. The questions must use the language of the user and the required form of the answer should coincide with the form the user would expect. A requirement of a yield in hundredweight when usual quotations are in bushels could be expected to cause trouble.

The data provided by the user must be complete enough to carry out the simulation. The precision of the output depends on the completeness and accuracy of the input and on the precision of the simulation routine calculations. A high level of precision comes at a cost and the model builder is required to assess the various trade-offs.

In an effort to reduce the required quantity of user input yet preserving a satisfactory level of precision, this model uses

what Candler et. al.[9] have called input by exception. A large number of parameters or coefficients used in the model are given values based on research and extension publications and other sources. These values will be used by the model unless the user chooses to change them. In this way the program will always "run", guesswork is minimized and the user must supply only those coefficients which he considers inappropriate in the basic program.

Of course, all parameters cannot be input in this fashion, but this does provide an effective method of limiting input to only those data which are unique to the particular situation being simulated or for which the user has better or more detailed information.

There is the temptation in simulation models to output everything the model calculates on the assumption that a manager's primary problem is lack of information and correspondingly that more information is always better. As pointed out by Ackoff,[10] this assumption is not necessarily valid. The printing out of everything a model calculates every time it is run will often provide a large amount of irrelevant data for the particular problem being considered. This is not only wasteful of computer time (printing is very time consuming relative to calculation) but may actually reduce the amount of information that is used because the user must search through an excessively thick stack of computer output to find values of variables he considers important.

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[9] Candler, Boehlje and Saathoff, op. cit., p. 75.

[10] Ackoff, Russell L., "Management Misinformation Systems," Management Science, Vol. 14, No. 4, p. B-147, December, 1967.

The appropriate kind and quantity of output depends on the user and the specific problem being addressed. Thus, it appears that a model such as the one being outlined in this paper which is designed for use on a wide variety of problems by both extension and research workers must have variable output. Therefore, provision should be made for tailoring of output, within certain specified limits, to the problem at hand.

The output from the model reported here has been divided into eleven different output reports which vary by type of material presented and degree of detail. Any combination of reports can be printed and the combination to be printed can be changed as simulation time progresses. The user dictates the nature of the output.

One potential additional merit in this variable output feature can come from monitoring the frequency of specific output requests. From this the farm advisor is better informed on the types of problems which give farmers the greatest concern. Such information should also prove of value in the development of report writers for other models of similar nature. It should be observed, however, that such data might prove of little value for models of different size or for different types of problems.

## Large Models vs. Aggregation of Small Models

There are presently two schools of thought as to the appropriate modeling strategy for manager oriented simulation models. The two strategies supported by these two schools could be called a small models strategy and a large models strategy, respectively. Supporters of the small models strategy contend that the proper way to

approach a whole farm problem is by use of a set of small algorithms rather than to use a large complicated one. The set of small algorithms, which are assumed to be comparable to the subroutines of a large model, are combined by the user to answer whole farm questions. The user decides which algorithms are required and the order in which they are to be run.

Harsh, Black and Tinsley[11] cite three advantages for this strategy. First, the small algorithms can be used to answer the most pressing "small" question as well as to provide some information needed to analyze a total farm problem. "Small", in this sense, refers to information interests relative to a certain part or subsystem of the total business. To the extent that these small algorithms may be used for a variety of situations, investment in their development can be easily justified.

Secondly, small models are easier to understand than large ones. Thus, with a greater understanding of the individual parts of the model the user better understands the complete system. Thirdly, it is contended that the piecemeal approach can be operated by less skilled personnel than required for large models. A reduction in the skill level required to use the model may expand demand for use of the model and/or improve the effectiveness of the models where they are used.

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[11] Harsh, Steve, Roy Black and Al Tinsley, Using Time-Share Computers at the Area and County Agent Level: The Michigan Experience, Unpublished Mimeograph, Department of Agricultural Economics, Michigan State University, 1970.

Other points offered in favor of small models include[12] (1) small models are less expensive to build than large ones, (2) it is easier for users to develop confidence in a model that is easier to understand and that can be used repeatedly at reasonable cost, (3) smaller models can be used by lower managerial levels where the executive is able to bring to bear maximum understanding of the problem and alternative solutions, and (4) it is much easier to maintain smaller models in an up to date state of readiness than is possible with large models.

Supporters of a large model strategy maintain that the whole is greater than the sum of its parts and that all sub-systems should be studied on their relationship to each other. Hence, whether the problem is conceived as partial or whole, the analysis of both is more effective if all interacting parts are taken into account. Hence, the primary advantage of the whole firm simulator is its relative ease in handling and feedback within the total computerized system. Small models may appear easier to use, but one can question not only whether use of these models can provide as good an answer as a large model, but also whether more understanding of the models and more work on the part of the user may be required to get a comparable answer.

Whole firm models will also have an advantage if investment evaluation is a part of the problem. This is because the interacting elements may pick up expense or income items which likely would be neglected when a number of small models are put together.

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[12] Jones, op. cit., p. 79, 1970.

The original conception of simulation envisioned large models answering all the important questions about a system. However, the enormous inputs required to build such a model and the fact that limited budgets and lack of trained personnel caused the capacity of the models developed to fall far short of expectations, forced a pull back towards smaller models.

The advantages of each of these strategies leads this author to conclude that neither represents a tenable long term position. The much lower cost of development and use plus the greater ease of updating likely means that small models will be best for a certain class of problems. Furthermore, training users, many of whom have had little contact with the computer, may best be done by starting with small models that are easier to explain and understand. Repeated use of smaller, more easily understood models may allow development of confidence in the use of computer models. As the technical competence and confidence of the users grow, larger models which can be used on larger more complex problems can be introduced.

One is lead to the conclusion that both large and small models are useful. Because of the investment required each large (and small) model must be closely evaluated and designed to be usable (or easily convertable) for as large a service area as possible. Although there is no apriori justification for assuming that the rate of return on investment is larger for small models than for large (small models cost less to construct and may be used more but deal with smaller potential saving per use), the larger development and maintenance cost involved with larger models makes the costs of constructing

an inappropriate model much greater. Thus, a more formal benefit/cost analysis should be considered prior to construction of large models.

Economic efficiency will cry out for interdepartmental and interstate cooperation and coordiantion. Many models designed in one state should be useful in a large number of states with little or no modification. The model outlined in this paper is perceived to be a model which appears on the large complex side of the continuum of relevant models.

# CHAPTER IV

# THE MODEL

## General Description and Important Model Concepts

A number of the general characteristics of the FArm Business Simulator (FABS) developed as part of this study were presented in the previous chapter. These characteristics include the use of a one month time unit, variable output, user-simulator interaction, limitation of stochastic elements to the dairy herd per se and generalization of the model to a wide variety of dairy farm business problems. The primary purpose of this chapter is to present a general outline of the specific model developed, including a discussion of certain important model relationships and concepts. The relationships and concepts discussed are specific to this particular model and the problems with which it was designed to cope.

## General Outline of Model

The model is designed to handle dairy and dairy-crop farm situations as well as any crop farm situation where the crops grown include only those frequently found on dairy farms. The crops included are corn, corn silage, hay, hay crop silage, wheat, oats

fieldbeans and soybeans. A dairy beef enterprise in included to the extent that dairy steers may be raised and sold. Steers cannot be purchased.

A general flow diagram of the model is shown on the following page. Each block represents a logical sub-system of activity within the complete farm firm system and is represented by a sub-routine in the computer program.

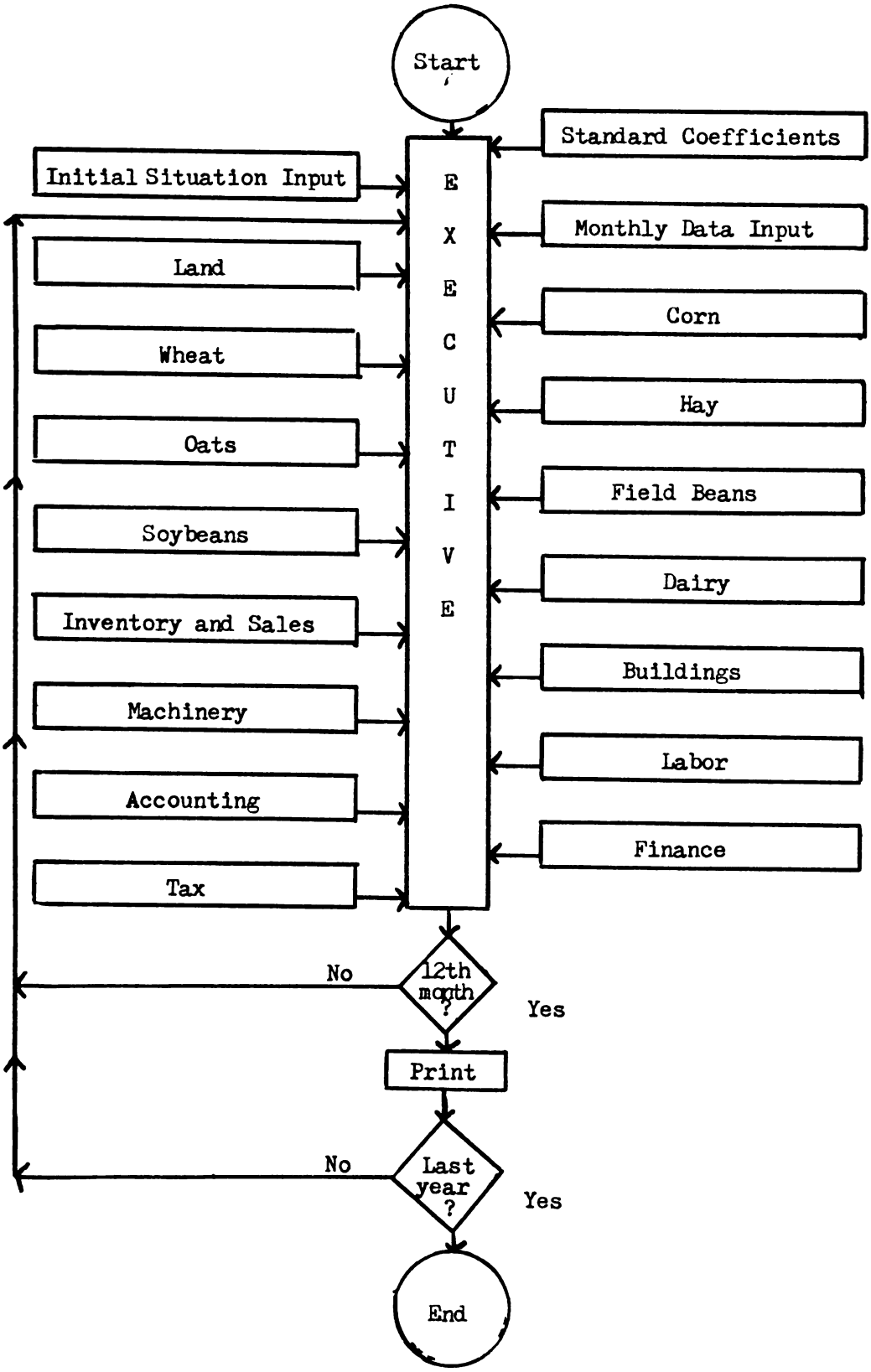



Figure 4.1. Flow Chart of Simulator

Fiscal or Calendar Basis

Simulation may be carried out on either a calendar or fiscal year basis. When a fiscal basis is used the year starts with the first month simulated and ends with the preceding months of the following year. That is, if the first month simulated is June, the fiscal year runs from June 1 through May 31. The fiscal year is completely defined by selecting the first month to be simulated.

When a calendar year basis is used the simulation year runs from January 1 through December 31 regardless of the first month simulated. If the first month simulated is not January, the first simulation year runs from the first month simulated through December of that year. Net income for the first part of that year can be input for end-of-year returns and income tax calculations. Income taxes are calculated on a calendar year basis regardless of whether a calendar or fiscal year is used.

Parameters

The parameters or coefficients used in the model are divided into two groups. The first group is composed of those parameters which reflect the specific situation being considered. This includes parameters indicating the initial situation for the business being analyzed, such as type of enterprise, numbers of livestock, number of acres, specification of machinery systems and initial debt situation, and control parameters such as number of years to be simulated and types of output to be printed. Initial values for all of these parameters must be input by the user. It is assumed that this set of parameters represent the minimum amount of data about a specific situation required to carry out simulation of alternatives.

The second group of parameters, which includes all other coefficients used in the model, are assigned initial values by the simulation program itself. These initial values represent an estimate of the value of each parameter based on Telfarm data, research reports from Michigan and other states, and record project and cost account data from other states. As indicated by the data sources, these values would be representative of an average farm that keeps records in a farm record project. Although these farms would be somewhat above average, they are likely quite representative of the group who could be expected to use the model.

These initial values are presented to the user who may either accept any given value or replace it with a value more appropriate to the situation being considered. Any or all of the initial values can be changed. If the user has data as to the proper value of the coefficients for his situation the value to be used can be entered.[1]

Presenting the parameters of a model to the user in this fashion has the advantage of informing the user of the assumptions underlying the simulation and of providing the user with benchmark values of parameters. Benchmark parameter values may be useful in developing superior values for the specific situation being considered. The user may know only that his situation is some amount or percentage above or below average.

Including all model parameters in the two groups also has the advantage of making updating of the model easier. Any model

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[1] Candler et. al. call this "input by exception."

coefficient can be changed by making only one change in a clearly defined position within the program. When coefficients are not grouped in this fashion it can be difficult to find all the places a particular parameter is used; particularly for a large model. This makes updating time consuming and mistake prone.

This configuration of input and preassigned model parameters allows use of the model under a wide range of data conditions. If there is detailed data for a specific case, this situation can be taken advantage of. However, in cases where data specific to a particular situation are limited, the model can still be used. It must, of course, be recognized that the less specific the data the less specific the answers derived.

Management Decisions and Decision Rules

In addition to parameters the model contains decision rules and management decisions. Decision rules are placed at points in the program where a number of different actions could be taken. The value of the parameter connected with the decision rule, sometimes in conjunction with the present values of other parameters, decides which action is to be taken. Thus, a change in the value of a parameter connected with a decision rule may change the action that takes place at the corresponding decision point. Examples of decision rules include the percentage of heifer calves to raise, if and under what conditions buildings are to be constructed and whether to use off farm grain storage.

All decision rule parameters are included in the second group of parameters. They have preassigned initial values but can be changed if the user desires. As is true for all parameters in the

second group and for most in the first, the values assigned these parameters can be changed at any time during the simulation and as frequently as desired. For example, a particular parameter may be assigned a value in month one, a different value in month three, a different value in month six of year two, and the original value in month nine of year four.

Management decisions include decisions to buy, sell or rent land, build buildings, buy or sell machinery, and buy or sell livestock. Decisions may be made in considerable detail or in quite general form. Greater detail implies that the user specifies more of the action involved in the management decision. Thus, a decision to build a barn can be specified as to month of occurrence, type, size, cost and financial arrangements or specified only as to month of occurrence and size. Any activity which is not specified by the user will be carried out using standard decision rules and coefficients from the two groups of parameter values.

All decisions must be specified as to month of occurrence and may occur during any month of simulation. This allows a normal progression of decisions through time and permits comparison of alternative time strategies of decisions.

## Specific Model Concepts

The specific concepts discussed below include only those considered most important or unique to this model. A detailed discussion of how all variables are handled by the simulator and an enumeration of the exact numbers utilized by the concepts discussed below appears in Appendices A and B.

Systems

The simulator is designed around systems of activity. There are eighty-seven different systems including ten livestock systems, 42 crop grow systems and 35 crop harvest systems. Each system requires a specific set of machinery and buildings and has associated with it a particular configuration of costs, production and labor requirements. Crop Grow systems are also associated with specific planting months. The systems included in the model were selected because they are or are expected to be widely used by Michigan farmers. In fact, an attempt was made to include all those systems which are in wide use so that the model would be easily usable for a large number of farm situations.

The systems are divided into mutually exclusive sets with each set representing different methods of carrying out a certain activity. For example, there are seven different dairy cow systems. These are (1) conventional stanchion, (2) cold covered free stall, (3) warm enclosed free stall, (4) cold covered free stall with liquid manure, (5) warm enclosed free stall with liquid manure, (6) open-lot, milking parlor and (7) user defined. The user must select one of these dairy systems for handling the dairy herd (if the farm situation contains a dairy enterprise). For the corn grow activity either a 2-row, 4-row, 6-row or user defined system must be chosen. In a similar manner systems are chosen for each of the other activities.

The particular machinery set used by any system can be determined by the user. A specific set of machines is assumed by the model. These machines are indicated by the three systems matrices found in the listing of group two parameters. In each of these matrices the

column headings are the systems and the row headings are the particular machines. If a system uses a particular machine there is a one in the matrix cell at the intersection of the system column and the machine row. If the cell is zero (or blank) that machine is not used by this system. The user can change the specific machines used by a system by changing the appropriate cells to the correct zero or one values.

Each mutually exclusive set of systems includes one user defined system. This is essentially an unlabled system for which, if selected, the user must specify the machines required, the labor requirements and the level of costs and production involved. The machines required are specified by changing values in the three system matrices in the same manner, indicated above, that the machines used by a system are changed. The other items are specified by giving the appropriate parameters non-zero values. These parameters are all included in the second parameter group. The availability of user defined systems makes it possible for a wide variety of different systems to be evaluated by the model. This is particularly true for new systems or modified systems which are not now in wide use.

The simulator does allow changing systems during a simulation run. In fact a change of systems may be the alternative or one of the alternatives being evaluated. The system change is accomplished by other parameter, decision rule and decision changes or the change may be completed solely within the model. In the absence of instructions to the contrary a system change will cause the model to buy any machines or buildings required and sell any machines which are no

longer used. It will automatically switch to the parameter set appropriate for the new system.

One of the primary reasons for using systems rather than enterprises is the significant gain in flexibility that is gained. This is particularly true for crops where the growing and harvest operations are considered as separate systems. Under an enterprise regime, each enterprise must have both the growing and the harvest system identified. Thus, if there are four different grow systems and five different harvest systems the total enterprise systems required to cover all combinations would be 20. This would significantly expand the size of the model required to handle the same situations.

This gain in flexibility is also important for such crops as corn which may be harvested as either corn grain or corn silage. In the Spring when the crop is planted it may not be known how much of the crop will be harvested as silage. If there are two enterprises, corn grain and corn silage, either the harvest decision must be made at planting time or complicated transfers must be developed to allow a shift of acreage from one enterprise to another at harvest time. The latter alternative would require, at minimum, methods to allow corn silage to be harvested as grain and corn grain to be harvested as silage. With separate grow and harvest systems corn can be grown and the harvest decisions made at harvest time and thus based on the appropriate parameter values. The hay crops which may be harvested as either hay, pasture or hay crop silage can also be more realistically handled with growing and harvest systems separate.

Crop Production Functions

It has long been known that production functions developed using either technical data or a number of representative firm situations are rarely representative of any one particular firm situation. It is difficult if not impossible to include all variables which influence the rate of output of any particular item. Thus, most production functions are fitted using only the most important independent variables. The factors ommitted are usually important enough for individual firm situations that estimates made using such a function will invariably differ considerably from observations made for any specific individual firm.

A number of studies have shown that farm crops are responsive to fertilizer rates. However, many factors such as natural fertility, soil texture, planting date and climate influence the absolute level of production for any given rate of fertilization. This essentially excludes use of absolute production functions in a model to be used in a number of different farm situations.

The farm business simulator employs a somewhat different method. The user is asked to specify a point on his production function for each crop. He is asked his average or recent level of production and the level of fertilization required to achieve that level. This is equivalent to specifying a point in factor-product space (shown below) that is on the production function for this individual firm. The model then generates a production function which goes through that point using average response relationships for the users area of the state to provide the functional shape.

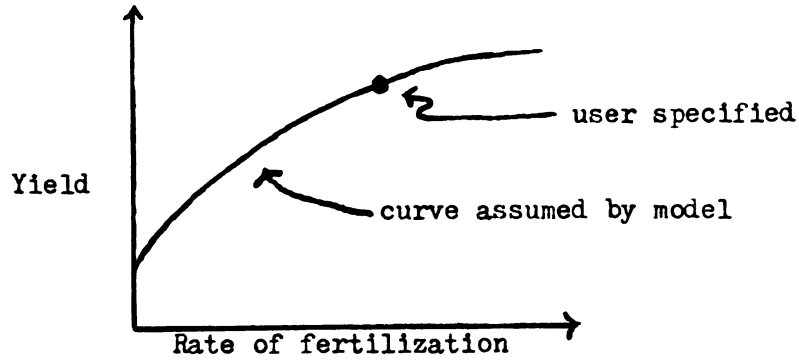



Figure 4.2. Generated production function.

The actual functional form used for each crop and each area is based on a crop yield response study by Ibach and Adams.[2] They used 1964 fertilizer application and yield data plus other data supplied by State agronomists to develop fertilizer response functions for all major crops for the 99 Agricultural Subregions of the United States. Four of these regions cover Michigan. A map indicating the regions for Michigan appears in at the end of Part I of the user manual presented in Appendix A.

The functions developed took the general form of Spillman Exponential functions ($Y = M - AR^X$). In their publication they present a number of points from these functions by crop for each area. These points were used to determine the expected relative yield at various fertilization rates. That is, the yield indicated

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[2] Ibach, D. B. and J. R. Adams, Crop Yield Response to Fertilizer in the United States, Statistical Bulletin No. 431, Economic Research Service and Statistical Reporting Service, United States Department of Agriculture, August, 1968.

for each fertilization rate was expressed as a percent of the zero fertilization yield. Linear interpolations were used for other fertilizer rates.

These relative yield numbers are used to adjust the yield when the rate of fertilization is other than that given by the user when he states what his yield has been and the rate of fertilization used to get that yield. The yield is adjusted by multiplying the yield by the ratio of the relative yield coefficient for the present level of fertilization over the relative yield coefficient for the old level of fertilization. This, in effect, provides a production function of the form estimated by Ibach and Adams but with the level determined by the individual situation.

To illustrate the actual procedure used, part of Table 48 from Part II of the Users Manual is reproduced in Table 4.1 below. Parameter identification numbers have been ommitted for simplicity. Only the part of the table concerned with corn is presented.

Table 4.1. FERTILIZER RATES AND RELATIVE YIELDS

| | Agricultural Subregions | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Crop | 39 | 40 | 41 | 54 | 39 | 40 | 41 | 54 |
| | ---Lbs. $N, P_2O_5, K_2O$--- | | | | ---Relative Yield--- | | | |
| Corn | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 100 |
| | 138 | 150 | 138 | 127 | 151 | 148 | 148 | 147 |
| | 261 | 273 | 261 | 214 | 179 | 163 | 170 | 167 |
| | 321 | 333 | 321 | 274 | 187 | 169 | 174 | 174 |

Assume that the user answered question 30 of Part I of the Users Manual by indicating that he had historically been applying about 138 pounds of plant food ($N + P_2O_5 + K_2O$) on corn and getting a 100 bushel yield. Further assume that the user was located in Agricultural Subregion 39 and that for the present year he is increasing his amount of plant food applied to 261 pounds.

To calculate the new yield the program searches the first column to find the 138 and then moves over four columns (in the same row) to find the corresponding relative yield (percent of zero fertilization yield) coefficient which is 151. Then using the same procedure the program finds the relative yield coefficient corresponding to the new 261 pound fertilization level, which is 179. Then the new yield is calculated as

$$100 \times \frac{179}{151} = 119 \text{ bushel}$$

In cases where the fertilizer application amounts do not correspond to numbers in the table, linear interpolations are made. That is, if the new fertilization rate had been 300 pounds of plant food the corresponding relative yield coefficient would be

$$179 + \left(\frac{300-261}{321-261}\right)(187-179) = 184$$

and the new yield would be

$$100 \times \frac{184}{151} = 122 \text{ bushel}$$

Livestock Production Relationships

The level of milk production of the dairy herd is assumed to be a function of (1) the quantity of grain concentrate fed, (2) the quality of forage fed, (3) the rate of culling, (4) the age composition of the herd and (5) the genetic capability of the herd and

herd management. To provide an indication of the genetic capability of the herd and general herd management the user must input the present production level of the herd and specify the corresponding grain concentrate quantity, forage quality, culling rate and initial age distribution. This provides one point on the five space surface of production. The user specified level of production is used as long as none of the five factors change. However, if any of these factors change the level of production changes.

Except for grain and forage, which are assumed dependent and are handled jointly, it is assumed that the five factors are independent for any given firm situation. Thus, changes in culling rate or age composition can be handled independent of each other and of feeding rates. General herd management is assumed constant throughout. Genetic capability of the herd changes only with the purchase of genetically superior or inferior animals or by parameter change by the user. If the user successively increases the level of production expected at constant age composition and feeding and culling rates, the result will be an apparent increase in either genetic potential or management quality.

The measurement of changing age composition and the effect of the change on production is made possible by use of an array which represents the herd. Each row in the array represents one animal. Every month this herd array is updated. Age is increased by one. Cows that die or are sold are removed. Animals purchased or born are added to the array. The selection of animals to die or be culled and the selection of freshening dates for individual animals is accomplished by use of probability distributions. A random number is

drawn for each animal at breeding and/or freshening time and the value of this number determines the fate of the animal until next lactation. The probability distributions are developed from the culling percentage specified by the user as well as death, involuntary sale rates and calving interval distributions included in the second group of parameters.

Maintenance of a herd array in this fashion provides the number of animals of each age. To obtain production as a function of age, a herd average mature equivalent production is calculated by using the initial distribution of animal ages and the user specified level of actual production. It is this herd average mature equivalent (M.E.) production that is adjusted for changes in feeding. The actual individual lactation production of each freshened animal in the herd is calculated by dividing the herd average M.E. production level by the M.E. coefficient for animals of that age and adding any genetic or culling induced production adjustment. Actual monthly production is calculated for each animal using the animals freshening date and normal lactation curves to determine the proportion of that lactation's production to occur during the month in question. Thus, the user inputs actual production rates and the program output indicates only actual production. Mature equivalent production rates exist only inside the program. The user never knows they exist.

The principle involved can be illustrated by assuming a three cow herd with a 13,000 pound herd average and individual cow freshening ages of 32, 51 and 105 months. As indicated in Table 76 of Part II of the User Manual the corresponding M.E. coefficients for these ages is 1.26, 1.06 and 1.01. Thus, the herd average mature

equivalent coefficient is 1.11 and the herd average mature equivalent lactation production (Z) = $13,000 \times 1.11 \times \frac{\text{calving interval}}{12} \times Y$ where the calving interval is in months and Y is an adjustment factor for the fact that the actual herd average of 13,000 was produced in part by animals which were sold after having produced at least part of the lactation but before the end of the dry period. This coefficient is explained in detail in Appendix B. The actual lactation production of the animal that freshened at 32 months = $\frac{Z}{1.26}$.

This procedure allows the production of an animal of a specified age to remain constant while the actual average herd production shifts with changes in age distribution. The expected effect of a large influx of two year old heifers will be accurately reflected.

Culling rate changes influence production levels in two ways. First, culling (at least voluntary culling) usually takes place either just before or at the beginning of the dry period. Thus, at a minimum the animal is in the herd during production but not during the dry period. Further, if the animal is replaced immediately, the beginning of a new lactation replaces what would have been a dry period. This is illustrated below where Q is the time of drying off or culling the animal and R is the freshening date of the animal were it not culled. The broken lactation curve represents replacement with a first calf heifer rather than a fresh cow.

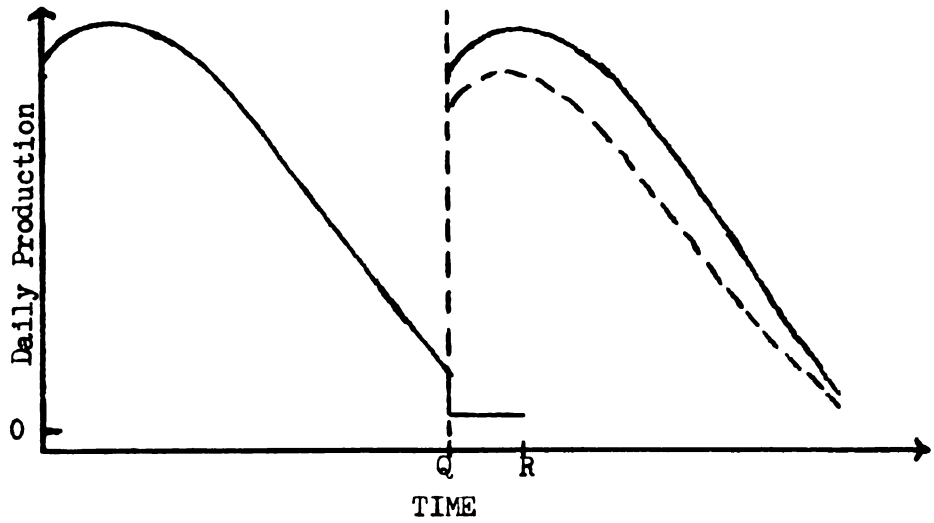



Figure 4.3. Effect of culling on daily production.

Second, animals culled have lower than average production. The replacement for a culled animal would on average be expected to produce at point T in Figure 4.4, while the culled animal would have produced near the level S. The quantity ST represents the average gain in production from culling and replacing low producing animals. If the animal is not replaced the herd average will increase by $\frac{\bar{X} - S}{N}$ where N is the number of animals before culling and $\bar{X}$ is actual average herd production ($\bar{X} > T$).

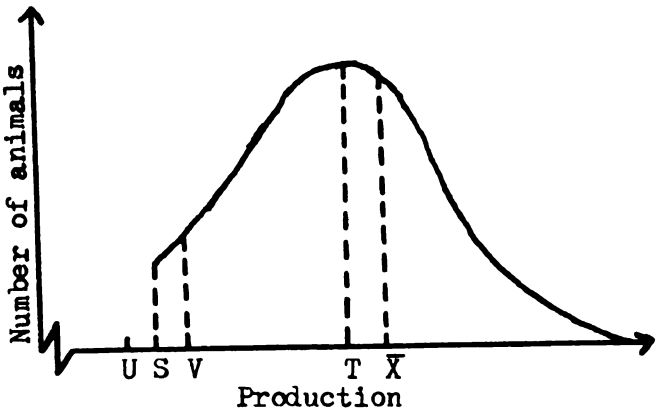



Figure 4.4. Expected distribution of a herd by production.

The influence of eliminating dry periods is automatically taken care of by the herd array matrix described in the above discussion of age composition. Also, the effect of culling at the historical rate is assumed in the level of herd production input by the user. However, the effect of changes in the rate of culling must be handled separately.

To discuss this, Figure 4.4 will be used as reference and three different rates of culling, $U^1$, $S^1$ and $V^1$ will be used. $U^1$, $S^1$ and $V^1$ are measured in terms of percent of average annual herd size and represent percent of the herd that must be culled in order to cull all animals with production levels below U, S and V respectively.

It is assumed that the lowest producing animals are always sold first. Thus, $0 \leq U \leqq S \leqq V \leq 99$.

Reflection of the effect of changes in the culling rate is accomplished by assigning certain animals a production adjustment parameter. At the beginning of each lactation each animal is assigned

a random number from the range 0 through 99. If the culling rate is reduced, say from $S^1$ to $U^1$, cows with a random number between $U^1$ and $S^1$ indicating an implied production level between U and S will not be culled. However, they should be if the average herd production is to be maintained. To represent the effects of this action the production adjustment parameter of each such animal is set equal to the difference between S and the production level implied by the number drawn. These differences are estimated in Table 75, Part II, Appendix A.

On the other hand, if the culling rate is increased, say, to the level $V^1$, animals will be culled which need not be culled to maintain production. When this occurs the animal cannot be assigned a positive valued production adjustment because it leaves the herd. The positive production adjustment is assigned to the next cow.

The production adjustment parameter for each cow is added to its age determined production level to calculate the actual production level. The production adjustment parameter also indicates any genetic superiority or inferiority indicated for purchased animals.

This procedure can be illustrated by assuming that the historical culling rate input was 30 percent and the user reduced the rate to 25 percent. Thus an animal assigned a random number of 26 should be culled to maintain production but will not. To indicate the decreased production the animal will be assigned a negative production adjustment of 2,000 pounds from Table 75, Part II, in Appendix A.

This method will allow the effects of changing culling practices to gradually exert their influence over time; as occurs in the real world. A reduction of culling rate will only gradually lower

production, but the resultant lower production will linger after the culling rate is returned to its previous level.

Changes in feeding rates are handled in a manner similar to that used for fertilizer except that the user specifies a point on a surface rather than a point on a function. This can be visualized in three dimension by assuming the usual X, Y and Z axes with Z representing milk production and X and Y representing quantity of grain concentrate and forage quality. By indicating historical production and feeding rates the user specifies the coordinates of one point on the production surface. Using this point as a base the program superimposes the remaining portion of the surface.

The shape of the surface is specified by use of transition constants or rate of change parameters which represent the expected change in production for given small changes in either grain concentrate quantity or forage quality for each level of the other factor.[3] Different sets of transition parameters are used for different levels of initial actual production.

If the level of grain feeding is changed, the level of grain feeding, the level of production and the forage quality would be used to determine the appropriate transition constants to use in calculating the new production and hay consumption levels. The transition constants represent the change in milk production brought about by a 500 pound change in grain feeding. Thus, if the change in the grain feeding rate was 250 pounds and the transition constant was

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[3] The transition constants were developed using unpublished data supplied by C. R. Hoglund, Department of Agricultural Economics, Michigan State University.

200 pounds the average rate of milk production could be changed by 100 pounds. If the change in the grain feeding rate is greater than 500 pounds, more than one transition constant is used.

For example, assume a user has indicated historical grain feeding and production levels, while feeding medium quality hay, of 4,250 and 12,000 pounds respectively, and that for the present month being simulated, the grain feeding rate is to be increased to 5,250 pounds. The change in actual average annual production is calculated using Table 4.2 below. Table 4.2 is a reproduction of Table 73, Part II, Appendix A with parameter identification numbers ommitted.

Table 4.2. GRAIN TRANSITION CONSTANTS

| Forage Quality | Level of Prod. (000) | Change in Level of Grain Feeding | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2000 to 2500 | 2500 to 3000 | 3000 to 3500 | 3500 to 4000 | 4000 to 4500 | 4500 to 5000 | 5000 to 5500 | 5500 to 6000 | 6000 to 6500 | 6500 to 7000 | 7000 to 7500 |
| | | ---------change in milk production - pounds---------- | | | | | | | | | | |
| ex. | 13 | 450 | 400 | 300 | 250 | 250 | 250 | 200 | 200 | 150 | 100 | 50 |
| ex. | 11-13 | 400 | 400 | 250 | 250 | 250 | 200 | 150 | 150 | 100 | 50 | 0 |
| ex. | 11 | 350 | 350 | 250 | 250 | 150 | 150 | 100 | 100 | 50 | 50 | 0 |
| med. | 13 | 600 | 450 | 450 | 350 | 300 | 200 | 200 | 200 | 150 | 150 | 0 |
| med. | 11-13 | 500 | 400 | 400 | 300 | 300 | 200 | 200 | 150 | 100 | 100 | 50 |
| med. | 11 | 350 | 400 | 250 | 250 | 200 | 200 | 100 | 100 | 100 | 100 | 0 |
| poor | 13 | 700 | 500 | 500 | 400 | 300 | 300 | 250 | 200 | 200 | 150 | 100 |
| poor | 11-13 | 650 | 500 | 450 | 350 | 250 | 250 | 200 | 200 | 150 | 100 | 100 |
| poor | 11 | 400 | 400 | 300 | 300 | 200 | 200 | 150 | 150 | 100 | 100 | 0 |

The forage quality and milk production levels indicate that the coefficients in line five are to be used. The grain feeding level change indicates that the coefficients of concern are 300, 200 and 200. The change in production

$$= \left(\frac{4500 - 4250}{500}\right) 300 + 200 + \left(\frac{5250 - 5000}{500}\right) 200 = 450 \text{ pounds.}$$

When forage quality is changed the transition constant represents a change of one in the quality index instead of 500 pounds of feed and the transition constants in Table 74, Part II, Appendix A are used. If both forage and grain feeding are changed, the model evaluates the changes separately and sequentially.

Machinery Costs

Machinery costs are divided into two groups; fixed and variable. Fixed costs include depreciation, insurance and interest. Depreciation is handled in a tax depreciation manner and thus depends solely on the purchase price and expected life of each machine on hand. Although it is recognized that some portion of depreciation may be due to wear and tear, the difficulties of measuring and enumerating this and the small proportion of depreciation usually represented by variable wear and tear makes the method used appear most appropriate. Interest and insurance are calculated as functions of the depreciated value of all machines.

The variable costs, which include repairs plus gas and oil, are specific to particular systems. For each system, two coefficients indicating the repairs and gas and oil costs appear in the group two parameter list. These cost parameters represent the expected annual repairs or gas and oil costs per unit of that system. The coefficients

used by the model are found in Table 69, Part II of Appendix A.

The economic implications of this procedure are shown in Figure 4.5. Average variable cost is a constant and represents the sum of repairs, gas and oil costs. Average fixed cost declines in the usual manner and average total cost is the vertical sum of the other two.

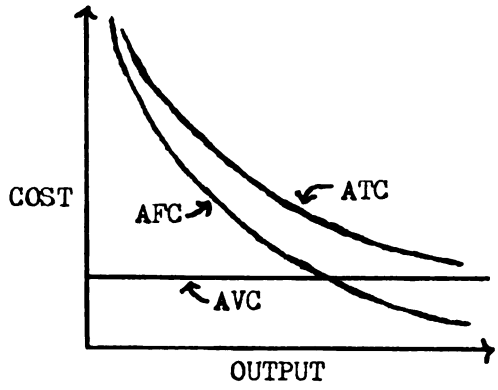



Figure 4.5. Machinery systems average costs.

Although it is generally assumed that average variable cost curve for inputs is U shaped or at least declines over the left segment of the curve, there appears to be little justification for that in this case. The items included in variable costs for machinery vary directly with the amount a machine is used. Although there is time involved in preparing machinery for use and carrying out other functions related to getting a system going, these activities rarely use gas and oil or cause repairs in themselves (except possibly for the pick-up truck). Even the time required to get to the field with a given machine will represent making more trips for larger acreage rather than on making better use of the trips required for a small acreage.

It is the specification of all machines used by each system that makes use of a horizontal average variable cost curve reasonable. Average variable costs will change (decline) as the level of output increases when the increased output implies use of larger and more efficient machines. Whether average variable costs will change (decline) when the same machinery is used more hours is much less clear. This model assumes they do not. In this model the variable machinery costs do change when systems are changed but the change in systems is explicit and involves a change to a specific machinery set.

Duplication of machines is carried out on an individual machine basis. Each machine has a capacity coefficient which represents the number of acres of a crop or crops the machine can handle. Whenever the number of acres of that crop or crops exceeds the coefficient, or an integer multiple of it, another machine of that type is purchased. This will effect the average fixed but not the average variable machinery costs. Assuming that Q represents the capacity coefficient for this system and that Q is applicable for all machines in the system, Figure 4.6 indicates the cost curves that are implied.

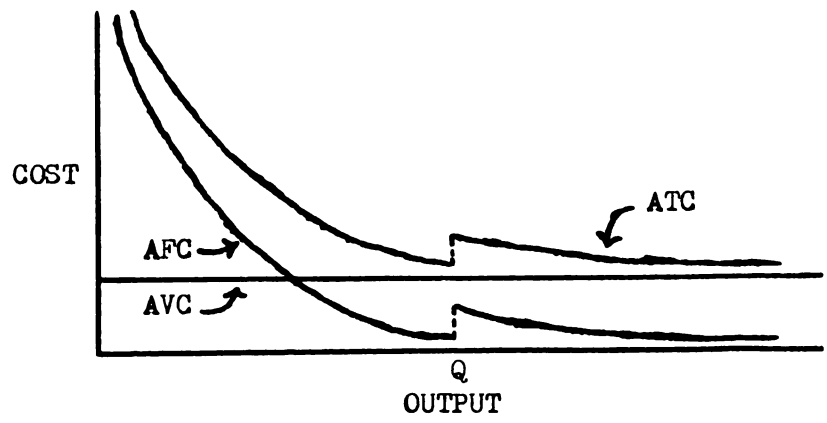



Figure 4.6. Effect of machine duplication on costs.

The variable machinery costs for crop grow systems are distributed throughout the year in the same proportions as the labor required. Costs for harvest systems occur during the harvest months and are distributed in proportion to the acreage harvested.

Labor Requirements

Labor requirements are specific to systems. Each system has an annual labor requirement which is presented in Tables 54, 55, 56 and 57, Part II, Appendix A. These, of course, can be changed as the user desires. The labor requirement listed for each system represents the expected labor required when the system's size is at the level at which this system is usually operated or would be constructed. This is equivalent to saying that the coefficients represent that level of operation at which the short run average labor requirement curve is tangent to the long run average curve or point A in Figure 4.7. If the wage rate were constant these curves would represent labor cost (with proper axis identification).

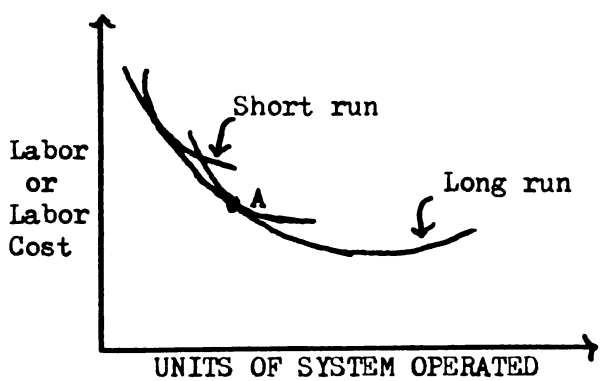



Figure 4.7. Average labor requirements.

Also included in the parameter list is a set of modification parameters for each crop system (Table 72, Part II, Appendix A). These parameters indicate the percent of the average labor requirement coefficients that would be incurred when the system is operated at other than expected or "normal" levels. In general these numbers increase from 1.0 as the level of operation is reduced from "normal" and declines from 1.0 as the level of operation increases. This provides short run average labor requirement curves of the form illustrated in Figure 4.7. Although these curves may turn up as indicated for the long run curve, there is little evidence to indicate that this actually occurs over relevant ranges of system operation. Actual curves for most systems appear to be quite flat or at least flatten out at relatively low levels of output.

Distribution of labor required for livestock and crop grow systems is carried out by use of distribution parameters (Table 71, Part II, Appendix A). These parameters indicate the percentage of the annual per unit labor requirement used during each month. The monthly per unit labor requirement is determined by multiplying the modified annual requirement by the distribution parameter.

When a crop is planted in two or more months, even when the same machinery is used, each month is represented by a different system. Thus, the labor distribution parameters are different for different planting months. The total requirement may also differ by month of planting. Harvest system labor requirements occur during the months of harvest and are distributed in proportion to acres harvested.

Product Prices

Prices of most farm products used in this model exhibit an annual seasonal pattern. To represent this seasonal pattern a set of monthly percentage coefficients was developed to indicate the expected relationship between the average annual price (weighted by months rather than quantity marketed) and individual monthly prices. Average prices for the most recent three year period were used to develop the monthly coefficients.

Although it was recognized that this procedure would often include some trend as well as seasonal fluctuation, it was assumed that relatively realistic prices would be obtained. Thus, for each commodity, thirteen coefficients are maintained; twelve monthly percentage coefficients and the annual average price.

To calculate the monthly price for any commodity the average annual price is multiplied by the percentage coefficient for the month in question. Using this procedure provides realistic monthly prices and allows changing the price level and the annual seasonal pattern separately. The coefficients used are presented in Table 53, Part II of the User Manual in Appendix A.

The prices used are average market prices. It is assumed that the market will buy or sell at that price. The difference between purchase and sales prices is determined by the commercial hauling rate. The effective purchase price is the market price plus the hauling charge for moving the product from the market to the farm. The effective sales price is the market price minus the cost of hauling to the market. This is equivalent to saying that the difference

between the at the farm price the elevator operator or feed mill will pay and the delivered price it charges is two times the hauling charge.

Machinery Set Specification

In order to reduce the quantity of input required for simulation, the model user is given a choice of either specifying the machinery on the farm being simulated or allowing the model to select a representative machinery set. To select a representative machinery set the simulator uses the three systems matrices (livestock systems matrix, crop grow systems matrix and harvest systems matrix). These matrices contain the parameter values indicating which machines are used with which systems.

For each machine the model first determines which if any systems being used require this machine. If any system in use requires this machine, the number units of each system using it, in conjunction with the maximum capacity coefficients described in the discussion of machinery costs, are employed to calculate the number of that machine required.

The assumed initial cost of each machine is taken from Table 68, Part II of the User Manual (Appendix A). This parameter list also includes the expected life of each machine. The ages of the machines are assigned consecutively according to three investment classes. The three classes are delineated as machines with a new cost of (1) under $2,000, (2) $2,000 through $5,000 and (3) over $5,000. That is, the first machine with a new cost of more than $5,000 is assigned an age of one, the second, two. The present value or depreciated value of

each machine is then calculated using the straight line depreciation method and the assigned age.

After this procedure has been carried out for each machine, the farm business has been assigned a representative set of used machinery that includes only those machines required by the systems being used. Further, the number of each machine on hand depends on the number of units of each system (number of animals or acres) found on that specific farm. Additions or deletions can then be made to the machinery set in the normal fashion.

The user should recognize, however, that provision has been made to allow entry of the actual machinery owned by the farm business and that such entry is encouraged. The closer the simulated machinery set replicates the real set, the better the simulated results should be. In fact the user can specify either just the number and kind of machines on hand or complete data about machinery on hand including purchase value, age and depreciated value.

Dairy Herd Initialization

Developing methods for generating appropriate starting conditions is often a problem in simulation model construction. This is particularly true when the system being investigated operates continually in a steady-state condition. It is often advised that the data obtained during an initial time period be excluded from consideration.[4]

The expected uses of this simulation model make discarding an initial time period of data impossible. The initial situation of the

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[4] Hillier, Frederick S. and Gerald J. Lieberman, Introduction to Operations Research, Holden-Day Inc., San Francisco, California, p. 462, 1967.

business being simulated is normally very important in determining the simulation results and the system being simulated does not really ever reach a steady-state condition. Other methods of solving the problem must be used.

Starting conditions are not a problem in this simulator except for the dairy herd. The dairy herd is simulated by maintenance of the herd matrix as discussed above. The starting condition problem is caused by the method used to handle culling and freshening. At the time each animal reaches breeding age for the first time or freshens, a random number is drawn which is used to determine whether the animal dies, is culled involuntarily (mastitis, disease, injury), is culled for low production or completes the lactation, and if the lactation is to be completed another random number is used to determine the next freshening date. All deaths occur at calving, involuntary culls are sold during the fifth month of lactation and low production culls are sold in the ninth month of lactation.

It is this assumption that each animal old enough to have been bred has been assigned sale or freshening dates that causes the problem. An animal in the tenth month of lactation obviously is not going to die or be culled that lactation (under model assumptions). The probability distributions used to determine the fate of that animal during that lactation must be adjusted to reflect that fact.

A set of conditional probability distributions were developed. The appropriate distribution to use depends on the number of months

the animals have been fresh. Let

$\alpha$ = the probability of dying,

$\beta$ = the probability of being involuntarily culled,

$\gamma'$ = the culling rate, and

= the number of months fresh

Then if $X \leq 5$ the probabilities are calculated given that the animal did not die.

The appropriate probability of being culled involuntarily is

$$\frac{\beta}{1 - \alpha}$$

and the probability of being culled for low production is

$$\frac{\gamma' - \beta}{1 - \alpha}$$

If $5 < X \leq 9$, the probability of being culled involuntarily is zero and the probability of being culled for low production is

$$\frac{\gamma'}{1 - \alpha - \beta}$$

This represents the probability of being culled for low production given that the animal neither died nor was culled involuntarily. If $X > 9$ the animal is not to be culled this lactation.

Use of conditional distributions in this manner allows specification of the herd characteristics at the day the simulation is started as needed for simulation. No warm up period is required for getting the correct starting conditions.

Building Capacities and Delays

Building requirements for both the dairy and storage are handled by use of capacities. The initial capacities are input by the user. Each time a factor changes which would require additional building

capacity, the capacity available is checked. The user uses decision rule parameters to specify whether buildings are to be built or animals and commodities to be sold when capacities are exceeded.

For the dairy herd capacities are calculated as a function of, but are not necessarily equal to, the physical number of stalls available and still not have capacity exceeded. The parameters used for calculation of capacity are listed among the group II Parameters. This procedure keeps temporarily greater than normal animal numbers from forcing building construction allows specification of an animal to stall ratio other than one. In addition it allows temporary relaxation of stalls per animal requirements while a building is being constructed.

A delay parameter is also used. This parameter is set equal to the number of months each dairy capacity must be exceeded before additional buildings are constructed. That is, if the parameter value is three, the number of cows must exceed capacity for three months before additional capacity will be automatically constructed.

Use of a delay parameter allows representation of some of the delays involved in building construction and can be used to force some of the costs which often accompany the process of increasing capacity. However, as a method of including such items as the time lag involved between the decision to build and the actual completion of construction, this procedure falls short. Much of the lag involved in this type of situation implies expenditure of management time on discussions, calculations and direction of construction. There may be little else involved which would change the value of simulation variables. The lag occurs more in the mind of the manager than in

alteration of physical or monetary characteristics of the firm business. For a contract job the additional facilities and the incurrence of their cost may indeed occur during the same month.

Further, to assume that actually exceeding capacity would be an important decision criteria for deciding to build additional capacity assumes that the manager lacks the desire or intelligence required to anticipate and plan for future firm building needs. For a well managed business exceeding capacity, the availability of new capacity and the incurrence of the cost of the new capacity could easily occur during the same month.

## Data Sources

An important dimension of the process of specifying the particular relationships or concepts included in a model is the data used. Inclusion of any relationship is always dependent upon finding data of sufficient quantity and quality to make model representation of the relationship realistic. In many cases the particular data available determines the exact way in which a relationship is included in the model.

The major problems of data collection are represented by two different situations. The first is the lack of data and in particular the lack of data in the correct form. In a number of cases the data desired for development of the model was not available because raw data had been analyzed to get averages rather than distributions or in some other manner which omitted the specific numbers desired for the model. In these cases, re-evaluation of the raw data is required. In other cases raw data which contained the numbers required did not

exist. The relationships which could have been included had appropriate data existed, of which weather is an example, were excluded from the model. Limited resources excluded the possibility of collecting the required data.

The second and possibly more serious problem is conflict or inconsistency between different sources of the same data. In numerous cases the two of three sources available for a particular coefficient or set of coefficients would vastly differ as to the correct value of those coefficients. Two different approaches to this problem were used. One is to develop a judgement weighted average of the sources to develop what is hoped to be superior coefficients. The second method is to accept one of the sources and properly footnote the data where ever it is presented. Both methods were used in collecting data for the FABS model.

The large number of coefficients included in the FABS model and the existence of a number of relationships, which should have been included in the model if there had been sufficient data, made the data collection process a lengthy one. A number of different sources were used. The sources used for the coefficients that are in the model are listed in Appendix C. Some of the other sources used are listed in the bibliography.

The magnitude of the data collection process implies something about the ease of updating the model. This will be discussed in a later chapter.

## Directions for Use

Use of the farm business simulator as it is presently designed involves use of the User Manual and Data Form 1 found in Appendix A.

The User Manual is divided into three parts. Part I contains the questions and data required for each business simulated. This corresponds to Part I on Data Form 1 and the data for the business indicated in Part I of the User Manual is recorded on Part I of Data Form 1.

Part II of the User Manual includes a listing of the parameters to be used by the simulator unless they are altered by the user. It is suggested that each user read through this part to see if there are any parameters the values of which should be changed in order to accurately simulate the business being considered.

User Manual Part III contains a discussion of the procedure used to change parameter values and make management decisions. The parameter value changes and management decisions for the alternative being simulated are entered in chronological order on Part II of Data Form 1. For each simulated month for which parameter values or management decisions are made, the entries on Part II of Data Form 1 indicating those changes must be preceded by a management decision record indicating the month and year in which the changes are to be made.

If there are parameter values in Part II of the User Manual which should be changed, then the parameters to be changed and their new values follow the first date record containing the first month and year simulated. Management decisions to occur during the first month are entered after the parameter changes. This is followed by

a date record indicating the next month in which parameters are to be changed or management decisions carried out which is followed by the specific changes to be made. In turn these changes are followed by a record indicating the next month for which entries are to be made.

All parameters in Part II of the User Manual and those in Part I that can be changed after initial entry are given identification numbers. These numbers are used whenever identification of a specific parameter is required. If the value of a specific parameter is to be changed, the change is accomplished by entering the parameter identification number and the new value.

When recording management decisions it must always be remembered that the model makes changes in the order in which they occur; even during one month. Thus, if a management decision requires new values for certain parameters these should be entered prior to entry of the decision itself. Conversly if a parameter is used for a management decision but the occurence of the decision makes a new value appropriate, the parameter value should be entered after the management decision.

After Data Form 1 has been completed, eighty column Hollerith cards are punched directly from the form. A different Data Form 1 must be completed for each alternative being considered.

# CHAPTER V

# TESTING AND APPLICATION

## General Problems of Validation

"...the problem of verifying or validating computer models remains today perhaps the most elusive of all the unresolved methodological problems associated with computer simulation techniques."[1] Although it is recognized that an unvalidated computer simulation model remains little more than a set of computer lanuage statements that will print out tables, graphs or plots, what constitutes validation, or even what procedures should be used during the validation phase, is yet to be conclusively determined.

Several different areas of concern contribute to the validation problem. The validity of a model is affected by the purpose or use for which the model is constructed. A model that is relatively valid for one use may be totally unsatisfactory for another. For example, a model designed and used for classroom teaching of management principles may contain many characteristics which make it useful for its intended purpose but be void in certain characteristics necessary for research or farm planning purposes. Any model is

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[1] Naylor, Thomas H. and J. M. Finger, "Verification of Computer Simulation Models," Management Science, Vol. 14, No. 2, p. B-92, October, 1967.

necessarily a simplification of its referent system and one useful method of simplification is to abstract from those characteristics of the referent system which are not essential for the intended use of the model.

It is usually difficult to determine the appropriate criteria to use in the model validation process. When a historical record on the system being simulated exists it is often recommended that the time paths of the values of important system variables be compared with the values of those variables as generated by the simulation model. However, this presents a problem of "how close" the two time paths should be. Which variables measure the goodness of fit of the simulated data? Even if this problem is surmounted there exists the problem that the historical time series represents only one sequence of conditions. Although the simulator closely replicates the historical time series, would it have done as well had the sequence of causal conditions been different? This can be illustrated by using the equation $Y = 2X_1$ to simulate the equation $Y = 2X_1 + 4X_2$. If during the historical time period $X_2$ was near zero, the simulator would do quite well. However, if the simulator is used for time periods when $X_2$ is large the model will do very poorly. Furthermore, the validation process can be expected to vary according to the specific criteria selected.

Most simulation models are complex. The number of relationships and variables is usually large. This makes it very costly, time consuming and practically impossible to check out the values of all variables under all possible conditions. In fact the purpose of most models is to predict the actions of a system under conditions

that have not previously existed to see what the value of certain variables might be. This means that some limited set of variables must be chosen without the assistance of any generally applicable set of decision rules.

Computer simulation models are often developed to simulate systems that do not exist. The nonexistence of the real system may even be the primary reason the researcher has turned to the simulation method. In this case there is no real world system with which to make comparisons. Any validating process or criteria which requires data from a real world referent system is inappropriate.

Use of validating criteria which require data from a real world referent system may also be inappropriate for systems that do exist. This occurs where the alternatives to be considered imply underlying conditions which differ widely from any that have been experienced by the real system. In this case there is no useful data for comparison.

The appropriate level of validation requirements depends on the availability of alternative models or methods of providing the data required. If projections must be or will be made, the most valid model or method should be used regardless of its absolute level of validity. Even the best method of weather prediction may be imperfect, but because predictions are required, it is used. Thus, determination of absolute criteria for separating valid from invalid models is impossible.

The extent and manner in which human participants are involved in the simulation influence the validation process. When human participants are used to represent actors in the reference system

their "representativeness" must be validated. Placing individuals in unfamiliar roles, requiring an individual to play a role inconsistent with his character or insufficiently motivating participants to act as they would in the real system (which may in fact be impossible) may all cause validation problems. When user-model interaction is involved the human participants used during validation must be representative of those expected to use the system. In many cases "representative" individuals may not exist, and even if they do a "representative" individual may not really test the extremes of the system.

Observations or measurements on the real system may be in error. This is particularly true when proxies or aggregations of variables are used in the validating criteria. Any measurement on a system is only an assertion about reality. Many characteristics about a system may not be measurable by any absolute scale or may be measurable only by indirect methods. Some undefined difference between the simulation system and the referent system can always be explained by measurement error. The magnitude of this difference influences the validity of verification measures.

Two General Approaches

Two reasonably comprehensive approaches to the problem of validity have been developed by Naylor and Finger[2] and Hermann.[3]

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[2] Ibid., p. B-95.

[3] Hermann, Charles F., "Validation Problems in Games and Simulations with Special Reference to Models of International Politics," Behavioral Science, Vol. 12, No. 3, p. 216, May, 1967.

The Naylor and Finger approach combines three methodological positions on verification to develop a multi-stage verification procedure.

The first stage of this procedure calls for the formulation of a set of hypotheses or postulates describing the behavior of the system of interest. This makes use of the rationalist approach which holds that any model or theory is merely a series of logical deductions from a set of unquestionable truths or assumptions "not themselves open to empirical verification or general appeal to objective experience."[4] It is not implied that a complete set of unquestionable truths exists for any model nor that each assumption must be an unquestionable truth. It does require a diligent search be made, using all information available, for a set of postulates or assumptions about the system which come as close to being unquestionable truths as possible and that the model be developed around these assumptions.

This is essentially a rejection of Friedman's[5] position that the validity of assumptions is irrelevant and a recognition that models can be expected to react properly under new or different conditions only if the causal relationships underlying the model are sound. Operationally, this stage involves use of the researcher's general knowledge of the system being simulated, any specific information available about the system and the results of the simulation

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[4] Blaugh, M., Economic Theory in Retrospect, Richard D. Irwin, Inc., Homewood, Illinois, p. 612, 1962.

[5] Friedman, Milton, "The Methodology of Positive Economics," in Friedman, Milton, Essays in Positive Economics, The University of Chicago Press, Chicago, Illinois, 1953.

of other "similar" systems to specify the components, select the variables and formulate the functional relationships to include in the model.

The second stage of this multi-stage procedure involves an attempt on the part of the analyst to verify the assumptions on which the model is based. Although using validation as part of the process of validation implies a certain level of circularity, what this stage calls for is the use of the "best" available statistical and non-statistical tests to empirically examine those aspects of the model to which such tests can be applied.

It is not suggested that the researcher should adopt an empiricist approach at this point and discard all assumptions that cannot be empirically tested. It is suggested that assumptions that can be tested be examined and that those found to be false by this procedure be rejected or replaced.

The third and final stage of this verification procedure consists of testing the model's ability to predict the behavior of the system under study. This stage represents the entire validation procedure as viewed by positive economics and assumes that the basic purpose of the model is prediction. In order to test the degree to which data generated by the simulation model conform to observed data, two alternatives are available; historical verification and verification by forecasting. For historical verification the historical record produced by the system being simulated is used to check the accuracy of the simulation model. Verification by forecasting requires use of the model to forecast the future path of the system being simulated and then comparing the actual path traveled with the model generated

forecast. The final decision concerning the validity of the model must be based on its ability to predict the time path of the system being simulated.

This multi-stage verification procedure treats validation as a continual process throughout model development instead of a test of the model after it is developed. Each stage of model construction involves a stage of validation. Although this method does not solve a number of the problems of validation it does provide a constructive approach for developing more valid models.

In an attempt to develop criteria with which to measure the validity of a model, Hermann presents five types of validity criteria. The first, internal validity, refers to the between-run variance when the initial conditions and any exogenous inputs introduced during simulation runs are constant across all runs. The smaller the between-run variance the greater internal validity is assumed to be. When the observed results of an operating model can be attributed to extraneous factors rather than internal model relationships, internal validity is low. The critical requirement for internal validity is that variation be accounted for by identifiable relationships within the simulation.

This criterion is of dubious value. Any model with stochastic elements will have between-run variance which is attributable to the interaction of those stochastic elements. This may legitimately be large if the variance of the model probability distributions is large. Minimum between-run variance would always occur with a deterministic model even though it might be less realistic and could include inappropriate relationships. Thus, a check for

internal validity can at most involve an observation of whether the values of variables are always within the range of possibility given various values of other variables.

The second criterion is face validity. Face validity is a surface or initial impression of a simulation's realism. A general impression that the model "looks good" or that "things don't seem right" can be an important check on the real world representativeness of the model. Bayesian statistical concepts may be useful in evaluating face validity. The most severe limitation of this criteria is that in some cases the experimenter will not know what behavior is "realistic", often because determination of realistic behavior of the system is the reason for constructing the model. Another problem is the lack of any explicit validity criteria.

Variable-parameter validity involves comparisons of simulation variables and parameters with their assumed counterparts in the real world. This third criterion involves direct comparison of simulation values with real world values and sensitivity analysis to compare the model response to variable value change to the real world response of changing the value of that variable. The primary advantage of this approach is that it isolates individual components of the simulation. It is thus possible to determine which particular features may be reducing the representativeness of the model. The primary disadvantage of applying variable-parameter validity is that a large model will have numerous variables and sensitivity analysis becomes a laborious process.

The fourth criterion employs "natural" events which occur in the referent system as criteria against which to compare outcomes

occurring in the simulation. Event validity may refer to either the magnitude or the occurrence of an event. Because most events are the result of the interaction of several relationships and variables, event validity may be quite useful for checking the total simulation or major sectors of the model. It is less useful, however, in discovering the exact parts of the model in which problems occur. The second problem encountered with event validity is the selection of the appropriate events and dimensions of those events which should be used in comparing occurrences in the simulation with its reference system. There is also the problem of determining the proper weight to give the importance of each event.

The last type of validity criterion is hypothesis validity. This is essentially a testing of the validity of the relationships in the model. If, in the real system X bears a certain relationship to Y, a corresponding relationship between model system $X^1$ and $Y^1$ should be present. In this case it is the relationships between variables that is important rather than the variables themselves although there is a certain degree of correspondence between the variables and relationships.

By combining these five types of validity criteria Hermann develops a unified approach to validation. "In the initial construction of the simulation or game as well as during its operation, face validity is appropriate because of its ease and simplicity. To establish the degree of control and stability available in the operating model,

internal validity should be conducted soon after the model's development."[6] Following internal validity checks, event validity criteria are applied by using the model on a number of real situations and paying close attention to all of the results generated. This phase may involve normal research or use of the model in its intended application. Whenever the results of a simulation or number of simulation runs produce results with an unacceptable divergence between the operating model and the observable reference system, variable-parameter and hypothesis validity criteria should be applied. Although these can be applied earlier to any variables or relationships which the researcher questions or is unsure of, general variable-parameter and hypothesis testing is not carried out because of the cost and size of the task.

Both of the approaches to validation outlined above provide only a procedure to use and a general idea of what to look for. Regardless of the approach or the criteria one only finds evidence to support or reject the realism of certain aspects of the model. "Certainly, the establishment of validity for one variation and one set of conditions does little to establish the virtue of other variations of the model.[7] This leads one to accept the Popper[8] philosophy that a model attains a degree of validity as it passes

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6 Hermann, op. cit., p. 226.

7 Conway, R. W., B. M. Johnson and M. L. Maxwell, "Some Problems of Digital Systems Simulation," Management Science, Vol. 6, No. 1, p. 104, October, 1959.

8 Popper, Karl R., The Logic of Scientific Discovery, Basic Books, Inc., New York, 1959.

tests designed to examine its validity. The more difficult the tests and the greater their number the greater the validity attributed to the model. Only when the model fails a test is anything conclusively determined.

In line with this basic philosophy, the validation procedures reported in this paper do not represent an exhaustive verification of the model developed. That is left for future papers. An attempt has been made, however, to show that the model does provide a reasonable representation of certain situations and that it may indeed be useful for those situations for which it was designed.

The validation procedures carried out for the FABS model consisted of four separate activities. During and immediately following development of the model a number of hypothetical problem situations were used to test the variables calculated for reasonableness and consistency. Two farm situations were developed which between them required use of all of the user defined systems. The model was used on an actual farm planning problem and an example research study was carried out using the model. These are discussed below.

## Variable and Subroutine Testing

The model was developed on a subroutine basis. After each individual subroutine was written it was run a number of times for given data situations and the results checked against the expected results which had been calculated independent of the model. This served two purposes. First, it was a check on the programming. No subroutine was correctly written the first time. Most subroutines

were run several times with major programming corrections after the initial runs and minor corrections after later runs.

Second, it served as a check on the model logic. Although considerable effort was made during conceptual development of the model to design a complete and consistent model, a few cases were found where important variables or relationships were ommitted or only partially specified.

After each subroutine appeared to be working it was run with certain important subroutine variables set at extreme values. This was designed primarily to be sure that the model would not "blow up" when extreme values were used, that the model was reacting in the right direction and that the output variable values were reasonable in magnitude.

After all of the subroutines were written and tested, the complete model was put together and tested. Three different hypothetical situations of increasing complexity and a number of variations of the more complex situation were used to test the complete model. This process focused on compatibility errors between the subroutines and proper functioning of the interactive elements of the model which involved more than one subroutine.

This procedure required numerous runs and is in fact a continuous process which will continue as the model is used in more situations. A major problem which is encountered at this stage of model construction is separating those relationships or variables which were ommitted from the model but should be included if it is to function properly from those that "it would be nice if they were included."

## Test of User Defined Systems

The user defined systems were developed to allow complete latitude in the types of systems that could be handled by the model. However, the lack of definition means that these systems must be incorporated into the model in a general framework. To test the operationability of these systems, two different farm situations were developed.

The first situation involved a large farm operator who was faced with the problem of deciding whether to purchase six or eight row equipment. The model contains six-row systems but not eight-row systems. Thus, to compare these alternatives the crop enterprise user systems have to be defined as eight-row systems and the appropriate data developed for input.

The input data required for use of the user defined systems is a list of the appropriate values for (1) variables that are used only by the user system(s) selected and (2) those variables that are also used by standard systems for which new values are required to reflect the characteristics of the specific user system(s) selected. The variables specific to user systems are limited to question 52, 54, 56, 57, 65, 66, 68, 69, 70, 71, 72, 80(a), 80(b), 80(c), 80(d), 81, 82 and 83 found in Part II of Appendix A. All of these variables are entered as coefficient value changes at the beginning of (before) the first month simulated. The fact that the user defined systems have been chosen as the systems in use in Q.19, Part I will cause all of the input variable values to be used.

For the eight-row system comparison, the data required consisted of (1) eight-row machine costs and life, (2) the labor requirements

for systems using the eight-row machines, (3) the operating costs for the eight-row machines, (4) the capacity of the eight-row machines, and (5) specification of the systems, which used the eight-row machines.

The results which can be generated by the model for evaluating the effects of user defined systems is voluminous. Some factors which might be important for the six-row, eight-row comparison are labor requirements, labor distribution, machinery costs and income measures. Although this comparison was made only to check the ability of the model to handle user defined systems and the data generated is specific to a particular hypothetical situation, examination of some of the data provides interesting insights about the model. Selected financial data from the comparison of the two alternatives is presented in Table 5.1.

Table 5.1. COMPARISON OF SIX AND EIGHT ROW SYSTEMS

Simulated Financial Data, 1971

| System and Year | Hired Labor | Gas & Oil | Machinery Repairs | Machinery Depreciation | Return to Labor & Mgt. |
|---|---|---|---|---|---|
| Eight-row crop systems | | | | | |
| year 1 | $13,800 | $3,701 | $2,692 | $17,483 | $16,035 |
| 2 | 13,800 | 3,765 | 2,727 | 17,483 | 13,171 |
| 3 | 13,800 | 3,753 | 2,721 | 17,483 | 18,542 |
| 4 | 13,923 | 3,924 | 2,813 | 17,483 | 17,789 |
| 5 | 13,945 | 3,977 | 2,841 | 17,483 | 22,571 |
| Six-row crop systems | | | | | |
| year 1 | $14,952 | $3,864 | $2,844 | $16,293 | $15,220 |
| 2 | 14,909 | 3,927 | 2,878 | 16,293 | 11,108 |
| 3 | 15,158 | 3,915 | 2,872 | 16,293 | 16,317 |
| 4 | 15,536 | 4,087 | 2,964 | 16,293 | 16,683 |
| 5 | 15,791 | 4,139 | 2,992 | 16,293 | 21,421 |

Hired labor, gas and oil and machinery repair costs are lower with the eight-row system. Although increased machinery depreciation partially offsets this, return to management and labor is higher for the eight-row system. The differences in the first four columns listed do not sum to the difference in return to labor and management because of the differences in insurance, interest (both the total investment and the ratio between owned and borrowed capital vary) and miscellaneous expense (which is a function of total other expenses).

Gas and oil as well as machinery repair costs show a negligible decline during year three. This is caused by a decline in the average number of heifers for that year which more than offsets the slight increase in cow numbers (see Table 5.2) and thus a lower machinery repair, gas and oil costs for the dairy enterprise. It should be noted that these cost differences are exactly the same for both systems and thus do not effect the comparative results of the two systems. Although there are stochastic elements in the dairy subroutine, the random number generator always generates the same sequence of random numbers. This means that any two runs with exactly the same initial dairy situations and the same coefficient changes and management decisions will have identical dairy enterprise numbers, costs and returns. Thus, a comparison of two cropping systems such as this will have exactly the same dairy and crop acreage situation.

Table 5.2. COMPARISON OF SIX AND EIGHT ROW SYSTEMS

Simulated Physical Data, 1971

| System and Year | Average No. of Cows | Number of Heifers | Labor Hours | |
|---|---|---|---|---|
| | | | Surplus Regular | Hourly Hired |
| Eight-row crop systems | | | | |
| year 1 | 128 | 72 | 2755 | 0 |
| 2 | 121 | 99 | 2722 | 0 |
| 3 | 122 | 90 | 2759 | 0 |
| 4 | 137 | 99 | 2091 | 62 |
| 5 | 140 | 98 | 1932 | 72 |
| Six-row crop systems | | | | |
| year 1 | 128 | 72 | 1696 | 461 |
| 2 | 121 | 99 | 1651 | 448 |
| 3 | 122 | 90 | 1770 | 531 |
| 4 | 137 | 99 | 1205 | 695 |
| 5 | 140 | 98 | 1123 | 783 |

The existence of identical dairy and crop acreage situations does not, however, limit the interactive features of the model. As indicated in Table 5.1, the labor cost declined slightly in year two for the six-row system. No comparable decline was experienced for the eight-row system. The fact that the crop acreage is the same for both systems could lead one to conclude that this decline was caused by the dairy enterprise, and it was. Dairy cow numbers and thus dairy enterprise requirements declined during year two (see Table 5.3). However, this decline occurred for both the six and eight row systems. The decline in labor cost for the six-row system occurred because the decline in livestock labor requirements allowed the hiring of less hourly labor. There was no corresponding decline for the eight-row system because the lower total crop requirements provided a situation where no hourly labor was hired. The operator and regular (full time) hired labor provided more than sufficient labor to handle both crops and livestock for the first three years.

Table 5.3. COMPARISON OF MONTHLY LABOR REQUIREMENTS

Simulated Data, 1971

| Year and Month | Six-Row System | | | Eight-Row System | | |
|---|---|---|---|---|---|---|
| | Livestock Labor Required | Labor After Crops* | Hourly Labor Hired | Livestock Labor Required | Labor After Crops* | Hourly Labor Hired |
| Year 1 | | | | | | |
| Jan. | 524 | 881 | 0 | 524 | 895 | 0 |
| Feb. | 534 | 890 | 0 | 534 | 903 | 0 |
| Mar. | 555 | 792 | 0 | 555 | 821 | 0 |
| Apr. | 554 | 682 | 0 | 554 | 770 | 0 |
| May | 523 | 659 | 0 | 523 | 751 | 0 |
| June | 517 | 569 | 0 | 517 | 663 | 0 |
| July | 527 | 472 | 55 | 527 | 536 | 0 |
| Aug. | 535 | 552 | 0 | 535 | 678 | 0 |
| Sept. | 533 | 726 | 0 | 533 | 821 | 0 |
| Oct. | 527 | 269 | 258 | 527 | 756 | 0 |
| Nov. | 542 | 395 | 148 | 542 | 806 | 0 |
| Dec. | 559 | 769 | 0 | 559 | 786 | 0 |
| Year 2 | | | | | | |
| Jan. | 560 | 881 | 0 | 560 | 895 | 0 |
| Feb. | 561 | 890 | 0 | 561 | 903 | 0 |
| Mar. | 564 | 792 | 0 | 564 | 821 | 0 |
| Apr. | 554 | 682 | 0 | 554 | 770 | 0 |
| May | 530 | 659 | 0 | 530 | 751 | 0 |
| June | 520 | 569 | 0 | 520 | 663 | 0 |
| July | 534 | 472 | 61 | 534 | 536 | 0 |
| Aug. | 533 | 552 | 0 | 533 | 678 | 0 |
| Sept. | 528 | 726 | 0 | 528 | 821 | 0 |
| Oct. | 512 | 269 | 243 | 512 | 756 | 0 |
| Nov. | 539 | 395 | 144 | 539 | 806 | 0 |
| Dec. | 529 | 769 | 0 | 529 | 786 | 0 |

* Hours of labor available after meeting crop requirements (inequality of row totals is caused by rounding).

This example illustrates one of the advantages of a complete farm business simulator. The effects of a change on the entire farm business are calculated. An ordinary partial budget or machinery investment simulator would normally assume that the entire quantity of labor saved from using the eight row system would be reflected in a reduction of labor expense.

This also illustrates the advantages of a detailed simulator with detailed output possible. Without the degree of detail inherent in this model the reason for this decline in labor cost, or possibly even the decline itself, would have been lost.

To check out the livestock user systems, a parlor-stanchion system was developed and input as a user system. This was compared with the stanchion system which is defined within the model. The results indicated decidedly lower labor costs which were partly offset by higher machinery operating costs and machinery depreciation, but a higher return to labor and management with the stanchion-parlor system.

As was the case for the eight-row and six-row crop systems comparison, the particular data generated is important only to the extent that it indicates the degree to which the user defined systems are operational. The data generated for both of these comparisons were inspected by a Michigan State farm management specialist and by the author. Visual inspection and comparison with budgeted data were used to evaluate the appropriateness of the results generated. In both cases the results were judged to be appropriate and apparently complete. Thus the user defined systems can be used to handle systems other than those specifically defined within the model.

Experience with these two situations, however, did indicate that the volume of input data required to change a majority of the systems in use, such as all crop systems when the eight-row crop machinery alternative was considered, is so large that such a change will likely be limited primarily to research application of the model. Cases where only a few user systems are required could be handled in many extension situations.

## Farm Planning Problems

A major development focus of this model has been farm planning. To test the potential usefulness of the model for farm planning problems, the model was used in two actual farm planning situations. The problem situations involved two college seniors, one who was planning to return to the home farm and one who was planning to start farming on his own. The basic results of these two tests of the model were nearly identical. Thus, only the first situation will be reported in detail.

For this situation, the farm, presently operated by the father, was too small to support two families. The alternatives being considered were two different approaches to increasing size of business. Although both alternatives involved increasing herd size, there were major differences in timing. The first alternative called for immediately building a new barn and buying bred heifers. The second alternative placed immediate emphasis on increasing youngstock numbers and delayed barn building for approximately one year. The labor, feed use, cash flow, debt and income characteristics were of primary concern.

The input data required for this problem consisted of one copy of the data indicated in Part I of the Users Manual (Appendix A) plus one set of coefficient changes and management decisions for each alternative being analyzed. Because of his familiarity with the actual farm situation, the student had little difficulty in providing the data required. In fact, both students were able to provide the data required with relative ease. However, this may provide a weak test of the degree of ease or difficulty with which other potential users may be able to provide the data required. These students had been exposed to farm business simulators in a class they were just completing and both were practically college graduates. Many farm managers have neither of these characteristics. However, because this model will be used by only the larger commercial farmers, most potential users would have either or both some college education and extensive extension experience. Thus, they may be just as capable of providing the data required as the students were.

The output data which can be generated for a farm planning problem, is indicated in section 21.1 of Appendix B. Much of the annual financial and physical data are output in the same format as that used by Telfarm and other farm accounting systems. Monthly physical and financial data are also generated. The actual data reported should depend upon the particular problem being analyzed and is determined by the user as part of the Part I (Users Manual, Appendix A) data requirements.

For the problem considered, the simulator was instructed to report data on monthly labor use, monthly and annual feed use, monthly cash flow and annual debt and income. Examples of the types of information

generated that were considered important to the problem can be indicated. The monthly labor data showed that the existing family labor would be able to handle the increased size of business regardless of the timing of the change except for the month of July when approximately 100 hours of labor would be needed. The feed use data indicated that a considerable amount of oats and shelled corn would have to be purchased in the spring and summer respectively after the herd size was increased. The cash flow summaries showed that, although there was no build up of short term debt over time with either alternative, making the change in the first year increased the total short term over the first two years by approximately $8,000.

Debt and income data indicated that although average incomes were only slightly higher (less than $1,000) for the first alternative and the maximum debt levels were approximately the same ($71,500 and $70,900) cattle numbers increased somewhat faster with the first alternative. The most unfavorable equity situation (.63) was achieved by the first alternative. This occurred during the first year, but is not considered an excessively risky situation. The lowest equity ratio achieved by the second alternative occurred during the second year when the equity ratio was .68.

Experience in using the model on these planning problems exemplifies the advantages of having experienced management personnel available to assist in preparation of input and interpretation of output. This is a learning experience similar to that of working through a budgeting problem. Having an experienced person available to provide guideline data and ideas and to question the validity of any data input which appears unreasonable helps individuals work

through the input and interpret the results to their problems. This is the educational role which could be played by extension personnel.

For the two situations discussed here, exact specification of the input and inspection of the output led to a number of changes in the alternatives being considered. Each problem used three computer simulation runs of each alternative. Although the third run was usually run out of curiosity and because it was free, the second was generally required for an acceptable answer to the problem.

For example, the problem situation being discussed in detail started out with a ten percent culling rate and a three and one-half ton hay yield on land with a rental rate of three dollars per acre. Discussion of the probability of being able to maintain a ten percent culling rate in the future (it did accurately represent the most recent past) caused him to change the input coefficient. When he observed the resulting production and crop sale levels brought about by the hay yield level, greater effort was made to determine the actual average rate and the yield coefficient was adjusted to a more reasonable rate.

Experience gained in working with these two situations indicated that this model could be used to generate data for use in a management by exception context. Much of the data generated is in the same form as farm accounting system summaries. All of the data is generated to be specific to a future point in time, and thus is a relevant benchmark against which actual accomplishment can be compared. Such benchmark data would be both forward looking and specific to the particular situation being considered.

## A Research Problem

A small research study was carried out to illustrate the usefulness of the model for research. The topic chosen was a comparison of fall versus year-round freshening of the dairy herd. This makes use of the monthly time period of the model and is a real economic problem in dairying. The milk price advantage of fall freshening is easy to see. However, with year round barn feeding, production may no longer be influenced by season of freshening and labor, building and machinery utilization efficiency may be significantly improved with year-round freshening.

The initial farm situation used was an actual farm business with a fall freshening herd. DHIA and Telfarm data were used to construct the initial farm situation. It was assumed that there was no effect of season of freshening on production. The desired seasonality of freshening was indicated by the freshening preference schedule. The freshening preference schedule is input in question 8, Part I (Users Manual, Appendix A) and indicates the desired age of freshening for animals by the month of year in which they are born. That is, if it is desired that an animal born in January freshen in July, the desired age of freshening is 30 (assuming that freshening at 18 months of age is unacceptable). The freshening preference schedules used are shown in Table 5.2. All other factors in the business were the same for both alternatives.

Table 5.4. DESIRED AGE OF FRESHENING

| Freshening Pattern | Month of Birth of Animal | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
| | ----------Freshening Age Desired (months)---------- | | | | | | | | | | | |
| Fall | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 24 | 24 | 23 | 22 | 21 |
| Year Round | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |

To avoid the problem of attempting to construct two comparable herd situations for these two different situations, the same initial herd was used with the ages of the youngstock adjusted to reflect prior attempts to achieve the desired freshening pattern. A ten year run was made with the first five years assumed to be transition years and thus not used.

The output reports or tables of simulator generated data which can be printed out for a research problem are the same as those available for farm planning problems. The format and data contained in these reports are indicated in section 21.1 of Appendix B.

The results of this analysis indicated a slightly higher average return to labor and management and a somewhat larger average herd size with year-round freshening. The first five years simulated (transition years) show this difference slowly developing. However, it should not be concluded from this data that year round freshening is superior. Insufficient prior study was carried out to be sure that all of the proper variables were held constant or varied. The problem should be run a number of times under slightly different conditions to be sure that the freshening pattern is causing the difference.

Further, the results apply only to areas with blend pricing systems. As presently designed, the model will not handle problems using base-excess pricing except where the average price to be used can be input. The exercise was carried out and reported here only to illustrate technique.

A second approach to research problems is to use the simulator as developed as the basic model but make slight programming changes to allow more complete study of the problem being investigated. For example, one interested in looking at the effect of year-round versus fall freshening under a base-excess pricing system could modify the milk price generating procedure, to reflect base-excess pricing. This allows consideration of significant and varied research problems with little actual programming on the part of the researcher.

# CHAPTER VI

# MODEL COST AND MAINTENANCE

There are three different types of costs involved in developing and using a computerized simulation model. These are (1) development costs, (2) operation costs, and (3) maintenance costs. This chapter discusses these different costs for the FABS model.

## Development Costs

The size and complexity of the FABS model made the development costs high relative to a number of other computer models that have been constructed. The author spent approximately one year developing the model and getting it on the computer. In addition one programmer worked full time and two others worked part time for nearly four and one-half months.

As previously indicated, a realistic estimate of the real cost of the computer use required for model development is difficult to determine. Although the marginal cost to the Department of Agricultural Economics was estimated at less than $200, the opportunity cost was undoubtedly much higher.

To make a rough estimate of the minimum development costs, the actual amount paid the author and an $8,000 per annum salary for programmers can be assumed. This provides a minimum cost of

approximately $10,850. Although a major portion of this can be charged to graduate education, it is still a cost of model construction.

## Operating Costs

Actual operating costs can be expected to vary widely from computer facility to computer facility and from problem to problem. However, estimates can be made which provide an indication of the costs that are likely to be incurred.

Operating costs can be divided into two cost groups: (1) computer use costs and (2) user preparation and interpretation costs. Three major factors influencing the computer cost of using this model are the number of years simulated, the quantity of print output and the number of alternatives considered. For most farm planning situations a three year simulation length seems most likely. This provides one year of change, a year of transition and a reasonably "normal" year of operation after the change. The quantity of print required depends on the problem. A number of problems would require only one-fourth or one-half of the reports available. Others would require all or nearly all. For this reason cost estimates are made for twenty-five, fifty and one-hundred percent of the total estimated print. The problem assumed is a typical or model type of problem with only a moderate number of management decisions. The cost estimates will be made for Michigan State University's CDC 3600, the computer on which the model was developed, and the Detroit based DACC teletype system.

Costs for operation of the CDC 3600 were estimated at $4.10 per minute of computer time plus a card input charge of $0.50 per thousand cards read in and a print charge of $0.20 per thousand lines printed.[1] Experience in using the model indicates that the computer time for a three year period is approximately 95 seconds. Assuming the model is on tape, card input would normally be under 200 cards (if tape is not used either a 9,000 card Fortran deck or a 5,000 card binary deck would be input). If all reports are printed, total print is approximately 600 lines per simulated year. Thus, for a three year run there would be a $6.50 computer cost, a $0.10 card input charge and a $0.36 print charge for a total of $6.96. The cost, if the reports required amount to only one-half or one-fourth of total print, are $6.78 and $6.69 respectively. If two alternatives are being considered, the cost of analyzing the two situations would be approximately $13.44.

The DACC system is a somewhat slower system with an estimated CPU time of ten seconds per simulated year instead of the seven seconds estimated for the 3600. The costs of using this system are divided into three parts; CPU time, connect time and storage. The costs for these are $0.15 per second prime time ($0.12 per second non-prime time), $9 per hour and $1 per thousand characters per month after the first 75 K.

The most difficult of these cost items to estimate on an individual use basis is storage charges. The total cost is a flat monthly

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[1] Estimate by Laura Robinson, Chief Programmer, Department of Agricultural Economics, Michigan State University.

fee based on the size of the program irrespective of the number of times per month the program will be used must be made. Such an estimate is complicated by the fact that the total cost of using the program will influence the frequency of its use.

To allow preparation of estimates it will be assumed that the program is used by ten users per month with an average of two alternatives considered per user. Using an estimate of 256 K as the total program size, the monthly storage charge is $181. This amounts to $9.05 per use.

The duration of connect time required depends on the amount of input and the quantity of print. For the FABS model connect time per simulated year is estimated at ten minutes for input and processing assuming paper tape input, and sixty minutes for print assuming all reports are printed. For a three year run this means connect charges of $31.50 with all print, $18.00 with fifty percent of print and $11.25 with twenty-five percent of print. The corresponding total costs are $45.05, $31.55 and $24.80 respectively. Thus a two alternative comparison would cost from $50 to $90. Table 5.4 presents cost estimates for a number of simulation periods using similar calculations. Costs for a two alternative comparison would be approximately double the figures given.

Table 6.1. ESTIMATED COMPUTER COSTS

FABS Simulator, 1971

| Computer and Amount of Print | Number of Years Simulated | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 10 |
| CDC 3600* | | | | | | |
| All print | $2.62 | $4.78 | $6.96 | $8.78 | $10.61 | $17.70 |
| ½ print | 2.56 | 4.66 | 6.78 | 8.54 | 10.31 | 17.10 |
| ¼ print | 2.53 | 4.60 | 6.69 | 8.42 | 10.16 | 16.80 |
| DACC** | | | | | | |
| All print | $21.05 | $33.05 | $45.05 | $57.05 | $69.05 | $129.05 |
| ½ print | 16.55 | 24.05 | 31.55 | 39.05 | 46.55 | 84.05 |
| ¼ print | 14.30 | 19.55 | 24.80 | 30.05 | 35.30 | 61.55 |

* Computer run times assumed were 35, 65, 95, 120, 145 and 240 seconds for 1, 2, 3, 4, 5 and 10 year runs respectively.

** Prime time rates.

The cost advantage of using the CDC 3600 computer whenever batch processing and a one or two day delay in printing output will not cause problems is obvious. However, the costs of using the remote access teletype system are not of such a magnitude as to preclude its use. The costs indicated here would be more than offset by a one percent saving on most investments presently being made.

The second type of operating cost is the user cost involved in preparing the data for input to the computer and interpreting the results. The first time the model is used by any one user, some time would be required to explain the model. Although this would provide a useful format for discussion of the particular problem in question, this discussion might proceed faster if a known technique such as budgeting were used. On the other hand, because the input forms ask the questions and list the variables to be used, the

enumeration of the problem situation and the alternatives to be considered may proceed faster than an open ended technique such as budgeting.

Other than these somewhat offsetting items the major preparation cost involved is punching the cards for batch processing or preparing the paper tape for remote access (or typing in the data directly if tape is not used). There are a minimum of 47 cards (or lines) of input data. Although there is no set maximum number of cards or lines, in most cases the number would not exceed 75. Punching and verifying this much data should not require over one-half hour of clerical or user time.

Interpretation of the results of the simulator would normally require more time than interpretation of the results of a budget that had been developed by its users. The exact meaning of a number of the variables would need to be discussed. This is in spite of the fact that an effort was made in designing the output reports to use variables and terminology as defined in Telfarm reports or as normally used by farmers. The degree to which this would increase interpretation time would depend upon the complexity of the farm situation and the user's degree of familiarity with the terminology used.

## Maintenance Costs

There are two costs involved in maintaining a model such as this. One is the cost of maintaining the program to keep it consistent with the software and hardware changes made by the computer facility to be used. Practically every computer facility is continually improving its software. In addition, the constant development of "new, bigger

and better" computers brings about frequent hardware changes. To keep a program working on a long term basis requires continual adjustment of the program to keep it compatible with the computers used.

The costs involved in this type of maintenance depends on the computer facility used and the frequency and magnitude of changes made. Any cost estimate would necessarily be short range and would depend on changes programmed to be made.

The second and more important maintenance cost is the cost associated with keeping the model updated. The coefficients included in the model must be periodically examined and changed to represent more recent experience and environmental conditions.

As pointed out in the discussion of model relationships and data sources in Chapter IV, finding appropriate coefficient values for a model as large as the FABS model is a difficult and time consuming task. Although the presence of "a value" which is referenced makes the updating job much easier than developing the appropriate coefficients when the model is initially constructed, finding new values for 3600 parameters remains a job of significant proportions. Some coefficients will require little thought or will be easy to get; such as mature equivalent coefficients or data from Telfarm reports. New values of other coefficients will be as hard to get as the originals.

The cost or time involved in updating this model is difficult to estimate prior to development of experience in updating models of this type. Based on the time required in developing the model, a

rough minimum estimate would be two weeks time by a well trained Agricultural Economist familiar with the types of data required.

## User Charges

A major factor influencing the demand for a computerized tool of analysis such as the FABS model is its cost to users. It is clear that the user should be charged for the operating costs, both for preparation keypunch work and actual computer and telephone charges. This is the actual cost incurred by the user and thus should be borne by the user.

However, the proportion of the development and updating costs which should be incorporated into the cost of using the program depends on your frame of reference. Viewed as a commercial venture, all costs must be covered by the users. Thus, a charge for development and updating must be included in the user charge. On the other hand model development and updating can be viewed as a public good. The cost is incurred only once regardless of the number of times the program is used. Viewed from this point of view none of the development and updating costs should be incorporated into the user charge.

This difference in viewpoint provides the basis for the difference of opinion about appropriate user charges between universities, which view development and updating as a public good, and the commercial firms which would like offer these services but find themselves in direct competition with the universities.

# CHAPTER VII

# POSSIBLE EXTENSIONS

Several possible extensions or modifications of the present model could be made. Although some of these extensions could be expected to improve performance of the model for the purposes for which it was originally designed, most of the potential extensions discussed below would either extend the scope of the model and make it applicable to additional problem areas or reduce the user burden involved in operation of the model. The extensions discussed include possible algorithm modification, use of teletype, separation of the subroutines and generalization of the model to more enterprises.

It should be pointed out that all of the possible modifications discussed in this section are dependent upon first placing the model on a larger computer, developing overlays for part of the present program or otherwise generating additional usable core space. With the computer presently being used there is practically no available memory remaining for additional variables or program.

## Possible Algorithm Modification

In any model of the type developed here, many minor algorithm changes could be made which would make the model more appropriate to a specific problem or a specific personal point of view. The

possible algorithm modifications suggested here include only those which would be expected to have a major effect on the model or use of the model.

## Price Level Change Parameters

In the model as presently designed any change in price levels or price relationships must be input by the user. This has the advantage that prices are known and that any price level or relationship can be input that the user desires. Also, this represents a very reasonable assumption if prices are expected to be constant through time. However, if prices are likely to be continually changing, as they have in the past few years, a large burden is placed on the user to input price changes for each year, or in some cases each month, if absolute prices are to be realistic. Even though the relative price relationships may remain correct through time the absolute values of variables will not. If absolute price levels become incorrect the output from the model becomes of little value as a data generator for management by exception.

To handle situations where continuous inflation (or deflation) is expected in all or a number of variables price level change parameters could be inserted. This would be accomplished by using parameters which have an initial value of one and expected price level changes would be represented by changing (either endogenously or exogenously) the values of these parameters. Insertion of these parameters such that they enter into the calculations in a multiplicative fashion allows use of constant prices by changing the values as the model moves through time.

By using a set of parameters with each parameter representing a different commodity or cost group, relative as well as absolute prices could be easily changed through time. The price change rates could be easily changed through time. The price change rates could be handled either as constants or entered as a series of index numbers. Use of index numbers would require addition of a set of arrays to contain the numbers. Constants could be handled either on a monthly or annual basis, or annual coefficients could be used with the program using log functions to convert the rate of change to a monthly basis.

## Group Price Changes

Use of a model of this type in areas with different technological or economic conditions requires that the values of a large number of variables be adjusted. As presently constructed the FABS model requires an individual entry for each parameter which is to be given a new value. This procedure works well and is efficient when only a few values are changed and when there is no pattern of relationship between groups of standard values and corresponding groups of adjusted values. However, in many cases it will be necessary to change groups of parameters by a constant or a specific percentage. A user may need all gas and oil costs to be raised by ten percent, and all machinery prices lowered by five percent.

To reduce the user burden of making all of the required changes individually a set of group price change parameters could be used. These parameters would serve as flags to the program that the values for a certain group of parameters are to be changed. The value of the

parameter would indicate the magnitude and direction of value change. The parameter values would then be changed by the program before simulation begins.

If a set of price level change parameters, such as those described in the preceding section, were inserted in the model, the group price changes discussed here could be incorporated in the price level change parameters. Setting the first year level of the price level change parameter equal to 1.1 would raise the initial value of the parameter by ten percent. Then, if subsequent values of the parameter were calculated (or input if index numbers were used) relative to that initial value, both the change in level and the change through time would be accomplished.

## Stochastic Elements

As indicated in chapter three there are several advantages of a deterministic model, particularly for extension application. There are, however, a number of possible applications of a stochastic model. A number of parts of a farm business do exhibit a large degree of variability and a stochastic model may best represent certain aspects of those situations. Further, a stochastic model may be very useful for a number of research and teaching applications.

Additional stochastic elements can be added to the model by calculating a standard deviation for each price, yield or cost used and adding this, multiplied by random standard normal deviate, to each price where ever it is used. Monthly or annual selection of new random numbers makes the model operate stochastically. This procedure

has the advantage that setting the random standard normal deviate at zero allows operation of the model in a deterministic mode.

An alternate, and possibly superior method when stochastic elements are added to an existing model, is to use a price and yield generator. This is a routine which uses the input price, standard deviation and standard normal deviate or some other method to generate the price, cost or yield value to be used for each month. The primary advantage of this procedure is that little of the existing program needs to be changed. Care must be exercised, however, to keep from destroying the input values that will be required for succeeding price calculations.

## Weather

A major factor influencing the amount of work accomplished and the timeliness of that work as well as machinery and labor requirements is weather. Explicit handling of the effects of weather could improve the performance of the model relative to tactical questions of machinery purchase, timeliness, enterprise combination and labor utilization.

There are presently at least two major problem areas which one must face if a realistic representation of weather is to be inserted in a model. The first is the problem of interaction between field days, non-field days, labor used and machinery required. For example, if there are insufficient field days to get a certain corn acreage planted, the acreage can be reduced, additional machinery could be purchased or a longer day could be worked. Different users may desire that different actions be taken for the same problem situation. Automatic reaction by the computer program requires that decision

rules be developed so that proper action is taken. A further dimension of this problem is the fact that while a one-crop model may be able to assume that all other activities are carried out when you are not planting or harvesting the crop being analyzed, a complete farm model must deal with the overlap and trade-offs necessary to mesh a multiple crop program.

The second problem is the apparent lack of data required. Areas in which additional information is required are:

1. Field days available--more information is required on the distribution of field days for different operations. The characteristics of harvest field days and planting field days may differ. Certainly hay harvest field days differ from corn plant field days. The relationships between these two different types of field days must also be determined.
2. Field days required--the number, combination, and timing of different types of field days required for each crop enterprise must be determined.
3. Losses or gains caused by timeliness--the losses incurred by not carrying out an operation at the optimum time must be specified. Also the interactive effect of altering the timing of a number of different operations on the same crop must be evaluated.

## Machinery Replacement Relationships

As presently designed the model handles machinery replacement in the normal fashion by replacing machines when their age equals their expected life. Although this appears to be a reasonable approach,

provides approximately correct answers and is indeed correct a large proportion of the time, any astute observer knows that actual patterns of machinery replacement often differ significantly from the patterns that would be generated by this approach. Many machines are traded before their physical life expires; sometimes for technological reasons but often for other reasons. The economics involved may be similar to that of the family car which is usually traded before its physical life expires. Assuming that a capital expenditure for replacing the car would not be required until the end of its physical life would be unrealistic.

This observation leads one to conclude that possibly a routine could be developed which would provide decision rules for machinery replacement. A study of management behavior patterns relative to machinery replacement decisions may be needed to provide a basis for developing such a routine. Although casual observation indicates that the economic position of the firm and the level of profitability of the business during the year in question are factors, their specific effect and importance are only partially known.

One possible approach which would allow further study of the problem would be to develop a random decision rule generator. This could be done by using a truncated normal distribution or a gamma distribution with a range equal to the physical life of the machine and assuming that the machine will be traded at an age equal to one-half life plus a random or predetermined number of standard deviations (with maximum age equal to life). Experimentation with the distribution and the number of standard deviations may produce a more representative replacement pattern.

## Dairy Herd Characteristics Input

The model presently requires detailed input of the characteristics of the dairy herd. This provides excellent data with which to simulate individual farm situations. However, the input burden placed on the user is quite heavy. One possible way to make input easier would be to require input only of the number of animals found on the farm and generate the herd characteristics (individual animals) using typical age and freshening distributions. This would not be quite as accurate as input of the actual data, but the loss may be small enough that the generated numbers would be sufficient for most applications.

One constructive approach for modifying the model in this way is to alter the input forms so that the user can input either the detailed characteristics of the herd or just the numbers of animals. A program segment would then be distributions to develop the information characteristics would provide.

Implementation of this modification will require first determining the typical distributions for individual herds. Although the data for these distributions is available the data appears not to be summarized in the required distribution form.

## Teletype Use

As previously indicated, the FABS model has been developed to make conversion to teletype simple. The width of reports has been limited to 72 columns and the model is designed to allow program interruption and data change between years.

Utilization of this model as a tool to assist decision makers with specific management decisions likely depends on an ability to

access the model at a location within reasonable driving distance from the manager's place of business. Although other teaching (adult and classroom) and extension applications can be made using batch processing, the delays involved in batch processing make it less adaptable for this application.

Further user-simulator interaction may provide an additional dimension of considerable use to managers. In cases where the proper sequence of events through time is totally unknown, the ability to work the model through time a step (year) at a time may allow discovery of superior alternatives. Other advantages and disadvantages of teletype use are discussed in chapter three.

The expected process to be used in transferring the model to teletype has been discussed previously. If the decision to transfer to teletype is carried out, the possibility of placing the model on a nationwide network such as the General Electric system should be given careful consideration. A network system could extend the availability of the model to a number of states. By developing different data subroutines containing all of the initial program values for each state (preferably by workers in that state) the model could be made applicable to a large area. Very minor program modification would allow only one of these data subroutines, depending on a state code number input by the user, to be called.

The major advantage of this method would be the reduced storage costs incurred for storage of the program. Each state involved would increase only the storage costs for its data subroutine and its share of storage costs for the program itself.

## Separation of Subroutines

Any large model carries out a number of different functions. An effort was made during development of the FABS model to develop subroutines which contained specific functions or logical units of activity in their entirity. For example, the labor subroutine handles all labor requirement and cost calculations.

With units of activity organized in this manner it would be possible to separate off certain of the subroutines, design appropriate input data, select or design the desired output reports and use the subroutines as programs by themselves. In this way persons interested only in certain parts of the model could use those parts without being forced to use the complete model.

The subroutines which appear to have the most potential as programs by themselves are labor, dairy, storage and sales, finance and machinery. The labor subroutine would allow a user to determine the expected labor requirements of alternative enterprise combinations. The dairy routine offers two possibilities. One alternative would be to separate off only the part of the routine used to generate animal numbers. The second approach would be to use the entire subroutine to generate animal numbers, production and feed requirements when different raise, purchase, sale and feeding practices are used. Similar opportunities exist for use of the other subroutines mentioned.

The primary problem that can be expected when these subroutines are adapted to operate independently is the difficulty of developing input that is compatible and complete. Much of the data which is now calculated using a number of variable values will have to be calculated exogenous to the model and entered by the user.

At this point it appears that there is little justification for using the complete model to answer questions which require use of only a small part of the model. If a problem is limited to questions of labor use, operation of the complete model is costly and the complete input compliment is still required to get dependable answers. A more appropriate approach would be to use a model designed specifically for labor problems, which does not require and generate data irrelevant to the problem.

## Generalization

The final possible extension of the model to be discussed here is generalization to additional enterprise areas. Beef, swine, poultry, fruit and vegetable enterprises could be added to the model by developing a subroutine to handle each enterprise added and appropriately modifying the storage, machinery, labor and buildings routines to handle the needs of the new enterprises.

This would allow use of the same model to consider nearly any farm firm problem situation that could be expected to arise in the northeast quarter of the United States. Switches from one enterprise combination to another or comparisons of enterprise combinations could be carried out with ease.

A major question must be evaluated before generalization of this type is undertaken. That is, whether it is better to add more enterprises to this model or use some of the ideas and routines from this model to develop new models to handle other enterprises. Although a number of farms shift the emphasis between their livestock enterprise and crop enterprise, few actually consider changing livestock

enterprises. If the number of users that would be making these livestock or major enterprise shifts is low it may make more sense to develop additional models rather than adding to the present one.

Construction of additional models has the advantage of allowing use of a less complicated model. It also makes model development somewhat less cumbersome.

# CHAPTER VIII

# SUMMARY AND IMPLICATIONS

## Summary

The scientific industrialization of agriculture is evolving a commercial farming sector made up of units of ever-increasing size and complexity. The primary objective of this study was to develop an improved technique of analysis which would be useful in assisting farm managers and researchers in dealing with this dynamic situation. More specifically, the objectives involved development and testing of a dairy farm business analysis model which (1) can reasonably represent Michigan dairy farms, (2) can be adjusted to evaluate individual farm situations, (3) allows evaluation of systems not now in operation, (4) is designed to allow additional enterprises to be added, and (5) offers flexibility in respect to input and output.

To provide an appropriate theoretical framework and background for development of the desired model, a critical review of the systems theory and simulation was conducted. Although no body of knowledge on systems could be found which could be called a theory, a systems concept which can provide a heuristic base for systems analysis, or a system approach to management, does exist. Use of this systems concept as an approach to management provides an analytical framework

for problem analyses which forces consideration of the whole business and focuses on evaluation of interactive elements.

Simulation has been widely used in non-agricultural business management as a method of evaluating alternatives and systems. It is just beginning to receive widespread use in agriculture. As a technique of analysis, simulation provides the basic design and structural flexibility required to develop a model with emphasis on interaction effects without excluding other management concepts.

That the model developed can reasonably represent many Michigan dairy farm situations is indicated by the results generated for both the farm planning and research problems simulated. Both farm managers and extension specialists found the simulated data to correspond closely with that expected for Michigan situations with the initial characteristics found on the farms used. The variability in the situations simulated indicate that with appropriate data input the model can be used to simulate a wide variety of situations in a large portion of the North Central and Northeastern United States.

The required input of the basic data for the farm being simulated plus the ability of the user to change any parameter within the model allows adjustment of the model to simulate very specific individual situations. Little difficulty was experienced in simulating the special characteristics of those businesses simulated. In fact, the primary limitation on simulating individual situations is the lack of knowledge about the individual situation being simulated. Actual values for many parameters are often unknown. For this reason the parameters listed in Part II of the Users Manual (Appendix A) are organized with those variables likely to have the

most effect on the outcome in most situations and/or those variables for which the user is most likely to know the appropriate value placed first.

The user defined systems which are an integral part of the model, allow simulation of any type of system for which the user can estimate the appropriate parameter values. User systems were developed and simulated for a stanchion-parlor dairy system and an eight-row cropping system. In both cases the results were in line with estimates made using other techniques. Although these particular systems are in use on some farms, a similar procedure could be used for systems not in use for which only engineering data is available.

Although the model developed is designed to allow the addition of other enterprises, the ease with which this can be carried out is untested. The present enterprises are organized by subroutine so that addition of an enterprise would involve only adding a subroutine for the enterprise in question and making the appropriate addition or correction to the labor, machinery, accounting and possibly storage or building subroutines.

The model user has nearly complete flexibility in input. Only the data specifying the basic characteristics of the situation to be simulated are required. The number of other coefficients to be input and the number and degree of detail of management decisions to be made is completely the user's decision. On the output side, there are eleven output reports which can be selected. These reports vary in both coverage and degree of detail. The user can select those reports which supply data relevant to the problem being evaluated.

Both farm planning and farm management research problems were simulated. Simulation of the farm planning problems indicated that alternatives could be simulated for specific farm situations and that the data generated could be useful in making management decisions. Simulation of a small research problem indicated that the model does provide a basic framework and tool of analysis which can be used to analyze certain types of problems. Although simulation of the situations discussed above provided only limited testing of the model, the results were positive and reinforcing. Using the philosophy of Popper, the conjecture that the model can be used to simulate individual dairy farm businesses has been supported but not proven. Extensive use of the model will be required before its actual usefulness is determined.

## Implications

### For Extension

This model has at least two possible applications in extension. First, as previously indicated, this and other similar type models can be used to compare and evaluate alternatives for individual farm businesses. This should allow farm managers to consider more alternatives in greater detail and with considerably more speed than has historically been possible (particularly when remote access rather than mail is used). When used in this fashion, however, the role of the extension worker may change. He will be freed from calculating budgets and checking farmer's budgets. However, he will now be forced to spend more time specifying the exact alternatives to be evaluated and interpreting the output. He will also be required to spend more

time in communication with the computer, either by mail or remote access teletype unit. To the degree that this allows or forces concentration on specification and analysis of alternatives rather than arithmetical calculations, this could improve the services of the extension worker. However, achievement of such improved services would likely require a period of intensive training on use of computer models for most extension workers involved.

The second potential application is to use the model to provide data for management control or management by exception. A farm business could be simulated for some period into the future and the data thus generated used as a benchmark for evaluating the actual results achieved over that period of time. This should provide a better basis for management control than has been available in the past (such as comparison with other farm group averages) and should allow improved management of individual farm businesses.

The application, which may have the most potential value, is a combination of the two listed above. Simulation of a number of alternatives to determine the one to be selected and then using the simulated data as a benchmark for control during and following adoption of the alternative may be the most productive way the model could be used.

For Research

Two different areas of research are implied by this model. The first, which was discussed in the previous chapter, is to make additions to the present FABS model. No simulation model is complete in every way and additional features which are useful for a certain

range of problems can always be added. As additional features are added, the realism of the model or range of problems which the model can be used to address, will improve.

The second area involves use of the model as a tool in farm management research. The monthly time period plus the capacity of being able to change the value of any coefficient makes this model useful for addressing many problems of a highly tactical nature which could not be handled by previous simulation models. Thus, this model could be used to simulate the effects of a wide variety of initial characteristics and environmental situations. Different price or credit environments could be evaluated on either a monthly or annual basis. The results of adopting certain technological advances could be estimated as soon as the engineering characteristics of the new technology were known. Use of the model in this way may reduce both survey and budgeting time as well as allowing earlier publication of the results.

For research problems where the model as presently designed will not (1) handle certain variables in the required manner, (2) generate the appropriate variable values or (3) report the required information, changes can be made in the model programming. For a wide array of problems, making adjustments to the FABS model could provide a model with the required characteristics with a minimum programming effort. Appendix B should make this a relatively simple procedure.

The FABS model can also be used as a tool for research in management per se. Different management strategies or decision rules can be evaluated under a variety of environmental situations. Alternative

management techniques may either use (such as management by exception) or be evaluated by the model. If placed on a remote access or interactive computer, the model could be used to provide a realistic environment within which to study the decision process of managers. This could also be carried out on a batch processing basis, but would require somewhat greater effort and a longer time span of study.

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# APPENDICES

# APPENDIX A

# FABS USER MANUAL

# AND INPUT DATA FORMS

FABS

(FArm Business Simulator)

USER MANUAL

## Introduction

is manual is designed to be used in conjunction with FABS Data
The manual is divided into three parts. The first part is a
of the basic information required about the farm to be simula-
represents the minimum data required to simulate a business.
sting corresponds to Part I of Data Form 1 on which the data for
iness is recorded.
rt II is a listing of the parameters or numbers which will be
the model unless they are changed by the user. It is suggested
e user read through these to see if any should be changed. Each
ient in Part II and most of those in Part I have an identifica-
mber just to the left (in parentheses) or just above the value
Use of these identification numbers is discussed in Part III.
rt III contains a discussion of data required and the procedure
sed in indicating management decisions and change of parameter
Parameter value changes and management decisions are placed in
ogical order on Part II of Data Form 1.
detailed description of each of the systems used by the simulator
in the appendix. For a detailed list of the machines used by
stem, see the systems matrices at the end of Part II.
l the information required for simulating an alternative is indi-
n the FABS Data Form 1. It is suggested that all data for each

alternative be placed on a separate form and not on the user manual. The computer cards are punched directly from Data Form 1 which has card and column numbers under each coefficient.

PART I

Required Input Data

General

1. The first month to be simulated is (enter month by number and then year)

_____ 19____

2. The number of years to be simulated is _____

3. Are summaries to be on a fiscal or calendar year basis. The fiscal year would start during the first month simulated (1 = calendar, 0 = fiscal). _____

4. The output desired is: (enter 1 if desired, 0 if not)

| | | |
|---|---|---|
| (a) | labor summary | _____ |
| (b) | annual financial statement | _____ |
| (c) | annual crop production & feed utilization summary | _____ |
| (d) | annual dairy cattle numbers summary | _____ |
| (e) | annual income and expense statements | _____ |
| (f) | annual production and yields summary | _____ |
| (g) | brief monthly cash flow summary | _____ |
| (h) | monthly crop production and feed utilization | _____ |
| (i) | monthly dairy cattle numbers summary | _____ |
| (j) | monthly cash flow statement | _____ |
| (k) | brief debt and income summary | _____ |

5. Notes:

6. Number of cows by lactation and month of freshening month prior to first month to be simulated.

| Lactation | Dec[a] | Nov | Oct | Sept | Aug | July | June | May | Apr | Mar | Feb | Jan | Dec | Nov | Oct | Before Oct |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | -1 | -2 | -3 | -4 | -5 | -6 | -7 | -8 | -9 | -10 | -11 | -12 | -13 | -14 | -15 | Before -15 |
| 1 | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | |
| 10 or over | | | | | | | | | | | | | | | | |

[a]Month headings can be used only if January is the first month to be simulated.

7. (a) Number of Heifers by Age (months)
(month prior to first month simulated)

| Age | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | | | | | | | | | | | | |

| Age | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | | | | | | | | | | | | |

| Age | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | | | | | | | | | | | | |

7. (b) The Number of Dairy Steers by Age (months)

| Age | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | | | | | | | | | | | | |

| Age | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | | | | | | | | | | | | |

8. Freshening Preference Schedule

| Month of Birth | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Desired Age of Freshening (months) | | | | | | | | | | | | |

9. The average value per animal is:

| | |
|---|---|
| Cows | (1-13)$_____ |
| Bred Heifers | (1-14)$_____ |
| Open Heifers (over 1 year) | (1-15)$_____ |
| Calves (under 1 year) | (1-16)$_____ |

10. Historical production experience for herd input in question 6:

Average annual actual production (lbs.) for this herd is (1-17)_____

when forage quality is (1 = excellent, 2 = medium 3 = poor) (1-18)_____

and pounds of feed fed per cow per year is (1-19)_____

and culling rate is (percent) (1-20)_____

11. For the first period simulated:

(a) Pounds of feed to be fed per cow per year (include HMC) (1-21)_____

(b) Average forage quality to be fed is (1-22)_____

(c) The culling rate to be used is (percent) (1-23)_____

12. Composition of concentrate fed (excluding high moisture corn and supplement fed separately)

| Grain | Lbs. |
|---|---|
| Ear Corn[1] | (1-24)_____ |
| Shelled Corn | (1-25)_____ |
| Oats | (1-26)_____ |
| Wheat[1] | (1-27)_____ |
| Supplement | (1-28)_____ |

13. (a) Is high moisture corn to be fed (1 = yes, 0 = no) (1-29)_____

(b) If so, the pounds fed per cow per day by month is:

| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lbs[2] | 1-30 | 1-31 | 1-32 | 1-33 | 1-34 | 1-35 | 1-36 | 1-37 | 1-38 | 1-39 | 1-40 | 1-41 |

(c) The moisture content of high moisture corn as fed is (percent) (1-42)_____

1. If ear corn or wheat supply becomes exhausted shelled corn will be used.

2. If there is insufficient HMC to meet this requirement, dry corn will be used instead.

(d) Pounds of supplement fed with HMC per cow per day (1-43)_____

14. Percent of Hay Equivalent From Various Forages by Month[1]

| Forage | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 1-44 | 1-47 | 1-50 | 1-53 | 1-56 | 1-59 | 1-62 | 1-65 | 1-68 | 1-71 | 1-74 | 1-77 |
| Hay Crop Silage | 1-45 | 1-48 | 1-51 | 1-54 | 1-57 | 1-60 | 1-63 | 1-66 | 1-69 | 1-72 | 1-75 | 1-78 |
| Corn Silage | 1-46 | 1-49 | 1-52 | 1-55 | 1-58 | 1-61 | 1-64 | 1-67 | 1-70 | 1-73 | 1-76 | 1-79 |

15. The average calving interval of this herd is (1-80)_____ months.

16. The % of heifer calves to be kept for replacements is (1-81)_____.

17. (a) The maximum number of cows to be allowed is (1-82)_____

(b) The maximum number of heifers over 1 year to be allowed is (1-83)_____

(c) The maximum number of heifers under 1 year to be allowed is (1-84)_____

18. (a) Type of bedding used for youngstock is (1 = straw, 2 = other) (1-85)_____

(b) Type of bedding used for dairy herd is (1 = straw, 2 = other) (1-86)_____

(c) <u>If</u> bedding other than straw is used, the average cost per animal per month is:

| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cows | 1-87 | 1-89 | 1-91 | 1-93 | 1-95 | 1-97 | 1-99 | 1-101 | 1-103 | 1-105 | 1-107 | 1-109 |
| Heifers | 1-88 | 1-90 | 1-92 | 1-94 | 1-96 | 1-98 | 1-100 | 1-102 | 1-104 | 1-106 | 1-108 | 1-100 |

1. Exclusive of H.E. from pasture.

Machinery

19. The systems to be used on this farm are (indicated by number). Use the last number (system) in each set of parentheses (user defined systems) only if you plan to define it.

| | | |
|---|---|---|
| 1. | Dairy Cows (1-7) | (3-111)_____ |
| 2. | Dairy Replacements (8-10) | (3-112)_____ |
| 3. | Corn Grow - April (1-4) | (3-113)_____ |
| 4. | Corn Grow - May (5-8) | (3-114)_____ |
| 5. | Corn Grow - June (9-12) | (3-115)_____ |
| 6. | Corn Silage Harvest (1-5) | (3-116)_____ |
| 7. | Corn Grain Harvest (6-11) | (3-117)_____ |
| 8. | Wheat Grow (Sept.) (13-15) | (3-118)_____ |
| 9. | Wheat Grow (Oct.) (16-18) | (3-119)_____ |
| 10. | Wheat Harvest (12-15) | (3-120)_____ |
| 11. | Oats Grow (Apr.) (19-21) | (3-121)_____ |
| 12. | Oats Grow (May) (22-24) | (3-122)_____ |
| 13. | Oats Harvest (16-19) | (3-123)_____ |
| 14. | Hay Crop Plant (25-28) | (3-124)_____ |
| 15. | Hay Crop Silage Harvest (20-24) | (3-125)_____ |
| 16. | Hay Crop Maintain (29-30) | (3-126)_____ |
| 17. | Hay Harvest (25-28) | (3-127)_____ |
| 18. | Fieldbean Grow - May (31-33) | (3-128)_____ |
| 19. | Fieldbean Grow - June (34-36) | (3-129)_____ |
| 20. | Fieldbean Harvest (29-32) | (3-130)_____ |
| 21. | Soybeans Grow - May (37-39) | (3-131)_____ |
| 22. | Soybeans Grow - June (40-42) | (3-132)_____ |
| 23. | Soybeans Harvest (33-35) | (3-133)_____ |

20. (a) Do you want to enter the specific machines presently on this farm? (1 = yes, 0 = no) If you enter "no", a representative set of machinery will be assumed _____.

(b) Do you want additional (other than replacement)machine purchased as the program determines that they are needed. (1 = yes, 0 = no) (1-134)_____.

21. (a) The present value of owned land (excluding buildings) on this farm is _____.

(b) The value of this land (by itself) in ten years is expected to be (1-135)_____.[1]

22. (a) Normal acreages of crops to be grown.

| Crop | Owned or Cash Rent Acreage | Share Rent Acreage |
|---|---|---|
| Corn | (1-136)_____ | (1-144)_____ |

1. If a number less than 50 is entered this will be used as the expected annual rate of inflation in land value.

22. (a) (con't)

| Crop | Owned or Cash Rent Acreage | Share Rent Acreage |
|---|---|---|
| Hay Crop (including silage and pasture) | (1-137)_____ | (1-145)_____ |
| Oats | (1-138)_____ | (1-146)_____ |
| Wheat | (1-139)_____ | (1-147)_____ |
| Soybeans | (1-140)_____ | (1-148)_____ |
| Fieldbeans | (1-141)_____ | (1-149)_____ |
| Government Programs | (1-142)_____ | (1-150)_____ |
| Total | (1-143)_____ | (1-151)_____ |

(b) Expected last year acreage.[1] Hay Crop Silage _____
Corn Silage _____

23. Acres cash rented (included in above acreage) (1-152)_____
Rental per acre (1-153)_____

Buildings

24.

| Purchase Period | Present Value | Average Age(yrs.) | Average Number of Yrs. Deprec. Over |
|---|---|---|---|
| Within last 5 yrs. | | | |
| 5-10 years ago | | | |
| More than 10 yrs. | | | |

25. Present Building Capacity is:

(a) Number of free stalls (1-154)_____
(b) Number of stanchions (1-155)_____
(c) Milking parlor capacity (no. of men)[2] (1-156)_____
(d) Number of dry cows and/or heifers (max.) (1-157)_____
(e) Number of calves (maximum) (1-158)_____
(f) Silage storage capacity-upright (tons) (1-159)_____
(g) Silage storage capacity-horizontal (tons) (1-160)_____
(h) Hay and straw storage capacity (tons) (1-161)_____
(i) Ear corn storage (bushels) (1-162)_____
(j) Grain bin storage (bushels) (1-163)_____
(k) High moisture corn storage (bu. dry equiv.) (1-164)_____

26. (a) Do you want dairy buildings and silage capacity to be purchased as required? (1 = yes, 0 = no) (1-165)_____

---

1. Actual first year acreages will be determined by simulation.

2. A 1 indicates a one-man parlor, 2 indicates a 2-man parlor, 3 indicates a one-man parlor and one 2-man parlor.

(b) Do you want grain storage buildings to be purchased as required (1 = yes, 0 = no) (1-166)_____. (If off-farm storage is allowed, that will be used rather than building.)

(c) Do you want hay and straw storage capacity to be purchased as required? (1 = yes, 0 = no) (1-167)_____. (If you answer no to question (a), (b) or (c), animals or crops in excess of capacity will be sold at freshening or harvest respectively.)

(d) Off-farm storage is used for:

(i) Fieldbeans (1-168)_____[1] (iii) Wheat (1-170)_____
(ii) Soybeans (1-169)_____ (iv) Shelled Corn (1-171)_____
(v) Oats (1-172)_____

Labor

27. (a) Hours of Labor Available Per Month[2]

| Number | i | | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 173 | 1 | Operator | 181 | 189 | 197 | 205 | 213 | 221 | 229 | 237 | 245 | 253 | 261 | 269 |
| 174 | 2 | Family | 182 | 190 | 198 | 206 | 214 | 222 | 230 | 238 | 246 | 254 | 262 | 270 |
| 175 | 3 | Year Hire (1) | 183 | 191 | 199 | 207 | 215 | 223 | 231 | 239 | 247 | 255 | 263 | 271 |
| 176 | 4 | Year Hire (2) | 184 | 192 | 200 | 208 | 216 | 224 | 232 | 240 | 248 | 256 | 264 | 272 |
| 177 | 5 | Year Hire (3) | 185 | 193 | 201 | 209 | 217 | 225 | 233 | 241 | 249 | 257 | 265 | 273 |
| Rate Per Hr.[3] | | | | | | | | | | | | | | |
| 178 | 6 | Hourly(1)[4] | 186 | 194 | 202 | 210 | 218 | 226 | 234 | 242 | 250 | 258 | 266 | 274 |
| 179 | 7 | Hourly(2)[4] | 187 | 195 | 203 | 211 | 219 | 227 | 235 | 243 | 251 | 259 | 267 | 275 |
| 180 | 8 | Hourly(3)[4] | 188 | 196 | 204 | 212 | 220 | 228 | 236 | 244 | 252 | 260 | 268 | 276 |

1. Enter 0 if off-farm storage is not used for this crop; enter 1 if off-farm storage is used for all this crop; enter 2 if off-farm storage is used for any amount of this crop in excess of farm storage capacity.
2. All identification numbers in this table must be preceded by a 1- to be complete.
3. The least expensive labor is used first.
4. It is assumed that this labor is hired only when needed.

(b) All additional labor will cost (1-277)_____ per hour.

28. The wage rate is:
Year hire (1) = (1-278)$_____per (1-281)_____[1]
Year hire (2) = (1-279)$_____per (1-282)_____[1]
Year Hire (3) = (1-280)$_____per (1-283)_____[1]

Crops

29. Average yield of oats planted in April and harvested on time when (1-284)_____ pounds of plant food is applied is (1-285)_____ bushels per acre.

30. Average yield of corn planted during period[2] (1-286)_____ and harvested on time with (1-287)_____ pounds of plant food applied is (1-288)_____ bushels per acre.

31. Average yield of wheat planted in September and harvested on time when (1-289)_____ pounds of plant food is applied at planting and (1-290)_____ pounds of nitrogen is applied in the spring is (1-291)_____ bushels per acre.

32. Average yield of hay when (1-292)_____ pounds of plant food are applied and 1st cutting is cut in June, 2nd cutting in July and 3rd cutting in August is:
(1-293)_____ tons first cutting
(1-294)_____ tons second cutting
(1-295)_____ tons third cutting

33. Average yield of fieldbeans planted in June and harvested on time when (1-296)_____ pounds of plant food is applied is (1-297)_____ bushels per acre.

34. Average yield of soybeans planted in June 1 to 15 is (1-298)_____ bushels per acre.

35. The number of hay cuttings (including pasturage) is (1-299)_____ (this number must be either 1, 2 or 3).

36. The number of acres of hay crop pastured is:
(1-300)_____acres first cutting
(1-301)_____acres second cutting
(1-302)_____acres third cutting

---

1. 1 = monthly, 0 = weekly.

2. 1 = before May 1; 2 = May 1 to May 15, 3 = May 16 to May 31; and 4 = after May 31.

37. (a) The amount of hay crop silage to be harvested is (1-303)_____[1]

(b) The amount of corn silage to be harvested is (1-304)_____[1]

(c) The amount of corn to be harvested as high moisture corn is (1-305)_____.[2]

38. The beginning inventory on hand is:

| | |
|---|---|
| (a) Hay crop silage (tons, 70% moisture) | _____ |
| (b) Corn silage (tons) | _____ |
| (c) Hay (tons) | _____ |
| (d) High moisture corn (bushels) | _____ |
| (e) Ear corn (bushels) | _____ |
| (f) Corn grain (bushels) | _____ |
| (g) Wheat (bushels) | _____ |
| (h) Oats (bushels) | _____ |
| (i) Soybeans (bushels) | _____ |
| (j) Fieldbeans (bushels) | _____ |
| (k) Supplement (ton) | _____ |

39. (a) The amount of N, $P_2O_5$ and $K_2O$ (lbs./acre) to be applied by crop is:

| | Lbs. N | Lbs. $P_2O_5$ | Lbs. $K_2O$ |
|---|---|---|---|
| (1) Corn | (1-306)_____ | (1-313)_____ | (1-320)_____ |
| (2) Soybeans | (1-307)_____ | (1-314)_____ | (1-321)_____ |
| (3) Fieldbeans | (1-308)_____ | (1-315)_____ | (1-322)_____ |
| (4) Wheat | (1-309)_____[3] | (1-316)_____ | (1-323)_____ |
| (5) Oats | (1-310)_____ | (1-317)_____ | (1-324)_____ |
| (6) Hay (seeding) | (1-311)_____ | (1-318)_____ | (1-325)_____ |
| (7) Hay (all acreage) | (1-312)_____ | (1-319)_____ | (1-326)_____ |

(b) The Agricultural Subregion for this farm is (see map) (1-327)____.

---

1. Enter -1 if enough is to be harvested to fill the silos.
Enter number of tons per cow ($0 \leq$ tons $\leq 25$) if a certain amount per cow is desired [up to silo capacity].
Enter number of tons ($> 25$) if a certain absolute tonage is to be harvested as silage [up to silo capacity].

2. Enter -1 if enough is to be harvested to fill the silos.
Enter number of bushels (dry equivalent) per cow ($0 \leq$ bushels $\leq 200$) if a certain amount per cow is desired.
Enter number of bushels (dry equivalent) if a certain absolute number of bushels is to be harvested as HMC.

3. Excluding topdressing.

40. (a) Current Debt Situation

| Beginning Bal. Due | Interest Rate (%) | Payment yr. (no.) | Amount of Payment[1] | Type of Loan[3] | Term of Loan[4] | Months Payments are to be made[2] 1 | 2 | 3 | 4 | 5 | 6 | Age of Loan[5] (mo.) | Loan Period[6] (yr.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

(b) Current cash and checking account balance is (1-328)$_____.

---

1. Includes principal and interest for equal payment loans but only principal for loans requiring constant principal payment plus interest accumulated. May be omitted if age of loan and loan period are both entered.

2. Enter months in which payments are to be made. Zero in column 1 indicates monthly payments.

3. 1 = equal payments including principal and interest.
   2 = amount of payment is principal, interest due is added.
   11 = pay interest only first year and equal payments thereafter.
   12 = pay interest only first two years and equal payments thereafter.
   13 = pay interest only first three years and equal payments thereafter.
   14 = pay interest only first four years and equal payments thereafter.
   15 = pay interest only first five years and equal payments thereafter.
   21 = pay interest only first year and principal payment plus interest thereafter.
   22 = pay interest only first two years and principal payment plus interest thereafter.
   23 = pay interest only first three years and principal payment plus interest thereafter.
   24 = pay interest only first four years and principal payment plus interest thereafter.
   25 = pay interest only first five years and principal payment plus interest thereafter.

4. 1 = short term, 2 = intermediate term, 3 = long term.

5. Required only when amount of payment is not entered and when type of loan is 11-15 or 21-25. This is the number of months between the date the loan was made and the first month simulated.

6. Years, required only when type of loan is 11-15 or 21-25 and when amount of payment is not entered.

41. (a) Withdrawals[1] for the farm families (family) is expected to be:

| | Jan. | Feb. | Mar. | Apr. | May. | June |
|---|---|---|---|---|---|---|
| With drawal | 1-329 | 1-330 | 1-331 | 1-332 | 1-333 | 1-334 |
| | July | Aug. | Sept. | Oct. | Nov. | Dec. |
| | 1-335 | 1-336 | 1-337 | 1-338 | 1-339 | 1-340 |

(b) Annual off-farm income is expected to be[2] (1-341)_____.
Number of exemptions to be claimed for tax purposes (1-342)____.

(c) Estimated taxes to be paid on income from year previous to simulation[3] (1-343)_____.

(d) Estimated taxable net farm income for first part of first year simulated[4] (1-344)_____.

42. (a) Are dairy steers to be raised (1 = yes, 0 = no) (1-345)_____.

If so:

(b) What percent of the bull calves are to be kept (1-346)_____.

(c) At what age (mo.) are steers placed on feed[5] (1-347)_____.

(d) At what age (mo.) are the steers sold (1-348) _____.

(e) Which ration is to be used during the feeding period[6] (1-349)___.

---

1. Exclude income taxes but include personal insurance.

2. Taxes will be estimated assuming that all off-farm income is in the form of wages, tips, etc.

3. Required only if program starts in January or February.

4. Required if program starts in any month other than January.

5. Until steers are placed on feed it is assumed that their requirements are the same as heifers of the same age.

6. May be 1 through 6, as indicated in Q.51 Part II.

AGRICULTURAL SUBREGIONS OF MICHIGAN

## PART II

The statement and tables below define variables which are used in the FABS program. The value found in the upper half of the matrix cell or in parentheses preceeding the line is the identification number for that variable. The number in the bottom center of the matrix cell or on the line is the value used by the program unless it is changed. Zero means a statement is not used.

The statements and tables in this part have been ordered so that those questions most important for most problem situations come first and those least likely to require change appear last. It is suggested that the first 58 questions be carefully evaluated by most users.

1. The opportunity value of operator's labor is (1-350) $5,000.

2. The opportunity value of family labor is (1-351) $2.25.

3. The opportunity rate of interest (percent) on equity investment in the farm business is (1-352) 6.0.

### Purchases and Sales

4. Sell all hay in excess of (1-353) .5 tons per cow in month (1-354) 4.

5. In month (1-355) 4 sell all corn grain in excess of (1-356) 6.0 times the amount of corn used during that month.

6. In month (1-357) 4 sell all oats in excess of (1-358) 4 times the amount of oats used during that month.

7. (a) Sell all wheat in month (1-359) 2 [1]
   (b) Sell all corn in month (1-360) 0 1
   (c) Sell all oats in month (1-361) 0 1
   (d) Sell all soybeans in month (1-362) 3 [1]
   (e) Sell all fieldbeans in month (1-363) 2 [1]

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1. Use 13 to indicate sale of entire crop at harvest.

8. Purchase (1-375) 0 bushels of shelled corn grain in month (1-376) 0.

9. Purchase (1-377) 0 bushels of high moisture corn in month (1-378) 0.

10. Purchase (2-8893) 0 tons of supplement in month (2-8894) 0. (If the number of tons entered is less than 2.0, that much supplement per cow will be purchased.)

11. In each year the following number of cows or bred heifers (1 = bred heifers, 2 = fresh cows) (1-390) 0 are to be purchased in the month indicated[1] at an average age of (1-391) 27 months.

| | | | |
|---|---|---|---|
| Jan. | (1-392) 0 | July | (1-398) 0 |
| Feb. | (1-393) 0 | Aug. | (1-399) 0 |
| Mar. | (1-394) 0 | Sep. | (1-400) 0 |
| Apr. | (1-395) 0 | Oct. | (1-401) 0 |
| May | (1-396) 0 | Nov. | (1-402) 0 |
| June | (1-397) 0 | Dec. | (1-403) 0 |

Loan Terms

12. Standard loan terms for intermediate term credit used to purchase machinery and livestock are:

(a) Period of loan in years (1-423) 3.
(b) Interest rate in percent (1-424) 10.
(c) Type of loan[2] (1-425) 1.
(d) Payments per year (1-426) 2.

13. Intermediate term loans are defined as loans with loan periods greater than (1-427) 1 year(s) and up through (1-428) 5 years. Loans with shorter loan periods are short term loans. Loans with longer loan periods are long term loans.

14. Standard loan terms for long term credit used for land and building purchase are:

(a) Period of loan in years (1-429) 20.
(b) Interest rate in percent (1-430) 8.
(c) Type of loan[3] (1-431) 1.
(d) Depreciation life (building) (1-432) 20.
(e) Payments per year[3] (1-433) 12.

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1. It is assumed that bred heifers are purchased the month prior to freshening and fresh cows the month at freshening.

2. From Q.40, Part I.

3. May be 1, 2, 3, 4, 6 or 12.

15. Interest rate on short term capital in percent is (1-434) 8 .

16. (a) Minimum checking account balance to be maintained is (1-435) $100 .

(b) Money remaining in the checking account at the end of the month in excess of (1-436) $1,000 is used to reduce debt.

Cropping Program

17. The percentage of the hay crop that is reseeded each year is (1-597) 33 .

18. The cost, labor and machinery requirements for 2nd and 3rd cuttings as a percent of 1st cutting requirements are:

| | hay | hay crop silage |
|---|---|---|
| 2nd cutting | (1-598) 65 | (1-600) 75 |
| 3rd cutting | (1-599) 50 | (1-601) 65 |

19. Hay equivalent produced by pasture is used as follows:

(a) 1st cutting (1-379) 50% May (1-383) 50% June (1-387) 0% July

(b) 2nd cutting[1] (1-380) 33% July (1-384) 34% Aug. (1-388) 33% Sept.

(c) 2nd cutting[2] (1-381) 60% July (1-385) 40% Aug.

(d) 3rd cutting (1-382) 60% Aug. (1-386) 40% Sept.

20. (a) The loss in feeding value when hay crop is harvested as pasture rather than hay is (2-2887) 8 percent.

(b) The gain in feeding value when hay crop is harvested as hay crop silage rather than hay is (2-2888) 10 percent.

21. (a) The wheat straw yield is (2-2537) .5 .

(b) The oat straw yield is (2-2538) .5 .

22. The percentage of total acreage planted or harvested during each month and the relative yield coefficients for different planting and harvesting dates are:

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1. 2 cut system.

2. 3 cut system.

| | % of Crop | | Relative Yield | |
|---|---|---|---|---|
| Corn planted in April | (1-474) | 5 | (1-518) | 100 |
| May 1-15 | (1-475) | 45 | (1-519) | 102 |
| May 15-30 | (1-476) | 50 | (1-520) | 90 |
| June | (1-477) | 0 | (1-521) | 79 |
| Oats planted in April | (1-478) | 100 | (1-522) | 100 |
| May | (1-479) | 0 | (1-523) | 100 |
| Wheat planted in Sept. | (1-480) | 50 | (1-524) | 100 |
| Oct. | (1-481) | 50 | (1-525) | 100 |
| Soybeans planted in May | (1-482) | 25 | (1-526) | 100 |
| June 1-15 | (1-483) | 75 | (1-527) | 100 |
| after June 15 | (1-484) | 0 | (1-528) | 85 |
| Fieldbeans planted in May | (1-485) | 0 | (1-529) | 100 |
| June | (1-486) | 100 | (1-530) | 100 |
| Corn silage harvest in | | | | |
| Sept. | (1-487) | 50 | (1-531) | 100 [1] |
| Oct. | (1-488) | 50 | (1-532) | 100 |
| Nov. | (1-489) | 0 | (1-533) | 94 |
| Corn grain harvest in Oct. | (1-490) | 50 | (1-534) | 100 [1] |
| Nov. | (1-491) | 50 | (1-535) | 95 |
| Dec. | (1-492) | 0 | (1-536) | 90 |
| Wheat harvest in July | (1-493) | 100 | (1-537) | 100 [1] |
| Aug. | (1-494) | 0 | (1-538) | 100 |
| Oat harvest in July | (1-495) | 0 | (1-539) | 100 [1] |
| Aug. | (1-496) | 100 | (1-540) | 100 |
| Soybean harvest in Sept. | (1-497) | 50 | (1-541) | 100 [1] |
| Oct. | (1-498) | 50 | (1-542) | 100 |
| Fieldbean harvest in Aug. | (1-499) | 0 | (1-543) | 100 [1] |
| Sept. | (1-500) | 25 | (1-544) | 100 |
| Oct. | (1-501) | 75 | (1-545) | 100 |
| 1st cutting Hay Crop | | | | |
| Silage harvest in May | (1-502) | 25 | (1-546) | 100 [1] |
| June | (1-503) | 75 | (1-547) | 100 |
| July | (1-504) | 0 | (1-548) | 100 |
| 2nd Cutting Hay Crop | | | | |
| Silage harvested in July | (1-505) | 75 | (1-549) | 100 [1] |
| Aug. | (1-506) | 25 | (1-550) | 100 |
| Sept. | (1-507) | 0 | (1-551) | |
| 3rd Cutting Hay Crop | | | | |
| Silage harvested in Aug. | (1-508) | 80 | (1-552) | 100 [1] |
| Sept. | (1-509) | 20 | (1-553) | 100 |
| 1st Cut Hay harvested in | | | | |
| May | (1-510) | 10 | (1-554) | 100 [1] |
| June | (1-511) | 70 | (1-555) | 100 |
| July | (1-512) | 20 | (1-556) | 100 |
| 2nd Cut Hay harvested in | | | | |
| July | (1-513) | 45 | (1-557) | 100 [1] |
| Aug. | (1-514) | 55 | (1-558) | 100 |
| Sept. | (1-515) | 0 | (1-559) | |

1. Relative yield for harvest of this crop must relate to the yield input in Part I. That is, if the yield input assumed harvest in a particular month (September) then the relative yield for that harvest month must equal 100.

22. (con't)

| 3rd Cut Hay harvested in | % of Crop | Relative Yield |
|---|---|---|
| Aug. | (1-516) 80 | (1-560) 100 [1] |
| Sept. | (1-517) 20 | (1-561) 100 |

23. Specific Variable Crop Costs Per Acre

| Cost Item | Corn | Wheat | Oats | Soy-beans | Field-beans | Seed Hay | Hay |
|---|---|---|---|---|---|---|---|
| Seed | 1-562 | 1-567 | 1-572 | 1-577 | 1-582 | 1-587 | 1-592 |
| | 3.95 | 6.50 | 3.94 | 4.50 | 3.69 | 5.58 | ---- |
| Pesticide | 1-563 | 1-568 | 1-573 | 1-578 | 1-583 | 1-588 | 1-593 |
| | 5,80 | 0 | .21 | 5.00 | 5.66 | ---- | ---- |
| Other Variable (grow)[a] | 1-564 | 1-569 | 1-574 | 1-579 | 1-584 | 1-589 | 1-594 |
| | 2.89 | 1.99 | 1.45 | 3.10 | 3.40 | .32 | 1.52 |
| Other Variable (harvest)[a] | 1-565 | 1-570 | 1-575 | 1-580 | 1-585 | 1-590 | 1-595 |
| | .80 | 1.04 | .65 | .90 | .95 | ---- | 1.26 |
| Other Variable (silage harvest)[a] | 1-566 | 1-571 | 1-576 | 1-581 | 1-586 | 1-591 | 1-596 |
| | 1.28 | ---- | ---- | ---- | ---- | ---- | .86 |

a. Excluding labor, machinery, equipment and fertilizer.

Operating Expense and Income

24. (a) Milk hauling charge per cwt. is (1-472) $ .30

(b) Milk is picked up (1 = every other day, 0.5 = every day) (1-473) 1

1. Relative yield for harvest of this crop must relate to the yield input in Part I. This is, if the yield input assumed harvest in a particular month (September) then the relative yield for that harvest month must equal 100.

25. Annual dairy herd costs per cow for
breeding fees (1-469) 7.50
Vet. Medicine (1-470) 11.00
Other dairy (1-471) 14.00

26. Cost per newborn heifer calves for milk replacer, feed supplements, antibiotics etc. is (1-440) $20

27. Monthly utility expenses are (1-605) $1.20 per cow per month.

28. Annual miscellaneous expenses are (1-606) $1.25 plus (1-607) 1.4 percent of other cash operating expenses (excluding insurance).

29. Property taxes are (1-608)[1] $3.50.
Months paid are (1-609) 10 and (1-610) 2 .

30. Expenses for conservation and fence repair are (1-611) $0.75 per tillable acre for conservation plus (1-612) $1.00 per acre of crop land pasture.

31. Land rent is paid in the months of (1-613) 5 and (1-614) 11 .

32. The landlord share for share rent acreage is (1-615) 33 .

33. Price per pound for fertilizer
.N is (1-616) 7.3 cents
$P_2O_5$ is (1-617) 8.7 cents
$K_2O$ is (1-618) 4.3 cents

34. Cost of hauling the following commodities is:
Hay or straw (per ton) (1-364) $4.00
Corn grain (per bu.) (1-365) .06
Oats (per bu.) (1-366) .05
Wheat (per bu.) (1-367) .05
Soybeans (per bu.) (1-368) .06
Field beans (per cwt.) (1-369) .10

35. Off-farm storage cost per month is:
Corn grain (per bu.) (1-370) $ .04
Oats (per bu.) (1-371) .04
Wheat (per bu.) (1-372) .04
Soybeans (per bu.) (1-373) .04
Field beans (per cwt.) (1-374) .06

36. Custom harvest rates per acre are:
(a) Corn silage (2-2359) 11.00
(b) Corn Grain (2-2360) 8.00
(c) Wheat (2-2361) 6.00

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1. Use a number between 0 and 10 for per acre owned value. If a number greater than 10 is used this will be assumed to be the total annual tax bill.

(d) Oats (2-2362) 6.00
(e) Field Beans (2-2363) 7.00
(f) Soybeans (2-2364) 6.00

37. (a) Machinery is insured at (2-2316) 100 percent of depreciated value.

(b) Machinery insurance cost as percent of amount of insurance is (2-2317) 0.65.

(c) Months insurance is paid (2-599) 3 (2-600) 9 .

38. (a) Amount of building insurance as a percent of new value is (1-633) 60 .

(b) Building insurance rate as a percent of amount of insurance is (1-634) .65 .

(c) Fire insurance on buildings, livestock and produce is paid during the month of (1-635) 3 .

39. (a) Cost of insurance on livestock is (2-8889) $1.18 per $1000 value.

(b) Cost of insurance on produce and supplies is (2-8890) $ .78 per $1000 value.

40. The market value of new buildings is (1-619) 60 percent of the purchase price.

41. (a) Distribution of Building Repair Cost and Labor Requirements

| | Month | | | | | |
|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June |
| % of annual total | 1-620 7 | 1-621 8 | 1-622 10 | 1-623 11 | 1-624 8 | 1-625 5 |
| | July | Aug | Sept | Oct | Nov | Dec |
| % of annual total | 1-626 8 | 1-627 9 | 1-628 8 | 1-629 8 | 1-630 8 | 1-631 10 |

(b) Annual building repair cost as a percent of new value is (1-632) 2.5 .

42. Average sale weight per animal (pounds) is:

(a) Dairy calves (2-2534) 100
(b) Cull cows (2-2535) 1300
(c) Dairy Steers (2-2536) 1000

43. Ag. program payments are (1-602)[1] $2.00. Months payments are received is (1-603) 5 and (1-604) 11 .

44. Machinery sold is valued at (2-2318) 90 percent of its depreciated value.

45. All machines have a (2-598) 10 percent salvage value.

46. (a) Income from the sale of land is distributed over (2-8891) 3 years.

(b) Annual income from the sale of land is received in month (2-8892) 3 .

Mortality and Feed Requirements

47. (a) Calf mortality rate is (1-419) _____ percent.
(b) Heifer mortality rate is (1-420) 2 percent.
(c) Percent of heifers sold for infertility is (1-421) 4 .
(d) Conception rate for heifers is (1-422) 70 .

48. (a) Approximately (2-2865) 2.8 percent of the cow herd is expected to die each year.

(b) Approximately (2-2866) 4.1 percent of the cow herd will be sold because of physical injury or disease each year. These animals are sold at one-half price each year.

49. Dairy Herd Forage and Grain Requirements

| Level of Grain Feeding (lbs.) | | Tons H.E. Required |
|---|---|---|
| 1 | (2-601) 2000 | (2-613) 7.0 |
| 2 | (2-602) 2500 | (2-614) 6.9 |
| 3 | (2-603) 3000 | (2-615) 6.8 |
| 4 | (2-604) 3500 | (2-616) 6.6 |
| 5 | (2-605) 4000 | (2-617) 6.4 |

1. Use a number between 0 and 10 for per crop acre value. If a number greater than 10 is used this will be assumed to be the total annual farm Ag. program payment.

49. (con't)

| Level of Grain Feeding (lbs.) | | Tons H.E. Required | |
|---|---|---|---|
| 6 | (2-606) 4500 | (3-618) | 6.2 |
| 7 | (2-607) 5000 | (2-619) | 6.0 |
| 8 | (2-608) 5500 | (2-620) | 5.8 |
| 9 | (2-609) 6000 | (2-621) | 5.6 |
| 10 | (2-610) 6500 | (2-622) | 5.3 |
| 11 | (2-611) 7000 | (2-623) | 5.1 |
| 12 | (2-612) 7500 | (2-624) | 4.8 |

50. (a) The average amount of feed in pounds fed per month to heifers under 12 months of age is (1-437) 120 .

(b) Annual hay equivalent requirements (tons) for heifers
Birth to 12 months (1-438) 1.5
12 months to freshening (1-439) 4.0

51. Feed Requirements for Beef Steers

Lbs. Per Animal Per Day on Feed

| | Ration Number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Feed | 1[a] | 2[a] | 3[a] | 4[a] | 5[b] | 6[b] | 7[b] | 8[b] |
| Corn Silage | 2-2319 42 | 2-2324 0 | 2-2329 22 | 2-2334 22 | 2-2339 58 | 2-2344 0 | 2-2349 28 | 2-2354 28 |
| Hay Crop Silage (70%) | 2-2320 0 | 2-2325 36 | 2-2330 20 | 2-2335 0 | 2-2340 0 | 2-2345 50 | 2-2350 26 | 2-2355 0 |
| Hay | 2-2321 0 | 2-2326 0 | 2-2331 0 | 2-2336 7 | 2-2341 0 | 2-2346 0 | 2-2351 0 | 2-2356 9 |
| Shelled Corn | 2-2322 0 | 2-2327 3.5 | 2-2332 1.75 | 2-2337 1.7 | 2-2342 0 | 2-2347 4.5 | 2-2352 | 2-2357 2.52 |
| Supplement | 2-2323 1¼ | 2-2328 0 | 2-2333 0 | 2-2338 0 | 2-2343 1¼ | 2-2348 0 | 2-2353 0 | 2-2358 0 |

a. Per standard to good 400 pound holstein and beef type calves fed to 1,000 lbs. with expected daily gain of 1.9 lbs and feeding period of 316 days.

b. For standard to good 650 pound holstein or beef type steers fed to 1,000 lbs with expected daily gain of 2.0 lbs and feeding periods of 225 days.

52. (a) Straw Requirements for Cows
Per Animal Per Season

| Season | System Number | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Winter (Oct.-Apr.) | 1-441<br>.5 | 1-445<br>.2 | 1-449<br>.2 | 1-453<br>.2 | 1-457<br>.2 | 1-461<br>.6 | 1-465<br>0 |
| Summer (May - Sept. | 1-442<br>0 | 1-446<br>.05 | 1-450<br>.05 | 1-453<br>.05 | 1-458<br>.05 | 1-462<br>4 | 1-466<br>0 |

52. (b) Straw Requirements for Heifers
Per Animal Per Season

| Season | System Number | | | | | | |
|---|---|---|---|---|---|---|---|
| | Under One Year | | | Over One Year | | | Blank Cells |
| | 8 | 9 | 10 | 8 | 9 | 10 | |
| Winter (Oct.-Apr.) | 1-443<br>.2 | 1-447<br>.10 | 1-451<br>0 | 1-455<br>.40 | 1-459<br>.15 | 1-463<br>0 | 1-467<br>0 |
| Summer (May-Spet.) | 1-444<br>.15 | 1-448<br>.05 | 1-452<br>0 | 1-456<br>0 | 1-460<br>0 | 1-464<br>0 | 1-468<br>0 |

53. Monthly Price Coefficients and Price Levels

| Month | Milk (cwt.) | Corn (bu.) | Wheat (bu.) | Oats (bu.) | Dry Beans (cwt.) | Soy-beans (bu.) | Hay (ton) | Cull[b] Cows (cwt.) | Dairy[c] Steers (cwt.) | Dairy Calves (cwt.) | Milk Cows (head) | Straw (ton) | Supple-ment (ton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 2-2365 | 2-2378 | 2-2391 | 2-2404 | 2-2417 | 2-2430 | 2-2443 | 2-456 | 2-2469 | 2-2482 | 2-2495 | 2-2508 | 2-2521 |
| | 1.02 | 1.03 | 1.07 | 1.12 | .99 | 1.02 | 1.04 | .92 | .98 | .98 | .96 | 1.03 | 1.00 |
| Feb. | 2-2366 | 2-2379 | 2-2392 | 2-2405 | 2-2418 | 2-2431 | 2-2444 | 2-2457 | 2-2470 | 2-2483 | 2-2496 | 2-2509 | 2-2522 |
| | 1.02 | 1.02 | 1.07 | 1.11 | 1.02 | 1.02 | 1.03 | .98 | .97 | .97 | .95 | 1.03 | .98 |
| Mar. | 2-2367 | 2-2380 | 2-2393 | 2-2406 | 2-2419 | 2-2432 | 2-2445 | 2-2458 | 2-2471 | 2-2484 | 2-2497 | 2-2510 | 2-2523 |
| | 1.01 | 1.03 | 1.10 | 1.08 | 1.02 | 1.02 | 1.05 | 1.02 | .97 | .97 | .96 | 1.04 | .98 |
| Apr. | 2-2368 | 2-2381 | 2-2394 | 2-2407 | 2-2420 | 2-2433 | 2-2446 | 2-2459 | 2-2472 | 2-2485 | 2-2498 | 2-2511 | 2-2524 |
| | .99 | 1.02 | 1.06 | 1.07 | 1.00 | 1.03 | 1.03 | 1.01 | .97 | .97 | .98 | 1.05 | .97 |
| May | 2-2369 | 2-2382 | 2-2395 | 2-2408 | 2-2421 | 2-2434 | 2-2447 | 2-2460 | 2-2473 | 2-2486 | 2-2499 | 2-2512 | 2-2525 |
| | .98 | 1.05 | 1.03 | 1.03 | 2.01 | 1.05 | 1.00 | 1.05 | 1.00 | 1.00 | .99 | 1.04 | .99 |
| June | 2-2370 | 2-2383 | 2-2396 | 2-2409 | 2-2422 | 2-2435 | 2-2448 | 2-2461 | 2-2474 | 2-2487 | 2-2500 | 2-2513 | 2-2526 |
| | .94 | 1.04 | .97 | 1.03 | 1.04 | 1.04 | 1.02 | 1.10 | 1.02 | 1.02 | 1.01 | 1.00 | 1.03 |
| July | 2-2371 | 2-2384 | 2-2397 | 2-2410 | 2-2423 | 2-2436 | 2-2449 | 2-2462 | 2-2475 | 2-2488 | 2-2501 | 2-2514 | 2-2527 |
| | .95 | 1.03 | .95 | .94 | 1.04 | 1.03 | .97 | 1.06 | 1.03 | 1.03 | 1.02 | .90 | 1.04 |
| Aug. | 2-2372 | 2-2385 | 2-2398 | 2-2411 | 2-2424 | 2-2437 | 2-2450 | 2-2563 | 2-2476 | 2-2489 | 2-2502 | 2-2515 | 2-2528 |
| | .98 | .99 | .90 | .88 | 1.05 | 1.05 | .96 | 1.04 | 1.02 | 1.02 | 1.04 | .90 | 1.05 |
| Sept. | 2-2373 | 2-2386 | 2-2399 | 2-2412 | 2-2425 | 2-2438 | 2-2451 | 2-2564 | 2-2477 | 2-2490 | 2-2503 | 2-2516 | 2-2529 |
| | 1.00 | .97 | .91 | .90 | .92 | .92 | .95 | 1.00 | 1.01 | 1.01 | 1.02 | .95 | 1.03 |
| Oct. | 2-2374 | 2-2387 | 2-2400 | 2-2413 | 2-2426 | 2-2439 | 2-2452 | 2-2565 | 2-2478 | 2-2491 | 2-2504 | 2-2517 | 2-2530 |
| | 1.03 | .93 | .94 | .90 | .94 | .93 | .98 | .96 | 1.01 | 1.01 | 1.02 | 1.01 | .99 |
| Nov. | 2-2375 | 2-2388 | 2-2401 | 2-2414 | 2-2427 | 2-2440 | 2-2453 | 2-2566 | 2-2479 | 2-2492 | 2-2505 | 2-2518 | 2-2531 |
| | 1.04 | .93 | .99 | .94 | .98 | .94 | .97 | .92 | 1.01 | 1.01 | 1.02 | 1.02 | .94 |
| Dec. | 2-2376 | 2-2389 | 2-2402 | 2-2415 | 2-2428 | 2-2441 | 2-2454 | 2-2567 | 2-2480 | 2-2493 | 2-2506 | 2-2519 | 2-2532 |
| | 1.04 | .98 | 1.01 | 1.00 | .99 | .95 | 1.00 | .94 | 1.01 | 1.01 | 1.03 | 1.03 | 1.00 |
| Average Price($)[a] | 2-2377 | 2-2390 | 2-2403 | 2-2416 | 2-2429 | 2-2442 | 2-2455 | 2-2568 | 2-2481 | 2-2494 | 2-2507 | 2-2520 | 2-2533 |
| | 5.46 | 1.06 | 1.22 | .64 | 7.70 | 2.38 | 22.02 | 19.30 | 24.32 | 32.50 | 310.00 | 16.50 | 106.15 |

a. Average price is a straight average of monthly prices and not a price weighted by amount marketed.

b. Slaughter Cows, Utility, Detroit.

c. Standard, Detroit.

54. Labor Requirements

Annual Dairy Cow Labor Requirements (Hours)

| No. of Cows | Dairy Cow System | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Less than 30 | 2-661<br>100 | 2-666<br>60 | 2-671<br>60 | 2-676<br>59 | 2-681<br>59 | 2-686<br>66 | 2-691<br>0 |
| 31-49 | 2-662<br>90 | 2-667<br>52 | 2-672<br>52 | 2-677<br>51 | 2-682<br>51 | 2-687<br>57 | 2-692<br>0 |
| 50-79 | 2-663<br>80 | 2-668<br>48 | 2-673<br>48 | 2-678<br>46 | 2-683<br>46 | 2-688<br>53 | 2-693<br>0 |
| 80-149 | 2-664<br>70 | 2-669<br>45 | 2-674<br>45 | 2-679<br>43 | 2-684<br>43 | 2-689<br>50 | 2-694<br>0 |
| 150 and over | 2-665<br>70 | 2-670<br>42 | 2-675<br>42 | 2-680<br>39 | 2-685<br>39 | 2-690<br>46 | 2-695<br>0 |

55. Livestock Monthly Labor Distribution Coefficients[a]

Portion of Average Monthly Requirement

| Animal | Jan. | Feb. | Mar. | Apr. | May. | June |
|---|---|---|---|---|---|---|
| Cows | 2-696<br>1 | 2-698<br>1 | 2-700<br>1 | 2-702<br>1 | 2-704<br>1 | 2-706<br>1 |
| Heifers | 2-697<br>1.2 | 2-699<br>1.2 | 2-701<br>1.2 | 2-703<br>1.2 | 2-705<br>.8 | 2-707<br>.8 |
| | July | Aug. | Sept. | Oct. | Nov. | Dec. |
| Cows | 2-708<br>1 | 2-710<br>1 | 2-712<br>1 | 2-714<br>1 | 2-716<br>1 | 2-718<br>1 |
| Heifers | 2-709<br>.8 | 2-711<br>.8 | 2-713<br>.8 | 2-715<br>.8 | 2-717<br>1.2 | 2-719<br>1.2 |

a. Equals portion of average month coefficient. Weighted average value for the year must equal 1. For example, data indicate that stanchion systems for cows might use = 1.2 for months 11, 12, 1, 2, 3, 4, and 8 for months 5, 6, 7, 8, 9, 10.

56. Annual Dairy Replacement Labor Requirements (Hours)

| Animal Age | Dairy Replacement System Number 8 | 9 | 10 |
|---|---|---|---|
| Under 12 months | (2-720) 15 | (2-722) 13 | (2-724) 0 |
| 12 Mo. to fresh | (2-721) 10 | (2-723) 8 | (2-725) 0 |

57. Crop Systems Annual Labor Requirements

| System | Hours | | Row |
|---|---|---|---|
| GS-1 Corn Grow, April, 2-row | (2-726) | 4.31 | 1 |
| GS-2 Corn Grow, April, 4-row | (2-727) | 3.56 | 2 |
| GS-3 Corn Grow, April, 6-row | (2-728) | 2.76 | 3 |
| GS-4 Corn Grow, April, User | (2-729) | | 4 |
| GS-5 Corn Grow, May, 2-row | (2-730) | 4.31 | 5 |
| GS-6 Corn Grow, May, 4-row | (2-731) | 3.56 | 6 |
| GS-7 Corn Grow, May, 6-row | (2-732) | 2.76 | 7 |
| GS-8 Corn Grow, May, User | (2-733) | | 8 |
| GS-9 Corn Grow, June, 2-row | (2-734) | 4.31 | 9 |
| GS-10 Corn Grow, June, 4-row | (2-735) | 3.56 | 10 |
| GS-11 Corn Grow, June, 6-row | (2-736) | 2.76 | 11 |
| GS-12 Corn Grow, June, User | (2-737) | | 12 |
| GS-13 Wheat Grow, Sept., 2-4 row | (2-738) | 1.93 | 13 |
| GS-14 Wheat Grow, Sept., 6-row | (2-739) | 1.81 | 14 |
| GS-15 Wheat Grow, Sept., User | (2-740) | | 15 |
| GS-16 Wheat Grow, Oct., 2-4 row | (2-741) | 1.93 | 16 |
| GS-17 Wheat Grow, Oct., 6-row | (2-742) | 1.81 | 17 |
| GS-18 Wheat Grow, Oct., User | (2-743) | | 18 |
| GS-19 Oats Grow, April, 2-4 row | (2-744) | 1.66 | 19 |
| GS-20 Oats Grow, April, 6-row | (2-745) | 1.53 | 20 |
| GS-21 Oats Grow, April, User | (2-746) | | 21 |
| GS-22 Oats Grow, May, 2-4 row | (2-747) | 1.66 | 22 |
| GS-23 Oats Grow, May, 6-row | (2-748) | 1.53 | 23 |
| GS-24 Oats Grow, May, User | (2-749) | | 24 |
| GS-25 Hay crop plant, direct, 2-4 row | (2-750) | .80 | 25 |
| GS-26 Hay crop plant, direct, 6-row | (2-751) | | 26 |
| GS-27 Hay crop plant, companion crop | (2-752) | .39 | 27 |
| GS-28 Hay crop plant, User | (2-753) | | 28 |
| GS-29 Hay crop maintain - fertilizer | (2-754) | .90 | 29 |
| GS-30 Hay crop maintain - User | (2-755) | | 30 |

57. (Cont'd.)

| System | Hours | | Row |
|---|---|---|---|
| GS-31 Field Bean Grow, May, 4-row | (2-756) | 3.92 | 31 |
| GS-32 Field Bean Grow, May, 6-row | (2-757) | 3.02 | 32 |
| GS-33 Field Bean Grow, May, User | (2-758) | | 33 |
| GS-34 Field Bean Grow, June, 4-row | (2-759) | 3.92 | 34 |
| GS-35 Field Bean Grow, June, 6-row | (2-760) | 3.02 | 35 |
| GS-36 Field Bean Grow, June, User | (2-761) | | 36 |
| GS-37 Soybeans Grow, May, 4-row | (2-762) | 3.22 | 37 |
| GS-38 Soybeans Grow, May, 6-row | (2-763) | 2.57 | 38 |
| GS-39 Soybeans Grow, May, User | (2-764) | | 39 |
| GS-40 Soybeans Grow, June, 4-row | (2-765) | 3.22 | 40 |
| GS-41 Soybeans Grow, June, 6-row | (2-766) | 2.57 | 41 |
| GS-42 Soybeans Grow, June, User | (2-767) | | 42 |
| HS-1 Corn silage harvest, custom | (2-768) | .50 | 43 |
| HS-2 Corn silage harvest, 1-row | (2-769) | 4.65 | 44 |
| HS-3 Corn silage harvest, 2-row | (2-770) | 4.01 | 45 |
| HS-4 Corn silage harvest, S.P. chopper | (2-771) | 3.13 | 46 |
| HS-5 Corn silage harvest, User | (2-772) | | 47 |
| HS-6 Corn grain harvest, custom | (2-773) | .25 | 48 |
| HS-7 Corn grain harvest, 1-row picker | (2-774) | 3.11 | 49 |
| HS-8 Corn grain harvest, 2-row picker | (2-775) | 2.51 | 50 |
| HS-9 Corn grain harvest, 2-row combine | (2-776) | 2.28 | 51 |
| HS-10 Corn grain harvest, 3-row combine | (2-777) | 2.02 | 52 |
| HS-11 Corn grain harvest, User | (2-778) | | 53 |
| HS-12 Wheat harvest, custom | (2-779) | .20 | 54 |
| HS-13 Wheat harvest, S.P. combine spread straw | (2-780) | 1.08 | 55 |
| HS-14 Wheat harvest, S.P. combine bale straw | (2-781) | 2.04 | 56 |
| HS-15 Wheat harvest, User | (2-782) | | 57 |
| HS-16 Oats harvest, custom | (2-783) | .20 | 58 |
| HS-17 Oats harvest, S.P. combine spread straw | (2-784) | 1.16 | 59 |
| HS-18 Oats harvest, S.P. combine bale straw | (2-785) | 2.07 | 60 |
| HS-19 Oats harvest, User | (2-786) | | 61 |
| HS-20 Hay crop silage harvest, mow, 1-row | (2-787) | 3.00 | 62 |
| HS-21 Hay crop silage harvest, windrow, 2-row | (2-788) | 2.60 | 63 |
| HS-22 Hay crop silage harvest, windrow, S.P. chopper | (2-789) | 2.40 | 64 |
| HS-23 Hay crop silage harvest, windrow, 1-row | (2-790) | 2.80 | 65 |
| HS-24 Hay crop silage harvest, User | (2-791) | | 66 |
| HS-25 Hay harvest, mow, bale, load behind wagon | (2-792) | 4.66 | 67 |

57. (Cont'd.)

| System | Hours | | Row |
|---|---|---|---|
| HS-26 Hay harvest, windrow, mow conveyor | (2-793) | 3.22 | 68 |
| HS-27 Hay harvest, windrow, kicker | (2-794) | 3.72 | 69 |
| HS-28 Hay harvest, User | (2-795) | | 70 |
| HS-29 Field Bean harvest, custom | (2-796) | .30 | 71 |
| HS-30 Field Bean harvest, 4-row, bean head | (2-797) | 2.38 | 72 |
| HS-31 Field Bean harvest, 6-row combine | (2-798) | 1.98 | 73 |
| HS-32 Field Bean harvest, User | (2-799) | | 74 |
| HS-33 Soybeans harvest, custom | (2-800) | | 75 |
| HS-34 Soybeans harvest, combine | (2-801) | 1.47 | 76 |
| HS-35 Soybeans harvest, User | (2-802) | | 77 |

Building Investment Costs and Requirements

58. (a) Cow capacity in a stanchion barn will be defined as the number of stanchions plus (1-405) 15 percent if there is enough space for (1-405) 100 percent of the additional animals in with the heifers.

(b) Cow capacity in a free stall or user defined barn will be defined as the number of free stalls plus (1-406) 25 percent, if there is enough room for (1-407) 60 percent of these animals with the heifers.

59. (a) If dairy buildings are to be purchased by the program, they will be purchased (1-408) 0 months after capacity is first exceeded and the cow building capacity purchased will equal (1-409) 20 animals, (1-410) 50 percent of the present building capacity or facilities for the animal numbers at the end of this month, which ever is larger.

60. When dairy building construction is calculated by the program, forage storage is constructed as follows:

| | Silos Storage (tons) | | Dry Hay Storage (tons) | |
|---|---|---|---|---|
| Cows | (1-411) | 12 | (1-414) | 0 |
| heifers over 1 yr. | (1-412) | 0 | (1-415) | 0 |
| heifers under 1 yr. | (1-413) | 0 | (1-416) | 1.5 |

61. The number of cows that can be handled with

One 1-man parlor is (1-417) 100
One 2-man parlor is (1-418) 200

62. When grain storage capacity is to be built by the program, high moisture corn storage will be built only if at least (1-389) 60. percent of that capacity will be used in the year built.

63. (a) Cost of hay storage capacity (per ton) is (1-636) $25.00.

(b) Cost of ear corn storage (per bushel) is (1-637) $1.50.

(c) Cost of grain bin storage (per bushel) is (1-638) $2.00.

64. The cost of milking parlors is:

(a) One man parlor (double-four herringbone)
Building (1-639) $9,900.

(b) One man parlor (double-four herringbone)
Equipment (1-640) $6,200.

(c) Two man parlor (double-eight herringbone)
Building (1-641) $12,100.

(d) Two man parlor (double-eight herringbone)
Equipment (1-642) $10,200.

(e) Life for parlor and barn equipment is (years) (1-643) 8 .

65. Heifer and Calf Building Costs

| Type of Animal | Cost Per Stall | | |
|---|---|---|---|
| | Conventional Pens | Free Stall | User Defined |
| Heifers & Dry Cows | (2-1) $270 | (2-3) $337 | (2-5) 0 |
| Calves | (2-2) $203 | (2-4) $253 | (2-6) 0 |

66. Per Cow Cost of Building Equipment

Includes Feeders, Ventilation System, Etc.

| Number of Stalls | Tie Stall Stanchion | Cold Covered | Warm Covered | Liquid Cold Covered | Liquid Warm Covered | Open Lot | User Defined |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Under 70 | (2-7) 200 | (2-12) 114 | (2-17) 154 | (2-22) 152 | (2-27) 192 | (2-32) 114 | (2-37) 0 |
| 70-89 | (2-8) 200 | (2-13) 100 | (2-18) 139 | (2-23) 127 | (2-28) 166 | (2-33) 100 | (2-38) 0 |
| 90-109 | (2-9) 200 | (2-14) 79 | (2-19) 117 | (2-24) 93 | (2-29) 131 | (2-34) 79 | (2-39) 0 |
| Over 109 | (2-10) 200 | (2-15) 69 | (2-20) 107 | (2-25) 78 | (2-30) 116 | (2-35) 69 | (2-40) 0 |

66. (Cont'd.)

Per Cow Cost of Dairy Building Excluding Equipment

| Tie Stall Stanchion | Cold Covered | Warm Covered | Liquid Cold Covered | Liquid Warm Covered | Open Lot | User Defined |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (2-11) 375 | (2-16) 223 | (2-21) 268 | (2-26) 283 | (2-31) 328 | (2-36) 197 | (2-41) 0 |

67. Upright and Horizontal Silo Costs

| Upright | | | Bunker | |
|---|---|---|---|---|
| Capacity Tons | Bushels | Cost | Minimum Tons[a] | Cost Per Ton |
| 2-42 150 | 2-53 4,280 | 2-64 2,870 | 2-75 0 | 2-86 $10.00 |
| 2-43 193 | 2-54 5,350 | 2-65 3,015 | 2-76 250 | 2-87 9.00 |
| 2-44 320 | 2-55 8,850 | 2-66 4,791 | 2-77 750 | 2-88 7.00 |
| 2-45 394 | 2-56 10,900 | 2-67 5,461 | 2-78 1,250 | 2-89 5.50 |
| 2-46 483 | 2-57 13,080 | 2-68 6,359 | 2-79 1,750 | 2-90 4.50 |
| 2-47 570 | 2-58 15,700 | 2-69 7,224 | 2-80 2,250 | 2-91 4.10 |
| 2-48 697 | 2-59 18,840 | 2-70 8,271 | 2-81 2,750 | 2-92 4.00 |
| 2-49 827 | 2-60 | 2-71 9,318 | 2-82 3,250 | 2-93 3.90 |
| 2-50 974 | 2-61 | 2-72 11,858 | 2-83 3,750 | 2-94 3.80 |
| 2-51 1,087 | 2-62 | 2-73 13,620 | 2-84 | 2-95 |
| 2-52 1,290 | 2-63 | 2-74 15,057 | 2-85 | 2-96 |

a. Number of tons capacity that must be built to achieve costs as low as that indicated under "cost per ton".

68. Machine Costs

Machine Purchase Price and Life

| Machine | Machine Code | Purchase Price | Life (Years) | Month of Replacement |
|---|---|---|---|---|
| 40 H.P. Tractor | 1 | (2-268) 4,130 | (2-378) 10 | (2-488) 10 |
| 41-60 H.P. Tractor | 2 | (2-269) 5,240 | (2-379) 10 | (2-489) 4 |
| 61-80 H.P. Tractor | 3 | (2-270) 7,830 | (2-380) 10 | (2-490) 4 |
| 81-100 H.P. Tractor | 4 | (2-271) 8,410 | (2-381) 10 | (2-491) 4 |
| 100 H.P. Tractor | 5 | (2-272) 9,780 | (2-382) 10 | (2-492) 4 |
| | 6 | (2-273) | (2-383) | (2-493) |
| | 7 | (2-274) | (2-384) | (2-494) |
| | 8 | (2-275) | (2-385) | (2-495) |
| Pick-up Truck | 9 | (2-276) 2,880 | (2-386) 5 | (2-496) 3 |
| Large Truck | 10 | (2-277) 4,600 | (2-387) 5 | (2-497) 7 |
| | 11 | (2-278) | (2-388) | (2-498) |
| Unloading Wagons | 12 | (2-279) 2,240 | (2-389) 10 | (2-499) 9 |
| Unloading Trucks | 13 | (2-280) 1,800 | (2-390) 8 | (2-500) 9 |
| Small Spreader | 14 | (2-281) 1,090 | (2-391) 10 | (2-501) 10 |
| Large Spreader | 15 | (2-282) 1,270 | (2-392) 10 | (2-502) 10 |
| Liquid Spreader | 16 | (2-283) 1,725 | (2-393) 5 | (2-503) 12 |
| Gutter Cleaner (30 cows) | 17 | (2-284) 1,640 | (2-394) 8 | (2-504) 2 |
| Scraper (loader) | 18 | (2-285) 890 | (2-395) 10 | (2-505) 10 |
| Liquid Pump | 19 | (2-286) 1,725 | (2-396) 5 | (2-506) 12 |
| | 20 | (2-287) | (2-397) | (2-507) |
| | 21 | (2-288) | (2-398) | (2-508) |
| 14' Silo Unloader | 22 | (2-289) 1,330 | (2-399) 8 | (2-509) 10 |
| 16' Silo Unloader | 23 | (2-290) 1,450 | (2-400) 8 | (2-510) 10 |
| 18' Silo Unloader | 24 | (2-291) 1,575 | (2-401) 8 | (2-511) 10 |
| 20' Silo Unloader | 25 | (2-292) 1,620 | (2-402) 8 | (2-512) 10 |
| 24' Silo Unloader | 26 | (2-293) 2,200 | (2-403) 8 | (2-513) 10 |
| 28' Silo Unloader | 27 | (2-294) 2,310 | (2-404) 8 | (2-514) 10 |
| 30' Silo Unloader | 28 | (2-295) 2,365 | (2-405) 8 | (2-515) 10 |
| Trench Unloader | 29 | (2-296) 2,300 | (2-406) 8 | (2-516) 10 |
| 400 Gal Bulk Tank | 30 | (2-297) 3,800 | (2-407) 10 | (2-517) 6 |
| 600 Gal Bulk Tank | 31 | (2-298) 4,575 | (2-408) 10 | (2-518) 6 |
| 800 Gal Bulk Tank | 32 | (2-299) 5,500 | (2-409) 10 | (2-519) 6 |
| 1000 Gal. Bulk Tank | 33 | (2-300) 6,500 | (2-410) 10 | (2-520) 6 |
| 1400 Gal. Bulk Tank | 34 | (2-301) 8,500 | (2-411) 10 | (2-521) 6 |
| 2000 Gal. Bulk Tank | 35 | (2-302) 10,000 | (2-412) 10 | (2-522) 6 |
| Milk Transfer | 36 | (2-303) 750 | (2-413) 8 | (2-523) 9 |
| Barn Equipment | 37 | (2-304) 1,500 | (2-414) 8 | (2-524) 11 |
| Parlor Equipment | 38 | (2-305) 6,200 | (2-415) 8 | (2-525) 11 |
| | 39 | (2-306) | (2-416) | (2-526) |
| 2 Row Cultivator | 40 | (2-307) 520 | (2-417) 10 | (2-527) 6 |
| 4 Row Cultivator | 41 | (2-308) 1,010 | (2-418) 10 | (2-528) 6 |
| 6 Row Cultivator | 42 | (2-309) 1,725 | (2-419) 10 | (2-529) 6 |
| Sprayer | 43 | (2-310) 660 | (2-420) 10 | (2-530) 6 |
| 2'14" plow | 44 | (2-311) 375 | (2-421) 10 | (2-531) 3 |
| 2-16" plow | 45 | (2-312) 400 | (2-422) 10 | (2-532) 3 |
| 3-14" plow | 46 | (2-313) 755 | (2-423) 10 | (2-533) 3 |

68. (Cont'd.)

| Machine | Machine Code | Purchase Price | Life (Years) | Month of Replacement |
|---|---|---|---|---|
| 3-16" plow | 47 | (2-314) 800 | (2-424) 10 | (2-534) 3 |
| 4-14" plow | 48 | (2-315) 1,150 | (2-425) 10 | (2-535) 3 |
| 4-16" plow | 49 | (2-316) 1,210 | (2-426) 10 | (2-536) 3 |
| 5-14" plow | 50 | (2-317) 1,365 | (2-427) 10 | (2-537) 3 |
| 5-16" plow | 51 | (2-318) 1,440 | (2-428) 10 | (2-538) 3 |
| 6-14" plow | 52 | (2-319) 1,490 | (2-429) 10 | (2-539) 3 |
| 6-16" plow | 53 | (2-320) 1,580 | (2-430) 10 | (2-540) 3 |
| 7-14" plow | 54 | (2-321) 2,300 | (2-431) 10 | (2-541) 3 |
| 7-16" plow | 55 | (2-322) 2,425 | (2-432) 10 | (2-542) 3 |
| 8-14" plow | 56 | (2-323) 2,700 | (2-433) 10 | (2-543) 3 |
| 8-16" plow | 57 | (2-324) 2,840 | (2-434) 10 | (2-544) 3 |
| | 58 | (2-325) | (2-435) | (2-545) |
| | 59 | (2-326) | (2-436) | (2-546) |
| 10' Disc | 60 | (2-327) 925 | (2-437) 12 | (2-547) 3 |
| 12' Disc | 61 | (2-328) 1,150 | (2-438) 12 | (2-548) 3 |
| 14' Disc | 62 | (2-329) 1,335 | (2-439) 12 | (2-549) 3 |
| 16' Disc | 63 | (2-330) 1,520 | (2-440) 12 | (2-550) 3 |
| 18' Disc | 64 | (2-331) 1,755 | (2-441) 12 | (2-551) 3 |
| 8' Harrow | 65 | (2-332) 160 | (2-442) 15 | (2-552) 3 |
| 12' Harrow | 66 | (2-333) 290 | (2-443) 15 | (2-553) 3 |
| 16' Harrow | 67 | (2-334) 400 | (2-444) 15 | (2-554) 3 |
| 20' Harrow | 68 | (2-335) 480 | (2-445) 15 | (2-555) 3 |
| 24' Harrow | 69 | (2-336) 555 | (2-446) 15 | (2-556) 3 |
| | 70 | (2-337) | (2-447) | (2-557) |
| 2 row planter | 71 | (2-338) 460 | (2-448) 10 | (2-558) 4 |
| 4 row planter | 72 | (2-339) 1,240 | (2-449) 10 | (2-559) 4 |
| 6 row planter | 73 | (2-340) 2,120 | (2-450) 10 | (2-560) 4 |
| Fertilizer Spreader | 74 | (2-341) 860 | (2-451) 8 | (2-561) 7 |
| Grain Drill | 75 | (2-342) 1,270 | (2-452) 12 | (2-562) 3 |
| | 76 | (2-343) | (2-453) | (2-563) |
| 1 Row Chopper | 77 | (2-344) 2,660 | (2-545) 8 | (2-564) 9 |
| 2 Row Chopper | 78 | (2-345) 2,990 | (2-455) 8 | (2-565) 9 |
| 2 Row Chopper (S.P.) | 79 | (2-346) 11,500 | (2-456) 8 | (2-566) 9 |
| Blower | 80 | (2-347) 1,240 | (2-457) 10 | (2-567) 9 |
| 3 Row Corn Head (Grain) | 81 | (2-348) 3,150 | (2-458) 10 | (2-568) 10 |
| 1 Row Corn Picker | 82 | (2-349) 2,070 | (2-459) 10 | (2-569) 10 |
| 2 Row Corn Picker | 83 | (2-350) 3,450 | (2-460) 10 | (2-570) 10 |
| 2 Row Corn Combine | 84 | (2-351) 7,480 | (2-461) 10 | (2-571) 10 |
| 3 Row Corn Combine | 85 | (2-352) 9,750 | (2-462) 10 | (2-572) 10 |
| Grain Wagons | 86 | (2-353) 540 | (2-463) 10 | (2-573) 7 |
| Grain Elevator | 87 | (2-354) 1,225 | (2-464) 10 | (2-574) 7 |
| 2 Row Corn Head (Grain) | 88 | (2-355) 2,280 | (2-465) 10 | (2-575) 10 |
| 10' Grain Combine | 89 | (2-356) 7,180 | (2-466) 10 | (2-576) 7 |
| 12' Grain Combine | 90 | (2-357) 8,300 | (2-467) 10 | (2-577) 7 |
| 14' Grain Combine | 91 | (2-358) 9,430 | (2-468) 10 | (2-578) 7 |
| Bale Kicker | 92 | (2-359) 1,270 | (2-469) 12 | (2-579) 3 |
| PTO Windrower | 93 | (2-360) 1,370 | (2-470) 8 | (2-580) 5 |
| 10' S.P. Windrower | 94 | (2-361) 4,350 | (2-471) 8 | (2-581) 5 |

68. (Cont'd.)

| Machine | Machine Code | Purchase Price | | Life (Years) | | Month of Replacement | |
|---|---|---|---|---|---|---|---|
| 14' S.P. Windrower | 95 | (2-362) | 6,560 | (2-473) | 8 | (2-582) | 5 |
| Windrow Turner | 96 | (2-363) | 170 | (2-474) | 10 | (2-583) | 5 |
| Baler | 97 | (2-364) | 2,100 | (2-475) | 10 | (2-584) | 5 |
| Wagons | 98 | (2-365) | 430 | (2-476) | 12 | (2-585) | 5 |
| Hay Elevator | 99 | (2-366) | 330 | (2-477) | 10 | (2-586) | 5 |
| Mow Conveyor (50A,Hay) | 100 | (2-367) | 1,000 | (2-478) | 10 | (2-587) | 5 |
| Mower | 101 | (2-368) | 640 | (2-478) | 10 | (2-588) | 5 |
| Rake | 102 | (2-369) | 620 | (2-479) | 10 | (2-589) | 5 |
| Crusher | 103 | (2-370) | 1,050 | (2-480) | 8 | (2-590) | 5 |
| Hay Head (1 Row Chopper) | 104 | (2-371) | 790 | (2-481) | 8 | (2-591) | 5 |
| Hay Head (2 Row Chopper | 105 | (2-372) | 1,185 | (2-482) | 8 | (2-592) | 5 |
| Bean Puller Attach | 106 | (2-373) | 540 | (2-483) | 10 | (2-593) | 8 |
| Bean Puller Attach (6 Row) | 107 | (2-374) | 785 | (2-484) | 10 | (2-594) | 8 |
| Bean Combine | 108 | (2-375) | 12,000 | (2-485) | 10 | (2-595) | 8 |
| Bean Attach (Combine) | 109 | (2-376) | 1,400 | (2-486) | 10 | (2-596) | 8 |
| | 110 | (2-377) | | (2-487) | | (2-597) | |

69. Annual Machine Repair and Gas and Oil Costs

| System | System Number | Repair Costs Per Unit | | Gas & Oil Cost Per Unit | |
|---|---|---|---|---|---|
| Dairy Cows | | | | | |
| Stanchion or tie stall | LS(1) | (2-1477) | $4.80 | (2-1564) | $5.40 |
| Cold covered free stall | LS(2) | (2-1478) | 5.28 | (2-1565) | 9.84 |
| Warm enclosed free stall | LS(3) | (2-1479) | 5.28 | (2-1566) | 9.84 |
| Cold, free stall, liquid | LS(4) | (2-1480) | 4.56 | (2-1567) | 11.40 |
| Warm free stall, liquid | LS(5) | (2-1481) | 4.56 | (2-1568) | 11.40 |
| Loose housing, open lot | LS(6) | (2-1482) | 5.64 | (2-1569) | 10.44 |
| Dairy Cow-User | LS(7) | (2-1483) | | (2-1570) | |
| Dairy Replacements | | | | | |
| Conventional pens | LS(8) | (2-1484) | 1.32 | (2-1571) | 2.52 |
| Free stall | LS(9) | (2-1485) | 2.40 | (2-1572) | 4.44 |
| User | LS(10) | (2-1486) | | (2-1573) | |

69. (Cont'd.)

| System | System Number | Repair Costs Per Unit | | Gas & Oil Cost Per Unit | |
|---|---|---|---|---|---|
| Corn Grow | | | | | |
| April, 2-row | GS(1) | (2-1487) | $ 1.16 | (2-1574) | $1.79 |
| April, 4-row | GS(2) | (2-1488) | .97 | (2-1575) | 1.49 |
| April, 6-row | GS(3) | (2-1489) | .81 | (2-1576) | 1.24 |
| April, User | GS(4) | (2-1490) | | (2-1577) | |
| May, 2-row | GS(5) | (2-1491) | 1.16 | (2-1578) | 1.79 |
| May, 4-row | GS(6) | (2-1492) | .97 | (2-1579) | 1.49 |
| May, 6-row | GS(7) | (2-1493) | .81 | (2-1580) | 1.24 |
| May, User | GS(8) | (2-1494) | | (2-1581) | |
| June, 2-row | GS(9) | (2-1495) | 1.16 | (2-1582) | 1.79 |
| June, 4-row | GS(10) | (2-1496) | .97 | (2-1583) | 1.49 |
| June, 6-row | GS(11) | (2-1497) | .81 | (2-1584) | 1.24 |
| June, User | GS(12) | (2-1498) | | (2-1585) | |
| Wheat Grow | | | | | |
| Sept., med. | GS(13) | (2-1499) | .76 | (2-1586) | .95 |
| Sept., large | GS(14) | (2-1500) | .72 | (2-1587) | .91 |
| Sept., User | GS(15) | (2-1501) | | (2-1588) | |
| Oct., med. | GS(16) | (2-1502) | .76 | (2-1589) | .95 |
| Oct., large | GS(17) | (2-1503) | .72 | (2-1590) | .91 |
| Oct., User | GS(18) | (2-1504) | | (2-1591) | |
| Oats Grow | | | | | |
| April, med. | GS(19) | (2-1505) | .76 | (2-1592) | .97 |
| April, large | GS(20) | (2-1506) | .72 | (2-1593) | .93 |
| April, User | GS(21) | (2-1507) | | (2-1594) | |
| May, med. | GS(22) | (2-1508) | .76 | (2-1595) | .97 |
| May, large | GS(23) | (2-1509) | .72 | (2-1596) | .93 |
| May, User | GS(24) | (2-1510) | | (2-1597) | |
| May Crop Plant | | | | | |
| Direct, med. | GS(25) | (2-1511) | .60 | (2-1598) | .97 |
| Direct, large | GS(26) | (2-1512) | .64 | (2-1599) | .90 |
| Companion Crop | GS(27) | (2-1513) | .07 | (2-1600) | .12 |
| User | GS(28) | (2-1514) | | (2-1601) | |
| Hay Crop Maintain | | | | | |
| Fertilizer | GS(29) | (2-1515) | .07 | (2-1602) | .13 |
| User | GS(30) | (2-1516) | | (2-1603) | |
| Field Beans Grow | | | | | |
| May, 4-row | GS(31) | (2-1517) | 1.36 | (2-1604) | 2.09 |

69. (Cont'd.)

| System | System Number | Repair Costs Per Unit | | Gas & Oil Cost Per Unit | |
|---|---|---|---|---|---|
| May, 6-row | GS(32) | (2-1518) | $1.23 | (2-1605) | $1.91 |
| May, User | GS(33) | (2-1519) | | (2-1606) | |
| June, 4-row | GS(34) | (2-1520) | 1.36 | (2-1607) | 2.09 |
| June, 6-row | GS(35) | (2-1521) | 1.23 | (2-1608) | 1.91 |
| June, User | GS(36) | (2-1522) | | (2-1609) | |
| Soybeans Grow | | | | | |
| May, 4-row | GS(37) | (2-1523) | 1.10 | (2-1610) | 1.65 |
| May, 6-row | GS(38) | (2-1524) | 1.06 | (2-1611) | 1.60 |
| May, User | GS(39) | (2-1525) | | (2-1612) | |
| June, 4-row | GS(40) | (2-1526) | 1.10 | (2-1613) | 1.65 |
| June, 6-row | GS(41) | (2-1527) | 1.06 | (2-1614) | 1.60 |
| June, User | GS(42) | (2-1528) | | (2-1615) | |
| Corn Silage Harvest | | | | | |
| Custom | HS(1) | (2-1529) | .84 | (2-1616) | 1.77 |
| 1-row | HS(2) | (2-1530) | 2.83 | (2-1617) | 2.84 |
| 2-row | HS(3) | (2-1531) | 2.56 | (2-1618) | 2.79 |
| 2-row S.P. | HS(4) | (2-1532) | 2.56 | (2-1619) | 2.79 |
| User | HS(5) | (2-1533) | | (2-1620) | |
| Corn Grain Harvest | | | | | |
| Custom | HS(6) | (2-1534) | .06 | (2-1621) | .18 |
| 1-row pick | HS(7) | (2-1535) | .76 | (2-1622) | 1.58 |
| 2-row pick | HS(8) | (2-1536) | .67 | (2-1623) | 1.25 |
| 2-row combine | HS(9) | (2-1537) | 1.05 | (2-1624) | .88 |
| 3-row combine | HS(10) | (2-1538) | .89 | (2-1625) | .80 |
| User | HS(11) | (2-1539) | | (2-1626) | |
| Wheat Harvest | | | | | |
| Custom | HS(12) | (2-1540) | .03 | (2-1627) | .09 |
| Combine, spread straw | HS(13) | (2-1541) | .60 | (2-1628) | .58 |
| Combine, bale straw | HS(14) | (2-1542) | .68 | (2-1629) | .69 |
| User | HS(15) | (2-1543) | | (2-1630) | |
| Oat Harvest | | | | | |
| Custom | HS(16) | (2-1544) | .03 | (2-1631) | .09 |
| Combine, spread straw | HS(17) | (2-1545) | .60 | (2-1632) | .58 |
| Combine, bale straw | HS(18) | (2-1546) | .68 | (2-1633) | .69 |
| User | HS(19) | (2-1547) | | (2-1634) | |

69. (Cont'd.)

| System | System Number | Repair Costs Per Unit | | Gas & Oil Cost Per Unit | |
|---|---|---|---|---|---|
| Hay Crop Silage Harvest | | | | | |
| Mow, 1-row chopper | HS(20) | (2-1548) | $1.89 | (2-1635) | $2.30 |
| Windrow, 2-row chopper | HS(21) | (2-1549) | 1.63 | (2-1636) | 1.59 |
| Windrow, S.P. chopper | HS(22) | (2-1550) | 2.09 | (2-1637) | 1.49 |
| Windrow, 1-row chopper | HS(23) | (2-1551) | 1.67 | (2-1638) | 1.62 |
| User | HS(24) | (2-1552) | | (2-1639) | |
| Hay Harvest | | | | | |
| Mow, rake, bale | HS(25) | (2-1553) | .93 | (2-1640) | 1.41 |
| Windrow, thrower, mow-conveyor | HS(26) | (2-1554) | 1.53 | (2-1641) | 1.25 |
| Windrow, bale, thrower | HS(27) | (2-1555) | .70 | (2-1642) | 1.20 |
| User | HS(28) | (2-1556) | | (2-1643) | |
| Field Bean Harvest | | | | | |
| Pull, rake, custom combine | HS(29) | (2-1557) | .03 | (2-1644) | .09 |
| Pull, rake, combine 4-row | HS(30) | (2-1558) | .92 | (2-1645) | .75 |
| Pull, rake, combine 6-row | HS(31) | (2-1559) | 1.13 | (2-1646) | .92 |
| User | HS(32) | (2-1560) | | (2-1647) | |
| Soybean Harvest | | | | | |
| Custom | HS(33) | (2-1561) | .03 | (2-1648) | .09 |
| Combine | HS(34) | (2-1562) | .48 | (2-1649) | .38 |
| User | HS(35) | (2-1563) | | (2-1650) | |

## Distribution and Relative Efficiency Coefficients For Machine Costs and Labor

The following tables contain the coefficients used for distributing machinery repair, gas and oil costs, and labor requirements throughout the year. Table 72 contains the relative efficiency coefficients for labor requirements for different sizes of operation. The labor distribution and relative efficiency coefficients relate to questions (table) 57.

70. Monthly Distribution of Gas and Oil and Machinery Repair Costs

| Month | Dairy Cows | | Dairy Replacements | | Corn Grow April | | Corn Grow May | | Corn Grow June | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Stanchion or Free Stall 1-6 | User 7 | Pen or Free Stall 8-9 | User 10 | 2,4, or 6 row 1-3 | User 4 | 2,4 or 6 row 5-7 | User 8 | 2,4, or 6 row 9-11 | User 12 |
| Jan. | 2-1651<br>8.34 | 2-1663 | 2-1675<br>8.34 | 2-1687 | 2-1699<br>0 | 2-1711 | 2-1723<br>0 | 2-1735 | 2-1747<br>0 | 2-1759 |
| Feb. | 2-1652<br>8.34 | 2-1664 | 2-1676<br>8.34 | 2-1688 | 2-1700<br>0 | 2-1712 | 2-1724<br>0 | 2-1736 | 2-1748<br>0 | 2-1760 |
| Mar. | 2-1653<br>8.34 | 2-1665 | 2-1677<br>8.34 | 2-1689 | 2-1701<br>14.43 | 2-1713 | 2-1725<br>4.12 | 2-1737 | 2-1749<br>2.06 | 2-1761 |
| Apr. | 2-1654<br>8.33 | 2-1666 | 2-1678<br>8.33 | 2-1690 | 2-1702<br>50.52 | 2-1714 | 2-1726<br>24.74 | 2-1738 | 2-1750<br>12.37 | 2-1762 |
| May | 2-1655<br>8.33 | 2-1667 | 2-1679<br>8.33 | 2-1691 | 2-1703<br>12.37 | 2-1715 | 2-1727<br>42.27 | 2-1739 | 2-1751<br>46.39 | 2-1763 |
| June | 2-1656<br>8.33 | 2-1668 | 2-1680<br>8.33 | 2-1692 | 2-1704<br>6.19 | 2-1716 | 2-1728<br>15.46 | 2-1740 | 2-1752<br>22.68 | 2-1764 |
| July | 2-1657<br>8.33 | 2-1669 | 2-1681<br>8.33 | 2-1693 | 2-1705<br>3.09 | 2-1717 | 2-1729<br>7.22 | 2-1741 | 2-1753<br>13.40 | 2-1765 |
| Aug. | 2-1658<br>8.33 | 2-1670 | 2-1682<br>8.33 | 2-1694 | 2-1706<br>0 | 2-1718 | 2-1730<br>0 | 2-1742 | 2-1754<br>0 | 2-1766 |
| Sept. | 2-1659<br>8.33 | 2-1671 | 2-1683<br>8.33 | 2-1695 | 2-1707<br>0 | 2-1719 | 2-1731<br>0 | 2-1743 | 2-1755<br>0 | 2-1767 |
| Oct. | 2-1660<br>8.33 | 2-1672 | 2-1684<br>8.33 | 2-1696 | 2-1708<br>0 | 2-1720 | 2-1732<br>0 | 2-1744 | 2-1756<br>0 | 2-1768 |
| Nov. | 2-1661<br>8.33 | 2-1673 | 2-1685<br>8.33 | 2-1697 | 2-1709<br>11.34 | 2-1721 | 2-1733<br>5.15 | 2-1745 | 2-1757<br>3.10 | 2-1769 |
| Dec. | 2-1662<br>8.34 | 2-1674 | 2-1686<br>8.34 | 2-1698 | 2-1710<br>2.06 | 2-1722 | 2-1734<br>1.03 | 2-1746 | 2-1758<br>0 | 2-1770 |

70. (Cont'd.)

| Month | Wheat Grow Sept. M or L[a] 13-14 | Wheat Grow Sept. User 15 | Wheat Grow Oct. M or L[a] 16-17 | Wheat Grow Oct. User 18 | Oats Grow April M or L[a] 19-20 | Oats Grow April User 21 | Oats Grow May M or L[a] 22-23 | Oats Grow May User 24 | Hay Crop Plant Direct 25-26 | Hay Crop Plant Companion 27 | Hay Crop Plant User 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 2-1771<br>0 | 2-1783 | 2-1795<br>0 | 2-1807 | 2-1819<br>0 | 2-1831 | 2-1843<br>0 | 2-1855 | 2-1867<br>0 | 2-1879<br>0 | 2-1891 |
| Feb. | 2-1772<br>0 | 2-1784 | 2-1796<br>0 | 2-1808 | 2-1820<br>0 | 2-1832 | 2-1844<br>0 | 2-1856 | 2-1868<br>0 | 2-1880<br>0 | 2-1892 |
| Mar. | 2-1773<br>3.95 | 2-1785 | 2-1797<br>3.95 | 2-1809 | 2-1821<br>11.84 | 2-1833 | 2-1845<br>7.89 | 2-1857 | 2-1869<br>0 | 2-1881<br>0 | 2-1893 |
| Apr. | 2-1774<br>14.47 | 2-1786 | 2-1798<br>14.47 | 2-1810 | 2-1822<br>28.95 | 2-1834 | 2-1846<br>35.53 | 2-1858 | 2-1870<br>0 | 2-1882<br>100.00 | 2-1894 |
| May | 2-1775<br>0 | 2-1787 | 2-1799<br>0 | 2-1811 | 2-1823<br>5.26 | 2-1835 | 2-1847<br>25.00 | 2-1859 | 2-1871<br>0 | 2-1883<br>0 | 2-1895 |
| June | 2-1776<br>0 | 2-1788 | 2-1800<br>0 | 2-1812 | 2-1824<br>0 | 2-1836 | 2-1848<br>5.26 | 2-1860 | 2-1872<br>0 | 2-1884<br>0 | 2-1896 |
| July | 2-1777<br>0 | 2-1789 | 2-1801<br>0 | 2-1813 | 2-1825<br>0 | 2-1837 | 2-1849<br>0 | 2-1861 | 2-1873<br>43.48 | 2-1885<br>0 | 2-1897 |
| Aug. | 2-1778<br>32.89 | 2-1790 | 2-1802<br>0 | 2-1814 | 2-1826<br>0 | 2-1838 | 2-1850<br>0 | 2-1862 | 2-1874<br>56.52 | 2-1886<br>0 | 2-1898 |
| Sept. | 2-1779<br>48.69 | 2-1791 | 2-1803<br>39.47 | 2-1815 | 2-1827<br>0 | 2-1839 | 2-1851<br>0 | 2-1863 | 2-1875<br>0 | 2-1887<br>0 | 2-1899 |
| Oct. | 2-1780<br>0 | 2-1792 | 2-1804<br>42.11 | 2-1816 | 2-1828<br>0 | 2-1840 | 2-1852<br>0 | 2-1864 | 2-1876<br>0 | 2-1888<br>0 | 2-1900 |
| Nov. | 2-1781<br>0 | 2-1793 | 2-1805<br>0 | 2-1817 | 2-1829<br>53.95 | 2-1841 | 2-1853<br>26.32 | 2-1865 | 2-1877<br>0 | 2-1889<br>0 | 2-1901 |
| Dec. | 2-1782<br>0 | 2-1794 | 2-1806<br>0 | 2-1818 | 2-1830<br>0 | 2-1842 | 2-1854<br>0 | 2-1866 | 2-1878<br>0 | 2-1890<br>0 | 2-1902 |

a. Medium or Large.

70. (Cont'd.)

| Month | Hay Crop Maintain | | Field Bean Grow May | | Field Bean Grow June | | Soybean Grow May | | Soybean Grow June | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Summer Fert. 29 | User 30 | 4 or 6 Row 31-32 | User 33 | 4 or 6 Row 34-35 | User 36 | 4 or 6 Row 37-38 | User 39 | 4or 6 Row 40-41 | User 42 |
| Jan. | 2-1903 0 | 2-1915 | 2-1927 0 | 2-1939 | 2-1951 0 | 2-1963 | 2-1975 0 | 2-1987 | 2-1999 0 | 2-2011 |
| Feb. | 2-1904 0 | 2-1916 | 2-1928 0 | 2-1940 | 2-1952 0 | 2-1964 | 2-1976 0 | 2-1988 | 2-2000 0 | 2-2012 |
| Mar. | 2-1905 0 | 2-1917 | 2-1929 2.94 | 2-1941 | 2-1953 0 | 2-1965 | 2-1977 0 | 2-1989 | 2-2001 0 | 2-2013 |
| Apr. | 2-1906 0 | 2-1918 | 2-1930 22.06 | 2-1942 | 2-1954 7.35 | 2-1966 | 2-1978 25.45 | 2-1990 | 2-2002 9.09 | 2-2014 |
| May | 2-1907 14.29 | 2-1919 | 2-1931 37.50 | 2-1943 | 2-1955 26.47 | 2-1967 | 2-1979 49.09 | 2-1991 | 2-2003 45.45 | 2-2015 |
| June | 2-1908 57.14 | 2-1920 | 2-1932 12.50 | 2-1944 | 2-1956 42.65 | 2-1968 | 2-1980 15.46 | 2-1992 | 2-2004 22.73 | 2-2016 |
| July | 2-1909 28.57 | 2-1921 | 2-1933 11.77 | 2-1945 | 2-1957 16.18 | 2-1969 | 2-1981 10.00 | 2-1993 | 2-2005 14.55 | 2-2017 |
| Aug. | 2-1910 0 | 2-1922 | 2-1934 4.41 | 2-1946 | 2-1958 5.88 | 2-1970 | 2-1982 0 | 2-1994 | 2-2006 8.18 | 2-2018 |
| Sept. | 2-1911 0 | 2-1923 | 2-1935 0 | 2-1947 | 2-1959 0 | 2-1971 | 2-1983 0 | 2-1995 | 2-2007 0 | 2-2019 |
| Oct. | 2-1912 0 | 2-1924 | 2-1936 0 | 2-1948 | 2-1960 0 | 2-1972 | 2-1984 0 | 2-1996 | 2-2008 0 | 2-2020 |
| Nov. | 2-1913 0 | 2-1925 | 2-1937 8.82 | 2-1949 | 2-1961 1.47 | 2-1973 | 2-1985 0 | 2-1997 | 2-2009 0 | 2-2021 |
| Dec. | 2-1914 0 | 2-1926 | 2-1938 0 | 2-1950 | 2-1962 0 | 2-1974 | 2-1986 0 | 2-1998 | 2-2010 0 | 2-2022 |

71. Monthly Distribution of Labor for Crop Grow Systems

| Month | Corn Grow | | | | | | Wheat Grow | | | | Oats Grow | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plant April | | Plant May | | Plant June | | Plant Sept. | | Plant Oct. | | Plant April | | Plant May | |
| | 2,4 or 6 row | User | 2,4 or 6 row | User | 2,4 or 6 row | User | 2,4 or 6 row | User | 2,4 or 6 row | User | 2,4 or 6 row | User | 2,4 or 6 row | User |
| Jan. | 2-803<br>3.09 | 2-815 | 2-827<br>3.09 | 2-839 | 2-851<br>3.09 | 2-863 | 2-875<br>3.11 | 2-887 | 2-899<br>3.11 | 2-911 | 2-923<br>3.61 | 2-935 | 2-947<br>3.01 | 2-959 |
| Feb. | 2-804<br>2.25 | 2-816 | 2-828<br>2.25 | 2-840 | 2-852<br>2.25 | 2-864 | 2-876<br>4.15 | 2-888 | 2-900<br>4.14 | 2-912 | 2-924<br>4.82 | 2-936 | 2-948<br>3.61 | 2-960 |
| Mar. | 2-805<br>5.06 | 2-817 | 2-829<br>5.05 | 2-841 | 2-853<br>5.06 | 2-865 | 2-877<br>7.25 | 2-889 | 2-901<br>7.25 | 2-913 | 2-925<br>26.51 | 2-937 | 2-949<br>5.42 | 2-961 |
| Apr. | 2-806<br>34.83 | 2-818 | 2-830<br>17.70 | 2-842 | 2-854<br>5.62 | 2-866 | 2-878<br>7.77 | 2-890 | 2-902<br>7.77 | 2-914 | 2-926<br>36.15 | 2-938 | 2-950<br>38.56 | 2-962 |
| May | 2-807<br>19.66 | 2-819 | 2-831<br>23.60 | 2-843 | 2-855<br>27.25 | 2-867 | 2-879<br>0 | 2-891 | 2-903<br>0 | 2-915 | 2-927<br>5.42 | 2-939 | 2-951<br>29.52 | 2-963 |
| June | 2-808<br>9.27 | 2-820 | 2-832<br>19.66 | 2-844 | 2-856<br>26.40 | 2-868 | 2-880<br>0 | 2-892 | 2-904<br>0 | 2-916 | 2-928<br>7.83 | 2-940 | 2-952<br>10.24 | 2-964 |
| July | 2-809<br>5.62 | 2-821 | 2-833<br>9.27 | 2-845 | 2-857<br>14.04 | 2-869 | 2-881<br>0 | 2-893 | 2-905<br>0 | 2-917 | 2-929<br>0 | 2-941 | 2-953<br>0 | 2-965 |
| Aug. | 2-810<br>2.81 | 2-822 | 2-834<br>8.43 | 2-846 | 2-858<br>9.27 | 2-870 | 2-882<br>21.76 | 2-894 | 2-906<br>0 | 2-918 | 2-930<br>0 | 2-942 | 2-954<br>0 | 2-966 |
| Sept. | 2-811<br>0 | 2-823 | 2-835<br>0 | 2-847 | 2-859<br>0 | 2-871 | 2-883<br>46.63 | 2-895 | 2-907<br>28.50 | 2-919 | 2-931<br>0 | 2-943 | 2-955<br>0 | 2-967 |
| Oct. | 2-812<br>0 | 2-824 | 2-836<br>0 | 2-848 | 2-860<br>0 | 2-872 | 2-884<br>3.11 | 2-896 | 2-908<br>41.97 | 2-920 | 2-932<br>3.01 | 2-944 | 2-956<br>3.01 | 2-968 |
| Nov. | 2-813<br>12.36 | 2-825 | 2-837<br>6.74 | 2-849 | 2-861<br>4.21 | 2-873 | 2-885<br>3.11 | 2-897 | 2-909<br>4.15 | 2-921 | 2-933<br>9.64 | 2-945 | 2-957<br>3.01 | 2-969 |
| Dec. | 2-814<br>5.05 | 2-826 | 2-838<br>4.21 | 2-850 | 2-862<br>2.81 | 2-874 | 2-886<br>3.11 | 2-898 | 2-910<br>3.11 | 2-922 | 2-934<br>3.01 | 2-946 | 2-958<br>3.62 | 2-970 |

71. (Cont'd.)

| Month i | | Hay Crop Plant | | | Hay Crop | | Field Bean Grow | | | | Soybeans Grow | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Maintain | | Plant May | | Plant June | | Plant May | | Plant June | |
| | | Direct 2,4 or 6 row | Companion Crop | User | Fert. | User | 4 or 6 row | User | 4 or 6 row | User | 4 or 6 row | User | 4 or 6 row | User |
| Jan. | 1 | 2-971 0 | 2-983 0 | 2-995 | 2-1007 0 | 2-1019 | 2-1031 2.81 | 2-1043 | 2-1055 2.81 | 2-1067 | 2-1079 1.55 | 2-1091 | 2-1103 1.55 | 2-1115 |
| Feb. | 2 | 2-972 0 | 2-984 0 | 2-996 | 2-1008 0 | 2-1020 | 2-1032 2.04 | 2-1044 | 2-1056 2.04 | 2-1068 | 2-1080 2.17 | 2-1092 | 2-1104 2.17 | 2-1116 |
| Mar. | 3 | 2-973 0 | 2-985 48.72 | 2-997 | 2-1009 0 | 2-1021 | 2-1033 4.59 | 2-1045 | 2-1057 4.59 | 2-1069 | 2-1081 5.28 | 2-1093 | 2-1105 2.18 | 2-1117 |
| Apr. | 4 | 2-974 0 | 2-986 51.28 | 2-998 | 2-1010 0 | 2-1022 | 2-1034 16.07 | 2-1046 | 2-1058 5.10 | 2-1070 | 2-1082 20.50 | 2-1094 | 2-1106 5.28 | 2-1118 |
| May | 5 | 2-975 0 | 2-987 0 | 2-999 | 2-1011 11.11 | 2-1023 | 2-1035 21.43 | 2-1047 | 2-1059 22.19 | 2-1071 | 2-1083 30.13 | 2-1095 | 2-1107 22.98 | 2-1119 |
| June | 6 | 2-976 2.50 | 2-988 0 | 2-1000 | 2-1012 66.66 | 2-1024 | 2-1036 19.39 | 2-1048 | 2-1060 29.08 | 2-1072 | 2-1084 20.19 | 2-1096 | 2-1108 30.44 | 2-1120 |
| July | 7 | 2-977 47.50 | 2-989 0 | 2-1001 | 2-1013 22.22 | 2-1025 | 2-1037 16.07 | 2-1049 | 2-1061 19.39 | 2-1073 | 2-1085 17.08 | 2-1097 | 2-1109 24.22 | 2-1121 |
| Aug. | 8 | 2-978 47.50 | 2-990 0 | 2-1002 | 2-1014 0 | 2-1026 | 2-1038 7.65 | 2-1051 | 2-1062 8.42 | 2-1074 | 2-1086 0 | 2-1098 | 2-1110 8.08 | 2-1122 |
| Sept. | 9 | 2-979 2.50 | 2-991 0 | 2-1003 | 2-1015 0 | 2-1027 | 2-1039 0 | 2-1051 | 2-1063 0 | 2-1075 | 2-1087 0 | 2-1099 | 2-1111 0 | 2-1123 |
| Oct. | 10 | 2-980 0 | 2-992 0 | 2-1004 | 2-1016 0 | 2-1028 | 2-1040 0 | 2-1052 | 2-1064 0 | 2-1076 | 2-1088 0 | 2-1100 | 2-1112 0 | 2-1124 |
| Nov. | 11 | 2-981 0 | 2-993 0 | 2-1005 | 2-1017 0 | 2-1029 | 2-1041 6.12 | 2-1053 | 2-1065 3.83 | 2-1077 | 2-1089 1.55 | 2-1101 | 2-1113 1.55 | 2-1125 |
| Dec. | 12 | 2-982 0 | 2-994 0 | 2-1006 | 2-1018 0 | 2-1030 | 2-1042 3.83 | 2-1054 | 2-1066 2.55 | 2-1078 | 2-1090 1.55 | 2-1102 | 2-1114 1.55 | 2-1126 |

72. Relative Labor Efficiency of Systems by Size

| Acres of Crop | Corn Grow | | | | Corn Harvest | | | | Oats Grow | | | Hay Crop Maintain | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 row | 4 row | 6 row | User | 1 row | 2 row | Custom 3 row or SP | user | 2-4 row | 6 row | User | Fert. | User |
| less than 26 | 2-1127<br>1.04 | 2-1134<br>1.05 | 2-1141<br>1.10 | 2-1148 | 2-1155<br>1.00 | 2-1162<br>1.05 | 2-1169<br>1.06 | 2-1176 | 2-1183<br>1.00 | 2-1190<br>1.02 | 2-1197 | 2-1204<br>1.05 | 2-1211 |
| 26-50 | 2-1128<br>1.00 | 2-1135<br>1.02 | 2-1142<br>1.06 | 2-1149 | 2-1156<br>.98 | 2-1163<br>1.00 | 2-1170<br>1.03 | 2-1177 | 2-1184<br>.97 | 2-1191<br>1.00 | 2-1198 | 2-1205<br>1.00 | 2-1212 |
| 51-75 | 2-1129<br>.98 | 2-1136<br>1.00 | 2-1143<br>1.03 | 2-1150 | 2-1157<br>.96 | 2-1164<br>.97 | 2-1171<br>1.02 | 2-1178 | 2-1185<br>.95 | 2-1192<br>.97 | 2-1199 | 2-1206<br>.95 | 2-1213 |
| 76-100 | 2-1130<br>.96 | 2-1137<br>.97 | 2-1144<br>1.01 | 2-1151 | 2-1158<br>.95 | 2-1165<br>.95 | 2-1172<br>1.00 | 2-1179 | 2-1186<br>.93 | 2-1193<br>.95 | 2-1200 | 2-1207<br>.95 | 2-1214 |
| 101-150 | 2-1131<br>.95 | 2-1138<br>.95 | 2-1145<br>1.00 | 2-1152 | 2-1159<br>.95 | 2-1166<br>.94 | 2-1173<br>.98 | 2-1180 | 2-1187<br>.92 | 2-1194<br>.93 | 2-1201 | 2-1208<br>.95 | 2-1215 |
| 151-200 | 2-1132<br>.94 | 2-1139<br>.94 | 2-1146<br>.97 | 2-1153 | 2-1160<br>.95 | 2-1167<br>.93 | 2-1174<br>.96 | 2-1181 | 2-1188<br>.91 | 2-1195<br>.91 | 2-1202 | 2-1209<br>.95 | 2-1216 |
| over 200 | 2-1133<br>.94 | 2-1140<br>.93 | 2-1147<br>.93 | 2-1154 | 2-1161<br>.95 | 2-1168<br>.93 | 2-1175<br>.94 | 2-1182 | 2-1189<br>.91 | 2-1196<br>.90 | 2-1203 | 2-1210<br>.95 | 2-1217 |
| j | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |

72. (Cont'd.)

| Acres of Crop | Wheat Grow | | | Field Beans Grow | | | Soybeans Grow | | | Hay Crop Plant | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2-4 row | 6 row | user | 4 row | 6 row | user | 4 row | 6 row | user | 2-4 row | 6 row | Comp-anion | user |
| less than 26 | 2-1218<br>1.00 | 2-1225<br>1.02 | 2-1232 | 2-1239<br>1.02 | 2-1246<br>1.03 | 2-1253 | 2-1260<br>1.04 | 2-1267<br>1.05 | 2-1274 | 2-1281<br>1.00 | 2-1288<br>1.02 | 2-1295<br>1.00 | 2-1302 |
| 26-50 | 2-1219<br>.97 | 2-1226<br>1.00 | 2-1233 | 2-1240<br>1.00 | 2-1247<br>1.01 | 2-1254 | 2-1261<br>1.00 | 2-1268<br>1.02 | 2-1275 | 2-1282<br>.98 | 2-1289<br>1.00 | 2-1296<br>1.00 | 2-1303 |
| 51-75 | 2-1220<br>.95 | 2-1227<br>.97 | 2-1234 | 2-1241<br>.98 | 2-1248<br>1.00 | 2-1255 | 2-1262<br>.97 | 2-1269<br>1.00 | 2-1276 | 2-1283<br>.97 | 2-1290<br>.98 | 2-1297<br>1.00 | 2-1304 |
| 76-100 | 2-1221<br>.93 | 2-1228<br>.95 | 2-1235 | 2-1242<br>.97 | 2-1249<br>.98 | 2-1256 | 2-1263<br>.95 | 2-1270<br>.97 | 2-1277 | 2-1284<br>.97 | 2-1291<br>.97 | 2-1298<br>1.00 | 2-1305 |
| 101-150 | 2-1222<br>.92 | 2-1229<br>.93 | 2-1336 | 2-1243<br>.96 | 2-1250<br>.97 | 2-1257 | 2-1264<br>.93 | 2-1271<br>.94 | 2-1278 | 2-1285<br>.97 | 2-1292<br>.97 | 2-1299<br>1.00 | 2-1306 |
| 151-200 | 2-1223<br>.91 | 2-1230<br>.91 | 2-1237 | 2-1244<br>.95 | 2-1251<br>.96 | 2-1258 | 2-1265<br>.91 | 2-1272<br>.92 | 2-1279 | 2-1286<br>.97 | 2-1293<br>.97 | 2-1300<br>1.00 | 2-1307 |
| over 200 | 2-1224<br>.91 | 2-1231<br>.90 | 2-1238 | 2-1245<br>.95 | 2-1252<br>.95 | 2-1259 | 2-1266<br>.90 | 2-1273<br>.90 | 2-1280 | 2-1287<br>.97 | 2-1294<br>.97 | 2-1301<br>1.00 | 2-1308 |
| j | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |

72. (Cont'd.)

| Acres of Crop | Wheat Harvest | | | | Oat Harvest | | | | Field Bean Harvest | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Custom | Combine spread | Combine bale | User | Custom | Combine spread | Combine bale | User | Custom | 4 row | 6 row | User |
| less than 26 | 2-1309 1.00 | 2-1316 1.00 | 2-1323 1.00 | 2-1330 | 2-1337 1.00 | 2-1344 1.00 | 2-1351 1.00 | 2-1358 | 2-1365 1.00 | 2-1372 1.02 | 2-1379 1.03 | 2-1386 |
| 26-50 | 2-1310 1.00 | 2-1317 .97 | 2-1324 .98 | 2-1331 | 2-1338 1.00 | 2-1345 .97 | 2-1352 .98 | 2-1359 | 2-1366 1.00 | 2-1373 1.00 | 2-1380 1.01 | 2-1387 |
| 51-75 | 2-1311 1.00 | 2-1318 .95 | 2-1325 .96 | 2-1332 | 2-1339 1.00 | 2-1346 .95 | 2-1353 .96 | 2-1360 | 2-1367 1.00 | 2-1374 .98 | 2-1381 1.00 | 2-1388 |
| 76-100 | 2-1312 1.00 | 2-1319 .93 | 2-1326 .95 | 2-1333 | 2-1340 1.00 | 2-1347 .93 | 2-1354 .95 | 2-1361 | 2-1368 1.00 | 2-1375 .97 | 2-1382 .98 | 2-1389 |
| 101-150 | 2-1313 1.00 | 2-1320 .92 | 2-1327 .94 | 2-1334 | 2-1341 1.00 | 2-1348 .92 | 2-1355 .94 | 2-1362 | 2-1369 1.00 | 2-1376 .96 | 2-1383 .97 | 2-1390 |
| 151-200 | 2-1324 1.00 | 2-1321 .91 | 2-1328 .93 | 2-1335 | 2-1342 1.00 | 2-1349 .91 | 2-1356 .93 | 2-1363 | 2-1370 1.00 | 2-1377 .95 | 2-1384 .96 | 2-1391 |
| over 200 | 2-1315 1.00 | 2-1322 .91 | 2-1329 .93 | 2-1336 | 2-1343 1.00 | 2-1350 .91 | 2-1357 .93 | 2-1364 | 2-1371 1.00 | 2-1378 .95 | 2-1385 .95 | 2-1392 |
| j | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |

72. (Cont'd.)

| Acres of Crop | Hay Crop Silage Harvest | | | | | Hay Harvest | | | | Soybean Harvest | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mow 1 row | Windrow 2 row | Windrow S.P. Chopper | Windrow 1 row | User | Mower Baler | Windrow Conveyor | Windrow Kicker | User | Custom | Combine | User |
| less than 26 | 2-1393<br>1.00 | 2-1400<br>1.05 | 2-1407<br>1.06 | 2-1414<br>1.00 | 2-1421 | 2-1428<br>1.02 | 2-1435<br>1.04 | 2-1442<br>1.03 | 2-1449 | 2-1456<br>1.00 | 2-1463<br>1.04 | 2-1470 |
| 26-50 | 2-1394<br>.98 | 2-1401<br>1.00 | 2-1408<br>1.03 | 2-1415<br>.98 | 2-1422 | 2-1429<br>1.00 | 2-1436<br>1.02 | 2-1443<br>1.01 | 2-1450 | 2-1457<br>1.00 | 2-1464<br>1.00 | 2-1471 |
| 51-75 | 2-1395<br>.96 | 2-1402<br>.97 | 2-1409<br>1.02 | 2-1416<br>.96 | 2-1423 | 2-1430<br>.98 | 2-1437<br>1.01 | 2-1444<br>1.00 | 2-1451 | 2-1458<br>1.00 | 2-1465<br>.97 | 2-1472 |
| 76-100 | 2-1396<br>.95 | 2-1403<br>.95 | 2-1410<br>1.00 | 2-1417<br>.95 | 2-1424 | 2-1431<br>.97 | 2-1438<br>1.00 | 2-1445<br>.98 | 2-1452 | 2-1459<br>1.00 | 2-1466<br>.95 | 2-1473 |
| 101-150 | 2-1397<br>.95 | 2-1404<br>.94 | 2-1411<br>.98 | 2-1418<br>.95 | 2-1425 | 2-1432<br>.96 | 2-1439<br>.98 | 2-1446<br>.96 | 2-1453 | 2-1460<br>1.00 | 2-1467<br>.93 | 2-1474 |
| 151-200 | 2-1398<br>.95 | 2-1405<br>.93 | 2-1412<br>.96 | 2-1419<br>.95 | 2-1426 | 2-1433<br>.96 | 2-1440<br>.96 | 2-1447<br>.95 | 2-1454 | 2-1461<br>1.00 | 2-1468<br>.91 | 2-1475 |
| over 200 | 2-1399<br>.95 | 2-1406<br>.93 | 2-1413<br>.96 | 2-1420<br>.96 | 2-1427 | 2-1434<br>.96 | 2-1441<br>.96 | 2-1448<br>.95 | 2-1455 | 2-1462<br>1.00 | 2-1469<br>.91 | 2-1476 |
| j | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |

73. Production Relationships

Grain Transition Constants

| Forage Quality | Level of Prod (000) | Change in Level of Grain Feeding | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2000 to 2500 | 2500 to 3000 | 3000 to 3500 | 3500 to 4000 | 4000 to 4500 | 4500 to 5000 | 5000 to 5500 | 5500 to 6000 | 6000 to 6500 | 6500 to 7000 | 7000 to 7500 |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | | Change in Milk Production - Pounds | | | | | | | | | | |
| ex. | over 13 | 2-97<br>450 | 2-106<br>400 | 2-115<br>300 | 2-124<br>250 | 2-133<br>250 | 2-142<br>250 | 2-151<br>200 | 2-160<br>200 | 2-169<br>150 | 2-178<br>100 | 2-187<br>50 |
| ex. | 11-13 | 2-98<br>400 | 2-107<br>400 | 2-116<br>250 | 2-125<br>250 | 2-134<br>250 | 2-143<br>200 | 2-152<br>150 | 2-161<br>150 | 2-170<br>100 | 2-179<br>50 | 2-188<br>0 |
| ex. | less than 11 | 2-99<br>350 | 2-108<br>350 | 2-117<br>250 | 2-126<br>250 | 2-135<br>150 | 2-144<br>150 | 2-153<br>100 | 2-162<br>100 | 2-171<br>50 | 2-180<br>50 | 2-189<br>0 |
| med. | over 13 | 2-100<br>600 | 2-109<br>450 | 2-118<br>450 | 2-127<br>350 | 2-136<br>300 | 2-145<br>200 | 2-154<br>200 | 2-163<br>200 | 2-172<br>150 | 2-181<br>150 | 2-190<br>0 |
| med. | 11-13 | 2-101<br>500 | 2-110<br>400 | 2-119<br>400 | 2-128<br>300 | 2-137<br>300 | 2-146<br>200 | 2-155<br>200 | 2-164<br>150 | 2-173<br>100 | 2-182<br>100 | 2-191<br>50 |
| med. | less than 11 | 2-102<br>350 | 2-111<br>400 | 2-120<br>250 | 2-129<br>250 | 2-138<br>200 | 2-147<br>200 | 2-156<br>100 | 2-165<br>100 | 2-174<br>100 | 2-183<br>100 | 2-192<br>0 |
| poor | over 13 | 2-103<br>700 | 2-112<br>500 | 2-121<br>500 | 2-130<br>400 | 2-139<br>300 | 2-148<br>300 | 2-157<br>250 | 2-166<br>200 | 2-175<br>200 | 2-184<br>150 | 2-193<br>100 |
| poor | 11-13 | 2-104<br>650 | 2-113<br>500 | 2-122<br>450 | 2-131<br>350 | 2-140<br>250 | 2-149<br>250 | 2-158<br>200 | 2-167<br>200 | 2-176<br>150 | 2-185<br>100 | 2-194<br>100 |
| poor | less than 11 | 2-105<br>400 | 2-114<br>400 | 2-123<br>300 | 2-132<br>300 | 2-141<br>200 | 2-150<br>200 | 2-159<br>150 | 2-168<br>150 | 2-177<br>100 | 2-186<br>100 | 2-195<br>0 |

74. Forage Transition Constants

| Change in Forage Quality | Level of Prod. (000) | Level of Grain Feeding (Pounds) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 | 5500 | 6000 | 6500 | 7000 | 7500 |
| | | Change in Milk Production (Pounds) | | | | | | | | | | | |
| Ex.-med. | over 13 | 2-196<br>800 | 2-202<br>650 | 2-208<br>600 | 2-214<br>450 | 2-220<br>350 | 2-226<br>300 | 2-232<br>350 | 2-238<br>350 | 2-244<br>350 | 2-250<br>350 | 2-256<br>300 | 2-262<br>350 |
| Ex.-med. | 11-13 | 2-197<br>700 | 2-203<br>600 | 2-209<br>600 | 2-215<br>450 | 2-221<br>400 | 2-227<br>350 | 2-233<br>350 | 2-239<br>300 | 2-245<br>300 | 2-251<br>300 | 2-257<br>250 | 2-263<br>200 |
| Ex.-med. | less than 11 | 2-198<br>450 | 2-204<br>450 | 2-210<br>400 | 2-216<br>400 | 2-222<br>400 | 2-228<br>350 | 2-234<br>300 | 2-240<br>300 | 2-246<br>300 | 2-252<br>250 | 2-258<br>200 | 2-264<br>0 |
| Med-poor | over 13 | 2-199<br>750 | 2-205<br>650 | 2-211<br>600 | 2-217<br>550 | 2-223<br>500 | 2-229<br>500 | 2-235<br>400 | 2-241<br>350 | 2-247<br>350 | 2-253<br>300 | 2-259<br>300 | 2-265<br>200 |
| Med-poor | 11-13 | 2-200<br>700 | 2-206<br>550 | 2-212<br>450 | 2-218<br>400 | 2-224<br>350 | 2-230<br>400 | 2-236<br>350 | 2-242<br>350 | 2-248<br>300 | 2-254<br>250 | 2-260<br>250 | 2-266<br>200 |
| Med-poor | less than 11 | 2-201<br>450 | 2-207<br>400 | 2-213<br>400 | 2-219<br>350 | 2-225<br>300 | 2-231<br>300 | 2-237<br>300 | 2-243<br>250 | 2-249<br>200 | 2-255<br>200 | 2-261<br>200 | 2-267<br>0 |
| j | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

75. Production Adjustment for Culling

| Difference between number drawn and required culling rate | Production Adjustment (lbs.) |
|---|---|
| (2-625) 1 | (2-640) 500 |
| (2-626) 2 | (2-641) 1000 |
| (2-627) 3 | (2-642) 1500 |
| (2-628) 4 | (2-643) 2000 |
| (2-629) 5 | (2-644) 2500 |
| (2-630) 6 | (2-645) 3000 |
| (2-631) 7 | (2-646) 3500 |
| (2-632) 8 | (2-647) 4000 |
| (2-633) 9 | (2-648) 4500 |
| (2-634) 10 | (2-649) 5000 |
| (2-635) (11-) 12 | (2-650) 5500 |
| (2-636) (13-) 14 | (2-651) 6000 |
| (2-637) (15-) 16 | (2-652) 6500 |
| (2-638) (17-) 18 | (2-653) 7000 |
| (2-639) (-) 19 | (2-654) 7500 |

76. Mature Equivalent Coefficients

| Age of Freshening (months) | M.E. Coefficient |
|---|---|
| (2-2867) 23 | (2-2877) 1.35 |
| (2-2868) 24 - 35 | (2-2878) 1.26 |
| (2-2869) 36 - 47 | (2-2879) 1.15 |
| (2-2870) 48 - 59 | (2-2880) 1.06 |
| (2-2871) 60 - 71 | (2-2881) 1.02 |
| (2-2872) 72 - 101 | (2-2882) 1.00 |
| (2-2873) 102 - 119 | (2-2883) 1.01 |
| (2-2874) 120 - 131 | (2-2884) 1.03 |
| (2-2875) 132 - 155 | (2-2885) 1.05 |
| (2-2876) 156 - 240 | (2-2886) 1.10 |

77. Milk Lactation Curves

Percent of Total Lactation Production Produced Each Month

| Month of Lactation[a] | Calving Interval (month) | | | | | |
|---|---|---|---|---|---|---|
| | 11 | 12 | 13 | 14 | 15 | 16 |
| 1 | 2-2763<br>5 | 2-2780<br>5 | 2-2797<br>5 | 2-2814<br>5 | 2-2831<br>5 | 2-2848<br>5 |
| 2 | 2-2764<br>12 | 2-2781<br>12 | 2-2798<br>12 | 2-2815<br>12 | 2-2832<br>11 | 2-2849<br>11 |
| 3 | 2-2765<br>14 | 2-2782<br>13 | 2-2799<br>13 | 2-2816<br>12 | 2-2833<br>12 | 2-2850<br>11 |
| 4 | 2-2766<br>13 | 2-2783<br>13 | 2-2800<br>12 | 2-2817<br>11 | 2-2834<br>11 | 2-2851<br>11 |
| 5 | 2-2767<br>13 | 2-2784<br>12 | 2-2801<br>11 | 2-2818<br>11 | 2-2835<br>11 | 2-2852<br>10 |
| 6 | 2-2768<br>12 | 2-2785<br>12 | 2-2802<br>11 | 2-2819<br>10 | 2-2836<br>10 | 2-2853<br>10 |
| 7 | 2-2769<br>10 | 2-2786<br>10 | 2-2803<br>9 | 2-2820<br>9 | 2-2837<br>9 | 2-2854<br>9 |
| 8 | 2-2770<br>9 | 2-2787<br>9 | 2-2804<br>8 | 2-2821<br>8 | 2-2838<br>8 | 2-2855<br>8 |
| 9 | 2-2771<br>7 | 2-2788<br>7 | 2-2805<br>7 | 2-2822<br>7 | 2-2839<br>7 | 2-2856<br>7 |
| 10 | 2-2772<br>5 | 2-2789<br>5 | 2-2806<br>6 | 2-2823<br>6 | 2-2840<br>6 | 2-2857<br>5 |
| 11 | 2-2773<br>0 | 2-2790<br>0 | 2-2807<br>2 | 2-2824<br>4 | 2-2841<br>4 | 2-2858<br>4 |
| 12 | 2-2744<br>0 | 2-2791<br>0 | 2-2808<br>2 | 2-2825<br>4 | 2-2842<br>4 | 2-2859<br>4 |
| 13 | 2-2775<br>- | 2-2792<br>0 | 2-2809<br>0 | 2-2826<br>1 | 2-2843<br>2 | 2-2860<br>3 |
| 14 | 2-2776<br>- | 2-2793<br>- | 2-2810<br>0 | 2-2827<br>0 | 2-2844<br>0 | 2-2861<br>1 |
| 15 | 2-2777<br>- | 2-2794<br>- | 2-2811<br>- | 2-2828<br>0 | 2-2845<br>0 | 2-2862<br>0 |
| 16 | 2-2778<br>- | 2-2795<br>- | 2-2812<br>- | 2-2829<br>- | 2-2846<br>0 | 2-2863<br>0 |
| 17 | 2-2779<br>- | 2-2796<br>- | 2-2813<br>- | 2-2830<br>- | 2-2847<br>- | 2-2864<br>0 |

a. Assumes freshening takes place on the 15th of the month.
Lactation month = simulation month - month last fresh + 1.

78. Frequency Distribution for Lactation Length

| Calving Interval (months) | Length of Lactation (Months) | | | | | |
|---|---|---|---|---|---|---|
| | 11 | 12 | 13 | 14 | 15 | 16 |
| 12.0 | 25 | 60 | 8 | 4 | 3 | 0 |
| 12.1 | 23 | 59 | 9 | 5 | 4 | 0 |
| 12.2 | 21 | 57 | 10 | 6 | 5 | 1 |
| 12.3 | 19 | 55 | 12 | 7 | 6 | 1 |
| 12.4 | 17 | 52 | 15 | 8 | 6 | 2 |
| 12.5 | 16 | 50 | 16 | 9 | 7 | 2 |
| 12.6 | 14 | 47 | 18 | 10 | 8 | 3 |
| 12.7 | 12 | 45 | 20 | 11 | 8 | 3 |
| 12.8 | 9 | 44 | 22 | 12 | 9 | 4 |
| 12.9 | 7 | 42 | 24 | 13 | 10 | 4 |
| | 2-655 | 2-656 | 2-657 | 2-658 | 2-659 | 2-660 |
| 13.0 | 5 | 40 | 25 | 15 | 10 | 5 |
| 13.1 | 4 | 36 | 26 | 18 | 11 | 5 |
| 13.2 | 4 | 32 | 26 | 21 | 12 | 5 |
| 13.3 | 4 | 27 | 29 | 22 | 13 | 5 |
| 13.4 | 3 | 22 | 32 | 24 | 13 | 6 |
| 13.5 | 3 | 19 | 32 | 26 | 14 | 6 |
| 13.6 | 2 | 16 | 32 | 29 | 14 | 7 |
| 13.7 | 1 | 14 | 30 | 33 | 15 | 7 |
| 13.8 | 0 | 12 | 28 | 36 | 16 | 8 |
| 13.9 | 0 | 10 | 27 | 38 | 17 | 8 |
| 14.0 | 0 | 7 | 25 | 40 | 19 | 9 |

79. Fertilizer Rates and Relative Yields

| Crop | Agricultural Subregion | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 39 | 40 | 41 | 54 | 39 | 40 | 41 | 54 |
| | Lbs. of N, $P_2O_5$ and $K_2O$ | | | | Relative Yield | | | |
| Corn | 2-2539<br>0 | 2-2567<br>0 | 2-2595<br>0 | 2-2623<br>0 | 2-2651<br>100 | 2-2679<br>100 | 2-2707<br>100 | 2-2735<br>100 |
| | 2-2540<br>138 | 2-2568<br>150 | 2-2596<br>138 | 2-2624<br>127 | 2-2652<br>151 | 2-2680<br>148 | 2-2708<br>148 | 2-2736<br>147 |
| | 2-2541<br>261 | 2-2569<br>273 | 2-2597<br>261 | 2-2625<br>214 | 2-2653<br>179 | 2-2681<br>163 | 2-2709<br>170 | 2-2737<br>167 |
| | 2-2542<br>321 | 2-2570<br>333 | 2-2598<br>321 | 2-2626<br>274 | 2-2654<br>187 | 2-2682<br>169 | 2-2710<br>174 | 2-2738<br>174 |
| Soybeans | 2-2543<br>0 | 2-2571<br>0 | 2-2599<br>0 | 2-2627<br>0 | 2-2655<br>100 | 2-2683<br>100 | 2-2711<br>100 | 2-2739<br>100 |
| | 2-2544<br>78 | 2-2572<br>79 | 2-2600<br>78 | 2-2628<br>0 | 2-2656<br>138 | 2-2684<br>152 | 2-2712<br>154 | 2-2740<br>100 |
| | 2-2545<br>124 | 2-2573<br>122 | 2-2601<br>122 | 2-2629<br>0 | 2-2657<br>156 | 2-2685<br>163 | 2-2713<br>171 | 2-2741 |
| | 2-2546<br>148 | 2-2574<br>142 | 2-2602<br>142 | 2-2630<br>0 | 2-2658<br>167 | 2-2686<br>177 | 2-2714<br>180 | 2-2742 |

79. (Cont'd.)

| Crop | Agricultural Subregion 39 | 40 | 41 | 54 | 39 | 40 | 41 | 54 |
|---|---|---|---|---|---|---|---|---|
| | Lbs. of N, $P_2O_5$ and $K_2O$ | | | | Relative Yield | | | |
| Field Beans | 2-2547<br>0 | 2-2575<br>0 | 2-2603<br>0 | 2-2631<br>0 | 2-2659<br>100 | 2-2687<br>100 | 2-2715<br>100 | 2-2743<br>100 |
| | 2-2548<br>57 | 2-2576<br>57 | 2-2604<br>57 | 2-2632<br>57 | 2-2660<br>116 | 2-2688<br>119 | 2-2716<br>118 | 2-2744<br>115 |
| | 2-2549<br>91 | 2-2577<br>91 | 2-2605<br>91 | 2-2633<br>91 | 2-2661<br>121 | 2-2689<br>123 | 2-2717<br>123 | 2-2745<br>121 |
| | 2-2550<br>120 | 2-2578<br>124 | 2-2606<br>120 | 2-2634<br>120 | 2-2662<br>124 | 2-2690<br>126 | 2-2718<br>126 | 2-2746<br>124 |
| | 2-2551<br>146 | 2-2579<br>157 | 2-2607<br>146 | 2-2635<br>146 | 2-2663<br>126 | 2-2691<br>127 | 2-2719<br>127 | 2-2747<br>125 |
| | 2-2552<br>156 | 2-2580<br>167 | 2-2608<br>156 | 2-2636<br>156 | 2-2664<br>128 | 2-2692<br>128 | 2-2720<br>128 | 2-2748<br>126 |
| Wheat | 2-2553<br>0 | 2-2581<br>0 | 2-2609<br>0 | 2-2637<br>0 | 2-2665<br>100 | 2-2693<br>100 | 2-2721<br>100 | 2-2749<br>100 |
| | 2-2554<br>67 | 2-2582<br>79 | 2-2610<br>67 | 2-2638<br>67 | 2-2666<br>152 | 2-2694<br>150 | 2-2722<br>154 | 2-2750<br>156 |
| | 2-2555<br>103 | 2-2583<br>114 | 2-2611<br>103 | 2-2639<br>103 | 2-2667<br>180 | 2-2695<br>175 | 2-2723<br>179 | 2-2751<br>184 |
| | 2-2556<br>138 | 2-2584<br>150 | 2-2612<br>138 | 2-2640<br>138 | 2-2668<br>198 | 2-2696<br>195 | 2-2724<br>199 | 2-2752<br>204 |
| | 2-2557<br>174 | 2-2584<br>186 | 2-2613<br>174 | 2-2641<br>174 | 2-2669<br>203 | 2-2697<br>204 | 2-2725<br>205 | 2-2752<br>212 |

79. (Cont'd.)

| Crop | Agricultural Subregion 39 | 40 | 41 | 54 | 39 | 40 | 41 | 54 |
|---|---|---|---|---|---|---|---|---|
| | Lbs. of N, $P_2O_5$ and $K_2O$ | | | | Relative Yield | | | |
| Oats | 2-2558<br>0 | 2-2586<br>0 | 2-2614<br>0 | 2-2641<br>0 | 2-2670<br>100 | 2-2698<br>100 | 2-2726<br>100 | 2-2753<br>100 |
| | 2-2559<br>145 | 2-2587<br>145 | 2-2615<br>145 | 2-2642<br>102 | 2-2671<br>151 | 2-2699<br>138 | 2-2727<br>137 | 2-2754<br>132 |
| | 2-2560<br>220 | 2-2588<br>232 | 2-2616<br>220 | 2-2643<br>145 | 2-2672<br>167 | 2-2700<br>161 | 2-2728<br>158 | 2-2755<br>154 |
| | 2-2561<br>260 | 2-2589<br>172 | 2-2617<br>260 | 2-2644<br>240 | 2-2673<br>172 | 2-2701<br>167 | 2-2729<br>165 | 2-2755<br>173 |
| Hay | 2-2562<br>0 | 2-2590<br>0 | 2-2618<br>0 | 2-2645<br>0 | 2-2674<br>100 | 2-2702<br>100 | 2-2729<br>100 | 2-2756<br>100 |
| | 2-2563<br>86 | 2-2591<br>86 | 2-2619<br>86 | 2-2646<br>86 | 2-2675<br>183 | 2-2703<br>290 | 2-2730<br>240 | 2-2757<br>186 |
| | 2-2564<br>153 | 2-2592<br>153 | 2-2620<br>153 | 2-2647<br>153 | 2-2676<br>206 | 2-2704<br>330 | 2-2731<br>290 | 2-2758<br>221 |
| | 2-2565<br>202 | 2-2593<br>202 | 2-2621<br>202 | 2-2648<br>202 | 2-2677<br>217 | 2-2705<br>360 | 2-2732<br>310 | 2-2759<br>236 |
| | 2-2566<br>244 | 2-2594<br>244 | 2-2622<br>244 | 2-2649<br>244 | 2-2678<br>228 | 2-2706<br>370 | 2-2733<br>320 | 2-2760<br>250 |

80. (a) Machine Capacities

Animals and Acres Handles by User Defined Machines

| Machine Code | Livestock Numbers | Crop Grow Acres | Harvest Acres |
|---|---|---|---|
| 7 | (2-2257) 2000 | (2-2266) 2000 | (2-2275) 2000 |
| 8 | (2-2258) 2000 | (2-2267) 2000 | (2-2276) 2000 |
| 11 | (2-2259) 2000 | (2-2268) 2000 | (2-2277) 2000 |
| 20 | (2-2260) 2000 | (2-2269) xxxx | (2-2278) xxxx |
| 39 | (2-2261) xxxx | (2-2270) 2000 | (2-2279) 2000 |
| 58 | (2-2262) xxxx | (2-2271) 2000 | (2-2280) xxxx |
| 70 | (2-2263) xxxx | (2-2272) 2000 | (2-2281) xxxx |
| 76 | (2-2264) xxxx | (2-2273) xxxx | (2-2282) 2000 |
| 110 | (2-2265) xxxx | (2-2274) xxxx | (2-2283) 2000 |

80. (b) Tonage Handled by Individual Silo Unloaders

| Silo Size (ft.) | Tons Handled |
|---|---|
| 12 | (2-2284) 106 |
| 14 | (2-2285) 200 |
| 16 | (2-2286) 261 |
| 18 | (2-2287) 428 |
| 20 | (2-2288) 483 |
| 24 | (2-2289) 827 |
| 28 | (2-2290) 974 |
| 30 | (2-2291) 1290 |

80. (c) Number of Acres or Animals that can be Handled by Certain Machines[a,b]

| Tractor H.P. or Machine | Machine Code | Dairy System | | | | | | | | | | Acres Spring Crops | | | | Acres Fall Harvested | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 2row | 4row | 6row | U | 2row | 4row | 6row | U |
| less than 41 | 1 | 2023<br>600 | 2031<br>1300 | 2039<br>1300 | 2047<br>1300 | 2055<br>1300 | 2063<br>570 | 2071 | 2079<br>1200 | 2087<br>1700 | 2095 | 2103<br>300 | 2111<br>450 | 2119<br>600 | 2127 | 2135<br>150 | 2143<br>300 | 2151<br>450 | 2159 |
| 41-60 | 2 | 2024<br>800 | 2032<br>800 | 2040<br>800 | 2048<br>1400 | 2056<br>1400 | 2064<br>800 | 2072 | 2080<br>1200 | 2088<br>1200 | 2096 | 2104<br>300 | 2112<br>450 | 2120<br>600 | 2128 | 2136<br>150 | 2144<br>300 | 2152<br>450 | 2160 |
| 61-80 | 3 | 2025<br>800 | 2033<br>800 | 2041<br>800 | 2049<br>1400 | 2057<br>1400 | 2065<br>800 | 2073 | 2081<br>1200 | 2089<br>1200 | 2097 | 2105<br>300 | 2113<br>450 | 2121<br>600 | 2129 | 2137<br>150 | 2145<br>300 | 2153<br>450 | 2161 |
| 81-100 | 4 | 2026<br>800 | 2034<br>800 | 2042<br>800 | 2050<br>1400 | 2058<br>1400 | 2066<br>800 | 2074 | 2082<br>1200 | 2090<br>1200 | 2098 | 2106<br>350 | 2114<br>500 | 2122<br>650 | 2130 | 2138<br>175 | 2146<br>325 | 2154<br>475 | 2162 |
| 100+ | 5 | 2027<br>800 | 2035<br>800 | 2043<br>800 | 2051<br>1400 | 2059<br>1400 | 2067<br>800 | 2075 | 2083<br>1200 | 2091<br>1200 | 2099 | 2107<br>450 | 2115<br>600 | 2123<br>750 | 2131 | 2139<br>200 | 2147<br>250 | 2155<br>500 | 2163 |
| | 6 | 2028<br>0 | 2036<br>0 | 2044 | 2052 | 2060 | 2068 | 2076 | 2084 | 2092 | 2100 | 2108 | 2116 | 2124 | 2132 | 2140 | 2148 | 2156 | 2164 |
| Pick-up truck | 9 | 2029<br>2000 | 2037<br>2000 | 2045<br>2000 | 2053<br>2000 | 2061<br>2000 | 2069<br>2000 | 2077 | 2085<br>2000 | 2093<br>2000 | 2101 | 2109<br>2000 | 2117<br>2000 | 2125<br>2000 | 2133 | 2141<br>2000 | 2149<br>2000 | 2157<br>2000 | 2165 |
| Lg.truck | 10 | 2030<br>2000 | 2038<br>2000 | 2046<br>2000 | 2054<br>2000 | 2062<br>2000 | 2070<br>2000 | 2078 | 2086<br>2000 | 2094<br>2000 | 2102 | 2110<br>2000 | 2118<br>2000 | 2126<br>2000 | 2134 | 2142<br>2000 | 2150<br>2000 | 2158<br>2000 | 2166 |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |

a. The number of tractors and trucks required will be assumed to be the maximum of the number required by the dairy plus spring crops and the number required by the dairy plus fall crops.

b. Each identification number in this table must be preceded by 2- to be complete. Only the last four digits of the number are listed above the coefficient.

80. (d) Number of Animals that can be Handled by Dairy Machines

| Machine | Machine Code | Dairy System Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Small Spreader | 14 | 2-2167<br>700 | 2-2176<br>800 | 2-2185<br>800 | 2-2194<br>2000 | 2-2203<br>2000 | 2-2212<br>800 | 2-2221 | 2-2230<br>1200 | 2-2239<br>1200 | 2-2248 |
| Large Spreader | 15 | 2-2168<br>800 | 2-2177<br>900 | 2-2186<br>900 | 2-2195<br>2000 | 2-2204<br>2000 | 2-2213<br>900 | 2-2222 | 2-2231<br>1200 | 2-2240<br>1200 | 2-2249 |
| Liquid Spreader | 16 | 2-2169<br>1400 | 2-2178<br>1400 | 2-2187<br>1400 | 2-2196<br>1400 | 2-2205<br>1400 | 2-2214<br>1400 | 2-2223 | 2-2232<br>1700 | 2-2241<br>1700 | 2-2250 |
| Gutter Cleaner | 17 | 2-2170<br>30 | 2-2179<br>30 | 2-2188<br>30 | 2-2197<br>30 | 2-2206<br>30 | 2-2215<br>30 | 2-2224 | 2-2233<br>40 | 2-2242<br>40 | 2-2251 |
| Scraper | 18 | 2-2171<br>1300 | 2-2180<br>1300 | 2-2189<br>1300 | 2-2198<br>1300 | 2-2207<br>1300 | 2-2216<br>1300 | 2-2225 | 2-2234<br>1700 | 2-2243<br>1700 | 2-2252 |
| Liquid Pump | 19 | 2-2172<br>1400 | 2-2181<br>1400 | 2-2190<br>1400 | 2-2199<br>1400 | 2-2208<br>1400 | 2-2217<br>1400 | 2-2226 | 2-2235<br>2000 | 2-2244<br>2000 | 2-2253 |
| Milk Transfer | 36 | 2-2173<br>50 | 2-2182<br>50 | 2-2191<br>50 | 2-2200<br>50 | 2-2209<br>50 | 2-2218<br>50 | 2-2227 | 2-2236<br>------ | 2-2245<br>------ | 2-2254 |
| Barn Equipment | 37 | 2-2174<br>50 | 2-2183<br>60 | 2-2192<br>35 | 2-2201<br>60 | 2-2210<br>35 | 2-2219<br>60 | 2-2228 | 2-2237<br>200 | 2-2246<br>240 | 2-2255 |
| Parlor Equipment | 38 | 2-2175<br>100 | 2-2184<br>100 | 2-2193<br>100 | 2-2202<br>100 | 2-2211<br>100 | 2-2220<br>100 | 2-2229 | 2-2238<br>------ | 2-2247<br>------ | 2-2256 |

80. (e) Maximum Acres Handled by Various Machines

| Machine | Machine Code(s) | | Maximum Acres | Crop |
|---|---|---|---|---|
| 2-Row Cultivator | 40 | (2-2292) | 350 | Corn & Beans |
| 4-Row Cultivator | 41 | (2-2293) | 550 | Corn & Beans |
| 6-Row Cultivator | 42 | (2-2294) | 750 | Corn & Beans |
| Sprayer | 43 | (2-2295) | 1500 | Crops |
| Plows (per bottom) | 44-57 | (2-2296) | 60 | Spring Plant Crops |
| Disc (per foot width) | 59-64 | (2-2297) | 40 | Spring Plant Crops |
| Harrow (per 4 ft. section) | 65-69 | (2-2298) | 160 | Spring Plant Crops |
| Planter (per 2 rows) | 71-73 | (2-2299) | 150 | Corn & Beans |
| Fertilizer Spreader | 74 | (2-2300) | 1500 | Spring Plant Crops |
| Grain Drill | 75 | (2-2301) | 200 | Small Grains & Hay Seeding |
| Pull Chopper (per row) | 77-78 | (2-2302) | 100 | Corn Silage |
| Pull Chopper (per row) | 77-78 | (2-2303) | 200 | Corn Silage |
| S.P. Chopper (per row) | 79 | (2-2304) | 150 | Hay Crop Silage |
| S.P. Chopper (per row) | 79 | (2-2305) | 300 | Hay Crop Silage |
| Blower | 80 | (2-2306) | 3000[a] | Upright Silo Cap. |
| Corn Picker (per row) | 82-83 | (2-2307) | 150 | Corn Grain |
| Corn Combine (per row) | 84-85 | (2-2308) | 200 | Corn Grain |
| 2 Grain Wagons | 86 | (2-2309) | 200 | Grain |
| Grain Combine (per 10' width) | 89-91 | (2-2310) | 300 | Small Grains or Beans (plus corn if used) |
| Windrowers (10'width) | 93-95 | (2-2311) | 3000 | Hay Crop |
| Baler | 97 | (2-2312) | 400 | Hay |
| Wagon (hay) | 98 | (2-2313) | 25 | Hay |
| Bean Puller (per row) | 106-107 | (2-2314) | 25 | Field Beans |
| Bean Combine | 108 | (2-2315) | 200 | Field Beans |

a. Tons.

## Machinery Use Matrices

The following matrices indicate which machines are used with each livestock, crop grow or harvest system. A one in the cell at the intersection of a machine row and a system column means that particular machine is used by that system. A zero or blank means that machine is not used by that system. To change the machines used by a system, the value (coefficient) in the appropriate cell is changed from one to zero or vice versa.

Identification numbers do not appear above the coefficient value as is the case for previous matrices. Identification numbers are developed using a matrix number code plus the row and column numbers of the coefficient. The matrix number codes are 4 for table 81, 5 for table 82 and 6 for table 83. The row numbers are indicated in a column labeled "i" at the extreme right hand side of the table. The column numbers appear at the top of each column. The matrix number code is the first digit of the identification number. This is followed by a dash. The second and third digits are the row numbers. The fourth and fifth digits are the column numbers. Thus the identification number for the use of a 41-60 horsepower tractor with a warm enclosed free stall dairy system is 4-0203. The zeros must be included.

81. Livestock Systems Machinery Use Matrix

| Machine | Machine Code | Dairy Cows: Stanchion or Tie Stall | Cold Covered Free Stall | Warm Enclosed Free Stall | Cold Free Stall Liquid | Warm Free Stall Liquid | Loose Housing Open Lot | U | Dairy Replacements: Conventional Pens | Free Stalls | U | i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | |
| 0-40 H.P. Tractor | 1 | | 1 | 1 | 1 | 1 | 1 | | | 1 | | 01 |
| 41-60 H.P. " | 2 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 02 |
| 61-80 H.P. " | 3 | | | | 1 | 1 | | | | | | 03 |
| 81-100 H.P. " | 4 | | | | | | | | | | | 04 |
| 100+ H.P. " | 5 | | | | | | | | | | | 05 |
| | 6 | | | | | | | | | | | 06 |
| | 7 | | | | | | | | | | | 07 |
| | 8 | | | | | | | | | | | 08 |
| Pick-up Truck | 9 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 09 |
| Large Truck | 10 | | | | | | | | | | | 10 |
| | 11 | | | | | | | | | | | 11 |
| Unloading Wagon | 12 | | | | | | | | | | | 12 |
| Unloading Truck | 13 | | | | | | | | | | | 13 |
| Small Spreader | 14 | | | | | | | | | | | 14 |
| Large Spreader | 15 | 1 | 1 | 1 | | | 1 | | 1 | 1 | | 15 |
| Liquid Spreader | 16 | | | | 1 | 1 | | | | | | 16 |
| Gutter Cleaner | 17 | 1 | | | | | | | | | | 17 |
| Scraper (loader) | 18 | | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 18 |
| Liquid Pump | 19 | | | | 1 | 1 | | | | | | 19 |
| | 20 | | | | | | | | | | | 20 |
| 12' Silo Unloader | 21 | | | | | | | | | | | 21 |
| 14' " " | 22 | 1 | | | | | | | 1 | 1 | | 22 |
| 16' " " | 23 | | | | | | | | | | | 23 |
| 18' " " | 24 | | | | | | 1 | | | | | 24 |
| 20' " " | 25 | | 1 | 1 | 1 | 1 | | | | | | 25 |

81. (Cont'd.)[a]

| Machine | Machine Code | Dairy Cows | | | | | | | Dairy Replacements | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stanchion or Tie Stall | Cold Covered Free Stall | Warm Enclosed Free Stall | Cold Free Stall Liquid | Warm Free Stall Liquid | Loose Housing Open Lot | U | Conventional Pens | Free Stalls | U | i |
| | | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | |
| 24' Silo Unloader | 26 | | | | | | | | | | | 26 |
| 28' Silo Unloader | 27 | | | | | | | | | | | 27 |
| 30' " " | 28 | | | | | | | | | | | 28 |
| Trench Silo " | 29 | | | | | | | | | | | 29 |
| 400 Gal. Bulk | 30 | | | | | | | | | | | 30 |
| 600 Gal. Bulk | 31 | 1 | | | | | | | | | | 31 |
| 800 Gal. Bulk | 32 | | | | | | 1 | | | | | 32 |
| 1000 " " | 33 | | 1 | 1 | 1 | 1 | | | | | | 33 |
| 1400 " " | 34 | | | | | | | | | | | 34 |
| 2000 " " | 35 | | | | | | | | | | | 35 |
| Milk Transfer | 36 | 1 | | | | | | | | | | 36 |
| Barn Equipment | 37 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 37 |
| Parlor Equipment | 38 | | 1 | 1 | 1 | 1 | 1 | | | | | 38 |

a. The matrix number code for this table is 4.

82. (a) Grow Systems Machinery Use Matrix

| Machine | Machine Code | Corn Grow-April | | | | Corn Grow-May | | | | Corn Grow-June | | | | i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2-row | 4-row | 6-row | U | 2-row | 4-row | 6-row | U | 2-row | 4-row | 6-row | U | |
| | | 01 | 02 | 02 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | |
| 0-40 H.P. Tractor | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | | 01 |
| 41-60 H.P. " | 2 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | | 02 |
| 61-80 H.P. " | 3 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | | 03 |
| 81-100 H.P. " | 4 | | | 1 | | | | 1 | | | | 1 | | 04 |
| 100+ H.P. " | 5 | | | | | | | | | | | | | 05 |
| | 6 | | | | | | | | | | | | | 06 |
| | 7 | | | | | | | | | | | | | 07 |
| | 8 | | | | | | | | | | | | | 08 |
| Pick-up Truck | 9 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | | 09 |
| Large Truck | 10 | | | | | | | | | | | | | 10 |
| | 11 | | | | | | | | | | | | | 11 |
| Unloading Wagon | 12 | | | | | | | | | | | | | 12 |
| Unloading Truck | 13 | | | | | | | | | | | | | 13 |
| | 39 | | | | | | | | | | | | | 14 |
| 2-row Cultivator | 40 | 1 | | | | 1 | | | | 1 | | | | 15 |
| 4-row Cultivator | 41 | | 1 | | | | 1 | | | | 1 | | | 16 |
| 6-row Cultivator | 42 | | | 1 | | | | 1 | | | | 1 | | 17 |
| Sprayer | 43 | 1 | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | | 18 |
| 2-14" Plow | 44 | | | | | | | | | | | | | 19 |
| 2-16" Plow | 45 | | | | | | | | | | | | | 20 |
| 3-14" Plow | 46 | | | | | | | | | | | | | 21 |
| 3-16" " | 47 | 1 | | | | 1 | | | | 1 | | | | 22 |
| 4-14" " | 48 | | | | | | | | | | | | | 23 |
| 4-16" " | 49 | | 1 | | | | 1 | | | | 1 | | | 24 |
| 5-14" " | 50 | | | | | | | | | | | | | 25 |

82. (a) (Cont'd.)[a]

| | Machine Code | Corn Grow-April | | | | Corn Grow-May | | | | Corn Grow-June | | | | i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2-row | 4-row | 6-row | U | 2-row | 4-row | 6-row | U | 2-row | 4-row | 6-row | U | |
| | | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | |
| 5-16" Plow | 51 | | | 1 | | | | 1 | | | | 1 | | 26 |
| 6-14" " | 52 | | | | | | | | | | | | | 27 |
| 6-16" " | 53 | | | | | | | | | | | | | 28 |
| 7-14 " | 54 | | | | | | | | | | | | | 29 |
| 7-16" " | 55 | | | | | | | | | | | | | 30 |
| 8-14" Plow | 56 | | | | | | | | | | | | | 31 |
| 8-16" " | 57 | | | | | | | | | | | | | 32 |
| | 58 | | | | | | | | | | | | | 33 |
| 8' Disc | 59 | | | | | | | | | | | | | 34 |
| 10' " | 60 | | | | | | | | | | | | | 35 |
| 12' Disc | 61 | 1 | 1 | | | 1 | 1 | | | 1 | 1 | | | 36 |
| 14' " | 62 | | | | | | | | | | | | | 37 |
| 16' " | 63 | | | 1 | | | | 1 | | | | 1 | | 38 |
| 18' " | 64 | | | | | | | | | | | | | 39 |
| 9' Harrow | 65 | | | | | | | | | | | | | 40 |
| 12' Harrow | 66 | 1 | 1 | | | 1 | 1 | | | 1 | 1 | | | 41 |
| 16' " | 67 | | | 1 | | | | 1 | | | | 1 | | 42 |
| 20' " | 68 | | | | | | | | | | | | | 43 |
| 24' " | 69 | | | | | | | | | | | | | 44 |
| | 70 | | | | | | | | | | | | | 45 |
| 2-row Planter | 71 | 1 | | | | 1 | | | | 1 | | | | 46 |
| 4-row " | 72 | | 1 | | | | 1 | | | | 1 | | | 47 |
| 6-row " | 73 | | | 1 | | | | 1 | | | | 1 | | 48 |
| Fert. Spreader | 74 | | 1 | 1 | | | 1 | 1 | | | 1 | 1 | | 49 |
| Grain Drill | 75 | | | | | | | | | | | | | 50 |

a. The matrix number code for this table is 5.

82. (b) Grow Systems Machinery Use Matrix

| Machine | Machine Code | Wheat Grow | | | | | | Oats Grow | | | | | | Hay Crop Plant | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | September | | | October | | | April | | | May | | | Fall Direct Seeding | | Spring Companion Crops | | |
| | | Med. | Lg. | U | Med. | Lg. | U | Med. | Lg. | U | Med. | Lg. | U | Med. | Lg. | | U | i |
| | | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | |
| 0-40 H.P. Tractor | 1 | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | | 01 |
| 41-60 H.P. " | 2 | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | | 02 |
| 61-80 H.P. " | 3 | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | | 03 |
| 81-100 H.P. " | 4 | | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 04 |
| 100+ H.P. " | 5 | | | | | | | | | | | | | | | | | 05 |
| | 6 | | | | | | | | | | | | | | | | | 06 |
| | 7 | | | | | | | | | | | | | | | | | 07 |
| | 8 | | | | | | | | | | | | | | | | | 08 |
| Pick-up Truck | 9 | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | | 09 |
| Large Truck | 10 | | | | | | | | | | | | | | | | | 10 |
| | 11 | | | | | | | | | | | | | | | | | 11 |
| Unloading Wagon | 12 | | | | | | | | | | | | | | | | | 12 |
| Unloading Truck | 13 | | | | | | | | | | | | | | | | | 13 |
| | 39 | | | | | | | | | | | | | | | | | 14 |
| 2-row Cultivator | 40 | | | | | | | | | | | | | | | | | 15 |
| 4-row Cultivator | 41 | | | | | | | | | | | | | | | | | 16 |
| 6-row " | 42 | | | | | | | | | | | | | | | | | 17 |
| Sprayer | 43 | | | | | | | 1 | 1 | | 1 | 1 | | | | | | 18 |
| 2-14" Plow | 44 | | | | | | | | | | | | | | | | | 19 |
| 2-16" " | 45 | | | | | | | | | | | | | | | | | 20 |
| 3-14" Plow | 46 | | | | | | | | | | | | | | | | | 21 |
| 3-16" " | 47 | | | | | | | | | | | | | | | | | 22 |
| 4-14" " | 48 | | | | | | | | | | | | | | | | | 23 |
| 4-16" " | 49 | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | | 24 |
| 5-14" " | 50 | | | | | | | | | | | | | | | | | 25 |

82. (b) (Cont'd.)[a]

| Machine | Machine Code | Wheat Grow | | | | | | Oats Grow | | | | | | Hay Crop Plant | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | September | | | October | | | April | | | May | | | Fall Direct Seeding | | Spring Companion Crops | | |
| | | Med. | Lg. | U | Med. | Lg. | U | Med. | Lg. | U | Med. | Lg. | U | Med. | Lg. | | U | i |
| | | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | |
| 5-16" Plow | 51 | | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 26 |
| 6-14" " | 52 | | | | | | | | | | | | | | | | | 27 |
| 6-16" " | 53 | | | | | | | | | | | | | | | | | 28 |
| 7-14" " | 54 | | | | | | | | | | | | | | | | | 29 |
| 7-16" " | 55 | | | | | | | | | | | | | | | | | 30 |
| 8-14" Plow | 56 | | | | | | | | | | | | | | | | | 31 |
| 8-16" " | 57 | | | | | | | | | | | | | | | | | 32 |
| | 58 | | | | | | | | | | | | | | | | | 33 |
| 8' Disc | 59 | | | | | | | | | | | | | | | | | 34 |
| 10' " | 60 | | | | | | | | | | | | | | | | | 35 |
| 12' Disc | 61 | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | | 36 |
| 14' " | 62 | | | | | | | | | | | | | | | | | 37 |
| 16' " | 63 | | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 38 |
| 18' " | 64 | | | | | | | | | | | | | | | | | 39 |
| 9' Harrow | 65 | | | | | | | | | | | | | | | | | 40 |
| 12' Harrow | 66 | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | | 41 |
| 16' " | 67 | | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 42 |
| 20' " | 68 | | | | | | | | | | | | | | | | | 43 |
| 24' " | 69 | | | | | | | | | | | | | | | | | 44 |
| | 70 | | | | | | | | | | | | | | | | | 45 |
| 2-row Planter | 71 | | | | | | | | | | | | | | | | | 46 |
| 4-row " | 72 | | | | | | | | | | | | | | | | | 47 |
| 6-row " | 73 | | | | | | | | | | | | | | | | | 48 |
| Fert.Spreader | 74 | | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 49 |
| Grain Drill | 75 | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | | 50 |

a. The matrix number code for this table is 5.

82. (c) Grow Systems Machinery Use Matrix

| Machine | Machine Code | Hay Crop Maintain Summer | | Field Beans Grow | | | | | | Soybeans Grow | | | | | | i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | May | | | June | | | May | | | June | | | |
| | | Fert. | U | 4-row | 6-row | U | 4-row | 6-row | U | 4-row | 6-row | U | 4-row | 6-row | U | |
| | | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | |
| 0-40 H.P. Tractor | 1 | | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 01 |
| 41-60 H.P. " | 2 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 02 |
| 61-80 H.P. " | 3 | | | 1 | | | 1 | | | 1 | | | 1 | | | 03 |
| 81-100 H.P. " | 4 | | | | 1 | | | 1 | | | 1 | | | 1 | | 04 |
| 100+ H.P. " | 5 | | | | | | | | | | | | | | | 05 |
| | 6 | | | | | | | | | | | | | | | 06 |
| | 7 | | | | | | | | | | | | | | | 07 |
| | 8 | | | | | | | | | | | | | | | 08 |
| Pick-up Truck | 9 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 09 |
| Large Truck | 10 | | | | | | | | | | | | | | | 10 |
| | 11 | | | | | | | | | | | | | | | 11 |
| Unloading Wagon | 12 | | | | | | | | | | | | | | | 12 |
| Unloading Truck | 13 | | | | | | | | | | | | | | | 13 |
| | 39 | | | | | | | | | | | | | | | 14 |
| 2-row Cultivator | 40 | | | | | | | | | | | | | | | 15 |
| 4-row Cultivator | 41 | | | 1 | | | 1 | | | 1 | | | 1 | | | 16 |
| 6-row " | 42 | | | | 1 | | | 1 | | | 1 | | | 1 | | 17 |
| Sprayer | 43 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 1 | 1 | | 18 |
| 2-14" Plow | 44 | | | | | | | | | | | | | | | 19 |
| 2-16" " | 45 | | | | | | | | | | | | | | | 20 |
| 3-14" Plow | 46 | | | | | | | | | | | | | | | 21 |
| 3-16" " | 47 | | | | | | | | | | | | | | | 22 |
| 4-14" " | 48 | | | | | | | | | | | | | | | 23 |
| 4-16" " | 49 | | | 1 | | | 1 | | | 1 | | | 1 | | | 24 |
| 5-14" " | 50 | | | | | | | | | | | | | | | 25 |

82. (c) (Cont'd.)[a]

| Machine | Machine Code | Hay Crop Maintain Summer Fert. | Hay Crop Maintain Summer U | Field Beans Grow May 4-row | Field Beans Grow May 6-row | Field Beans Grow May U | Field Beans Grow June 4-row | Field Beans Grow June 6-row | Field Beans Grow June U | Soybeans Grow May 4-row | Soybeans Grow May 6-row | Soybeans Grow May U | Soybeans Grow June 4-row | Soybeans Grow June 6-row | Soybeans Grow June U | i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | |
| 5-16" Plow | 51 | | | | 1 | | | 1 | | | 1 | | | 1 | | 26 |
| 6-14" " | 52 | | | | | | | | | | | | | | | 27 |
| 6-16" " | 53 | | | | | | | | | | | | | | | 28 |
| 7-14" " | 54 | | | | | | | | | | | | | | | 29 |
| 7-16" " | 55 | | | | | | | | | | | | | | | 30 |
| 8-14" Plow | 56 | | | | | | | | | | | | | | | 31 |
| 8-16" " | 57 | | | | | | | | | | | | | | | 32 |
| | 58 | | | | | | | | | | | | | | | 33 |
| 8' Disc | 59 | | | | | | | | | | | | | | | 34 |
| 10' " | 60 | | | | | | | | | | | | | | | 35 |
| 12' Disc | 61 | | | 1 | | | 1 | | | 1 | | | 1 | | | 36 |
| 14' " | 62 | | | | | | | | | | | | | | | 37 |
| 16' " | 63 | | | | 1 | | | 1 | | | 1 | | | 1 | | 38 |
| 18' " | 64 | | | | | | | | | | | | | | | 39 |
| 9' Harrow | 65 | | | | | | | | | | | | | | | 40 |
| 12' Harrow | 66 | | | 1 | | | 1 | | | 1 | | | 1 | | | 41 |
| 16' " | 67 | | | | 1 | | | 1 | | | 1 | | | 1 | | 42 |
| 20' " | 68 | | | | | | | | | | | | | | | 43 |
| 24' " | 69 | | | | | | | | | | | | | | | 44 |
| | 70 | | | | | | | | | | | | | | | 45 |
| 2-row Planter | 71 | | | | | | | | | | | | | | | 46 |
| 4-row " | 72 | | | 1 | | | 1 | | | 1 | | | 1 | | | 47 |
| 6-row " | 73 | | | | 1 | | | 1 | | | 1 | | | 1 | | 48 |
| Fert. Spreader | 74 | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | 49 |
| Grain Drill | 75 | | | | | | | | | | | | | | | 50 |

a. The matrix number code for this table is 5.

83. (a) Harvest Systems Machinery Use Matrix

| Machine | Machine Code | Corn Silage Harvest | | | | | Corn Grain Harvest | | | | | | i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Custom | 1-row | 2-row | 2-row S.P. | U | Custom | 1-row Pick | 2-row Pick | 2-row Combine | 3-row Combine | U | |
| | | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | |
| 0-40 H.P. Tractor | 1 | | 1 | 1 | 1 | | | 1 | | | | | 01 |
| 41-60 H.P. " | 2 | | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | | 02 |
| 61-80 H.P. " | 3 | | 1 | 1 | | | | | 1 | | | | 03 |
| 81-100 H.P. " | 4 | | | | | | | | | | | | 04 |
| 100+ H.P. " | 5 | | | | | | | | | | | | 05 |
| | 6 | | | | | | | | | | | | 06 |
| | 7 | | | | | | | | | | | | 07 |
| | 8 | | | | | | | | | | | | 08 |
| Pick-up Truck | 9 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | 09 |
| Large Truck | 10 | | | | | | | | | | | | 10 |
| | 11 | | | | | | | | | | | | 11 |
| Unloading Wagon | 12 | | 1 | 1 | 1 | | | | | | | | 12 |
| Unloading Truck | 13 | | | | | | | | | | | | 13 |
| | 39 | | | | | | | | | | | | 14 |
| 2-row Cultivator | 40 | | | | | | | | | | | | 15 |
| 4-row Cultivator | 41 | | | | | | | | | | | | 16 |
| 6- row " | 42 | | | | | | | | | | | | 17 |
| Sprayer | 43 | | | | | | | | | | | | 18 |
| | 76 | | | | | | | | | | | | 19 |
| 1-row Chopper | 77 | | 1 | | | | | | | | | | 20 |
| 2-row Chopper | 78 | | | 1 | | | | | | | | | 21 |
| 2-row S.P. " | 79 | | | | 1 | | | | | | | | 22 |
| Blower | 80 | | 1 | 1 | 1 | | | | | | | | 23 |
| 3-row Corn Hd. (Grain) | 81 | | | | | | | | | | 1 | | 24 |
| 1-row Corn Pick. | 82 | | | | | | | 1 | | | | | 25 |
| 2-row Corn Pick. | 83 | | | | | | | | 1 | | | | 26 |
| 2-row Corn Com. | 84 | | | | | | | | | | | | 27 |

83. (a) (Cont'd.)[a]

| Machine | Machine Code | Corn Silage Harvest | | | | | Corn Grain Harvest | | | | | | i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Custom | 1-row | 2-row | 2-row S.P. | U | Custom | 1-row Pick | 2-row Pick | 2-row Combine | 3-row Combine | U | |
| | | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | |
| 3-row Corn Combine | 85 | | | | | | | | | | | | 28 |
| Grain Wagon | 86 | | | | | | | 1 | 1 | 1 | 1 | | 29 |
| Grain Elevator | 87 | | | | | | | 1 | 1 | 1 | 1 | | 30 |
| 2-row Corn Hd.(Grain) | 88 | | | | | | | | | 1 | | | 31 |
| 10' Grain Combine | 89 | | | | | | | | | | | | 32 |
| 12' Grain Combine | 90 | | | | | | | | | 1 | 1 | | 33 |
| 14' " " | 91 | | | | | | | | | | | | 34 |
| Bale Thrower | 92 | | | | | | | | | | | | 35 |
| 12' PTO Windrower | 93 | | | | | | | | | | | | 36 |
| 12' S.P. Windrower | 94 | | | | | | | | | | | | 37 |
| 14' S.P. Windrower | 95 | | | | | | | | | | | | 38 |
| Windrow Turner | 96 | | | | | | | | | | | | 39 |
| Baler | 97 | | | | | | | | | | | | 40 |
| Wagons | 98 | | | | | | | | | | | | 41 |
| Hay Elevator | 99 | | | | | | | | | | | | 42 |
| Mow Conveyor | 100 | | | | | | | | | | | | 43 |
| Mower | 101 | | | | | | | | | | | | 44 |
| Rake | 102 | | | | | | | | | | | | 45 |
| Conditioner | 103 | | | | | | | | | | | | 46 |
| Hay Hd.(1-row Chop.) | 104 | | | | | | | | | | | | 47 |
| Hay Hd.(2-row Chop.) | 105 | | | | | | | | | | | | 48 |
| 4-row Bean Pull Att. | 106 | | | | | | | | | | | | 49 |
| 6-row " " | 107 | | | | | | | | | | | | 50 |
| Bean Combine | 108 | | | | | | | | | | | | 51 |
| Bean Attachment | 109 | | | | | | | | | | | | 52 |
| | 110 | | | | | | | | | | | | 53 |

a. The matrix number code for this table is 6.

83. (b) Harvest Systems Machinery Use Matrix

| Machine | Machine Code | Wheat Harvest | | | | Oat Harvest | | | | Hay Crop Silage Harvest | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Combine | | | | Combine | | | Mow | Windrow | | | | |
| | | Cus-tom | Spread Straw | Bale Straw | U | Cus-tom | Spread Straw | Bale Straw | U | 1-row Chop | 2-row Chop | S.P. Chop | 1-row Chop | U | i |
| | | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | |
| 0-40 H.P. Tractor | 1 | | 1 | 1 | | | 1 | 1 | | 1 | 1 | 1 | 1 | | 01 |
| 41-60 H.P. " | 2 | | | | | | | | | 1 | | | | | 02 |
| 61-80 H.P. " | 3 | | | 1 | | | | 1 | | 1 | 1 | 1 | 1 | | 03 |
| 81-100 H.P. " | 4 | | | | | | | | | | 1 | | | | 04 |
| 100+ H.P. " | 5 | | | | | | | | | | | | | | 05 |
| | 6 | | | | | | | | | | | | | | 06 |
| | 7 | | | | | | | | | | | | | | 07 |
| | 8 | | | | | | | | | | | | | | 08 |
| Pick-up Truck | 9 | | | | | | | | | | | | | | 09 |
| Large Truck | 10 | | | | | | | | | | | | | | 10 |
| | 11 | | | | | | | | | | | | | | 11 |
| Unloading Wagon | 12 | | | | | | | | | 1 | 1 | 1 | 1 | | 12 |
| Unloading Truck | 13 | | | | | | | | | | | | | | 13 |
| | 39 | | | | | | | | | | | | | | 14 |
| 2-row Cultivator | 40 | | | | | | | | | | | | | | 15 |
| 4-row Cultivator | 41 | | | | | | | | | | | | | | 16 |
| 6-row " | 42 | | | | | | | | | | | | | | 17 |
| Sprayer | 43 | | | | | | | | | | | | | | 18 |
| | 76 | | | | | | | | | | | | | | 19 |
| 1-row Chopper | 77 | | | | | | | | | 1 | | | 1 | | 20 |
| 2-row Chopper | 78 | | | | | | | | | | 1 | | | | 21 |
| 2-row S.P. | 79 | | | | | | | | | | | 1 | | | 22 |
| Blower | 80 | | | | | | | | | 1 | 1 | 1 | 1 | | 23 |
| 3-row Corn Head | 81 | | | | | | | | | | | | | | 24 |
| 1-row Corn Pick. | 82 | | | | | | | | | | | | | | 25 |
| 2-row " " | 83 | | | | | | | | | | | | | | 26 |
| 2-row Combine | 84 | | | | | | | | | | | | | | 27 |

83. (b) (Cont'd.)[a]

| Machine | Machine Code | Wheat Harvest | | | | Oat Harvest | | | | Hay Crop Silage Harvest | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Combine | | | | Combine | | | Mow | Windrow | | | | |
| | | Cus-tom | Spread Straw | Bale Straw | U | Cus-tom | Spread Straw | Bale Straw | U | 1-row Chop | 2-row Chop | S.P. Chop | 1-row Chop | U | i |
| | | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | |
| 3-row Combine | 85 | | | | | | | | | | | | | | 28 |
| Grain Wagons | 86 | | 1 | 1 | | | 1 | 1 | | | | | | | 29 |
| Grain Elevator | 87 | | 1 | 1 | | | 1 | 1 | | | | | | | 30 |
| 2-row Corn Head | 88 | | | | | | | | | | | | | | 31 |
| 10' Grain Com. | 89 | | | | | | | | | | | | | | 32 |
| 12' Grain Com. | 90 | | 1 | 1 | | | 1 | 1 | | | | | | | 33 |
| 14' " " | 91 | | | | | | | | | | | | | | 34 |
| Bale Thrower | 92 | | | | | | | | | | | | | | 35 |
| PTO Windrower | 93 | | | | | | | | | | 1 | 1 | 1 | | 36 |
| 12' S.P. " | 94 | | | | | | | | | | | | | | 37 |
| 14' S.P. Windrower | 95 | | | | | | | | | | | | | | 38 |
| Windrow Turner | 96 | | | | | | | | | | | | | | 39 |
| Baler | 97 | | | 1 | | | | 1 | | | | | | | 40 |
| Wagons | 98 | | | 1 | | | | 1 | | | | | | | 41 |
| Hay Elevator | 99 | | | 1 | | | | 1 | | | | | | | 42 |
| Mow Conveyor | 100 | | | | | | | | | | | | | | 43 |
| Mower | 101 | | | | | | | | | 1 | | | | | 44 |
| Rake | 102 | | | | | | | | | 1 | | | | | 45 |
| Conditioner | 103 | | | | | | | | | 1 | | | | | 46 |
| Hay Head(1-row chopper) | 104 | | | | | | | | | | | | 1 | | 47 |
| Hay Head (2-row chopper) | 105 | | | | | | | | | | 1 | 1 | | | 48 |
| 4-row Bean Pull. Attachment | 106 | | | | | | | | | | | | | | 49 |
| 6-row " " | 107 | | | | | | | | | | | | | | 50 |
| Bean Combine | 108 | | | | | | | | | | | | | | 51 |
| Bean Att.(Comb.) | 109 | | | | | | | | | | | | | | 52 |
| | 110 | | | | | | | | | | | | | | 53 |

a. The matrix number code for this table is 6.

83. (c) Harvest Systems Machinery Use Matrix

| Machine | Machine Code | Hay Harvest: Mow Rake Bale | Hay Harvest: Windrow Thrower Mow-Conv. | Hay Harvest: Windrow Bale Thrower | Hay Harvest: U | Field Bean Harvest: Pull and Rake Custom Combine | Field Bean Harvest: Pull and Rake Comb. 4-row | Field Bean Harvest: Pull and Rake Comb. 6-row | Field Bean Harvest: Pull and Rake U | Soybean Harvest: Custom | Soybean Harvest: Combine | Soybean Harvest: U | i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | |
| 0-40 H.P. Tractor | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | | 1 | | 01 |
| 41-60 H.P. " | 2 | 1 | 1 | 1 | | 1 | 1 | 1 | | | | | 02 |
| 61-80 H.P. " | 3 | | | | | | | | | | | | 03 |
| 81-100 H.P. " | 4 | | | | | | | | | | | | 04 |
| 100+ H.P. " | 5 | | | | | | | | | | | | 05 |
| | 6 | | | | | | | | | | | | 06 |
| | 7 | | | | | | | | | | | | 07 |
| | 8 | | | | | | | | | | | | 08 |
| Pick-up Truck | 9 | 1 | 1 | 1 | | 1 | 1 | 1 | | | | | 09 |
| Large Truck | 10 | | | | | | | | | | | | 10 |
| | 11 | | | | | | | | | | | | 11 |
| Unloading Wagon | 12 | | | | | | | | | | | | 12 |
| Unloading Truck | 13 | | | | | | | | | | | | 13 |
| | 39 | | | | | | | | | | | | 14 |
| 2-row Cultivator | 40 | | | | | | | | | | | | 15 |
| 4-row Cultivator | 41 | | | | | 1 | 1 | | | | | | 16 |
| 6-row " | 42 | | | | | | | 1 | | | | | 17 |
| Sprayer | 43 | | | | | | | | | | | | 18 |
| | 76 | | | | | | | | | | | | 19 |
| 1-row Chopper | 77 | | | | | | | | | | | | 20 |
| 2-row Chopper | 78 | | | | | | | | | | | | 21 |
| 2-row S.P. Chopper | 79 | | | | | | | | | | | | 22 |
| Blower | 80 | | | | | | | | | | | | 23 |
| 3-row Corn Head | 81 | | | | | | | | | | | | 24 |
| 1-row Corn Picker | 82 | | | | | | | | | | | | 25 |
| 2-row " " | 83 | | | | | | | | | | | | 26 |
| 2-row Corn Combine | 84 | | | | | | | | | | | | 27 |

83. (c) (Cont'd)[a]

| Machine | Machine Code | Hay Harvest: Mow Rake Bale | Hay Harvest: Windrow Thrower Mow-Conv. | Hay Harvest: Windrow Bale Thrower | Hay Harvest: U | Field Bean Harvest: Pull and Rake: Custom Combine | Field Bean Harvest: Pull and Rake: Comb. 4-row | Field Bean Harvest: Pull and Rake: Comb. 6-row | Field Bean Harvest: Pull and Rake: U | Soybean Harvest: Custom Combine | Soybean Harvest: U | i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | |
| 3-row Corn Combine | 85 | | | | | | | | | | | | 28 |
| Grain Wagons | 86 | | | | | | 1 | 1 | | | 1 | | 29 |
| Grain Elevator | 87 | | | | | 1 | 1 | 1 | | 1 | 1 | | 30 |
| 2-row Corn Head(Grain) | 88 | | | | | | | | | | | | 31 |
| 10' Grain Combine | 89 | | | | | | | | | | | | 32 |
| 12' Grain Combine | 90 | | | | | | 1 | | | | 1 | | 33 |
| 14' " " | 91 | | | | | | | | | | | | 34 |
| Bale Thrower | 92 | | 1 | 1 | | | | | | | | | 35 |
| PTO Windrower | 93 | | | 1 | | | | | | | | | 36 |
| 12' S.P. " | 94 | | 1 | | | | | | | | | | 37 |
| 14' S.P. Windrower | 95 | | | | | | | | | | | | 38 |
| Windrow Turner | 96 | | 1 | 1 | | | | | | | | | 39 |
| Baler | 97 | 1 | 1 | 1 | | | | | | | | | 40 |
| Wagons | 98 | 1 | 1 | 1 | | | | | | | | | 41 |
| Hay Elevator | 99 | 1 | 1 | 1 | | | | | | | | | 42 |
| Mow Conveyor | 100 | | 1 | | | | | | | | | | 43 |
| Mower | 101 | 1 | | | | | | | | | | | 44 |
| Rake | 102 | 1 | | | | 1 | 1 | 1 | | | | | 45 |
| Conditioner | 103 | 1 | | | | | | | | | | | 46 |
| Hay Head(1-row Chop) | 104 | | | | | | | | | | | | 47 |
| Hay Head(2-row Chop) | 105 | | | | | | | | | | | | 48 |
| 4-row Bean Pull Att. | 106 | | | | | 1 | 1 | | | | | | 49 |
| 6-row " " " | 107 | | | | | | | 1 | | | | | 50 |
| Bean Combine | 108 | | | | | | | 1 | | | | | 51 |
| Bean Attach.(Comb.) | 109 | | | | | | 1 | | | | | | 52 |
| | 110 | | | | | | | | | | | | 53 |

a. The matrix number code for this table is 6.

## PART III

There are two ways that changes in the farm firm situation or management decisions can be reflected. One way is by changing the value of some of the coefficients in Parts I or II. The second is by purchase or sale of assets. These changes are accomplished by data input on Part II of Data Form 1 immediately following input of the data required in Part I. Each numbered set of two lines on Part II of Data Form 1 is used for one record. Only one date, parameter change or management decision is to be placed in each record.

### Date Records

The date (month) during which each parameter change or decision is to take place is indicated by the date record which preceeds it. A date record has zeros in the first two spaces, the month of the year the change is made in the third and fourth spaces and the last two digits of the year of the change in spaces five and six. For example, if the first changes are to occur during March of 1972, the first record would appear as follows:

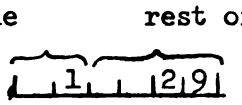
month year

1. 0,0,0,3,7,2

This record would be followed by decision records indicating the changes and decisions to be carried out for that month. All changes (decision records) following a date record should be listed in the order in which they are to occur. Only one date record is to be entered for each month changes are made. No date record is required for months in which no change is made.

## Identification Numbers

Each coefficient in Part II has an identification number just to the left (in parentheses) or just above (when date is in table or matrix form) the coefficient value listed. Similar identification numbers are placed to the left of the line or above the space provided for most coefficients in Part I of this manual. Each of these identification numbers consists of two parts separated by a hyphen. That part of the number to the left of the hyphen is the identification number code. When identification numbers are being entered on Data Form 1 the code part of the identification number must be entered separate from the rest of the number. For example, if the identification number is 1-29, the code part of the number is 1 and the number would be entered in the proper spaces as




Those coefficients in Part I which have no identification number can not be changed after the initial value is entered. In most cases these coefficients are required to specify the initial situation for the business but will normally change through time. Examples include the beginning inventory values which are of value only as starting values. There would be no reason to specify a new beginning inventory after the first year.

## Changes and Decisions

There are eleven different types of changes or decisions that can be used. Each type of change is identified by a number and represents a different purchase, sell or parameter change action. The eleven types of change are:

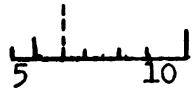
| Number | Type of Change |
|---|---|
| 01 | Change in value of a coefficient |
| 02 | Building purchase (detailed) |
| 03 | Building purchase (brief) |
| 04 | Machine purchase |
| 05 | Machine sale |
| 06 | Livestock purchase |
| 07 | Livestock sale |
| 08 | Land purchase |
| 09 | Land sale |
| 10 | Machinery inventory input (detailed) |
| 11 | Machinery inventory input (brief) |

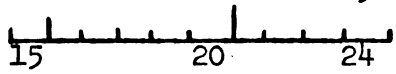
For each decision or parameter change, one decision record must be entered indicating the data necessary to make that change. Each type of change and the data record required to represent that change is discussed below. The numbers below a data line indicate the spaces or columns in which the data is to be placed.

1. **Change in Coefficient Value**

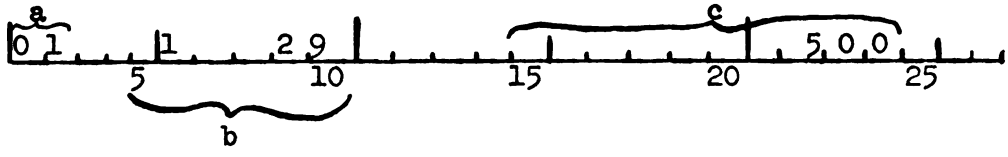
Data required:

(a) Type of change number 


(b) Identification number of coefficient changed 


(c) New value of coefficient 


Example:

4. 

Explanation: This changes the coefficient indicated to the new value entered. The new value will be used for the month in which the change is made (except for decisions entered prior to this one) as well as future months.

2. Building Purchase (Detailed)

Data required:

(a) Type of change number 02 (2)

(b) Building cost (5–10)

(c) Expected building life (years) (12)

(d) Loan period (years) (14)

(e) Interest rate (17)

(f) Loan type[1] (19)

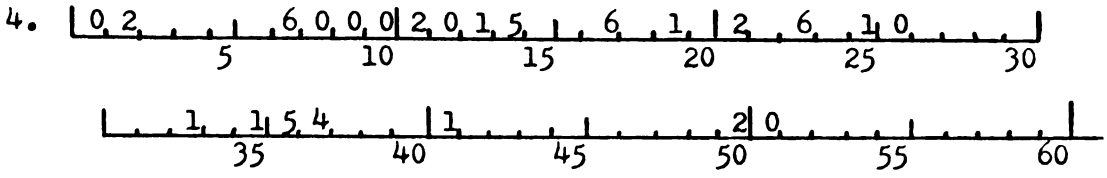
(g) Months payments made (20, 23, 25, 27, 29, 30)

(h) Building capacity coefficient changed[2] (32, 35, 37)

(i) New value of coefficient (42–45, 51)

(j) New value is 0 = new total capacity
1 = amount added to capacity (41)

Example:




---

1. Use same loan type definitions and entry methods as shown in question 40 Part I.

2. From question 25 Part I. If more than one is changed, list the additional ones with number 01 changes. Leave blank if no capacity coefficient is changed.

Explanation: This will purchase the buildings and change the value of buildings, the financial position, the capacity value and the depreciation for this and future months as indicated.

3. Building Purchase (Brief)

Data required:

(a) Type of change number 2

(b) Building capacity coefficient changed[1] 6 10

(c) New value of coefficient 15 24

(d) New value is 0 = new total capacity
1 = amount added to capacity 27

Example:

4. a 0 3 b 1 1 5 4 c 2 0 d 1

5 10 15 20 25

Explanation: This will purchase buildings to increase the building capacity indicated to the level or by the amount entered as the new value. Costs incurred and loan conditions are those indicated in Part II. The value of buildings will be changed, depreciation will be changed and the financial situation will be adjusted.

Note: The type of buildings purchased will depend on the systems being used. If this represents a change in systems, be sure that the system change is indicated before the building purchase change.

---

1. From question 25, Part I. If more than one coefficient is changed, list the additional ones with number 01 changes. Leave blank if no capacity coefficient is changed.

4. Machine Purchase

Data required:

(a) Type of change number 2

(b) Machine code[1] 5 7

(c) Machine life (years) 11

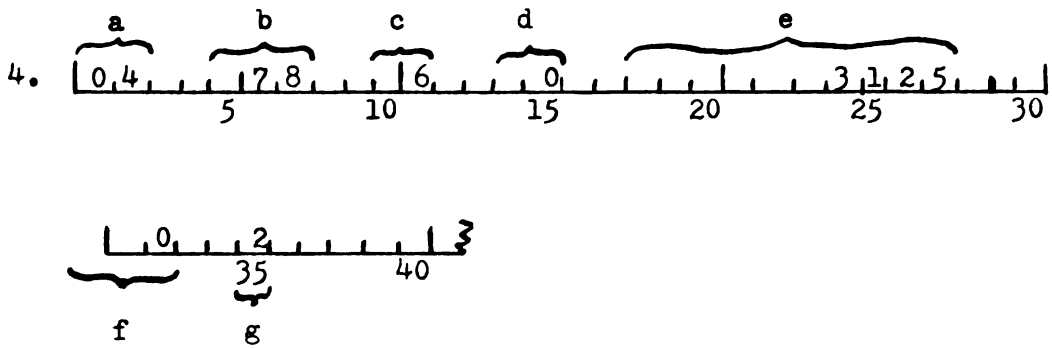
(d) Age (years) 15

(e) Purchase price[2] 18 27

(f) Code number of machine traded in[3] 30 32

(g) Cash (=1) or Loan (=2)[4] 35

Example:




Explanation: This purchases the machine indicated, enters it in the machinery inventory and makes the appropriate cash or loan transactions. If a machine is traded in, the oldest machine with the code number indicated will be traded.

---

1. From questions 34 or 55 Part II.

2. Enter -1 if a simulator generated price is to be used. If trade-in is involved, enter the "boot" value paid.

3. Enter 0 to indicate no trade-in.

4. If loan is indicated, standard loan conditions from question 15 Part II will be used.

Note: If purchase of the machine involves a change in a system being used, be sure to change the system's matrix.

5. Machine Sale

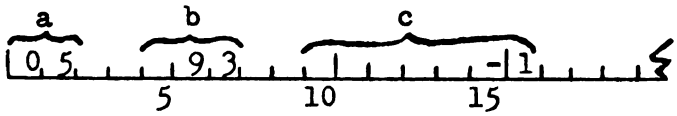
Data required:

(a) Type of change number 05 (2)

(b) Machine code of machine sold[1] (5–7)

(c) Sale price[2] (10–16)

Example:

4. 


Explanation: The oldest machine of the code indicated is sold at the price indicated. If sale of the machine involves a change in a system used, be sure to change the system's matrix accordingly.

6. Livestock Purchase

Data required:

(a) Type of change number 06 (2)

(b) Number of animals (5–8)

(c) Age (months) (12)

(d) Price each[3] (13–18)

---

1. From questions 34 or 55 Part II.

2. Enter -1 if machine is to be sold at depreciated value minus 10%.

3. Enter -1 if a simulator generated price is to be used.

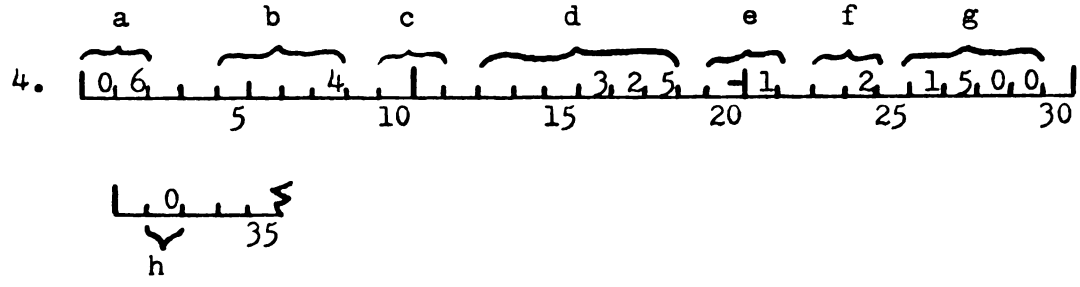
(e) Months since last fresh[1] 21

(f) Months until next fresh (if bred)[2] 24

(g) Genetic superiority or inferiority (lbs. per lactation) 26 29

(h) Cash (=1) or loan (=0) 31

Example:




Explanation: This purchases the number of animals indicated and adds them to the herd. If the next freshening date is not known, one will be assigned. If bred heifers are purchased months until next fresh must be given a value. Not more than 10 livestock purchase decisions can be made during any one month.

7. Livestock Sale

Data required:

(a) Type of change number 0 7

(b) Number of animals 2 (5 8)

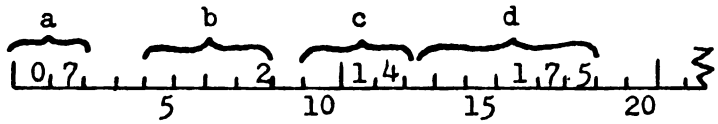
(c) Age (months)[3] 10 12

(d) Price each[4] 13 18

---

1. Enter 0 if fresh cows are purchased, -1 is animals have never freshened.
2. Enter -1 if the animal is to freshen in the month purchased, leave blank if the next freshening date is unknown.
3. Enter a negative value if animals sold are steers.
4. Enter -1 if simulator generated price is to be used.

Example:

4. 


Explanation: This sells the number of animals indicated. The animals sold are those whose age is closest to the age indicated. If there are not enough animals of the age indicated available, those one month older will be sold, then those one month younger, then those two months older. This process continues until the required number are sold. If cows are being sold and there is more than one animal of that age, those fresh over ten months are sold first, followed by those fresh the shortest period of time.

8. Land Purchase

Data required:

(a) Type of change number 0,8 (2)

(b) Value of land[1] (5–12)

(c) Cash down payment (15–22)

New normal acreages (owned or cash rented only)

(d) Corn (25–28)

(e) Hay Crop (29–32)

(f) Oats (33–36)

(g) Wheat (37–40)

(h) Soybeans (41–44)

(i) Fieldbeans (45–48)

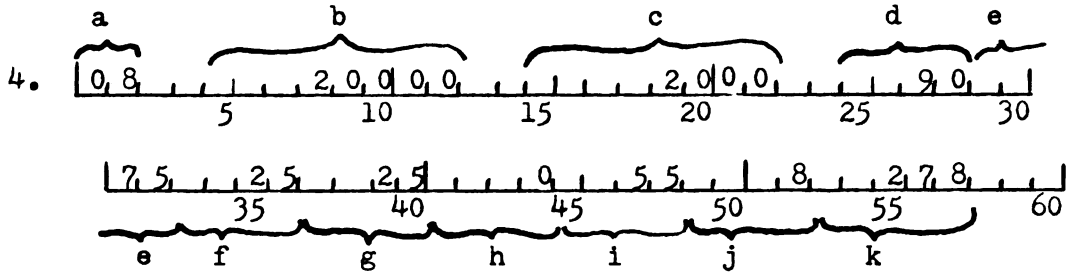
(j) Gov't. programs (49–52)

(k) Total (53–57)

---

1. If borrowing is necessary, loan terms from question 16 Part II will be used.

Example:




Explanation: The value of the land minus the down payment will be added to loans outstanding. The down payment will be added to cash land expenditures. The acreages indicated will be the new total owned and cash rented acreage. If the share-rented acreage changes at the same time, this should be indicated by entering decision records with type 01 changes.

9. Land Sale

Data required:

(a) Type of change number 09 (2)

(b) Value of land sold (5–12)

New normal acreages (owned and cash-rented only)

(c) Corn (15–18)

(d) Hay Crop (19–22)

(e) Oats (23–26)

(f) Wheat (27–30)

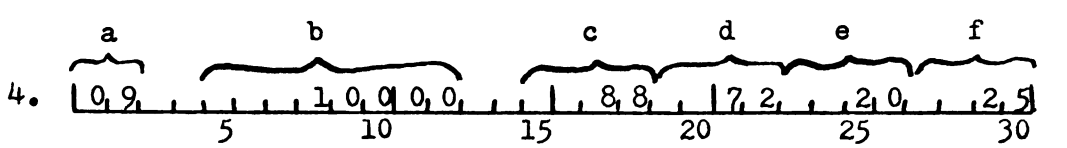
(g) Soybeans (31–34)

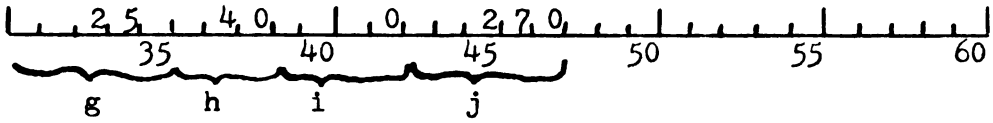
(h) Fieldbeans (35–38)

(i) Gov't. payments (39–42)

(j) Total (43–47)

Example:






Explanation: The acreages indicated are the new total acreages of crops grown on owned or rented land. If the share-rent acreage changes at the same time this should be indicated with a number 10 type change decision record. The value received for the land will be distributed over the number of years indicated in question 54 Part II with not more than 30 percent of the total received during the first year and interest received as indicated in question 16 part II.

10. Machinery Inventory Input (Detailed)

Data required:

(a) Type of change number 10 (2)

(b) Machinery code (5 7)

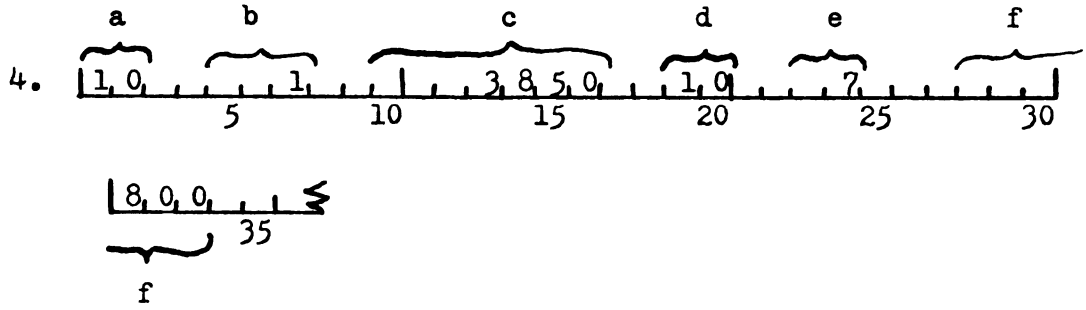
(c) Approximate purchase price (10 16)

(d) Life (20)

(e) Age (24)

(f) Present value (27 33)

Example:



Explanation: This decision record is used to input present machinery inventory when the answer to question 20 Part I is yes (=1) ie. when the user inputs the beginning machinery inventory. This can be used only in the first month of simulation. One record is used for each machine.

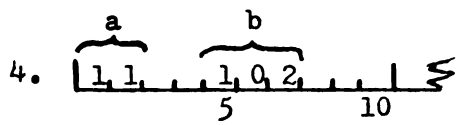
11. Machinery Inventory Input (Brief)

Data required:

(a) Type of change number (2)

(b) Machine code (7)

Example:




Explanation: This is used to input the beginning machinery inventory when the user does not want to specify the life, age and present value of each machine but wants the specific machinery contained in the beginning inventory. Values for these items will be assigned by the program. Type 11 changes can be combined with type 10 changes to enter the complete inventory. This type of change can be used only in the first month of simulation.

List of Systems

## Livestock Systems

### Dairy Cows

1. In stanchion or tie stall barn with gutter cleaner, milk transfer system, bulk tank and silo unloader.

2. Cold covered free stall system, herringbone parlor, manure scraper and silo unloader.

3. Warm covered free stall system, herringbone parlor, manure scraper and silo unloader.

4. Cold covered free stall system, herringbone parlor, liquid manure and silo unloader.

5. Warm covered free stall system, herringbone parlor, liquid manure and silo unloader.

6. Loose housing open lot, herringbone parlor, manure scraper and silo unloader.

7. User defined.

### Dairy Replacements

8. Conventional pens cleaned by manure loader, silage fed to older animals. In outside lots during summer.

9. Free stalls for animals over 6-9 months, manure scraper into conventional spreader, silage fed.

10. User defined.

## Crop Grow Systems

### Corn Grow - April

1. Two row system, 2, 3 and 4 plow tractors, 3-16" plow, 10' disc, 12' harrow, 1 spray, 1 cultivation. Plant in April.
2. 4 row system, 2, 3 and 4 plow tractors, 4-16" plow, 12' disc, 12' harrow, 1 spray, 1 cultivation, fertilizer spreader. Plant in April.
3. 6 row system, 2, 3, 4 and 5 plow tractors, 5-16" plow, 16' disc, 16' harrow, 1 spray, 1 cultivation, fertilizer spreader. Plant in April.
4. User defined.

### Corn Grow - May

5. 2 row system. Identical to 1 except for timing.
6. 4 row system. Identical to 2 except for timing.
7. 6 row system. Identical to 3 except for timing.
8. User defined.

### Corn Grow - June

9. 2 row system. Identical to 1 except for timing.
10. 4 row system. Identical to 2 except for timing.
11. 6 row system. Identical to 3 except for timing.
12. User defined.

### Wheat Grow - September

13. Plant in Sept., 2, 3 and 4 plow tractors, 4-16" plow, drill, 12' disc, 12' harrow, compatible with 2 or 4 row corn grow system.
14. Plant Sept., large equipment (compatible with 6 row corn grow), 2, 4, and 5 plow tractors, 16' disc, 16' harrow, drill.
15. User defined.

Wheat Grow - October

16. Plant in Oct. Same as 13 except for timing.

17. Plant in Oct. Same as 14 except for timing.

18. User defined.

Oats Grow - April

19. Plant April, 2, 3 and 4 plow tractors, 4-16" plow, drill. Compatible with 2 or 4 row corn grow system.

20. Plant April, large equipment. Compatible with 6 row corn grow, 2, 4, 5 plow tractors, 16' disc, 16' harrow, drill, 5-16" plow.

21. User defined.

Oats Grow - May

22. Plant May. Same as 19 except for timing.

23. Plant May. Same as 20 except for timing.

24. User defined.

Hay Crop Plant

25. Direct seeding, 2, 3 and 4 plow tractors, 4-16" plow, drill, 12' disc, 12' harrow, compatible with 2 or 4 row corn grow.

26. Direct seeding, 2, 4 and 5 plow tractor, 5-16" plow, 16' disc, 16' harrow, drill. Compatible with 6 row corn grow.

27. Companion crop, spring seeding, 2 plow tractor, seeder.

28. User defined.

Hay Crop Grow

29. Fertilizer spreader for summer application.

30. User defined.

Fieldbean Grow - May

31. 4 row, plant May, spray, 1 cultivation, 2, 3 and 4 plow tractors, 4-16" plow, 12' disc, 12' harrow.

32. 6 row, plant May, sprayer, 1 cultivation, 2, 3, 4 and 5 plow tractors, 16' disc, 16' harrow, 5-16" plow.

33. User defined.

Fieldbean Grow - June

34. 4 row. Same as 31 except for timing.

35. 6 row. Same as 32 except for timing.

36. User defined.

Soybeans Grow - May

37. 4 row, 2, 3 and 4 plow tractors, spray, cultivate, 12' disc, 12' harrow, 4-16" plow, plant in May.

38. 6 row, 2, 4 and 5 plow tractors, 16' disc, 16' harrow, 5-16" plow, spray, 1 cultivation, plant in May.

39. User defined.

Soybeans Grow - June

40. 4 row. Same as 37 except for timing.

41. 6 row. Same as 38 except for timing.

42. User defined.

## Harvest Systems

### Corn Silage Harvest

1. Custom harvest, all men and machines provided by the custom operator.
2. 1 row chopper, 2, 3 and 4 plow tractors, unloading wagons, blower.
3. 2 row chopper, 2, 3 and 4 plow tractors, unloading wagons and blower.
4. Self propelled chopper, 2 and 3 plow tractors, unloading wagons, blower.
5. User defined.

### Corn Grain Harvest

6. Custom, custom combine and trucks, man and elevator required for unloading.
7. 1 row picker, 2 and 3 plow tractor, grain wagons, elevator.
8. 2 row picker, 3 and 4 plow tractors, grain wagons, elevator.
9. 2 row combine, 3 plow tractor, grain wagons, elevator.
10. 3 row combine, 3 plow tractor, 2 grain wagons, elevator.
11. User defined.

### Wheat Harvest

12. Custom hire of combining and trucks, one man and elevator required.
13. S.P. Combine, spread straw, grain wagons, 2 plow tractor, elevator.
14. S.P. Combine, bale straw, grain wagons, hay wagons, 2 and 4 plow tractors, grain elevator, hay elevator, baler.
15. User defined.

### Oats Harvest

16. Custom combine, one man and elevator required.
17. S.P. Combine, spread straw, grain wagons, 2 plow tractor, elevator.

18. S.P. Combine, bale straw, grain wagons, hay wagons, 2 and 4 plow tractors, grain elevator, hay elevator, baler.

19. User defined.

Hay Crop Silage Harvest

20. Mow, crush, rake, chop with 1 row corn chopper with hay head, 2 unloading wagons, blower, 2, 3 and 4 plow tractors.

21. Windrower, chop with 2 row corn chopper with hay head, 2 unloading wagons, blower, 2, 4 and 5 plow tractors.

22. Windrower, S.P. Chopper, 2 unloading wagons, blower, 2 and 4 plow tractors.

23. Windrower, 1 row chopper with hay head, 2 unloading wagons, blower, 2, 3 and 4 plow tractors.

24. User defined.

Hay Harvest

25. Mower, crusher, rake, baler, wagons. Load behind the baler, elevator. Hand bale handling.

26. Windrower, bale with kicker, use mow conveyor, elevator, wagons.

27. PTO windrower, bale with kicker, place bales in mow by hand.

28. User defined.

Field Bean Harvest

29. Custom combine, 4 row pull, rake, 2 and 3 plow tractors, grain elevator.

30. 4 row pull rake, combine with bean head, 2 and 3 plow tractors, grain elevator, grain wagons.

31. 6 row pull, rake, bean combine, 2 and 3 plow tractors, grain elevator, grain wagons.

32. User defined.

Soybeans Harvest

33. Custom combine, 1 man and elevator for unloading.

34. Combine, elevator, grain wagons, 2 plow tractor.

35. User defined.

# FABS

(FArm Business Simulator)

DATA FORM 1

FABS DATA FORM 1

Note:

Each number entered on this form should be placed in the right-hand portion of the space allotted. The spaces are divided into segments and one number should be placed in each segment. If there is a decimal point in the number, it occupies one space. For example, the number 26 would be entered as / / / / /2 /6/ and 13.2 would be entered as follows: / / / / /1 /3 /. /2/.

## Part I

Card 1
(80)

1. Month / / / (1-2) Year / / / (3-4)

2. Years / / / (5-6)

3. Fiscal or Calendar / / (7)

4. (a) / / (8)
   (b) / / (9)
   (c) / / (10)
   (d) / / (11)
   (e) / / (12)
   (f) / / (13)
   (g) / / (14)
   (h) / / (15)
   (i) / / (16)
   (j) / / (17)

5. Notes:

Dairy

6. Number of Cows by Lactation and Month of Freshening Month Prior to First Month to be Simulated

| Card | Lactation | Dec[a] | Nov | Oct | Sept | Aug | July | June | May | Apr | Mar | Feb | Jan | Dec | Nov | Oct | Before Oct |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | -1 | -2 | -3 | -4 | -5 | -6 | -7 | -8 | -9 | -10 | -11 | -12 | -13 | -14 | -15 | Before -15 |
| 2 | 1 | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // |
| 3 | 2 | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // |
| 4 | 3 | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // |
| 5 | 4 | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // |
| 6 | 5 | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // |
| 7 | 6 | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // |
| 8 | 7 | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // |
| 9 | 8 | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // |
| 10 | 9 | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // |
| 11 | 10 or over | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // | // |
| | (79-80) | (1-3) | (4-6) | (7-9) | (10-12) | (13-15) | (16-18) | (19-21) | (22-24) | (25-27) | (28-30) | (31-33) | (34-36) | (37-39) | (40-42) | (43-45) | (46-48) |

a. Month headings can be used only if January is the first month to be simulated.

Card 12
(79-80)

7. (a) Heifers

| Age | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | / | / | / | / | / | / | / | / | / | / | / | / |
| | (1-2) | (3-4) | (5-6) | (7-8) | (9-10) | (11-12) | (13-14) | (15-16) | (17-18) | (19-20) | (21-22) | (23-24) |

| Age | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | / | / | / | / | / | / | / | / | / | / | / | / |
| | (25-26) | (27-28) | (29-30) | (31-32) | (33-34) | (35-36) | (37-38) | (39-40) | (41-42) | (43-44) | (45-46) | (47-48) |

| Age | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | / | / | / | / | / | / | / | / | / | / | / | / |
| | (49-50) | (51-52) | (53-54) | (55-56) | (57-58) | (59 60) | (61-62) | (63-64) | (65-66) | (67-68) | (69-70) | (71-72) |

Card 13
(79-80)

7. (b) Steers

| Age | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | / / | / / | / / | / / | / / | / / | / / | / / | / / | / / | / / | / / |
| | (1-3) | (4-6) | (7-9) | (10-12) | (13-15) | (16-18) | (19-21) | (22-24) | (25-27) | (28-30) | (31-33) | (34-36) |

| Age | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | / / | / / | / / | / / | / / | / / | / / | / / | / / | / / | / / | / / |
| | (37-39) | (40-42) | (43-45) | (46-48) | (49-51) | (52-54) | (55-57) | (58-60) | (61-63) | (64-66) | (67-69) | (70-72) |

Card 14
(NO)

8. Freshening Preference

| Mo. of Birth | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Fresh. | / | / | / | / | / | / | / | / | / | / | / | / |
| | (1-2) | (3-4) | (5-6) | (7-8) | (9-10) | (11-12) | (13-14) | (15-16) | (17-18) | (19-20) | (21-22) | (23-24) |

9. Cows / / / (25-27)
   Bred heifers / / / (28-30)
   Open heifers / / / (31-33)
   Calves / / / (34-36)

10. Production / / / / / (37-41)
    Forage quality / (42)
    Lbs. feed / / / / / (43-47)
    Culling rate / / / / (48-51)

11. Lbs. feed to be fed / / / / / (52-55)
    Forage quality to use / (56)
    Culling rate to use / / / / (57-60)

12. Concentrate lbs.
    Ear corn / / / / (61-64)
    Shelled corn / / / / (65-68)
    Oats / / / / (69-72)
    Wheat / / / / (73-76)
    Supplement / / / / (77-80)

Card 15
(79-80)

13. (a) Corn fed? / / (1)

13. (b)

| | Jan | Feb | March | April | May | June |
|---|---|---|---|---|---|---|
| lbs. | / / / / (2-6) | / / / / (7-11) | / / / / (12-16) | / / / / (17-21) | / / / / (22-26) | / / / / (27-31) |

| | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|
| lbs. | / / / / (32-36) | / / / / (37-41) | / / / / (42-46) | / / / / (47-51) | / / / / (52-56) | / / / / (57-61) |

13. (c) % moisture / / / / / (62-66)

13. (d) HMC supplement / / / / / / (67-71)

14. Forage H.E. percentages

| CARD | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 Hay | | | | | | | | | | | | |
| 17 HCS | | | | | | | | | | | | |
| 18 CS | | | | | | | | | | | | |
| | (1-4) | (5-8) | (9-12) | (13-16) | (17-20) | (21-24) | (25-28) | (29-32) | (33-36) | (37-40) | (41-44) | (45-48) |

Card 19
(79-80)

15. Calving interval ____ (1-5)

16. % heifer raises ____ (6-8)

17. Maximum number cows ____ (9-12)

Maximum heifers under 1 year ____ (13-16)

Maximum heifers over 1 year ____ (17-20)

18. Youngstock bedding ____ (21)

Cow bedding ____ (22)

| CARD | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 C | | | | | | | | | | | | |
| 21 E | | | | | | | | | | | | |
| | (1-5) | (6-10) | (11-15) | (16-20) | (21-25) | (26-30) | (31-35) | (36-40) | (41-45) | (46-50) | (51-55) | (56-60) |

Card 22
(79-80)

19. Cows ____ (1-2)

2. Heifers ____ (3-4)

3. Corn - Apr. ____ (5-6)

4. Corn - May ____ (7-8)

5. Corn - June ____ (9-10)

6. C.S. ____ (11-12)

7. C. grain ____ (13-14)

8. Wheat - Sept. ____ (15-16)

9. Wheat - Oct. ____ (17-18)

10. Wheat - har. ____ (19-20)

19. (Cont'd.)

11. Oats - Apr. ___ (21-22)
12. Oats - May ___ (23-24)
13. Oats - har. ___ (25-26)
14. Hay plant ___ (27-28)
15. HCS ___ (29-30)
16. Hay grow ___ (31-32)
17. Hay ___ (33-34)
18. F. beans - May ___ (35-36)
19. F. beans - June ___ (37-38)
20. F. beans - har. ___ (39-40)
21. Soy. - May ___ (41-42)
22. Soy. - June ___ (43-44)
23. Soy. - har. ___ (45-46)

20. Enter machinery? ___ (47)

Buy machinery? ___ (48)

21. Land value now. _____ (49-55)

Land value, 10 year _____ (56-62)

Card 23
(NO)

| 22. Crop | Own or rent | share rent |
|---|---|---|
| Corn | ____ (1-4) | ____ (5-8) |
| Hay | ____ (9-12) | ____ (13-16) |
| Oats | ____ (17-20) | ____ (21-24) |

22. (Cont'd.)

| Crop | Own or rent | share rent |
|---|---|---|
| Wheat | (25-28) | (29-32) |
| Soybeans | (33-36) | (37-40) |
| Fieldbeans | (41-44) | (45-48) |
| Gov't programs | (49-52) | (53-56) |
| TOTAL | (57-60) | (61-64) |

22. (b) Hay crop silage (65-67)

Corn silage (68-71)

23. Acres rented (72-75)

Rent rate (76-80)

Card 24
(79-80)

24.

| | Value | Age | Year's |
|---|---|---|---|
| years | (1-6) | (7-12) | (13-18) |
| years | (19-24) | (25-30) | (31-36) |
| years | (37-42) | (43-48) | (49-54) |

Card 25
(79-80)

25. Building Capacity

(a) Free stalls ____ (1-5)

(b) Stanchions ____ (6-10)

(c) Parlor ____ (11-15)

(d) Heifers ____ (16-20)

(e) Calves ____ (21-25)

(f) U-silo ____ (26-30)

(g) H-silo ____ (31-35)

(h) Hay ____ (36-40)

(i) E. corn ____ (41-45)

(j) Grain ____ (46-50)

(k) HMC ____ (51-55)

26. (a) Dairy buildings? ____ (56)

(b) Grain storage? ____ (57)

(c) Hay storage? ____ (58)

(d) (i) Fieldbeans ____ (59)

(ii) Soybeans ____ (60)

(iii) Wheat ____ (61)

(iv) Corn ____ (62)

(v) Oats ____ (63)

27. Labor

| Number | Type | January | February | March | April | May | June |
|---|---|---|---|---|---|---|---|
| | Operator | | | | | | |
| | Family | | | | | | |
| | Hire(1) | | | | | | |
| | Hire(2) | | | | | | |
| | Hire (3) | | | | | | |
| Rate | | | | | | | |
| | Hour(1) | | | | | | |
| | Hour(2) | | | | | | |
| | Hour(3) | | | | | | |
| (1-5) | | (6-10) | (11-15) | (16-20) | (21-25) | (26-30) | (31-35) |

| Type | July | August | September | October | November | December | Card |
|---|---|---|---|---|---|---|---|
| Operator | | | | | | | 26 |
| Family | | | | | | | 27 |
| Hire(1) | | | | | | | 28 |
| Hire(2) | | | | | | | 29 |
| Hire(3) | | | | | | | 30 |
| | | | | | | | |
| Hour(1) | | | | | | | 31 |
| Hour(2) | | | | | | | 32 |
| Hour(3) | | | | | | | 33 |
| | (36-40) | 41-45) | (46-50) | (51-55) | (56-60) | (61-65) | |

Card 34
(79-80)

27. (b) Labor cost ____ (1-5)

28. Hire(1) ____ (6-10) ____ (11-15)

Hire(2) ____ (16-20) ____ (21-25)

Hire(3) ____ (26-30) ____ (31-35)

Card 35
(79-80)

29. Plant food ____ (1-4)

Bu. oats ____ (5-9)

30. Period ____ (10)

Plant food ____ (11-14)

Bu. Corn ____ (15-19)

31. Plant food ____ (20-23)

Spring N ____ (24-26)

Bu. Wheat ____ (27-31)

32. Plant food ____ (32-35)

Tons 1st ____ (36-39)

Tons 2nd ____ (40-43)

Tons 3rd ____ (44-47)

33. Plant food ____ (48-51)

Bu. Fieldbeans ____ (52-56)

34. Bu. Soybeans ____ (57-61)

35. Cuttings ____ (62)

36. Pasture 1st ____ (63-67)

Pasture 2nd ____ (68-72)

Pasture 3rd ____ (73-77)

Card 36
(79-80)

37. Hay crop silage ____ (1-5)

Corn silage ____ (6-10)

H.M. corn ____ (11-15)

38. (a) Hay crop silage ____ (16-20)

(b) Corn silage ____ (21-25)

(c) Hay ____ (26-30)

(d) HMC ____ (31-35)

(e) Ear corn ____ (36-40)

(f) Shelled corn ____ (41-45)

(g) Wheat ____ (46-50)

38. (Cont'd.)

(h) Oats _____ (51-55)

(i) Soybeans _____ (56-60)

(j) Fieldbeans _____ (61-65)

(k) Straw _____ (66-70)

(l) Supplement _____ (71-75)

Card 37
(79-80)

39. (a) Plant food

| | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|
| (1) Corn | (1-3) | (4-6) | (7-9) |
| (2) Soybeans | (10-12) | (13-15) | (16-18) |
| (3) Fieldbeans | (19-21) | (22-24) | (25-27) |
| (4) Wheat | (28-30) | (31-33) | (34-36) |
| (5) Oats | (37-39) | (40-42) | (43-45) |
| (6) Hay-seed | (46-48) | (49-51) | (52-54) |
| (7) Hay | (55-57) | (58-60) | (61-63) |

(b) Region _____ (64-65)

40. (a) Debt

| CARD | Balance | Rate | No. | Amount | TYPE | TERM | Month 1 | 2 | 3 | 4 | 5 | 6 | AGE | YEARS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 | | | | | | | | | | | | | | |
| 39 | | | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | | | |
| 41 | | | | | | | | | | | | | | |
| 42 | | | | | | | | | | | | | | |
| 43 | | | | | | | | | | | | | | |
| 44 | | | | | | | | | | | | | | |
| 45 | | | | | | | | | | | | | | |
| (79-80) | (1-9) | | (10-14) | (15-16) | | (17-24) | (25-26) | (27) | 28-29 | 30-31 | 32-33 | 34-35 | 36-37 | 38-39 | (40-42) | (43-45) |

(b) Cash / / / / / / / / (46-53)

Card 46
(79-80)

41. (a) Withdrawals

| Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| (1-5) | (6-10) | (11-15) | (16-20) | (21-25) | (26-30) | (31-35) | (36-40) | (41-45) | (46-50) | (51-55) | (56-60) |

Card 47
(79-80)

(b) Off-farm income / / / / / / (1-6)

Exemptions / / (7-8)

(c) Estimated tax / / / / / /
(9-13)

(d) Estimated income / / / / / / /
(14-19)

42. (a) Steers? / /
(20)

(b) Percent / / / /
(21-24)

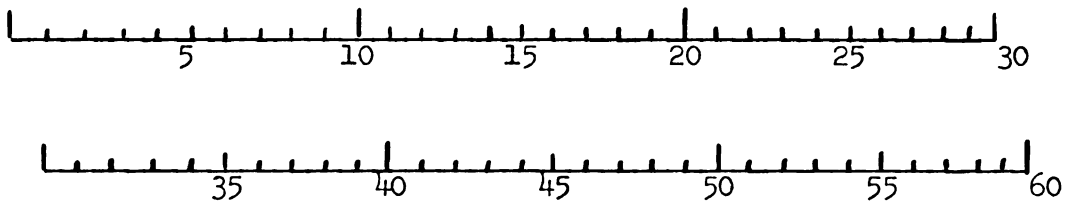
(c) Age on feed / / / /
(25-28)

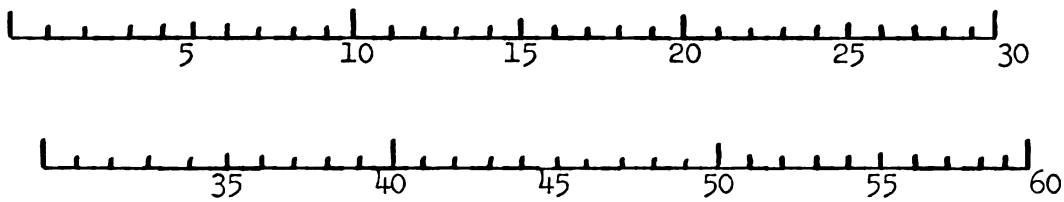
(d) Age sold / / / /
(29-32)

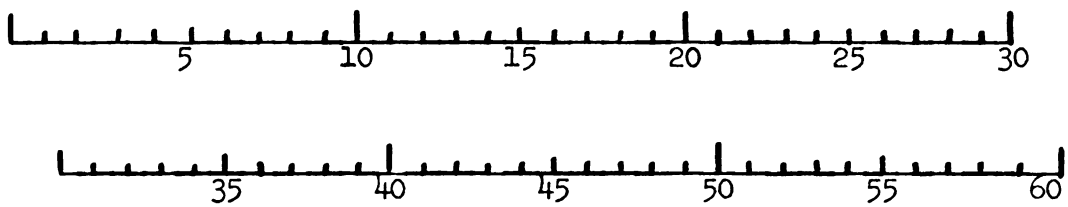
(e) Ration / /
(33)

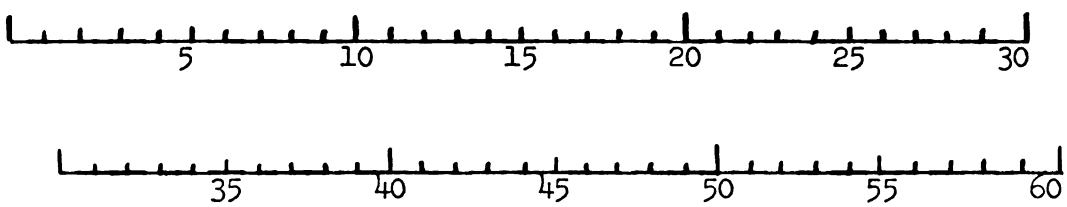
PART II

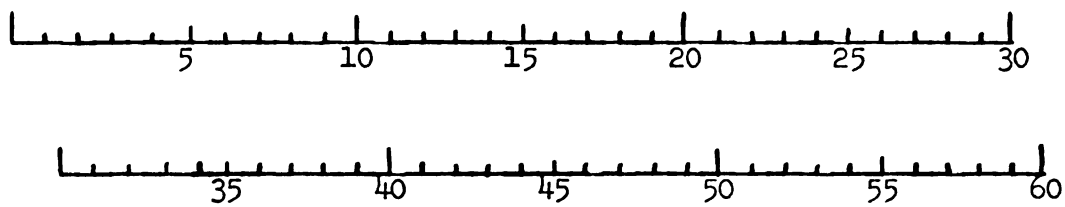
Changes and Management Decisions

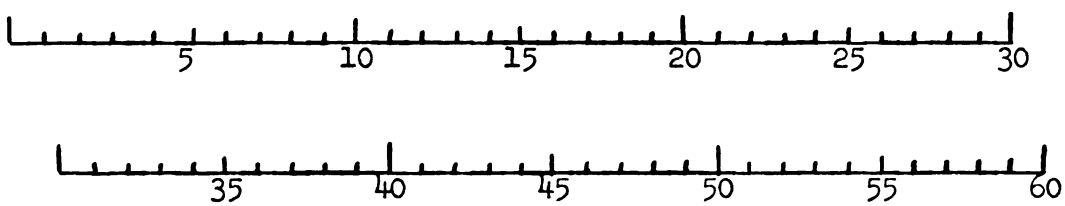
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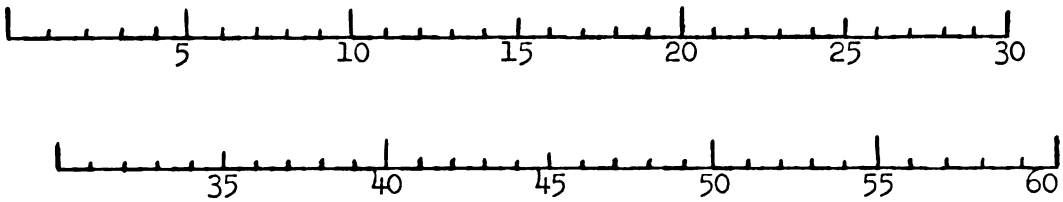

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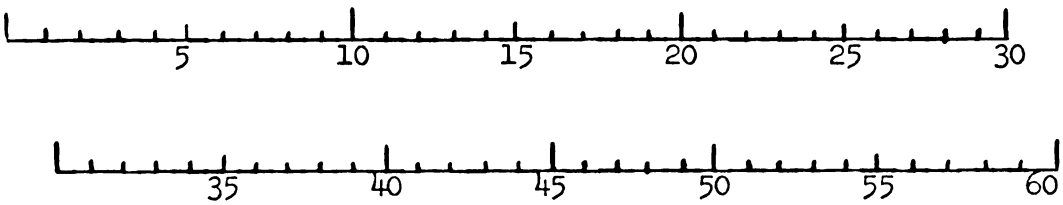

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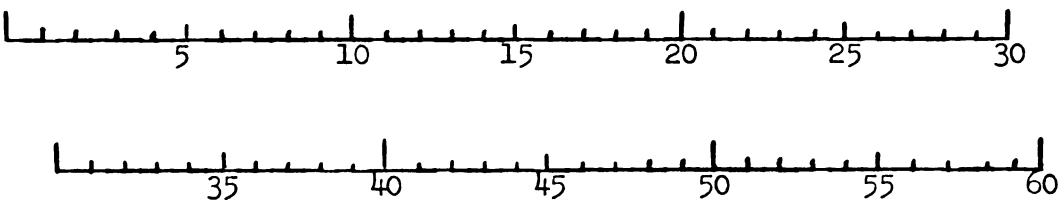

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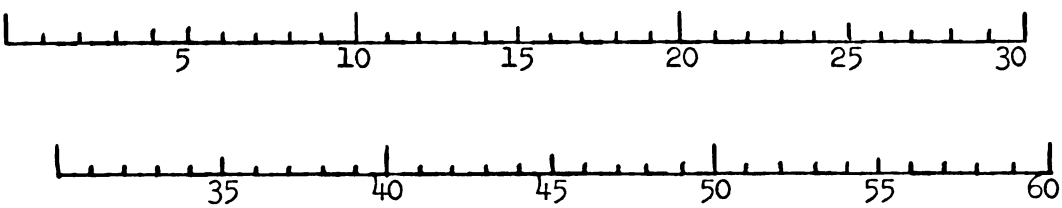

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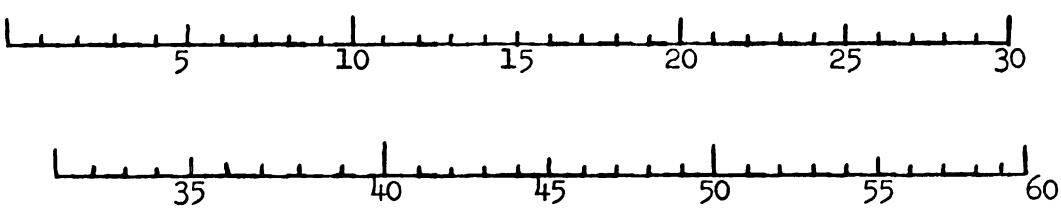

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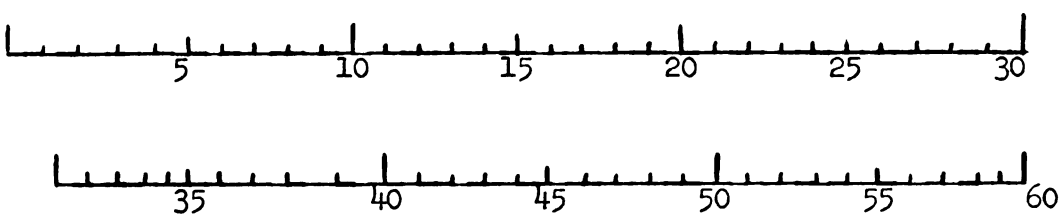
7. 

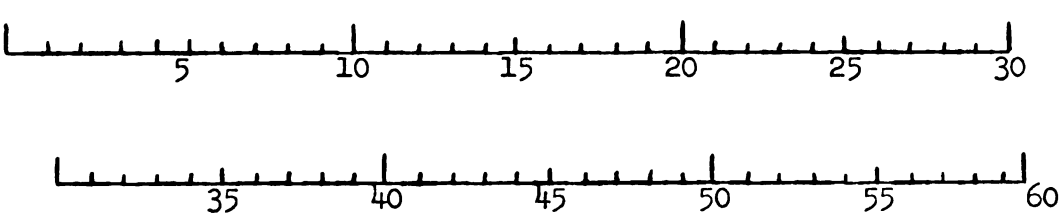

8. 

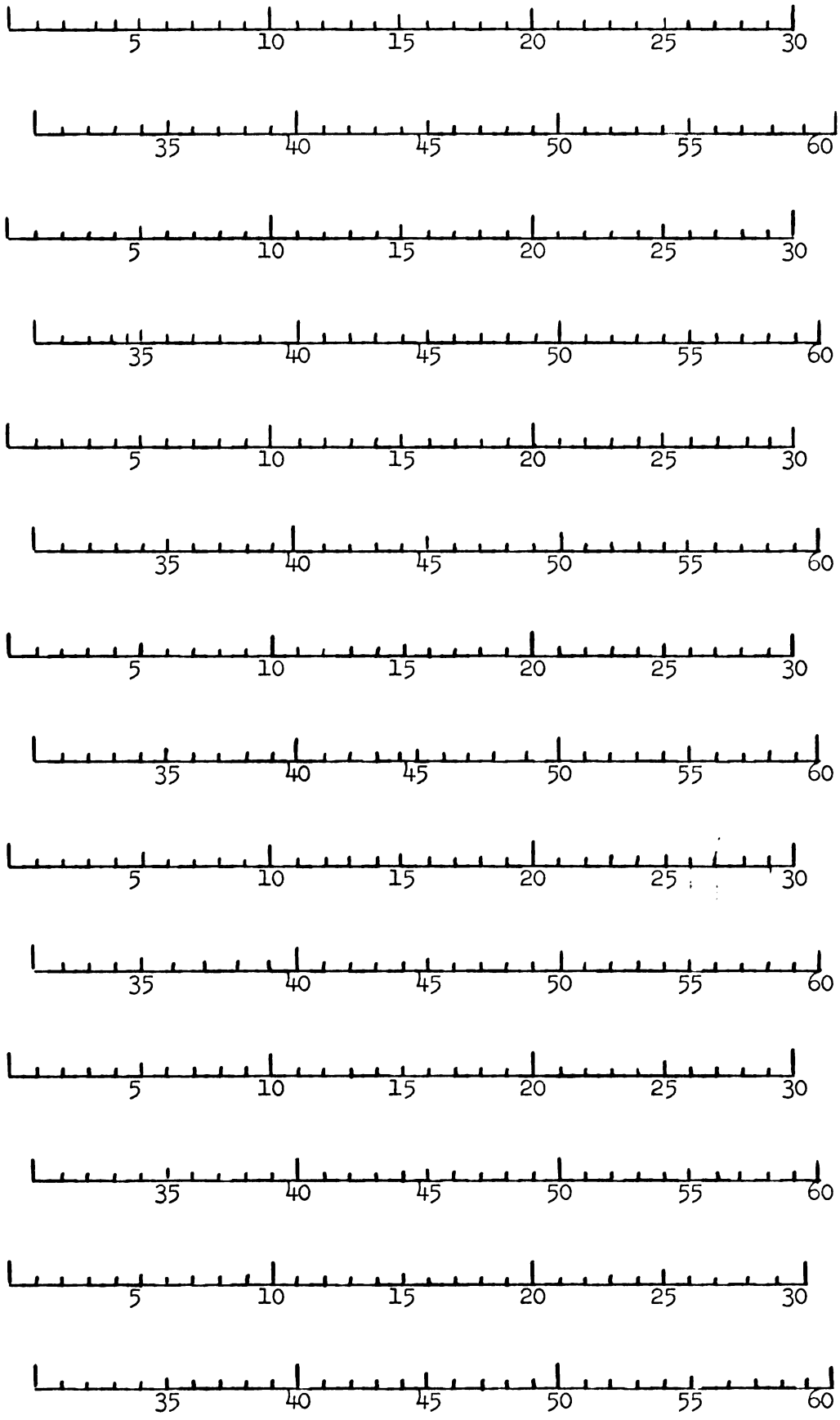

9. 


10. 


11. 


12. 


13. 


5 10 15 20 25 30
35 40 45 50 55 60
5 10 15 20 25 30
35 40 45 50 55 60
5 10 15 20 25 30
35 40 45 50 55 60
5 10 15 20 25 30
35 40 45 50 55 60
5 10 15 20 25 30
35 40 45 50 55 60
5 10 15 20 25 30
35 40 45 50 55 60
5 10 15 20 25 30
35 40 45 50 55 60
5 10 15 20 25 30
35 40 45 50 55 60

# APPENDIX B

## DETAILED DESCRIPTION OF FARM BUSINESS SIMULATOR (FABS) COMPUTER PROGRAM ROUTINES

PROGRAM FABS

FABS is the main program which controls the order of subroutine execution and the period simulated.

1.1 Numbered common are zeroed out at beginning of simulation (labeled common automatically start with zero values).

1.2 The following variables are maintained and incremented where appropriate:

1. MONTH1 = Calendar month ($1 \leq$ MONTH1 $\geq 12$)
2. MONTH2 = Simulator month (1,2...)
3. IYR = Simulation calendar year
4. IYR1 = Calendar year simulation started

1.3 Subroutines are called in appropriate order

1.4 Controls for years simulated are maintained.

SUBROUTINE READI

This subroutine reads in data for the initial farm situation and makes any alterations required for use of the data by the rest of the model.

2.1 The data indicated in part I of the users manual is read in. All data is read in Fw.0 format with w indicated by the spaces allotted on Data Form 1.

2.2 The following variables are changed from percentage to decimal.

1. CULL1 = Required (historical) culling rate
2. CULL2 = Culling rate to be used
3. HMCH2O = Moisture content of high moisture corn
4. HESORC(J,K) = Proportion of hay equivalent fed from each source
5. PCTHEF = Proportion of heifer calves raised
6. DEBT(I,2) = Interest rate on debt outstanding
7. PCTBUL = Proportion of bull calves raised
8. VLAND2 = Rate of increase in land value (if rate rather than final value is entered)

2.3 System numbers are checked to be sure that each is within the proper range.

2.4 Entry points in DAIRY and BUILDI routines are called by READI. The entry point in the DAIRY subroutine (DAIRY2) enters the animals into the herd matrix from the ICOW, IHEFER and ISTEER arrays which the basic data had previously been read into. The entry point in the BUILDI array (BUILDO) enters the initial building set into the building set matrix from the BLDGS array into which the basic data was read by the READI routine. Entry points are used to free the array space used by the four

arrays for other use. These arrays are equivalenced to the DEBT(I,J) matrix.

2.5 The DEBT(I,J) matrix is zeroed out and the initial number of debts outstanding (JCNT3) is calculated.

SUBROUTINE INPUT

INPUT reads in and handles coefficient changes and management decisions.

3.1 The year and month in which coefficient changes and management decisions are to be made are indicated by date records (cards). A date record indicating the month and year must precede the records (cards) indicating the changes to be made in that month. The first record (card) must be a date record indicating the first month simulated. The types of coefficient change and management decisions are indicated by type of change numbers.

3.1.1 If the type of change number is 1, the value in the coefficient is changed as indicated. That is, the coefficient is set equal to the new value given.

3.1.2 If the type of change number is 2, the new buildings are added to the building set matrix (see BUILDI subroutine). If the value of (Q.40, Part II)[1] is less than 100, this is accomplished by setting up essentially two building sets. One set has a purchase value of EQUITY times the building cost. This has a code value of 1. The second has a purchase value of the building cost minus the purchase value of the first set. This has a code value of 2. Both have an age of zero and a life taken from input. Depreciated value for each equals the purchase value.

The purchase is added to the current debt situation matrix. The beginning balance due equals the building cost. The interest rate, loan type, life and months payments are made as taken from input.

1. Throughout this Appendix, references to (Q.X, Part Y) refer to question number X of Part Y of the user manual, Appendix A.

The building capacity coefficient is changed to the new value.

3.1.3 If the type of change number is 3, new buildings are purchased. If the new value of the coefficient is the new total capacity (indicated by "new value" variable set at 0) the amount purchased is the new capacity value (from input) minus the old value. Otherwise (if the "new value" variable is set to 1), the amount purchased is the amount indicated by the new value of the coefficient. The cost of the change is calculated as follows: If the capacity coefficient being changed is:

A. CAPCT(1) or CAPCT(2) (Q.25(a) or Q.25(b), Part I), the cost is derived from the BC array (Q.66, Part II). The building equipment cost per stall is indicated by BC(i,j) where i = 1 if stalls added is $\leq$ 70

2 if stalls added is 70-89

3 if stalls added is 90-109

4 if stalls added is $>$ 109

and j equals the number of the dairy cow system in use (SYS(1), Q.19, Part I). The building cost is the number of stalls times BC(5,j).

B. CAPCT(3) (Q.25(c), Part I), and the number of "parlors" to be purchased is odd, one 1-man parlor is purchased. If the number of "parlors" to be purchased is equal to or greater than 2 the number of two-man parlors is calculated by dividing the number of "parlors" purchased by two and rounding off to integer. The building cost equals the number of one-man parlors multiplied by PCOST1 (Q.64(a), Part II) plus the number of two-man parlors multiplied by PCOST3 (Q.64(c), Part II). The parlor equipment cost is the number of one-man parlors

multiplied by PCOST1 (Q.64(b), Part II) plus the number of two-man parlors multiplied by PCOST4 (Q.64(d), Part II). Two variables, "one-man parlors" and "two-man parlors" are maintained and the numbers built are added to the total.

For both A and B above, the building cost is added to the building set matrix. If the value of EQUITY (Q.40, Part II) is less than 100, two building sets are added to the building set matrix. One set with a code value of 1 has a purchase value equal to EQUITY multiplied by the total building cost. The second set with a code value of 2 has a purchase value of the building cost minus the purchase value of the first set. For both sets depreciated value equals purchase value, age equals zero and life is equal to the depreciation life indicated in Q.14, Part II. If EQUITY = 100, only one set is added and the code is 1.

The value of equipment purchased is added to the machinery inventory matrix. A code number of 111 will be used for barn equipment and 112 for parlor equipment. New value and depreciated value equal the cost. Life equals PLIFE (Q.64(e), Part II) and age is zero.

For either A or B above the building cost is added to the equipment cost and the total is entered in the current debt situation matrix (DEBT(i,j)). The beginning balance equals the total calculated cost. Interest rate, number of payments, loan period and type of loan are taken from Q.14, Part II and the term of loan is 4 for buildings, 5 for land, 6 for machinery, and 7 for livestock.

C. CAPCT(4) (Q.25(d), Part I), the cost is equal to the increase in capacity multiplied by the (1,j) position of the HCBC matrix (Q.65, Part II), where: j = (replacement system no. (SYS(2), Q.52, Part II)) - 7.

This cost is added to the building set matrix and the current debt situation is the same manner as indicated in (B) above.

D. CAPCT(5) (Q.25(e), Part I), the cost is equal to the increase in capacity multiplied by the (2,j) position of the HCBC matrix (Q.65, Part II), where: j = (replacement system no. (SYS(2), Q.52, Part II)) - 7. The cost is added to the building set matrix and the current debt situation in the same manner as indicated in (B) above.

E. CAPCT(6) (Q.25(f), Part I), the silo to purchase is found by searching SC(i,1) (Q.67, Part II), for the smallest tonnage which exceeds the amount to be purchased. If this is SC(r,1), where r is a specific value of "i", the silo cost is SC(r,3) and the unloader cost is XMP(K,1) (Q.68, Part II) where K is the machine code number calculated below. The silo cost is entered into the building set and current debt by the same method as used in (B) above. The unloader is added to the machinery set. New value and depreciated value equal the unloader cost. Age is zero. The machine code number (K) is:

15 if r = 1 or 2
17 if r = 3
18 if r = 4 or 5
19 if r = 6, 7 or 8
20 if r = 9
21 if r = 10 or 11

Life is XMP(K,2) (Q.68, Part II). A "1" is placed in the system matrix cell LSM(machine code, SYS(1)), from (Q.81, Part II).

The cost is added to the current debt situation matrix. The loan term, interest rate and loan type come from Q.12, Part II, and the payment months and amount of payment are calculated as in (B) above.

F. CAPCT(7) (Q.25(g), Part I), the cost per ton is chosen by selecting the highest value of i possible for which the minimum tons still exceeds the tonnage calculated (Q.67, Part II). If that value of i = r, then SC(r,5) is the cost per ton. The cost of the silo is SC(r,5) multiplied by the tons to be built. The cost is added to the building set matrix and the current debt situation as in (B) above.

G. CAPCT(8) (Q.25(h), Part I), cost equals the tonnage required multiplied by SCOST1 (Q.63(a), Part II). Cost is added to the building set and the current debt situation as indicated in (B) above.

H. CAPCT(9) (Q.25(i), Part I), cost is the bushels multiplied by SCOST2 (Q.63(b), Part II). This is added to the building set and the current debt situation as in (B) above.

I. CAPCT(10) (Q.25(j), Part I), the procedure is the same as that indicated in H above except that SCOST3 (Q.63(c), Part II) is used.

J. CAPCT(11) (Q.25(k), Part I), the size of silo to build is found by searching SC(i,2), i = 1,...,7 to find the smallest number which is larger than the bushels of storage to be purchased. If that value of i = r, then SC(r,3) is the silo cost and MP(K,1) is the unloader cost where K is defined as in E above. These costs are handled in the same manner as the silo purchases in E above.

For each of the above A through J the capacity coefficients should be changed to the new value when new capacity is constructed.

3.1.4 If the type of change number is 4, indicating machinery purchase,

life and age are taken from input. Purchase value is taken from input if a positive price is entered; or from Q.68, Part II if -1 is entered in price. If the price is generated by the model, the amount of cash or loan paid is the appropriate price from Q.68, Part II (indexed as XMP (machine code, 1)) minus the depreciated value of the machine traded in; new value and depreciated value both equal the price generated (Q.68, Part II). If the purchase ("boot") price is entered, the new value and the depreciated value are the "boot" value plus the depreciated value of the trade-in and the cash or loan paid is the "boot" amount input. If cash is paid, the "machinery purchase" and "cash machinery investment" accumulation are increased by the amount actually paid, otherwise only machinery purchase is increased.

If the machine is purchased on loan, the loan amount is added to the current debt situation. Beginning balance is the loan amount. Loan term, number of payments, interest rate and type of loan are taken from Q.12, Part II.

3.1.5 If the type of change number is 5, indicating machinery sale, a machine with the code indicated will be found (if there is more than one, the oldest is selected) and removed from the machinery inventory matrix. "Machinery sales," as accumulation, will be increased by the amount indicated or the depreciated value minus 10 percent (if -1 is input). If the sale value differs from the depreciated value, the difference is added to the accumulated depreciation, i.e. (depreciated value-sale value) is added to depreciation.

3.1.6 If the type of change number is 6, the data is put in a 10 x 5 matrix called STOCKH (livestock purchase hold) of animals to be purchased. For each group of animals input by a code 6, the matrix

contains (1) number of animals, (2) age, (3) months since last fresh, (4) month until next fresh, and (5) production adjustment. Each group of animals occupies one line of the matrix.

The number of animals purchased is added to cows bought, heifers over 1 year bought, or heifers under 1 year depending on age and freshening. The cost of the animals is calculated by multiplying the price each by the number of animals. If the price is input, that price is used. If the price is to be generated (-1 in price entry) the number of animals is added to the appropriate "_____purchase" group with cost calculated in storage and sales. "Bought" variables indicate animal numbers regardless of pricing mechanism. "Purchase" variables are messages to the storage and sales routine. Purchase groups are: (1) cows purchased, (2) bred heifers purchased, (3) open heifers purchased (over 1 year) and (4) heifers under 1 year purchased. If the price is given, the value of the purchase is added to "livestock purchases" and, if cash is paid, it is also added to "cash livestock investment." If a loan is used, the value is added to the current debt situation. The value is the beginning balance. Interest rate, loan term, type of loan and number of payments come from Q.12, Part II. Months of payment and amount of payment are calculated as in 3.1.2 B above.

3.1.7 If the type of change number is 7, the animals to be sold are put in a "livestock sale hold" matrix (SLIVEH). This is a 10 x 3 matrix with each row containing (1) number of animals (in the group), (2) age, and (3) price each.

3.1.8 If the type of change number is 8, the normal acreage coefficients, CPACRE(8,2) (Q.22, Part I), are given their new values. The

down payment is added to an accumulation called "cash land investment" and the value of the land minus the down payment is the beginning balance added to the current debt situation. Interest rate, term of loan, type of loan and payments per year are taken from Q.14, Part II. Months payments are to be made and amount of payment are calculated as in C(2) above. The value of the land is added to PURLD (land purchase) and to VLANDM (the value of all land owned by the business).

3.1.9 If the type of change number is 9, the value of the land is added to SALELD (land sale income) and the new normal acreages replace the old ones in CPACRE (Q.22, Part I). The value of the sale is subtracted from VLANDM.

3.1.10 If the type of change number is 10, the machinery listed is put directly in the machinery inventory matrix. The values in each row of input correspond to the values to be put in rows of the machinery inventory matrix. This type of change can be used only in the first month simulated.

3.1.11 If the type of change number is 11, the machinery listed is put directly in the machinery inventory matrix. The values for life, age and depreciated value are calculated by the machinery routine. This type of change can be used only in the first month simulated.

3.2 Listed below are the variable names and identification numbers of all variables listed in Parts I and II of the Users Manual (Appendix A).

Table B1. VARIABLE NAMES OF PARAMETERS DESCRIBED IN USERS MANUAL

| Question Number | Variable Name | Identification Numbers | Question Number | Variable Name | Identification Numbers |
|---|---|---|---|---|---|
| ----------Part I---------- | | | | | |
| 1 | ISTART | | 16 | PCTHEF* | 1-81 |
| | IYR | | 17(a) | COWMAX | 34 |
| 2 | IYEARS | | (b) | HEFMAX | 1-83 |
| 3 | IBASIS | | (c) | CAVMAX | 1-84 |
| 4 | IOUTPT(11) | | 18 | BEDYG | 1-85 |
| 5 | | | | BEDCW | 1-86 |
| 6 | ICOWS(10,16) | | | BEDCST(2,12) | 1-87 th. 1-110 |
| 7(a) | IHEFER(36) | | 19 | SYS(23) | 3-111 th. 3-133 |
| (b) | ISTEER(24) | | 20(a) | MENTER | |
| 8 | FRESH(12) | 1-1 th. 1-12 | (b) | BUYMCH | 1-134 |
| 9 | VALUE(4) | 1-13 th. 1-16 | 21 | VLAND1 | |
| 10 | ACTPR1 | 1-17 | | VLAND2** | 1-135 |
| | FORAG1 | 1-18 | 22(a) | CPACRE(8,2) | 1-136 th. 1-151 |
| | FEED1 | 1-19 | (b) | CSACRE | |
| | CULL1* | 1-20 | | HSACRE | |
| 11(a) | FEED2 | 1-21 | 23 | ARENT | 1-152 |
| (b) | FORAG2 | 1-22 | | RENTRT | 1-153 |
| (c) | CULL2* | 1-23 | 24 | BLDGS(3,3) | |
| 12 | GRIST(5) | 1-24 th. 1-28 | 25 | CAPCT(11) | 1-154 th. 1-164 |
| 13(a) | HMCFED | 1-29 | 26 | BUILD | 1-165 |
| (b) | HMCLBS(12) | 1-30 th. 1-41 | | GSTOR | 1-166 |
| (c) | HMCH2O* | 1-42 | | HSTOR | 1-167 |
| (d) | HMCSUP | 1-43 | | OFFS(5) | 1-168 th. 1-172 |
| 14 | HESORC(3,12)* | 1-44 th. 1-79 | 27(a) | XLABOR(8,13) | 1-173 th. 1-276 |
| 15 | CALVIN | 1-80 | | | |

Table B1 (Cont'd.)

| Question Number | Variable Name | Identification Numbers |
|---|---|---|
| 27(b) | ADLABR | 1-277 |
| 28 | WAGERT(3,2) | 1-278 th. 1-283 |
| 29 | PFOODO | 1-284 |
| | YIELDO | 1-285 |
| 30 | PERIOD | 1-286 |
| | PFOODC | 1-287 |
| | YIELDC | 1-288 |
| 31 | PFOODW | 1-289 |
| | SPRNW | 1-290 |
| | YIELDW | 1-291 |
| 32 | PFOODH | 1-292 |
| | YIELD1 | 1-293 |
| | YIELD2 | 1-294 |
| | YIELD3 | 1-295 |
| 33 | PFOODF | 1-296 |
| | YIELDF | 1-297 |
| 34 | YIELDS | 1-298 |
| 35 | CUTS | 1-299 |
| 36 | PAST1 | 1-300 |
| | PAST2 | 1-301 |
| | PAST3 | 1-302 |
| 37 | HCSHRV | 1-303 |
| | CSHRV | 1-304 |
| | HMC | 1-305 |
| 38 | CPINV(11) | |
| 39(a) | FERT(7,3) | 1-306 th. 1-326 |
| (b) | ASR | 1-327 |
| 40(a) | DEBT(8,13) | |
| (b) | CASH | 1-328 |
| 41(a) | XLIVNG(12) | 1-329 th. 1-340 |
| (b) | OINCOM | 1-341 |
| | EXM | 1-342 |
| (c) | TAXEST | 1-343 |
| (d) | ESTINC | 1-344 |
| 42(a) | DSTEER | 1-345 |
| (b) | PCTBUL* | 1-346 |
| (c) | FEDAGE | 1-347 |
| (d) | SLDAGE | 1-348 |
| (e) | RATION | 1-349 |
| ----------Part II---------- | | |
| 1 | VOLABR | 1-350 |
| 2 | VFLABR | 1-351 |
| 3 | EQINT* | 1-352 |
| 4 | EXSHAY | 1-353 |
| | SELMOH | 1-354 |
| 5 | SELMOC | 1-355 |
| | EXSC | 1-356 |
| 6 | SELMOO | 1-357 |
| | EXSO | 1-358 |
| 7 | SELMO(5) | 1-359 th. 1-363 |

Table B1 (Cont'd.)

| Question Number | Variable Name | Identification Numbers | Question Number | Variable Name | Identification Numbers |
|---|---|---|---|---|---|
| 8 | CORNBT | 1-375 | 19 | PASTHE(10)* | 1-379 th. 1-388 |
| | BTMOC | 1-376 | 20(a) | PLOSS* | 2-2887 |
| 9 | HMCBT | 1-377 | (b) | HSAV* | 2-2888 |
| | BTMHMC | 1-378 | 21(a) | WSYELD | 2-2537 |
| 10 | TONSUP | 2-8893 | (b) | OSYELD | 2-2538 |
| | SUPMO | 2-8894 | 22 | CROPCO(44,2)* | 1-474 th. 1-561 |
| 11 | CWORBH | 1-390 | 23 | SVCC(5,7) | 1-562 th. 1-596 |
| | AGEBT | 1-391 | 24(a) | HAULMK | 1-472 |
| | XNBRBT(12) | 1-393 th. 1-403 | (b) | PKUP | 1-473 |
| 12 | PERODI | 1-423 | 25 | BRDFEE | 1-469 |
| | RATEI* | 1-424 | | ZVET | 1-470 |
| | TYPEI | 1-425 | | OTHERD | 1-471 |
| | PMTSI | 1-426 | 26 | REPLAC | 1-440 |
| 13 | STMAX | 1-427 | 27 | UTILRT | 1-605 |
| | XITMAX | 1-428 | 28 | ZMISC1 | 1-606 |
| 14 | PERODL | 1-429 | | ZMISC2* | 1-607 |
| | RATEL* | 1-430 | 29 | PTYTAX | 1-608 |
| | TYPEL | 1-431 | | TAXM1 | 1-609 |
| | DEPRLF | 1-432 | | TAXM2 | 1-610 |
| | PMTSL | 1-433 | 30 | ZCONS1 | 1-611 |
| 15 | SRATE* | 1-434 | | ZCONS2 | 1-612 |
| 16(a) | BALMIN | 1-435 | 31 | RENTM1 | 1-613 |
| (b) | BALMAX | 1-436 | | RENTM2 | 1-614 |
| 17 | RESEED* | 1-597 | 32 | SHARE | 1-615 |
| 18 | CUTCOF(2,2)* | 1-598 th. 1-601 | 33 | PRICEN* | 1-616 |

Table B1 (Cont'd.)

| Question Number | Variable Name | Identification Numbers | Question Number | Variable Name | Identification Numbers |
|---|---|---|---|---|---|
| | PRICEP* | 1-617 | 46(a) | TAXYRS | 2-8891 |
| | PRICEK* | 1-618 | (b) | CLDMO | 2-8892 |
| 34 | HAUL(6) | 1-364 th. 1-369 | 47 | CMORTL* | 1-419 |
| 35 | STORE(5) | 1-370 th. 1-374 | | HMORTL* | 1-420 |
| 36 | CUSTOM(6) | 2-2359 th. 2-2364 | | XINFRT* | 1-421 |
| 37(a) | PCTINM* | 2-2316 | | CONCEP* | 1-422 |
| (b) | RTINSM* | 2-2317 | 48(a) | CWMORT* | 2-2865 |
| (c) | XINM01 | 2-599 | (b) | SINVOL* | 2-2866 |
| | XINM02 | 2-600 | 49 | FGR(12,2) | 2-601 th. 2-624 |
| 38(a) | BIAMT* | 1-633 | 50(a) | CALFED | 1-437 |
| (b) | BINSRT* | 1-634 | (b) | CALFHE | 1-438 |
| (c) | XINSMO | 1-635 | | HEIFHE | 1-439 |
| 39(a) | RTINSL | 2-8889 | 51 | FEDBEF(5,8) | 2-2319 th. 2-2358 |
| (b) | RTINSS | 2-8890 | 52 | STRAWR(4,7) | 1-441 th. 1-468 |
| 40 | EQUITY* | 1-619 | 53 | PRICE(13,13) | 2-2365 th. 2-2533 |
| 41(a) | BLDRD(12)* | 1-620 th. 1-631 | 54 | DCS(5,7) | 2-661 th. 2-695 |
| (b) | BREPAR* | 1-632 | 55 | XMDC(2,12) | 2-696 th. 2-719 |
| 42 | CALFWT | 2-2534 | 56 | DRS(2,3) | 2-720 th. 2-725 |
| | COWWT | 2-2535 | 57 | CPS(77) | 2-726 th. 2-802 |
| | STERWT | 2-2536 | 58(a) | COWCAP(4)* | 1-404 th. 1-405 |
| 43 | GOVTPA | 1-602 | (b) | COWCAP(4)* | 1-406 th. 1-407 |
| | GOVTM1 | 1-603 | 59 | DELAY | 1-408 |
| | GOVTM2 | 1-604 | | BLDMIN | 1-409 |
| 44 | DELETE | | | AMTBLD | 1-410 |
| 45 | SALVAG* | 2-598 | 60 | STORAG(3,2) | 1-411 th. 1-416 |

Table B1 (Cont'd.)

| Question Number | Variable Name | Identification Numbers |
|---|---|---|
| 61 | PARLR1 | 1-417 |
| | PARLR2 | 1-418 |
| 62 | HMCMIN | 1-389 |
| 63(a) | SCOST1 | 1-636 |
| (b) | SCOST2 | 1-637 |
| (c) | SCOST3 | 1-638 |
| 64(a) | PCOST1 | 1-639 |
| (b) | PCOST2 | 1-640 |
| (c) | PCOST3 | 1-641 |
| (d) | PCOST4 | 1-642 |
| (e) | PLIFE | 1-643 |
| 65 | HCBC(2,3) | 2-1 th. 2-6 |
| 66 | BC(5,7) | 2-7 th. 2-41 |
| 67 | SC(11,5) | 2-42 th. 2-96 |
| 68 | XMP(110,3) | 2-268 th. 2-597 |
| 69 | XMRGO(87,2) | 2-1477 th. 2-1650 |
| 70 | XMDMC(12,31)* | 2-1651 th. 2-2022 |
| 71 | CPD(12,27)* | 2-803 th. 2-1126 |
| 72 | RLE(7,50) | 2-1127 th. 2-1476 |
| 73 | GTC(9,11) | 2-97 th. 2-195 |
| 74 | FTC(6,12) | 2-196 th. 2-267 |
| 75 | PRAD(15,2) | 2-625 th. 2-654 |
| 76 | XMATUR(10,2) | 2-2867 th. 2-2886 |
| 77 | XLP(17,6)* | 2-2763 th. 2-2864 |
| 78 | FQD(6)* | 2-655 th. 2-660 |
| 79 | RELYLD(28,8) | 2-2539 th. 2-2762 |
| 80(a) | URQ(9,3) | 2-2257 th. 2-2283 |
| (b) | TONS(8) | 2-2284 th. 2-2291 |
| (c) | TCR(8,18) | 2-2023 th. 2-2166 |
| (d) | DMR(9,10) | 2-2167 th. 2-2256 |
| (e) | XMACP(24) | 2-2292 th. 2-2315 |
| 81 | LSM(38,10) | 4-1-1 th. 4-38-10 |
| 82 | JGSM(50,42) | 5-1-1 th. 5-50-42 |
| 83 | JHSM(53,35) | 6-1-1 th. 6-53-35 |

SUBROUTINE LAND

This subroutine calculates government payments, property taxes, land rent, conservation expenses and land inflation or deflation.

4.1 Income from government payments is calculated using GOVTPA (Q.43, Part II). If GOVTPA is $\leq 10$, multiply the number by the total acres from Q.22, Part I. If the number is $> 10$, the number itself equals government payments income. One-half of the calculated value of government payments is income in each of the two months indicated by GOVTM1 and GOVTM2 (Q.43, Part II). Calculations are made during the months payment is received.

4.2 If PTYTAX is $\leq 10$, land taxes are calculated by multiplying PTYTAX (Q.29, Part II), by the total number of acres owned. Owned acreage is calculated as the total acres owned or cash rented (CPACRE(8,1) from Q.22, Part I) minus the acreage cash rented (ARENT from Q.23(a), Part I). If the PTYTAX is greater than 10, the number listed is the property tax expense. The amount of tax is divided equally between months TAXM1 and TAXM2 (Q.29, Part II). Calculations are made during the months payment is made.

4.3 The land rent is calculated by multiplying ARENT by RENTRT (Q.23, Part I). One-half of this is paid in each of the two months RENTM1 and RENTM2 (Q.31, Part II). Calculation is also made in these months. If the calculation in the latter month of the year is larger than that paid during the first month the difference is added to the latter months rent cost (if a new fiscal year is not started between the two months).

4.4 Conservation and fence repair are calculated by multiplying the number of tillable acres, CPACRE(8,1) + CPACRE(8,2) (Q.22, Part I),

by ZCONS1 (Q.30, Part II), and adding ZCONS2 multiplied by the maximum acreage of first, second, or third cutting pasture (Q.36, Part I). One-third of this expense occurs in April and the rest is evenly divided among the next five months. Each month is calculated separately during the simulation of that month.

4.5 The monthly rate of inflation is calculated during each month of simulation. If VLAND2 (Q.21(b), Part I) is greater than 50 the monthly rate of inflation (r) equals

$$e^{\left(\frac{\ln(Q21(b)) - \ln(Q21(a))}{120}\right)} - 1$$

If VLAND2 is less than 50, (r) equals

$$e^{\left(\frac{\ln[(Q21(b)\ (1 + (Q21(a))] - \ln Q21(a)}{12}\right)} - 1$$

Each month the new value of land equals the old value (last month) multiplied by one plus the rate of inflation ( r ).

Land value is maintained for the first month (before calculations) and the last month of the year (after calculations).

4.6 Variables calculated by this subroutine are listed below.

| Variable Definition | Name | Dimension Code[a] |
|---|---|---|
| 1. Income from government payments | GOVTP | (13) |
| 2. Land taxes | TAXLD | ( 1) |
| 3. Land rent | RENTLD | ( 2) |
| 4. Conservation and fence repair | CONS | (13) |
| 5. Rate of inflation | RINFLA | ( 1) |
| 6. Land value--beginning of year | LANDVB | ( 1) |
| --end of year | LANDVE | ( 1) |
| --this month | VLANDM | ( 1) |

a. Throughout the description of this program, dimension codes indicate the dimension of the variable and will be defined as follows:

( 1) - Value is used only in this month or is maintained until changed

( 2) - Values for this month and an accumulated sum for the year are used (1 = this month, 2 = accumulated sum)

( 3) - Values for this month, the previous month and an accumulated sum are used

(12) - Values maintained for each month of the year

(13) - Values maintained for each month (i = 1, ..., 12) and for an annual total (i = 13).

SUBROUTINE YLDADJ

This subroutine calculates and adjusts crop yields based on standard yield and fertilization input data and actual fertilization rates.

5.1 Crop yields are calculated in the first month simulated and adjusted whenever standard or actual data are changed (Q.29-34 or 39, Part I and Q.22, Part II). The present yield coefficients maintained include:

YELDC1 = Corn grain yield

YELDO1 = Oat yield

YELDW1 = Wheat yield

YELDH1 = Hay yield

YELDF1 = Field bean yield

YELDS1 = Soybean yield

In the first month these are initialized from Q.29-34, Part I such that:

YELDC1 = YIELDC

YELDO1 = YIELDO

YELDW1 = YIELDW

YELDH1 = YIELD1 + YIELD2 + YIELD3

YELDF1 = YIELDF

YELDS1 = YIELDS

Each present crop yield coefficient is then divided by an appropriate relative crop yield coefficient from Q.22, Part II so that the yields maintained are 100 percent of relative yield (and calculated relative to the selected period of planting). Old standard relative yield coefficients which represent the values of the relative crop yield

coefficients which were used to calculate the existing present crop yield coefficients are also maintained for all crops except hay (i.e. the relative planting yield for hay is assumed equal to 1.0). The variables used for this purpose are C09X, where X is the first letter of the crop name.

In order to check whether the standard crop yield has changed or not the old standard crop yield levels are maintained as variables. These are initialized the first month by setting them equal to the input or new standard yield:

SYELDC = YIELDC

SYELDO = YIELDO

SYELDW = YIELDW

SYELDH = YIELD1 + YIELD2 + YIELD3

SYELDF = YIELDF

SYELDS = YIELDS

5.3 Also maintained are the old standard plant food levels. These are initialized in the first month by setting them equal to the input or new standard fertilization rates from Q.29-34, Part I as indicated below:

| | | | | | | |
|---|---|---|---|---|---|---|
| Old Standard | Plant | Food | for | | Oats | = FOODO1 = PFOODO |
| " | " | " | " | " | Corn | = FOODC1 = PFOODC |
| " | " | " | " | " | Wheat | = FOODW1 = PFOODW |
| " | " | " | " | " | Hay | = FOODH1 = PFOODH |
| " | " | " | " | " | Field beans | = FOODF1 = PFOODF |

Also maintained are the present or old actual plant food application levels. These are initially set equal to the actual or new fertilization rate from Q.39, Part I. That is:

$$FOODC2 = \sum_{j=1}^{3} Fert(1,j)$$

$$FOODO2 = \sum_{j=1}^{3} Fert(5,j)$$

$$FOODW2 = \sum_{j=1}^{3} Fert(4,j)$$

$$FOODH2 = \sum_{j=1}^{3} Fert(7,j)$$

$$FOODF1 = \sum_{j=1}^{3} Fert(3,j)$$

5.4 If during any month either the new standard yield, the new standard plant food level (Q.29-34, Part I), the relative yield coefficient (Q.22, Part II) or the new actual fertilization rate (Q.39, Part I) is changed, a new yield for that crop is calculated.

Taking corn as an example, in the first month the yield (YELDC1) is calculated.

In all following months (2,...) a new corn yield (YELDC1) is calculated if any of the following are true:

(1) $FOODC2 \neq \sum_{j=1}^{3} Fert(1,j)$

(2) $SYELDC \neq YIELDC$

(3) $FOODC1 \neq PFOODC$

(4) $C09C \neq CROPCO(K,2)$ where K = the standard planting period for corn (PERIOD)

or

(5) $PEROD1 \neq PERIOD$

Calculation of the yield involves sending to the yield adjustment subroutine (YLDCAL) (1) the present yield coefficient, (2) the new standard yield, (3) the old standard yield, (4) the new standard fertilization rate, (5) the old standard fertilization rate, (6) the

old actual level of fertilization, (7) the new actual level of fertilization, (8) the first (i) value for that crop (in RELYLD(i,j)), (9) the last (i) value for that crop (in YELYLD(i,j)), (10) the new standard yield divided by the new relative yield coefficient and (11) the agricultural subregion (Q.39(b), Part I).

For corn this would be (1) YELDC1, (2) YIELDC, (3) SYELDC, (4) PFOODC, (5) FOODC1, (6) FOODC2, (7) $\sum_{j=1}^{3}$ Fert(1,j), (8) 1, and (9) 4, (10) YIELDC/CROPCO(k,2) and (11) ASR.

The new present yield coefficient and new values for the old standard coefficients are calculated by calling the YLDCAL subroutine. Following the call of YLDCAL the old standard relative yield coefficient is updated by setting it equal to the appropriate present relative yield coefficient.

A parallel procedure is used for oats, wheat and field beans except that no planting period is explicitly involved. For hay the same procedure is used except the first, second and third cutting rates are recalculated by making them the same ratio to total yield as given in Q.32, Part I. That is:

$$\text{YLDH11} = \left(\frac{\text{YIELD1}}{\text{YLDTOT}}\right) \text{YELDH1}$$

$$\text{YLDH12} = \left(\frac{\text{YIELD2}}{\text{YLDTOT}}\right) \text{YELDH1}$$

$$\text{YLDH13} = \left(\frac{\text{YIELD3}}{\text{YLDTOT}}\right) \text{YELDH1}$$

where YLDTOT = YIELD1 + YIELD2 + YIELD3

and YLDH11 = 1st cutting hay yield

YLDH12 = 2nd cutting hay yield

YLDH13 = 3rd cutting hay yield

The variables calculated and maintained for this subroutine are listed below:

| Variable Definition | Name | Dimension Code |
|---|---|---|
| Corn Grain Yield Coefficient | YELDC1 | (1) |
| Oats " " | YELDO1 | (1) |
| Wheat " " | YELDW1 | (1) |
| Hay " " | YELDH1 | (1) |
| Field Beans " " | YELDF1 | (1) |
| Soybeans " " | YELDS1 | (1) |
| Standard Plant Food Oats | FOODO1 | (1) |
| " " " Corn | FOODC1 | (1) |
| " " " Wheat | FOODW1 | (1) |
| " " " Hay | FOODH1 | (1) |
| " " " Field Beans | FOODF1 | (1) |
| Standard Corn Yield | SYELDC | (1) |
| " Oats " | SYELDO | (1) |
| " Wheat " | SYELDW | (1) |
| " Hay " | SYELDH | (1) |
| " Field Beans Yield | SYELDF | (1) |
| " Soybean " | SYELDS | (1) |
| Present Plant Food Level Corn | FOODC2 | (1) |
| " " " " Oats | FOODO2 | (1) |
| " " " " Wheat | FOODW2 | (1) |
| " " " " Hay | FOODH2 | (1) |
| " " " " Field Beans | FOODF2 | (1) |
| 1st Cutting Hay Yield | YLDH11 | (1) |
| 2nd " " " | YLDH12 | (1) |
| 3rd " " " | YLDH13 | (1) |

SUBROUTINE YLDCAL

This subroutine calculates and adjusts yields for all crops except soybeans. It is called only from the YLDADJ subroutine.

6.1 The yield is calculated using the Agricultural Subregion (ASR) to indicate which of the first four columns (j) of RELYLD(i,j) to work from initially.

6.1.1 First find the two fertilizer levels which the new standard fertilization rate is between (within the two (i) values given). Call the lower "low" and the higher "high." Then

$$\% \text{ increment} = \frac{\text{new standard fertilization rate - "low"}}{\text{"high" - "low"}}$$

Using the same two rows, the relative yields are found four columns over (in j + 4 of RELYLD(i,j)).

$$\begin{matrix}\text{The standard} \\ \text{relative yield}\end{matrix} = \begin{matrix}\text{relative yield} \\ \text{for "low"}\end{matrix} + \% \text{ increment} \left( \left( \begin{matrix}\text{rel. yield} \\ \text{high}\end{matrix} \right) - \left( \begin{matrix}\text{rel. yield} \\ \text{low}\end{matrix} \right) \right)$$

If the new standard fertilization rate is equal to or greater than the rate found in the row indicated by the highest (i) value, the relative yield used is the relative yield found in that row.

6.1.2 The new relative yield is found in the same manner using the new actual fertilization level. Then the new value of the present yield coefficient is

$$\text{new standard yield} \left( \frac{\text{new relative yield}}{\text{standard relative yield}} \right)$$

Then (1) the old standard yield is set equal to the new standard yield (2) the old standard fertilization rate is set equal to the new standard fertilization rate and (3) the old actual fertilization rate is set equal to the new actual fertilization rate.

SUBROUTINE CORN

This subroutine handles the calculations required for the production and harvesting of corn silage and corn grain (including high moisture corn).

7.1 The total acreage of corn is taken from Q.22(a), Part I. The acreage planted during each of the four planting periods is calculated using this figure and Q.22, Part II.

The acreage of each of the three corn grow systems indicated in Q.19, Part I as being used are calculated from the same figures by combining the middle two plant periods into the plant May system. The rest of the corn grow system from GS(1),...,GS(12) are set equal to zero.[1]

The corn grain yield coefficient is calculated by the crop yield adjustment subroutine. The corn silage yield coefficient is the corn grain yield coefficient (YELDC1) divided by 5. The weighted average grow silage yield is calculated by multiplying the silage yield coefficient by the relative yields according to planting date (Q.22, Part II) and weighting according to the percentage planted in each planting period. The average harvested yield is calculated from the average grow yield by using the relative harvest yields and harvesting percentages in the same manner as corn silage grow. This calculation is done in September.

7.2 If, corn silage is grown, the amount to be harvested is calculated during the first month (Sept., Oct. or Nov.) in which the percentage of

1. The acreages for all of the grow systems are contained in the GS(42) array.

the corn silage to be harvested (Q.22, Part II) is not equal to zero. If the coefficient in Q.37(b), Part I is:

(a) between 0 and 25, the silage requirement is the coefficient multiplied by the number of cows.

(b) greater than 25, the coefficient equals the silage tons to be harvested.

(c) -1, the silage to be harvested is the total silo capacity minus the inventory of corn silage and hay crop silage on hand (STORES, Q.38, Part I).

The total acreage of corn to be harvested as silage is the minimum of the total tonnage to be harvested divided by the average yield and total corn acreage. The total acreage of corn grain is calculated by subtracting the acreage of silage from total acreage.

7.3 The landlord share acres equivalent for corn is calculated as the corn share rent acreage from Q.22, Part I multiplied by landlord share coefficient from Q.32, Part II. If the landlord share equivalent acreage is less than or equal to the acreage of corn grain, "landlord corn grain" acreage equals landlord share acres equivalent and landlord corn silage acreage equals zero.

If the landlord share equivalent acreage is greater than the acreage of corn grain, "landlord corn grain" acreage equals acres of corn grain and the difference equals "landlord corn silage."

7.4 In the month planting takes place, seed and pesticide costs are calculated as SVCC(1,1) and SVCC(2,1), (Q.23, Part II), multiplied by the acres of that system.

Other variable costs of growing are distributed in the same way as labor and calculated for each growing system each month as:

(number of acres of that planting system)(CPD(month,j))(SVCC(3,1))

Where CPD is from Q.71, Part II, SVCC is from Q.23, Part II and

| | | | | |
|---|---|---|---|---|
| j = 1 | if system is | April Corn Grow | System No. | 11-13 (Q.19, Part I) |
| = 2 | " | April | " | 14 |
| = 3 | " | May | " | 15-17 |
| = 4 | " | May | " | 18 |
| = 5 | " | June | " | 19-21 |
| = 6 | " | June | " | 22 |

Fertilizer cost is calculated using fertilizer quantities from Q.39(a), Part I and prices from Q.33, Part II.

7.5 In September, October and November the acres of corn silage harvested[1] are calculated using the total silage acreage from above and Q.22, Part II. The quantity of silage is calculated as the acreage harvested multiplied by the average grow silage yield and the relative harvest yield coefficient. Other variable costs for harvest are calculated by using acres harvested and SVCC(1,5).

In October, November and December the acres of corn for grain harvested are calculated using the total grain acreage and the coefficient from Q.22, Part II. Other harvest costs are calculated using SVCC(4,1).

All harvest costs, requirements and production occur during the month of harvest.

The amount of grain harvested is calculated from the acreage harvested, the yield coefficient and the coefficient from Q.22, Part II. If the corn harvest system is 7 or 8 the amount harvested is multiplied by 2 and added to ear corn produced. Otherwise the harvested amount is added to corn grain produced.

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1. The acreage of each harvest system used each month are contained in HS(35). This indicates the actual acres of that crop harvested that month.

The "landlords share of grain" harvested (bu.) in each month in which harvest takes place is the landlord corn grain acreage multiplied by the percent of crop coefficient for this month for corn from Q.22, Part II multiplied by the corn grain yield multiplied by the relative yield from Q.22, Part II. The "landlords share of corn silage" is calculated in the same manner using landlord corn silage acreage and the corn silage percent of crop coefficients.

If the corn grain harvest system is not 7 or 8 the amount of corn grain produced is then calculated as the total amount harvested for the month minus the landlords share. The amount of corn silage produced is calculated in the same manner. The landlords share is accumulated for the year for both crops. If the corn harvest system is 7 or 8 the landlords share of the grain is multiplied by 2 to get landlord share of ear corn and this is subtracted from ear corn harvested to get ear corn produced.

7.6 In the first month in which corn grain is harvested (corn grain produced has a positive value) the quantity of high moisture corn to be harvested is calculated. If Q.37(c), Part I is:

(1) -1, the HMC to be harvested is the total HMC storage space from Q.25(k), Part I minus the quantity of HMC on hand from STORED (4,14).

(2) between 0 and 200, bushels of HMC to be harvested is the coefficient multiplied by the number of cows.

(3) greater than 200, bushels of HMC to be harvested is equal to the coefficient.

The quantity calculated is compared with storage capacity Q.25(k), Part I. If Q.26(b), Part I is zero and the quantity to be harvested is

greater than storage capacity minus STORED (4), the quantity to be harvested is reduced to storage capacity minus STORED (4). If Q.26(b), Part I is 1, and the quantity to be harvested does not exceed the storage capacity available by more than Q.62, Part II of the smallest size silo SC(1,2), the quantity to be harvested is reduced to the storage capacity available. If the quantity to be harvested does exceed that quantity, the flag variable HMCEXD is set equal to 1 and the total calculated quantity is to be harvested.

If the quantity of HMC harvested to date equals the quantity to be harvested the above section is skipped.

The program maintains two variables "high moisture corn harvested this year to date" and "high moisture corn harvested this month." During each month that corn is harvested the quantity of HMC harvested to date this year is compared with the total to be harvested. If the quantity harvested to date is less than the quantity to be harvested, HMC harvested this month is set equal to the minimum of (1) "corn grain harvested" or (2) quantity of HMC to be harvested minus quantity of HMC harvested to date. Then HMC harvested this month is added to HMC harvested to date and subtracted from "corn grain harvested this month."

If the harvest system for corn silage is 1(Q.19(6), Part I), the silage custom harvest cost equals the acres harvested this month multiplied by the corn silage coefficient in Q.36, Part II. If the corn grain harvest system (Q.19(7), Part I) is 6, the corn grain custom harvest cost is the acres harvested this month multiplied by the corn grain coefficient from Q.36, Part II.

Variables Calculated and Maintained for this Subroutine are:

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Seed Cost | SEEDC | (1) |
| 2. Pesticide Cost | PESTC | (1) |
| 3. Fertilizer Cost | FERTC | (1) |
| 4. Silage Produced (Tons) | CSPR1 | (1) |
| 5. Other Grow Cost | OGROWC | (1) |
| 6. Other Harvest Costs | OHRVC | (1) |
| 7. Grain Produced (Bu.) | CORNG | (1) |
| 8. Acres of Corn Grow April | XN(3) | (1) |
| 9. Acres of Corn Grow May | XN(4) | (1) |
| 10. Acres of Corn Grow June | XN(5) | (1) |
| 11. Acres of Silage Harvested | ACSHRV | (2) |
| 12. Acres of Grain Harvested | ACGHRV | (2) |
| 13. Ear Corn Produced | ECORN | (1) |
| 14. High Moisture Corn Harvested (Bu.) | HMCHRV | (2) |
| 15. Landlord Share - Corn Grain | CGLS | (2) |
| 16. Landlord Share - Corn Silage | CSLS | (2) |
| 17. Landlord Share - Ear Corn | ECLS | (2) |
| 18. Acres of Corn Silage | XN(6) | (1) |
| 19. Acres of Corn Grain | XN(7) | (1) |
| 20. Custom Harvest Cost | CUSTMC | (1) |
| 21. Acres of Corn Grow Systems | GS(1),...,GS(12) | |
| 22. Acres of Corn Harvest Systems | HS(1),...,HS(11) | |

SUBROUTINE HAY

This subroutine handles all calculations on the production and harvesting of hay and hay crop silage.

8.1 Total acres of hay crop is taken from Q.22(a), Part I. The acres to be seeded is calculated in June if grow systems 25 and 26 are used and in March if system 27 is used. Acres to be seeded is calculated by use of total acres multiplied by the reseeding rate, RESEED (Q.23, Part I).

Seed cost is calculated using the acres seeded and SVCC(1,6) from Q.23, Part II. This occurs in August with direct seeding and April with companion crop seeding.

Pesticide costs for the direct seeded acreage are calculated using acres seeded and SVCC(2,6) from Q.23, Part II. This occurs in September.

Other variable costs are calculated using SVCC(3,6) and acres seeded. These are distributed in the same proportion as labor and are calculated as:

(acres reseeded) (CPD(month,j)) (SVCC(3,6))

Where SVCC(3,6) is from Q.23, Part II

CPD(i,j) is from Q.71, Part II

and j = 13 for direct seeding

14 for companion crop seeding

15 for user seeding distribution.

Fertilizer costs are calculated using actual application rates (Q.83, Part II), the acres seeded and prices in Q.33, Part II.

8.2 The acreage of the hay crop to be harvested as hay crop silage is calculated (in May) if one of the harvest systems 20 through 24 are being used. The average expected yield for each cutting is calculated

using the relative yield coefficients (Q.22(a), Part I) plus the present yield coefficients for each cutting and calculating a weighted average with the percent harvested during each month as weights.

The amount of silage to be harvested is then calculated using Q.37, Part I. If the coefficient in Q.37, Part I is

(a) between 0 and 25, the H.C. silage requirement is the coefficient multiplied by the number of cows.

(b) greater than 25, the coefficient equals the silage tons to be harvested.

(c) -1, the silage to be calculated is the total silo capacity minus the inventory of corn silage and hay crop silage on hand. (Stores, Q.38, Part I).

The acreage of first cutting harvested as hay crop silage is the minimum of (1) the total tonnage requirement divided by the average yield calculated above and (2) the total acreage of [hay—(acres of 1st cutting harvested as pasture)] from Q.36, Part I. If this is insufficient to meet the silage requirements and Q.35, Part I is $\geq 2$ the acres of second cutting harvested as silage is calculated as the minimum of (1) total acres of hay minus acres of second cutting pasture and (2) the [total H.C. silage requirement minus the first cutting silage harvested] divided by the yield of second cutting Hay Crop Silage.

If this does not meet the silage requirements and Q.34, Part I is 3, similar calculations are made for third cutting. The acreage of hay by cutting is the total acreage of hay minus (1) the acreage used for pasture and (2) the acreage harvested as silage.

In May, June and July the acreage of Hay Crop silage to be

harvested this month is calculated by using the percentage of crop harvested from Q.22, Part II and the acreage of first cutting to be harvested as silage as calculated above. In July, August and September similar calculations are made for second cutting (if Q.35, Part I is $\geq$ 2) and in August and September similar calculations are made for third cutting (if Q.35, Part I is 3).

In the same months the same acreage calculations are made for hay using the total hay acreage from above and percentage coefficients from Q.22, Part II.

8.3 The landlord share acres equivalent for hay is calculated as the hay share rent acreage from Q.22, Part I multiplied by the landlord share coefficient from Q.32, Part II.

The landlords share (tons) is calculated as the landlord share acres equivalent multiplied by the first cutting coefficient for that month multiplied by the corresponding relative yield (Q.22, Part II) multiplied by the first cutting yield plus (if Q.35, Part I is 2 or 3) the landlord share acres equivalent multiplied by the corresponding second cutting coefficients plus (if Q.35, Part I is 3) a similar calculation for third cutting. This sum (landlord share of hay) is subtracted from hay harvested to get hay produced.

8.4 Hay crop pesticide cost occurs in May and is SVCC(2,7) multiplied by the total number of acres of hay. Other variable grow costs are distributed in the same manner as grow labor and is calculated as:

(acres of hay crop) (SVCC(3,7)) (CPD(month,j))

Where SVCC(3,7) is from Q.23, Part II,

CPD(i,j) is from Q.71, Part II

and j = 13 if system 25 or 26 is used

j = 14 if system 27 is used

= 15 " " 28 " "

Other variable harvest costs for hay are calculated as [(Acres of first cutting harvested) + (acres of second cutting harvested) (CUTCOF (1,1)) + (acres of third cutting) (CUTCOF(2,1)] SVCC(4,7).

Where (1) the acres are calculated above

(2) CUTCOF(i,j) is from Q.18, Part II

(3) SVCC(i,j) is from Q.23, Part II.

Other variable costs for hay crop silage are calculated in a similar manner. That is, other variable harvest cost equals:

[(Acres of 1st cut HCS) + (Acres of 2nd cut HCS) (CUTCOF(1,2)) + (Acres of 3rd cut HCS) (CUTCOF(2,2))] SVCC(5,7).

These calculations are made during May through September.

8.5 The quantity of hay harvested in any month is calculated using the basic yield for each cutting as calculated above and multiplying this by relative yield for that cutting from Q.22, Part II and multiplying the result by the number of acres harvested.

The quantity of hay crop silage harvested is calculated using the same basic yield coefficients, plus a percentage saving factor to allow for reduced harvesting losses, multiplied by 3. This product is then multiplied by the HCS relative yield coefficients for the month of harvest from Q.22, Part II and the result is multiplied by the number of acres of the cutting being harvested.

8.6 The amount of pasture hay equivalent produced is calculated using pasture acres from Q.36, Part I and the distribution of pasture use from Q.19, Part II and adjusting for the reduction in hay equivalent harvested because it is pastured (PLOSS). This is calculated for the

months of May through September and assumed to be zero during other months. The calculations for each month are as follows:

May tons = Acres of first cutting from Q.36, Part I multiplied by yield of first cutting as calculated above multiplied by the proper coefficient from Q.19, Part II.

June tons = Same as May except use June coefficient.

July tons = Same as May except use July coefficient plus acres of second cutting from Q.36, Part I multiplied by the yield of second cutting multiplied by the July coefficient in row 2 if Q.35, Part I is 2 of the July coefficient from row 3 is Q.35, Part I is 3.

Aug. tons = Acres of second cutting from Q.36, Part I multiplied by the yield of second cutting multiplied by the August coefficient in row 2 if Q.35, Part I is 2 or the August coefficient from row 3 if Q.35, Part I is 3 plus acres of third cutting pasture multiplied by third cutting yield multiplied by the August third cutting coefficient from Q.19, Part II.

Sept. tons = Acres of second cutting multiplied by second cutting yield multiplied by September coefficient from row 2 Q. 19, Part II, if Q.35, Part I is 2.

or

Acres of third cutting multiplied by the third cutting yield multiplied by the September coefficient for third cutting, if Q.35, Part I is 3.

8.7 Fertilizer cost for each nutrient is calculated as the quantities of N, $P_2O_5$ and $K_2O$ from Q.39, Part I multiplied by their respective price

from Q.33, Part II, each multiplied by the acres of hay. The grow fertilizer cost equals the sum of the cost of the three elements.

Total Fertilizer Cost = Seeding Fertilizer Cost + Grow Fertilizer Cost

Total Pesticide Cost = Seeding Pesticide Cost + Grow Pesticide Cost

Total Other Variable Cost for Growing = Seeding Other Variable Cost + Grow Other Variable Cost

8.8 The variables calculated and maintained for this subroutine are:

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Acres 1st Cutting Hay Harvested | A1HAY | (2) |
| 2. " " " HCS " | A1HCS | (2) |
| 3. " 2nd " Hay " | A2HAY | (2) |
| 4. " " " HCS " | A2HCS | (2) |
| 5. " 3rd " Hay " | A3HAY | (2) |
| 6. " " " HCS " | A3HCS | (2) |
| 7. Seed Cost | SEEDH | (1) |
| 8. Pesticide Cost | PESTH | (1) |
| 9. Other Variable Cost (Grow) | OGROWH | (1) |
| 10. Other Variable Cost (Harvest) | OHRVH | (1) |
| 11. Tons of Hay Produced | HAYPRO | (1) |
| 12. Tons of Hay Crop Silage Harvested | HCSPR1 | (1) |
| 13. Fertilizer Cost | FERTH | (1) |
| 14. Pasture Hay Equivalent Produced | HEPAST | (2) |
| 15. Landlord Share of Hay (Tons) | HAYLS | (2) |
| 16. Acres of Hay Crop Silage | HCSLS | (2) |
| 17. Acres of Hay | XN(16) | (1) |
| 18. Acres Equivalent of HCS | XN(15) | (1) |
| 19. Acres Equivalent of Hay | XN(17) | (1) |
| 20. Acres of Hay Grow Systems | GS(25),...,GS(30) | |
| 21. Acres of Hay Harvest Systems | HS(20),...,HS(28) | |

SUBROUTINE WHEAT

This subroutine makes all calculations relative to the production and harvest of wheat and wheat straw.

9.1 The total acreage of wheat is taken from Q.22(a), Part I. Wheat planted in each planting month is calculated using Q.22, Part II and total acreage.

Seed cost is calculated in each month planting occurs and is the acres planted (acres of each system) multiplied by the cost of SVCC(1,2) from Q.23, Part II.

Pesticide costs are calculated as the cost in SVCC(2,2), Q.23, Part II, multiplied by acres. The cost occurs in May.

Other variable growing costs are distributed as wheat labor is distributed and are calculated for each grow system used as:

(acres of that system) (CPD(month,j)) (SVCC(3,2))

Where CPD(i,j) is from Q.71, Part II,

SVCC(3,2) is from Q.23, Part II

and j = 7 if system is September Wheat Grow

= 8 if system is October Wheat Grow

= 9 if system is User Wheat Grow

Fertilizer cost is calculated using Q.39(a), Part I, the amount of spring nitrogen applied (SPRNW), and Q.33, Part II. It occurs in the month of planting and is the acres planted multiplied by the sum of the three nutrient amounts multiplied by their respective prices.

9.2 The acres of wheat harvested in any one month is the total acreage multiplied by the harvest coefficients in Q.22, Part II.

The grow yield coefficient is calculated as a weighted average of the present yield coefficient for wheat multiplied by the relative grow

yields from Q.22, Part II. The weights are the percentage of the crop that is harvested each month.

The amount of wheat harvested is the number of acres harvested in that month multiplied by the yield. The yield in the grow yield coefficient from above multiplied by the relative yield coefficient for harvest in that month (Q.22, Part II).

9.3 The landlord share acreage equivalent for wheat is calculated as the wheat share rent acreage from Q.22, Part I multiplied by the landlord share coefficient from Q.32, Part II.

The landlord share wheat (bu.) is calculated each month during which harvest takes place and equals the product of landlord share acreage equivalent, grow yield, percentage of crop coefficient and the relative yield coefficient (Q.22, Part II).

The amount of wheat produced is the amount harvested minus the landlord share for that month. Landlords share is also accumulated.

9.4 All harvest costs and labor occur in the month of harvest. Other variable harvest costs are calculated as the acreage harvested multiplied by coefficient SVCC(4,2) (Q.23, Part II).

If wheat harvest system 14 is used, the straw yield is the coefficient in Q.31, Part I multiplied by the acres harvested. If the wheat harvest system is 12 (Q.19(9), Part I) the custom combining charge is the acres harvested this month multiplied by the wheat coefficient from Q.36, Part II.

9.5 The variables calculated and maintained by this subroutine are:

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Seed Cost | SEEDW | (1) |
| 2. Pesticide Cost | PESTW | (1) |
| 3. Fertilizer Cost | FERTW | (1) |
| 4. Other Variable Grow Cost | OGROWW | (1) |
| 5. Other Variable Harvest Cost | OHRVW | (1) |
| 6. Bu. Wheat Produced | WHEAT | (1) |
| 7. Tons Straw Produced | STRAWW | (1) |
| 8. Acres of Wheat Harvested | XN(10) | (1) |
| 9. Acres of Wheat Plant September | XN(8) | (1) |
| 10. Acres of Wheat Plant October | XN(9) | (1) |
| 11. Landlord Share -Wheat (Bu.) | WLS | (2) |
| 12. Custom Combining | CUSTMW | (1) |
| 13. Acres of Wheat Harvested This Month | AWHRV | (1) |
| 14. Acres of Wheat Grow Systems | GS(13),...,GS(18) | |
| 15. Acres of Wheat Harvest Systems | HS(12),...,HS(15) | |

SUBROUTINE OATS

This subroutine makes all calculations relative to the production and harvest of oats and oat straw.

10.1 The total acreage of oats is taken from Q.22(a), Part I. Oats planted in each planting month is calculated using Q.22, Part II and total acreage.

Seed cost is calculated in each month planting occurs and is the acres planted (acres of each system) multiplied by the cost of SVCC(1,3) from Q.23, Part II.

Pesticide costs are calculated as the cost in SVCC(2,3), Q.23, Part II, multiplied by acres. The cost occurs in June.

Other variable growing costs are distributed as oats labor is distributed and are calculated for each grow system used as:

(acres of that system) (CPD(month,j)) (SVCC(3,3))

Where CPD(i,j) is from Q.71, Part II,

SVCC(3,3) is from Q.23, Part II

and j = 10 if system is April oat grow

= 11 if system is May oat grow

= 12 if system is User oat grow

Fertilizer cost is calculated using Q.39(a), Part I and Q.33, Part II. It occurs in the month of planting and is the acres planted multiplied by the sum of the three nutrient amounts multiplied by their respective prices.

10.2 The acres of oats harvested in any one month is the total acreage multiplied by the harvest coefficients in Q.22, Part II.

The grow yield coefficient is calculated as a weighted average of the present yield coefficient for oats multiplied by the relative grow

yields from Q.22, Part II. The weights are the percentage of the crop that is harvested each month.

The amount of oats harvested is the number of acres harvested in that month multiplied by the yield. The yield is the grow yield coefficient from above multiplied by the relative yield coefficient for harvest in that month (Q.22, Part II).

10.3 The landlord share acreage equivalent for oats is calculated as the oats share rent acreage from Q.22, Part I multiplied by the landlord share coefficient from Q.32, Part II.

The landlord share oats (bu.) is calculated each month during which harvest takes place and equals the product of landlord share acreage equivalent, grow yield, percentage of crop coefficient and the relative yield coefficient (Q.22, Part II).

The amount of oats produced is the amount harvested minus the landlords share for that month. Landlords share is also accumulated.

10.4 All harvest costs and labor occur in the month of harvest. Other variable harvest costs are calculated as the acreage harvested multiplied by coefficient SVCC(4,3).

If oat harvest system 18 is used the straw yield is the coefficient in Q.31, Part I multiplied by the acres harvested. If the oats harvest system is 16 (Q.19(11), Part I), the custom combining charge is the acres harvested this month multiplied by the oats coefficient from Q.36, Part II.

10.5 The variables calculated and maintained by this subroutine are:

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Seed Cost | SEEDO | (1) |
| 2. Pesticide Cost | PESTO | (1) |
| 3. Fertilizer Cost | FERTO | (1) |
| 4. Other Variable Grow Cost | OGROWO | (1) |
| 5. Other Variable Harvest Cost | OHRVO | (1) |
| 6. Bu. Oats Produced | OATS | (1) |
| 7. Tons Straw Produced | STRAWO | (1) |
| 8. Acres of Oats Harvested | XN(13) | (1) |
| 9. Acres of Oats Plant April | XN(11) | (1) |
| 10. Acres of Oats Plant May | XN(12) | (1) |
| 11. Landlord Share - Oats | OATSLS | (2) |
| 12. Custom Combining | CUSTMO | (1) |
| 13. Acres of Oats Harvested | AOHRV | (2) |
| 14. Acres of Oat Harvest Systems | GS(19),...,GS(24) | |
| 15. Acres of Wheat Harvest Systems | HS(16),...,HS(19) | |

SUBROUTINE FIELD BEANS

This subroutine makes all calculations relative to the production and harvest of Field Beans.

11.1 The total acreage of field beans is taken from Q.22(a), Part I. The acreage planted during each of the two planting periods is calculated by multiplying the total acreage by the coefficients for field bean grow in Q.22, Part II.

Seed cost is calculated in each month planting occurs and is the acres planted (acres of each system) multiplied by the cost of SVCC(1,5) from Q.23, Part II.

Pesticide costs are calculated as the cost in SVCC(2,5) (Q.23, Part II) multiplied by acres. The costs occur in the month of planting.

Other variable growing costs are distributed as field bean labor is distributed and are calculated for each grow system used as:

(acres of that system) (CPD(month,j)) (SVCC(3,5))

Where CPD(i,j) is from Q.71, Part II,

SVCC(3,5) is from Q.22, Part II

and j = 18 if system is May plant (4-6 row)

= 19 if system is May plant (User)

= 20 if system is June plant (4-6 row)

= 21 if system is June plant (User)

Fertilizer cost is calculated using Q.39(a), Part I and Q.33, Part II. It occurs in the month of planting and is the acres planted multiplied by the sum of the three nutrient amounts multiplied by their respective prices.

11.2 The acres of field beans harvested in any one month is the total acreage multiplied by the harvest coefficients in Q.22, Part II.

The grow yield coefficient is calculated as a weighted average of the present yield coefficient for field beans multiplied by the relative grow yields from Q.22, Part II. The weights are the percentage of the crop that is harvested each month.

The amount of field beans harvested is the number of acres harvested in that month multiplied by the yield. The yield is the grow yield coefficient from above multiplied by the relative yield coefficient for harvest in that month (Q.22, Part II).

11.3 The landlord share acreage equivalent for field beans is calculated as the field beans share rent acreage from Q.22, Part I multiplied by the landlord share coefficient from Q.32, Part II.

The landlord share field beans (bu.) is calculated each month during which harvest takes place and equals the product of landlord share acreage equivalent, grow yield, percentage of crop coefficient and the relative yield coefficient (Q.22, Part II).

The amount of field beans produced is the amount harvested minus the landlords share for that month. Landlords share is also accumulated.

11.4 All harvest costs and labor occur in the month of harvest. Other variable harvest costs are calculated as the acreage harvested multiplied by coefficient SVCC(4,5) (Q.23, Part II).

If the field bean harvest system is 29 (Q.19(18), Part I), the custom field bean harvest charge for this month is the acres harvested this month multiplied by the field bean coefficient from Q.35, Part II.

11.5 The variables calculated and maintained by this subroutine are:

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Seed Cost | SEEDF | (1) |
| 2. Pesticide Cost | PESTF | (1) |
| 3. Fertilizer Cost | FERTF | (1) |
| 4. Other Variable Grow Cost | OGROWF | (1) |
| 5. Other Variable Harvest Cost | OHRVF | (1) |
| 6. Bushels Field Beans Produced | FBEANS | (1) |
| 7. Acres Field Beans Planted May | XN(18) | (1) |
| 8. Acres Field Beans Planted June | XN(19) | (1) |
| 9. Acres Field Beans Harvested | XN(20) | (1) |
| 10. Landlords Share - Field Beans | FLS | (2) |
| 11. Custom Combining | CUSTMF | (1) |
| 12. Acres of Field Beans Harvested | AFHRV(2) | (2) |
| 13. Acres of Field Beans Grow Systems | GS(31),...,GS(36) | |
| 14. Acres of Field Beans Harvest Systems | HS(20),...,HS(32) | |

SUBROUTINE SOYBEANS

This subroutine makes all calculations relative to the production and harvest of soybeans.

12.1 The total acreage of soybeans is taken from Q.22(a), Part I. Soybeans planted in each of the three planting periods are calculated using the total acreage and the percent of crop coefficients for soybeans from Q.22, Part II. The acreage for the May plant system comes directly from the May plant period. The June plant system acreage is a sum of the two June plant periods (June 1-15 and after June 15).

Seed cost is calculated in each month planting occurs and is the acres planted (acres of each system) multiplied by the cost of SVCC(1,4) from Q.23, Part II.

Pesticide costs are calculated as the cost in SVCC(2,4) (Q.23, Part II) multiplied by acres. The cost occurs during the month of planting.

Other variable growing costs are distributed as soybean labor is distributed and are calculated for each grow system used as:

(acres of that system) (CPD(month,j)) (SVCC(3,4))

Where CPD(i,j) is from Q.71, Part II

SVCC(3,4) is from Q.23, Part II,

and j = 22 if system is plant May (4-6 row)

= 23 if system is plant May (User)

= 24 if system is plant June (4-6 row)

= 25 if system is plant June (User)

Fertilizer cost is calculated using Q.39(a), Part I and Q.33, Part II. It occurs in the month of planting and is the acres multiplied by the sum of the three nutrient amounts multiplied by their respective

prices.

12.2 The acres of soybeans harvested in any one month is the total acreage multiplied by the harvest coefficients in Q.22, Part II.

The grow yield coefficient is calculated as a weighted average of the present yield coefficient for soybeans multiplied by the relative yield coefficients for planting soybeans from Q.22, Part II for each planting period. The weights for the average are the percentage of the crop planted in each period.

The quantity of soybeans harvested during each month is the product of number of acres harvested in that month, grow yield, and the relative harvest yield coefficient (Q.22, Part II).

12.3 The landlord share acreage equivalent for soybeans is calculated as the soybeans share rent acreage from Q.22, Part I multiplied by the landlord share coefficient from Q.32, Part II.

The landlord share soybeans (bu.) is calculated each month during which harvest takes place and equals the product of landlord share acreage equivalent, average grow yield, percentage of crop coefficient and the relative yield coefficient (Q.22, Part II).

The amount of soybeans produced is the amount harvested minus the landlords share for that month. Landlords share is also accumulated.

12.4 All harvest costs and labor occur in the month of harvest. Other variable harvest costs are calculated as the acreage harvested multiplied by coefficient SVCC(4,4) (Q.23, Part II).

If the soybean harvest system is 33(Q.19(21), Part I), the custom combining charge is the acres harvested this month multiplied by the soybean coefficient from Q.36, Part II.

12.5 The variables calculated and maintained by this subroutine are:

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Seed Cost | SEEDS | (1) |
| 2. Pesticide Cost | PESTS | (1) |
| 3. Fertilizer Cost | FERTS | (1) |
| 4. Other Variable Grow Cost | OGROWS | (1) |
| 5. Other Variable Harvest Cost | OHRVS | (1) |
| 6. Bu. Soybeans Produced | SOYB | (1) |
| 7. Acres Soybeans Harvested | XN(23) | (1) |
| 8. Acres Soybeans Plant May | XN(21) | (1) |
| 9. Acres Soybeans Plant June | XN(22) | (1) |
| 10. Landlord Share - Soybeans | SLS | (2) |
| 11. Custom Combining | CUSTMS | (1) |
| 12. Acres of Soybeans Harvested | ASHRV | (2) |
| 13. Acres of Soybean Grow Systems | GS(37),...,GS(42) | |
| 14. Acres of Soybean Harvest Systems | HS(33),...,HS(35) | |

SUBROUTINE DAIRY

This subroutine maintains and updates the dairy herd characteristics, including the dairy beef-enterprise. It makes all calculations relative to production, purchase and sale of animals and determines feed requirements. This subroutine is divided into two parts; an entry point and the subroutine itself. The entry point enters the animals in the herd matrix. It is called from the READI routine and is used at the beginning of the first month only. The main part of the subroutine is called each month. The use of an entry point was necessitated by the need to conserve core space. It was not required to provide the appropriate flow of calculations. Sections 13.1 and 13.2 below are included in the entry point.

13.1 It is assumed that (1) all animals freshened at the average "desired age of freshening (months)" (Q.8, Part I) plus one month and (2) that the length of each lactation of all animals was equal to the average calving interval. It is further assumed that the characteristics of the herd are input as of the month prior to the first month simulated. These assumptions plus the input data in Q.6,7, and 8, Part I are used to develop an array which represents the characteristics of the herd. The array format is as follows:

| Animal Number | Age | Month Last Fresh | Next Month Fresh | Production Level | Production Adjustment |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| . | | | | | |
| . | | | | | |
| . | | | | | |
| . | | | | | |
| . | | | | | |
| 300? | | | | | |

One animal number (row) is assigned to each animal. For example, if there were 3 first calf heifers that freshened in the month prior to the first month to be simulated the (1,1) cell of the matrix in Q.6, Part I would have 3 in it. Thus rows 1, 2 and 3 would be assigned to those 3 animals. Age would be calculated by

Age = (average desired age of freshening) + 1 (i - 1) calving interval + j - 1 = 25 + 1 + (1 - 1) 13 + 1 - 1 = 26 months

This is rounded off to the nearest month. Age as calculated here is as of the month prior to the first month simulated. The main program will update this to the first month during the first month calculations which are common to all months.

Last month fresh ("Last") = 1 - j = 1 - 1 = 0

Before calculating next month fresh the animal is subjected to a probability of being culled at the end of this lactation. An integer between 0 and 99 is drawn from the uniform distribution. This number is used in conjunction with the appropriate probability distributions to determine the fate of the animal. The appropriate probability distribution to use depends on the number of months the animal has been fresh.

Let C = calving interval = CALVIN(Q.15, Part I)

$\alpha$ = probability of dying = CWMORT(Q.48(a), Part II) x $\frac{C(100)}{12}$

$\beta$ = probability of being involuntarily culled = SINVOL(Q.50(b), Part II) x $\frac{C(100)}{12}$

$\delta$ = culling rate used = CULL2(Q.11, Part II) x $\frac{C(100)}{12}$

X = number of months fresh = j

Then if $X \leq 5$

(1) and the number drawn is less than $\frac{\beta}{1-\alpha}$ ,

the animal is sold during the fifth month of lactation. This is accomplished by placing a flag (100,000) in the production adjustment column indicating involuntary sale of the animal for beef in the fifth month of lactation. The animal is assigned a value of "next" (next month fresh) equal to the last month fresh plus the average calving interval, rounded to the nearest integer.

(2) and the number drawn is between $\frac{\beta}{1-\alpha}$ and $\frac{\delta-\beta}{1-\alpha}$

the animal is culled during the ninth month of lactation. This is accomplished by placing a flag (200,000) in the production adjustment column indicating that the animal is to be culled during the ninth month of lactation. The animal is assigned a value of "next" equal to the last month fresh plus the average calving interval, rounded to the nearest integer.

If $5 < X \leq 9$ and the number drawn is less than $\frac{\delta}{1-\alpha-\beta}$

the animal is culled during the ninth month of lactation as indicated in the above paragraph.

If $X > 9$ the animal is not to be culled this lactation.

If the animal is not to be sold the value of "next" is calculated. To calculate "next" a number between 0 and 99 is drawn from a uniform distribution and if the number is:

| | | | | |
|---|---|---|---|---|
| 0 - 4, | "next" | = | "last" | + 11 |
| 5 - 44, | " | = | " | + 12 |
| 45 - 69, | " | = | " | + 13 |
| 70 - 84, | " | = | " | + 14 |
| 85 - 94, | " | = | " | + 15 |
| 95 - 99, | " | = | " | + 16 |

Use of a frequency distribution of length of lactation in this way, however, may result in "next" coefficient less than one. Thus if the calculation alone gives values of "next" less than one, they will be assigned coefficients according to the following table:

| Number | Next Month Fresh |
|---|---|
| 0 - 4 | 3 |
| 5 - 44 | 2 |
| 45 - 99 | 1 |

13.2 All heifers are also listed in this array. A heifer is indicated by setting "last" equal to -100. Unbred heifers will have only the "last" and age columns non-zero. For bred heifers "next month fresh" will have a value. This value is calculated by first calculating the month in which the animal is born which =

(first month simulated - 1) - j or (first month simulated - 1) - 1 + 12 where the month must be between 1 and 12.

If the age of the animal is $\geq$ [(the "desired age of freshening" for animals born in that month) - 9] the animal is assigned a freshening date. A number between 0 and 99 is drawn from the uniform distribution and the "age of freshening" for that animal is:

(a) "desired age of freshening" if $0 \leq$ number $\leq 69$

(b) "desired age of freshening" + 1 if $70 \leq$ number $\leq 89$

(c) "desired age of freshening" + 2 if $90 \leq$ number $\leq 99$

Then "next" = ["age of freshening" - age].

If "next" 1 assign it as follows:

| Number | Next Month Fresh |
|---|---|
| 0 - 24 | 3 |
| 25 - 49 | 2 |
| 50 - 99 | 1 |

13.3 The steers are now added to the array. One row is assigned to each steer. The age is entered from input and the production adjustment column is flagged (400,000) to indicate that the animal is a steer.

At this point the array contains the herd characteristics, except for production level, as of the month prior to the first month to be simulated.

At the beginning of each month the number of steer calves, STERC and steers on feed, STERF, is calculated. This is necessary because the age of placing animals on feed can be changed at the beginning of each month. "Steer calves" is given an initial value in the first month simulated equal to the number of steers in Q.7(b), Part I whose age was less than FEDAGE (Q.42(c), Part I). "Steers on feed" is calculated in the first month as the number of steers whose age is equal to or greater than (Q.42(c), Part I).

Note: The number of units of the dairy replacements system is calculated as the sum of the number of heifers under 1 year, the number of heifers over 1 year, number of steer calves and number of steers on feed.

The variable indicating the beginning number of animals (CATNO2(5)) and the beginning cattle inventory value is calculated at the beginning of the first month. Values for the number of cows (all animals that have freshened), heifers over one year of age, heifers under one year of age, steers on feed and steer calves are maintained at all times. These values are adjusted as each purchase, sale or freshening takes place. The variable CATNO2(5) is used to maintain these values between months.

13.4 An average mature equivalent milk production lactation average for the herd is calculated before the production levels are assigned. This is accomplished by first calculating a herd average mature equivalent coefficient.

The herd average mature equivalent coefficient is calculated by:

(1) Finding the age at which each of the animals freshened, which equals (age) - (absolute value of last month fresh)

(2) As the age of freshening of each animal is calculated, accumulate a sum of M.E. coefficients and then divide the sum by the number of cows, M.E. Coefficients to be used are taken from Q.76, Part II.

If no initial herd is input, the average mature equivalent coefficient is set equal to one. This coefficient is calculated only during the first month simulated.

13.5 The following algorithm calculates the herd M.E. lactation average during the first month and whenever the grain fed or forage quality levels are changed in Q.11, Part II.

Define the pounds of grain fed, forage quality and actual production from Q.10, Part I as "grain fed," "forage quality 1" and "actual production 1" respectively. Define the level of grain feeding and the forage quality in Q.11, Part I as "grain fed 2" and "forage quality 2."

The production adjustment routine maintains three variables called "grain fed 3," "forage quality 3" and "actual production 3." These are initially (in the first month) set equal to "grain fed 1," "forage quality 1" and "actual production 1." These variables are also used to test whether a new M.E. production average should be calculated (i.e. if "2" values do not equal "3" values for grain and roughage quality the calculation should be made).

13.5.1 If "grain fed 3" does not equal "grain fed 2," the actual production is adjusted for grain feeding level.

A. First the row (i) of the grain transition constants table to be used is calculated. The calculation is as follows:

i = 1 if "forage quality 3" = 1 and "actual production" is > 13,000

i = 2 if "forage quality 3" = 1 and 11,000 $\leq$ "actual production" $\leq$ 13,000

= 3 " " " " = 1 and "actual production" is < 11,000

= 4 " " " " = 2 and "actual production" is > 13,000

= 5 " " " " = 2 and 11,000 $\leq$ "actual production" $\leq$ 13,000

= 6 " " " " = 2 and "actual production" is < 11,000

= 7 " " " " = 3 and "actual production" is > 13,000

= 8 " " " " = 3 and 11,000 $\leq$ "actual production" 13,000

= 9 " " " " = 3 and "actual production" is < 11,000

B. The column (J) indicated by the old level of grain feeding is calculated using integer arithmetic as follows:

$$J = \frac{\text{"grain fed 3"} - 1500}{500}$$

$$1 \leq J \leq 11$$

C. The column (K) indicated by the new level of grain feeding is calculated using integer arithmetic as:

$$K = \frac{\text{"grain fed 2"} - 1500}{500}$$

D. If "grain fed 2" is greater than "grain fed 3" ($K \geq J$), then when

(1) K = J, the new "actual production 3" equals

$$\text{(action production 3)} + GTC(i,J) \left(\frac{\text{"grain fed 2"} - \text{"grain fed 3"}}{500}\right)$$

where GTC(i,j) is from Q.73, Part II.

(2) K > J, values of L,M and N are calculated, using integer arithmetic for M, where

$$M = \left(\frac{\text{"grain fed 3"}}{1000}\right) \quad 1000$$

$$L = \text{"grain fed 3"} - M$$

If L > 500 then subtract 500 from L

$$\text{and } N = \frac{500 - L}{500}$$

Then P, Q and R are calculated using integer arithmetic for P, where

$$P = \left(\frac{\text{"grain fed 2"}}{1000}\right) 1000$$

$$Q = \text{"grain fed 2"} - P$$

If P > 500 then subtract 500 from P

$$\text{and } R = \frac{P}{500}$$

Then the new "actual production 3" equals

$$(\text{"actual production 3"}) + (N)GTC(i,J) + (R)GTC(i,K) + \sum_{j=J+1}^{K-1} GTC(i,j)$$

E. If "grain fed 2" is less than "grain fed 3" ($K \leq J$), then when

(1) K = J, the new "actual production 3" equals

$$(\text{"actual production 3"}) - \left(\frac{\text{"grain fed 3"} - \text{"grain fed 2"}}{500}\right) GTC(i,J)$$

NOTE: This is identical to D.(1)

(2) K < J, values of L, M and N are calculated (using integer arithmetic for M) where

$$M = \left(\frac{\text{"grain fed 3"}}{1000}\right) 1000$$

$$L = \text{"grain fed 3"} - M$$

If L > 500 subtract 500 from L

$$N = \frac{L}{500}$$

Then P, Q and R are calculated (using integer arithmetic for P) where

$$P = \left(\frac{\text{"grain fed 2"}}{1000}\right) 1000$$

$$Q = \text{"grain fed 2"} - P$$

If Q > 500 subtract 500 from Q

$$\text{and } R = \left(\frac{500 - P}{500}\right)$$

Then the new "actual production 3" equals

$$\text{("actual production 3")} - (N)GTC(i,J) - (R)GTC(i,K) - \sum_{j=K+1}^{J-1} GTC(i,j)$$

After "actual production 3" is adjusted for the change in grain feeding level "grain fed 3" is set equal to "grain fed 2."

13.5.2 If "forage quality 3" does not equal "forage quality 2," the actual production is adjusted for forage quality change.

A. First the correct column (J) is calculated using integer arithmetic where

$$J = \frac{\text{"grain fed 3"} - 1250}{500}$$

$$1 \leq J \leq 12$$

B. If "forage quality 3" = 1 and "forage quality 2" = 2 and:

(1) "actual production 1" > 13,000, then the new "actual production 3" equals ("actual production 3") - FTC(1,J), where FTC(i,j) is from Q.74, Part II.

(2) 11,000 ≤ actual production 1 ≤ 13,000, then the new actual production 3" equals ("actual production 3") - FTC(2,J)

(3) "actual production 1" < 11,000, then the new "actual production 3" equals ("actual production 3") - FTC(3,J).

C. If "forage quality 3" = 2 and "forage quality 2" = 1 the adjustments are the same as for B above except that FTC(i,J) is <u>added</u> to the old "actual production 3" to get the new value.

D. If "forage quality 3" = 2 and "forage quality 2" = 3 and:

(1) "actual production 1" > 13,000, then the new "actual production 3" equals ("actual production 3") - FTC(4,J)

(2) 11,000 ≤ "actual production 1" ≤ 13,000, then the new "actual production 3" equals ("actual production 3") - FTC(5,J)

(3) "actual production 1" < 11,000, then the new "actual production 3" equals ("actual production 3") - FTC(6,J).

E. If "forage quality 3" = 3 and "forage quality 2" = 2 the same equations are used as in D. above except that in each case FTC(i,j) is added to "actual production 3."

F. If "forage quality 3" = 1 and "forage quality 2" = 3 and:

(1) "actual production 1" > 13,000, then the new "actual production 3" equals ("actual production 3") - FTC(1,J) - FTC(4,J)

(2) 11,000 ≤ "actual production 1" ≤ 13,000, then the new "actual production 3" equals ("actual production 3") - FTC(2,J) - FTC(5,J)

(3) "actual production 1" < 11,000, then the new "actual production 3" equals ("actual production 3") - FTC(3,J) - FTC(6,J).

G. If "forage quality 3" = 3 and "forage quality 2" = 1, the same equations are used as in F. above except that in each case the two FTC(i,j) are added to "actual production 3."

After "actual production 3" has been adjusted for the change in roughage quality, "forage quality 3" is set equal to forage quality 2.

13.5.3 The herd average M.E. lactation average is calculated after an adjustment for a change in grain feeding level or forage quality or both is made. The initial calculation of the M.E. lactation average is

$$AVELAC = (ACTPR3)\left(\frac{C}{12}\right) \quad (AVGME)$$

where AVELAC = herd M.E. lactation average

C = calving interval (Q.15, Part I)

and AVGME = herd average M.E. coefficient

This adjusts the actual production for length of lactation and

average age of the herd. However, because the actual production level is achieved by sale of some animals prior to completion of the lactation (before the dry period), production must be adjusted for this. This is accomplished by multiplying the above calculated average by

$$1 - \left[\frac{C - 9}{C} (\delta - \alpha - \beta) + \frac{C - 5}{C} (\alpha + \beta)\right]$$

where the symbol definitions are those used in section 13.1.

The production level of each animal for any lactation equals a/b

where a = herd M.E. lactation average

b = M.E. Coefficient for that animal

The production level for each animal that has freshened is entered at the beginning of the first month to complete entry of the dairy herd. This same equation is used to calculate the production during all future lactations. These calculations are carried out for each animal at the time it freshens. This procedure allows for a gradual influence of changes in feeding rates.

To represent the lactation curve of the animals a matrix with row identification indicating month of lactation, column identification representing the length of lactation in months and the cells containing the percent of the total lactation milk production produced in that month is used (Q.77, Part II).

If we call this matrix XLP(i,j), the amount of milk produced by any cow in any month would be:

(Production level) (XLP(Simulation month - last month fresh,
next month fresh - last month fresh)).

13.6 Each month the characteristics of the herd are updated. The age is advanced one month. If an animal becomes 20 years of age it is sold for beef.

As cows are sold, purchased, etc. a running total called present number of cows (COWS) is maintained which is the total of the number of cows that have freshened and remain in the herd. The initial value comes from the number of cows from Q.6, Part I. Each cow that is added increases this by one, each one sold decreases it by one.

The number of "Heifers under one year of age" and "heifers over 1 year of age" are maintained in a manner similar to cows. The heifers born and raised are added to "heifers under 1 year of age." For each animal whose age is changed from 12 months to 13 months the "heifers under 1 year of age" is decreased by 1 and the "heifers over 1 year of age" is increased by 1.

13.6.1 As the ages of the animals are being updated, when an animal of 12 months becomes 13 months of age the animal is sold if the number of heifers over 1 year of age is equal or greater than Q.17(b), Part I.

If Q.26(a), Part I is zero and:

(a) the number of heifers equals or exceeds 25(d), Part I, the animal is sold

(b) the number of heifers is less than 25(d), Part I, the animals age is set to 13, "heifers under 1 year" decreased by 1 and "heifers over 1 year increased by 1.

If Q.26(a), Part I is 1 and:

(a) the number of heifers equals or exceeds 25(d), Part I and

  (1) DELAY(Q.59, Part II) - EXCED2 is greater than zero, the animal is sold and HEFEXD is set equal to 1

  (2) DELAY(Q.59, Part II) - EXCED2 is less than or equal to zero, the animals age is updated as in (b) above

(b) the number of heifers is less than 25(d), Part I, the animals age is updated as in (b) above.

When an animal is sold, the "heifers under 1 year sale" is increased by 1, "heifers under 1 year" is decreased by 1 and the row is set equal to (-1, blank, blank, blank, blank) and heifers under 1 year sold is increased by 1.

13.6.2 If the animal whose age is being updated is a steer (as indicated by the flag in the production adjustment column) and the age equals the age animals are put on feed (Q.42(c), Part I) then "steer calves" is reduced by one and "steers on feed" is increased by one. If the age equals the sale age (Q.42(d), Part I) then "steers sales" is increased by one "steers on feed" is reduced by one and the animal is removed from the herd matrix.

Bred heifers indicated to be purchased by Q.11, Part II (Purchases made each year) are added to the herd by setting the age column of a previously empty row equal to the age indicated and setting the value of "next" equal to the present month plus 1. The number of animals purchased is added to a "bred heifers purchased" variable, heifers over 1 year bought and number of heifers over 1 year.

Fresh cows purchased annually by Q.11, Part II, are added to the herd by setting the age column of a previously empty row equal to the age indicated, setting the month of freshening equal to the present month and flagging the production adjustment column (600,000) to indicate that no calf is born. The number of animals purchased is added to "cows purchased," cows bought and number of cows.

13.7 In the updating of the herd inventory all animals not to freshen this month (i.e. animals for which next month fresh does not equal this month) are updated first. Then those that freshen this month which have freshened before ("last month fresh has a value") are updated. Last

updated are animals freshening for the first time.

13.7.1 Prior to the calculations involved in cow freshening, calculations as to whether there is space for her or not are made. If the system in use is 1 (i.e. Q.19(a), Part I = 1), the number of cows equals or exceeds capacity 1 and Q.26(a), Part I is 0 the animal is sold. If capacity is greater than the number of cows, the normal freshening calculations are allowed to occur. If the system used is 2 through 7 (Q.19(a), Part I = 2 through 7), the number of cows equals or exceeds capacity 2 and Q.26(a), Part I is 0, the animal is sold. If not, the normal freshening calculations are allowed to occur.

If Q.26(a), Part I is 1 and:

(a) Q.19(a), Part I = 1 and number of cows equals or exceeds capacity 1 or Q.19(a), Part I = 2 through 7 and number of cows exceeds capacity 2 and:

(1) DELAY - EXCED1 is greater than zero, the animal is sold by changing the row to (-1, blank, blank, blank, blank) and adding 1 to "fresh cows sale" if the animal has freshened ("last month fresh" has a value) or "bred heifers sale" if the animal had not freshened. Also if the animal is a cow add 1 to cows sold and subtract 1 from number of cows. If the animal is a bred heifer add 1 to heifers over 1 year sold and subtract 1 from heifers over 1 year. The flag variable called COWEXD which is initialized at zero is set equal to 1.

(2) DELAY(Q.13, Part II) - EXCED1 is less than or equal to zero the animal goes through normal freshening calculations and COWEXD is set equal to one.

(b) the number of cows does not exceed capacity 1, the cow goes through normal freshening calculations.

Capacity 1 is the minimum of (1) the number of cows from Q.17(a), Part I and (2) "stall capacity 1." Capacity 2 is the minimum of (1) the number of cows from Q.17(a), Part I and (2) "stall capacity 2."

"Stall Capacity 1" = cow stall capacity (Q.25(b), Part I) + K + L

Where K = the minimum of (1) the number of cows that are allowed to be housed with the heifers which equals the product of the stall capacity for cows (Q.25(b), Part I), the percentage that number of cows can exceed capacity (COWCAP(1)) and the percentage of that excess capacity that must be housed with heifers (COWCAP(2), Q.58(a), Part II) and (2) the number of spaces available for housing cows with the heifers which equals the total heifer and dry cow capacity minus the number of heifers.

and L = the amount by which the number of cows may exceed the number of cow stalls without any requirement that they be housed elsewhere. This equals the product of total existing cow stall capacity (Q.25(b), Part I), the percentage that number of cows can exceed capacity (COWCAP(1)) and the percentage of that excess that can be housed with the cows (1 - COWCAP(2), Q.58(a), Part II).

"Stall Capacity 2" is calculated the same way except that

(1) Free Stall capacity is used (Q.25(a), Part I)

(2) The percentage figures in Q.58(b), Part II are used instead of those in Q.58(a), Part II. That is, COWCAP(3) and COWCAP(4) replace COWCAP(1) and COWCAP(2) respectively.

13.7.2 For each animal, if "next month fresh" is the month presently being simulated:

A. "Month last fresh" becomes the present month.

Note: Simulated months are numbered consecutively from 1 to the number of years simulated times 12.

B. If the production adjustment column is not flagged to indicate that no calf is born (600,000), a number Z, from 0 - 99 is drawn from a uniform distribution.

If $0 \leq Z < \alpha/2$ the calf was a bull, but it died. It is added to bull calves born and bull calves died.

$\alpha/2 \leq Z < \alpha$ the calf was a heifer, but it died. It is added to heifer calves born and heifer calves (heifers under 1 year) died.

$\alpha \leq Z < [\alpha + \frac{100-\alpha}{2}]$ the calf is a bull and is added to an accumulation variable indicating the number of bull calves that could be raised.

$\alpha + \frac{100-\alpha}{2} \leq Z \leq 99$ the calf is a heifer and is added to an accumulation variable indicating the number of heifer calves that could be raised.

Where: $\alpha$ = calf mortality rate (Q.47, Part II)

The variable "calves born" is increased by one regardless of the fate of the calf.

C. A new level of production is calculated from the age of the animal and the herd M.E. lactation average using the procedure indicated in 12.3 above. The production adjustment, if any, is then added to the production level.

D. Prior to calculation of "next" (next month fresh) the animal is

subjected to a probability of dying or being culled. A second number, Z, between 0 and 99 is drawn from a uniform distribution. If:

(1) $0 \leq Z < \alpha$, the animal died this month, age becomes -1 (to indicate that the row is empty) and the rest of row becomes zero. A variable called "cows died" is increased by one, number of cows is decreased by one, and the animal is removed from the herd matrix.

(2) $\alpha \leq Z < (\alpha + \beta)$, the animal is to be sold at one-half regular cow prices in the fifth month of lactation. This is indicated by placing a flag (100,000) in the production adjustment column. "Next" is set equal to the present month plus the average calving interval.

(3) $(\alpha + \beta) \leq Z < \gamma$, the animal is to be culled for low production and sold in the ninth month of lactation. This is indicated by a 200,000 in the production adjustment column. "Next" is set equal to the present month plus the average calving interval.

(4) $\gamma \leq Z < \delta$, and the culling rate used is less than the required rate, the animal should be culled if production is to be maintained but she is not so a negative production adjustment is assigned. The magnitude of the production adjustment is taken from Q.75, Part II. To represent the fact that the greater the difference between the required and actually

used culling rates the greater the effect on production, the magnitude of the production adjustment is determined by the absolute value of the difference between Z and the required culling rate.

(5) $\gamma \leq Z < \delta$ and the required culling rate is less than the used rate, the animal is culled at the end of the lactation but need not be to maintain production. A positive production adjustment, with magnitude determined as in (4) above, is added to an array of positive adjustments. For each animal that is updated but not culled a positive production adjust- is added to the production adjustment column if the array of adjustments contains any values.

Where $\alpha$ = Percent of cows dying (CWMORT) $\left(\frac{\text{average calving interval}}{12}\right)$

$\beta$ = Involuntary sale percentage (SINVOL) $\left(\frac{\text{average calving interval}}{12}\right)$

$\gamma$ = Minimum of (i) culling rate required to maintain production (Q.10, Part I)

(ii) culling rate used (Q.11, Part I)

$\delta$ = Maximum of (i) and (ii) above.

E. The new value of "next" is then calculated in the same manner as when the array is being initialized (section 13.1) except that there will be no problem with the "next" value being less than one.

13.7.3 Open heifers (indicated by a -100 in the "last" column and a zero in the "next" column), whose age equals the desired age of freshening minus nine, are subjected to a probability of dying or being

culled for sterility and then given a date of freshening. This is accomplished by drawing a number, Z, from a uniform distribution (0,99) and if:

A. $0 \leq Z < \alpha$, the animal dies this month, "heifers over one year died" is increased by 1 and number of heifers over one year is decreased by one.

B. $\alpha \leq Z < (\alpha + \beta)$, the animal is culled for sterility in three months. This is accomplished by giving the animal a value of "next" equal to the present month plus three and flagging the production adjustment column (300,000).

C. $(\alpha + \beta) \leq Z < (\alpha + \beta \quad)$, the value of "next" is the present month plus nine.

D. $(\alpha + \beta + \quad) \leq Z < 91$, the value of "next" is the present month plus 10.

E. $91 \leq Z < 100$, the value of "next" is the present month plus 11.

where: $\alpha$ = the mortality rate for heifers

$\beta$ = the percent of heifers sold for infertility

$\gamma$ = conception rate for heifers

13.7.4 Cows in their ninth month of lactation that are flagged to be culled (200,000) are sold for beef. That is, for each such animal, the variable indicating the number of cows sold for beef (cows sale - beef)[1] is increased by one and the row values in the matrix are set to (-1, 0, 0, 0, 0). However, because it is assumed that the animal is sold on the fifteenth of the month, the milk production for this month

1. Animal "sale" variables indicate the number of animals of that type to be sold (a value calculated for) by the STORES routine. Animal "sold" variables indicate the number of animals sold regardless of whether the value is input or calculated by the STORES routine.

is calculated and one-half of that amount is added to the total milk produced for the month. "Cows sold" is increased by one and the number of cows is decreased by one.

Animals in their fifth month of lactation which are flagged to be culled for physical injury, mastitis, etc. are sold. The herd matrix row values are set to (-1, 0, 0, 0, 0) and the number of cows sold for beef is increased by one-half. However, because it is assumed that the animal is sold on the fifteenth of the month, the milk production for this month is calculated and one-half of that amount is added to the total milk produced for the month. "Cows sold" is increased by one and the number of cows is decreased by one.

Heifers that have been flagged to be culled for sterility (300,000), and for which the value of "next" equals the present simulation month, are sold. Open heifers sale is increased by one, heifers over one year is decreased by one and the row of the herd matrix is set to (-1, 0, 0, 0, 0).

13.7.5 Each animal which is not culled is assigned a positive production adjustment if the array containing positive adjustments contains any values. This is accomplished by adding the first number of the array to the production adjustment column of the herd matrix row for that animal and shifting the array of adjustments.

13.8 Animals indicated to be sold by input type of change 7 (Part III) as indicated in the "livestock sale hold" matrix are found in the herd matrix. If the number of animals to be sold is negative, the sign of the number indicates that steers are to be sold and the magnitude indicates the number to be sold. If insufficient animals of the age indicated are available, those one month older will be sold; then those

one month younger, then those two months older. The age range is continually widened until the indicated number of animals are sold or all animals of that sex are sold. If the number of cows (steers) to be sold exceeds the number of cows, heifers and heifer calves (steer calves and steers on feed) on hand, all those on hand are sold.

If females are sold, milk production for this month (if any) is calculated and one-half of the amount added to milk production for the month. The row for that animal is changed to (-1, 0, 0, 0, 0). If price is input, the number of animals times the price is added to livestock sales for this month. If price is generated (-1 entered for price) the number of animals is added to cows sale (dairy), bred heifer sale, open heifer sale or heifers under 1 year sale depending on age. If the animals sold have freshened "cows sold" is increased by one and "cows" decreased by one. If the animal was over one year of age "heifers over one year sold" is increased by one and "heifers over one year" decreased by one. If the animal is less than 12 months of age "heifers under one year sold" is increased by one and "heifers under one year" is decreased by one.

If steers are sold and the price is input, the value of the steers price times number sold is added to livestock sales. If price is to be generated the number of animals sold is added to steers sale. If the age of the steers is less than the age at which steers are put on feed (Q.42, Part I) steer calves is reduced by the number sold. Otherwise steers on feed is reduced by the number sold. Regardless of age, steers sold is increased by the number sold.

If the number of animals to be sold exceeds the number on hand, the unsold number is maintained as a variable, CATNO3(1) for females

and CATNO3(2) for steers. If these numbers are non-zero, calves that would otherwise be raised (calculated later) are sold.

13.9 Milk production is then calculated as indicated in section 13.5.3 for each animal and added to the total production for the month. This calculation occurs at this time to avoid inclusion of a complete months milk production for cows purchased or sold.

13.10 Following this, the animals indicated to be purchased by input type of change 6 (Part III) as indicated by the livestock purchase hold matrix, are added to the herd. One row in the herd matrix is assigned to each animal. Age is taken from input. If the animal has freshened, the value of "last" equals the number of the simulation month minus the "months since last fresh" from input.

If fresh cows are purchased ("last" equals zero),[1] freshening occurs in the same manner as indicated in section 13.7.2. If the animals purchased are to freshen this month ("next" equals -1), calving and freshening occur in the manner indicated in 13.7.2. If a bred heifer is purchased ("last" equals -1 and "next" is greater than zero), last is set equal to -100 and next is calculated as the present month simulated plus the months until next fresh from input. If unbred heifers are purchased "last" is set equal to -100 and the number of animals purchased is added to heifers under one year or heifers over one year as determined by age .

If "months since last fresh" has a value but "months until next fresh" does not the animal is subjected to a probability of being culled. If the number Z, drawn from a uniform distribution (0,99) is:

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1. In this paragraph "last" and "next" refer to input values of "months since last fresh" and "months until next fresh" respectively.

A. $0 \leq Z < \gamma$ The animal is flagged to be culled in the ninth month of lactation. [200,000 in production adjustment column]

B. $\gamma \leq Z < \delta$ and culling rate used is less than the required rate, the animal is given a negative production adjustment.

C. $\gamma \leq Z < \delta$ and the required rate of culling is less than the used rate, the animal is flagged to be culled in the ninth month of lactation and a positive production adjustment is added to the production adjustment array.

Where: $\gamma$ = Minimum of

(i) culling rate required to maintain production (Q.10, Part I), and

(ii) culling rate used (Q.11, Part II)

and $\delta$ = Maximum of (i) and (ii) above.

If the animal is not to be culled, a value of "next" is calculated by the same method as used when the herd array is set up except that the month "next fresh" must be after (greater than) the month presently being simulated.

The production adjustment is taken from input. The production level is calculated by calculating the age of freshening, which equals the age minus the "months since last fresh," using this to choose the coefficient to be multiplied by the herd M.E. average production and adding the production adjustment to the resultant product.

After each animal is entered, the milk production for that month is calculated and one-half is added to milk production for the month. This represents the assumption that purchase takes place on the fifteenth of the month.

13.11 The number of bulls born multiplied by the percentage to be

raised (Q.42(b), Part I), gives the number of bull calves to be raised as steers. Each animal kept is assigned a row with a zero in the age column and 400,000 in the production adjustment column. The number of bull calves raised is added to "steer calves." The number of bull calves not raised is added to "calves sale" and bull calves sold.

The number of heifer calves to be raised is calculated as the number born multiplifed by the percentage to be raised (Q.16, Part I). After the number of heifer calves to be raised is calculated, that number is considered relative to the user determined maximum (Q.17(c), Part I). If the number of heifers under one year is equal or greater than Q.17(c), Part I the animals are added to "calves sold." If the animals to be raised plus "heifers under one year of age" is greater than Q.17(c), Part I, the number of calves to be raised minus K, where K equals Q.17(c), Part I minus "heifers under one year of age," are added to "calves sale" and heifer calves sold, and subtracted from calves to be raised.

For each heifer entered a -100 and a zero are placed in the "last" and age columns, respectively, of the herd matrix.

The number to be raised, thus adjusted is then compared to building capacity. If Q.26(a), Part I is 0 and:

(a) number of heifers under one year plus calves to be kept is less than Q.25(e), Part I the calves are added to the herd as indicated above and heifers under one year of age is increased by the number raised.

(b) the number of heifers under one year is equal or greater than Q.25(e), Part I, all the calves to be kept are added to "calves sale" and heifer calves sold.

(c) the number of heifers under one year plus calves to be kept is greater than Q.25(e), Part I, the number of calves equal to [Q.25(e), Part I, minus the number of heifers under one year] is added to the herd and the difference between calves raised and that number is added to "calves sale" and heifer calves sold.

If Q.26(a), Part I, is 1 and:

(a) the number of heifers under one year plus calves to be kept is less than Q.25(e), Part I the calves are added to the herd as indicated in (a) above.

(b) the number of heifers under one year plus calves to be kept is greater than Q.25(e), Part I and DELAY - EXCD3 is greater than zero, the number of calves equal to Q.25(e) minus the number of heifers under one year are added to the herd and the remaining number is added to calves sale and heifer calves sold. CAFEXD is set equal to one.

(c) the number of heifers under one year plus calves to be kept is greater than Q.25(e), Part I and DELAY - EXCD3 is less than or equal to zero, the number of calves kept is added to the herd.

13.12 The cow grain requirement is calculated by dividing the level of grain feeding by 12 and multiplying by the number of cows. The number of cows is calculated as the number of cows on hand at the end of the month plus one-half the number of "cows sold" minus one-half the number of cows bought.

Grain required for heifers is pounds per heifer (Q.50(a), Part II) multiplied by the sum of the number of heifers under 12 months of age

and the number of steer calves plus one-half the number of heifers under one year sold minus one-half the number purchased.

NOTE: Handling grain requirements in this way makes the amount of grain used in any month a function of the number of animals but not stage of lactation.

Hay equivalent requirement for cows equals the number of cows (calculated above) multiplied by one-twelfth of the hay equivalent per cow for the given grain feeding level, (Q.42, Part II).

Requirements for heifers is the number of heifers under 12 months plus steer calves as calculated above multiplied by one-twelfth the first requirement from Q.52, Part II, plus one-twelfth the second requirement multiplied by K, where K equals the number of heifers over one year of age plus one-half the number of heifers over one year sold minus the number purchased.

13.13 The equations for calculation of certain other costs directly associated with the dairy herd are listed below:

Calf Costs = number of animals 0 months of age multiplied by cost per calf (Q.26, Part II).

Breeding Fees = (number of "heifers bred" + number of cows fresh for 3 months) multiplied by the breeding cost per cow (Q.25, Part II).

Vet., Medicine Cost = number of cows (used in section 13.12 above) multiplied by one-twelfth the veterinary cost per cow (Q.25, Part II).

Other Dairy Costs = number of cows (used above) multiplied by one-twelfth the other cost per cow (Q.25, Part II).

Milk Marketing = Cwt. milk sold this month muliplifed by cost per cwt. (Q.24(a), Part II).

Livestock Insurance = the cost per $1,000 value (Q.39(a), Part II) multiplifed by the beginning inventory value of livestock.

13.14 If Q.18(a), Part I is one, a straw requirement is calculated for cows. If Q.18(b), Part I is one, a straw requirement is calculated for heifers.

Straw requirements for the cows is STRAWR(i, Dairy system no.) from Q.52, Part II multiplied by the product of 1/k and the number of cows; where i = 1 and k = 7 if month is October through April and i = 2 and k = 5 if month is May through September. The requirement for heifers is the sum of (a) STRAWR(i, Replacements system no. - 7) multiplied by the sum of the number of heifers under one year of age and the number of steer calves, and (2) STRAWR(i, Replacements system no. - 4), multiplifed by the product of 1/k and the number of heifers over one year plus the number of steers on feed, where i = 3 and k = 7 during October through April and i = 4 and k = 5 during May through September. Total Straw requirement for the month is the sum of heifer requirement plus cow requirements.

If 18(a) is two the cow bedding cost is calculated as the (1, month) element of the bedding cost matrix multiplied by the number of cows. If 18(b), Part I, is two the young stock bedding cost is the (2, month) element of the bedding cost matrix multiplifed by the total number of youngstock (all heifers plus all steers).

13.15 The ending inventory value of the animals is calculated as the sum of the number of cows, heifers over one year, heifers under one

year, steer calves and steers on feed, multiplied by the respective prices from Q.9, Part I. The ending inventory value for each year is the beginning inventory value for the next. Beginning and ending inventory values are maintained for use at the end of the year.

13.16 Dairy replacement system size is the sum of (1) the number of heifers under one year, (2) the number of heifers over one year, (3) steer calves and (4) "steers on feed." The annual average number of animals in each category is calculated as the average of the twelve month values.

13.17 The following variables are calculated and maintained by this subroutine:

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Number of cows | XN(1) | ( 1) |
| 2. Average no. Heifers under 1 yr. | HF1A | ( 1) |
| Number of Heifers under 1 yr. | HF1 | (12) |
| 3. Average number Heifers over 1 yr. | HF2A | ( 1) |
| Number of Heifers over 1 year | HF2 | (12) |
| 4. Average no. Heifer calves raised | CALVSA | ( 1) |
| Heifer calves raised - no. | CALVS | (13) |
| 5. Cows bought | COWBT | (13) |
| 6. Heifers over 1 year bought (#) | HF2BT | (13) |
| 7. Heifers under 1 year bought (#) | HF1BT | (13) |
| 8. Cows sold | CWSLD | (13) |
| 9. Heifers over 1 year sold | HF2SLD | (13) |
| 10. Heifers under 1 year sold | HF1SLD | (13) |
| 11. Cows died | CWDID | (13) |
| 12. Heifers over 1 year died | HF2DID | (13) |
| 13. Calves died (heifers under 1 yr. died | HF1DID | (13) |
| 14. Milk sold (lbs.) | XMILK | (13) |
| 15. Grain required | GRAIN | ( 1) |
| 16. Hay equivalent required | HERQ | ( 1) |
| 17. Calf costs | CALFC | ( 1) |

| Variable Definition (Cont'd.) | Name | Dimension Code |
|---|---|---|
| 18. Breeding fees | BREEDC | ( 1) |
| 19. Vet medicine | VETC | ( 1) |
| 20. Other dairy costs | ODAIRY | ( 1) |
| 21. Marketing expense | XMKTCW | ( 1) |
| 22. Bedding cost | BED | ( 1) |
| 23. "Cows purchased" (#) | CWPUR | ( 1) |
| 24. Bred Heifers purchased (#) | BHPUR | ( 1) |
| 25. Open Heifers purchased (#) | OHPUR | ( 1) |
| 26. Heifers under 1 yr. purchased (#) | HF1PUR | ( 1) |
| 27. Cows sale (beef) | BCSALE | ( 1) |
| 28. Cows sale (dairy) | DCSALE | ( 1) |
| 29. Bred Heifers sale | BHSALE | ( 1) |
| 30. Open Heifers sale | OHSALE | ( 1) |
| 31. Heifers under 1 year sale | HF1SAL | ( 1) |
| 32. Calves born | CBORN | ( 1) |
| 33. Inventory value of cattle (a) Beg. | CATLVE | ( 1) |
| (b) End | CATLVE | ( 1) |
| 34. Steer calves | STERC | (13) |
| 35. Steers on feed | STERF | (13) |
| 36. Dairy replacement system size | XLS(2) | ( 1) |
| 37. Bull calves raised | BULLCR | (13) |
| 38. Number of Cows | COWNO | (12) |
| 39. Average number of Cows | COWNOA | ( 1) |
| 40. Calves sale (at birth) | CVSALE | ( 1) |
| 41. Livestock insurance | LINSP | ( 1) |
| 42. Cattle numbers (beginning of year) | CATNO | ( 5) |
| 43. Cattle numbers | CATNO2 | ( 5) |
| 44. Steers sale | STSALE | ( 1) |
| 45. Steers sold | STSLD | (13) |

SUBROUTINE STORES

This subroutine maintains the quantities of crops on hand and determines the quantities of each to be used, sold or purchased. It calculates the income from crop sales, the cost of purchases and the costs of storage and selling. The value of livestock sold is also calculated.

14.1 The initial values input in Q.38, Part I are used to initialize columns 13 and 14 of the STORED(12,14) array with the beginning amount of each of the crops on hand. The STORED array is arranged with the first 12 columns indicating the quantity of that crop or commodity on hand each month. Column 13 contains the beginning inventory values for the year. Column 14 indicates the present quantity on hand. Each row contains the values for one crop or commodity as listed below.

1. Hay crop silage (tons)
2. Corn silage (tons)
3. Hay (tons)
4. High moisture Corn (bushels 15.5% basis)
5. Ear Corn (bushels)
6. Corn grain (bushels)
7. Wheat (bushels)
8. Oats (bushels)
9. Soybeans (bushels)
10. Field Beans (bushels)
11. Straw (tons)
12. Supplement (tons)

In the first month, a beginning crop inventory is calculated to provide the beginning inventory of crops for the first year. For succeeding years the end inventory for one year provides the beginning inventory for the next. The crop inventory value is calculated as STORED(i,13) values multiplied by the appropriate prices from Q.53, Part II. Hay crop silage and corn silage are converted to a hay equivalent basis and valued at the

price of hay. The quantity of ear corn is divided by 2 and the corn grain price is used. The quantity of field beans is multiplied by 0.6 because the price is quoted in hundredweight but production is in bushels.

If this month equals the month in which insurance is paid as indicated by Q.38(c), Part II, the insurance on supplies (crops on hand) is calculated as the beginning crop inventory value multiplied by the supplies insurance rate (Q.39(b), Part II).

The quantity of each crop harvested as determined by the individual crop routines is added to the monthly variables indicating the quantities produced.

14.2 The quantities of hay crop silage, corn silage and high moisture corn produced this month from the hay and corn routines are added to the correct elements of the array.

If the answer to Q.26(c), Part I is one, the quantity of hay harvested is added to STORED(3,14). Then if STORED(3,14) plus STORED(11, 14) is greater than Q.25(b), Part I the variable HAYEXD is set equal to 1.

If the answer to Q.26(c), Part I is 0 and storage capacity (Q.25(h), Part I) minus the sum of STORED(3,14) and STORED(11,14) is:

(1) greater than the quantity of hay harvested this month, the quantity is added to STORED(3,14)

(2) less than the quantity of hay harvested, hay tonnage equal to the storage available (Q.25(h), Part I - STORED(3,14) - STORED(11,14) is added to STORED(3,14) and the difference between the quantity harvested and the quantity added to STORED(3,14) is added to "hay sold."

14.3 If ear corn is harvested (ear corn harvested variable from the corn routine is greater than zero), the ear corn storage capacity available, Q.25(i), Part I minus STORED(5,14) is calculated. If the capacity is greater than the amount harvested, the amount harvested is added to STORED(5,14). If the amount harvested is greater than the capacity available and Q.26(b), Part I is one the quantity harvested is added to STORED(5,14) and the variable ear corn capacity exceeded (ECNEXD) is set to one. If the amount harvested is greater than capacity and Q.26(b), Part I is zero, the amount of corn equal to the capacity available is added to STORED(5,14) and the quantity harvested minus the quantity added to STORED(5,14) is added to "ear corn sold."

14.4 If shelled corn (corn grain) is harvested and:

(1) the corn sale month from Q.7, Part II is equal to 13, the entire amount harvested is added to "corn grain sold."

(2) Q.26(d)(iv), Part I is one, the quantity harvested is added to STORED(6,14) and the "off farm stored" variable for corn. The quantity of each crop stored off farm is maintained as the variable array OFSTOR where OFSTOR(1) = Corn
(2) = Wheat
(3) = Oats
(4) = Soybeans
(5) = Field Beans

(3) Q.26(d)(iv), Part I is not 1 and grain capacity available is greater than or equal to the quantity harvested, the quantity harvested is added to STORED(6,14). The grain capacity available equals Q.25(j), Part I minus:

(a) STORED(7,14) minus the quantity of wheat stored off the farm, if Q.26(d)(iii), Part I is not one,

(b) STORED(8,14) minus the quantity of oats stored off the

farm, if Q.26(d)(v), Part I is not one,

(c) STORED(9,14) minus the quantity of soybeans stored off the farm, if Q.26(d)(ii), Part I is not one,

(d) STORED(10,14) minus the quantity of field beans stored off the farm, if Q.26(d)(i) is not one, and

(e) STORED(6,14) minus the quantity of corn stored off the farm, if Q.26(d)(iv) is not one.

(4) Q.26(d)(iv), Part I is 2 and the quantity harvested is greater than grain capacity available, the amount harvested is added to STORED(6,14) and the difference between the amount harvested and the capacity available is added to "off farm stored corn."

(5) Q.26(d)(iv), Part I is 0 and the quantity harvested is greater than grain capacity available and Q.26(b), Part I is zero, the amount of capacity available is added to STORED(6,14) and the difference between the amount harvested and the capacity available is added to "corn grain sold"

(6) Q.26(d)(iv), Part I is zero and the quantity harvested is less than grain capacity available, and Q.26(b), Part I is 1, the amount harvested is added to STORED(6,14) and the variable GRNEXD is set equal to one.

14.5 If wheat is harvested, the same routine is used as is used for corn grain except that (1) Q.26(d)(iv), Part I is replaced by Q.26(d)(iii), (2) STORED(6,14) is replaced by STORED(7,14), (3) the quantity harvested comes from the wheat routine. The variables "off farm stored corn," "corn grain sold" and corn sale month are replaced with "off farm stored wheat," "wheat sold" and wheat sale month (SELMO(1)).

For oats, soybeans and field beans the same method is used as shown

for wheat except that the corn variables are replaced by the other crop variables as indicated below.

Corresponding Variables by Crop

| Corn | Oats | Soybeans | Field beans |
|---|---|---|---|
| Q.26(d)(iv) | Q.26(d)(v) | Q.26(d)(ii) | Q.26(d)(i) |
| STORED(6,14) | STORED(8,14) | STORED(9,14) | STORED(10,14) |
| OFSTOR(1) | OFSTOR(3) | OFSTOR(4) | OFSTOR(5) |
| SELMO(2) | SELMO(3) | SELMO(4) | SELMO(5) |
| Corn grain sold | Oats sold | Soybeans sold | Field beans sold |

14.6 Straw harvested from the oat routine is added to straw harvested in the wheat routine to get total straw harvested. If the answer to Q.26(c), Part I is 1, the quantity of straw harvested is added to STORED(11,14) and then if STORED(3,14) plus STORED(11,14) is greater than Q.25(h), Part I the variable HAYEXD is set equal to 1.

If the answer to Q.26(c) is 0 and storage capacity (Q.25(h), Part I) minus the sum of STORED(3,14) and STORED(11,14) is:

(1) greater than the quantity of straw harvested this month, the quantity harvested is added to stored (11,14).

(2) less than the quantity of straw harvested this month, straw tonnage equal to the storage available, (Q.25(h), Part I - STORED(3,14) - STORED(11,14), is added to STORED(11,14) and the difference between the quantity harvested and the quantity added to STORED(11,14) is added to the "straw sold" variable.

If the month being simulated equals the month in which supplement is to be purchased (Q.10, Part II), the quantity to be purchased is calculated. If the input quantity (Q.10, Part II) is greater than or equal to 2.0, the quantity to be purchased equals the input quantity.

If the input quantity is less than 2.0 the quantity to be purchased is calculated as the input quantity multiplied by the number of cows. The quantity purchased is added to the supplement purchase variable and STORED(12,14).

The number of days in the present month is calculated and maintained for use in calculating quantities of feed fed later in this subroutine. 14.7 The pounds of grain required by the dairy herd for this month is taken from the dairy routine. If Q.13(a), Part I equals one, the amount of high moisture corn fed is calculated by multiplying the number of cows for the month (from the dairy routine) by the product of the Q.13(b), Part I coefficient corresponding to the correct month and the number of days per month. This is converted to bushels of 15.5% corn equivalent by multiplying the calculated pounds of high moisture corn by

$$\frac{(100 - (Q.13(c), \text{ Part I})}{94.5(56)}$$

This bushels of corn equivalent is subtracted from the total grain requirement.

If high moisture corn stored, STORED(4,14), is greater than the calculated quantity, that quantity is subtracted from STORED(4,14). If STORED(4,14) is less than this amount, STORED(4,14) is subtracted from the total HMC requirement, STORED(4,14) is set equal to zero and the program moves to consider STORE(5,14). High moisture corn used is increased by the amount STORED(4,14) is decreased.

If ear corn stored STORED(5,14), is greater than twice the (remaining HMC requirement, then twice the remaining HMC requirement is subtracted from STORED(5,14). If STORED(5,14) is less than twice the remaining HMC requirement, one-half STORED(5,14) is subtracted from

the remaining HMC requirement, STORED(5,14) is set equal to zero and the program moves to consider STORED(6,14). Ear corn is increased by the amount STORED(5,14) is decreased.

The remaining HMC requirement is added to "corn used." If STORED(6,14) is greater than the now remaining HMC requirement then the remaining HMC requirement is subtracted from STORED(6,14). If STORED(6,14) is less than the remaining HMC requirement, STORED(6,14) is subtracted from the remaining HMC requirement, STORED(6,14) is set equal to zero and the now remaining HMC requirement is added to "corn purchase."

The pounds of supplement fed separately to cows is calculated by multiplying Q.13(d), Part I by the sum of the number of cows and the number of days per month. This total is subtracted from the total grain requirement and added to the variable "supplement used." If the quantity fed is less than or equal to STORED(12,14), the quantity is subtracted from STORED(12,14). If the quantity fed is greater than STORED(12,14), the difference between the quantity fed and STORED(12,14) is added to supplement purchased and STORED(12,14) is set equal to zero.

14,8 The remaining total grain requirement (Total - HMC and supplement feed separately) is used to calculate the amounts of each grain and supplement to be used. The amount of each grain and supplement to be used is calculated by first determining the ratio of each to total quantity. This ratio is the quantity of the individual item divided by total of all items in the grist ( $\sum_{i=1}^{5}$ GRIST(i)). The ratio for each crop is then multiplied by the remaining total grain requirement to determine the quantity of that crop required. The quantity of each

grain is then divided by its weight per bushel (ear corn, 35 pounds; shelled corn, 56 pounds; wheat, 60 pounds; oats 32 pounds) to determine the bushels required. Supplement required is converted to tons by dividing by 2000.

After the quantities of each corn, oats and wheat to be fed are calculated that quantity is subtracted from the corresponding "off farm stored" variable. If this variable becomes less than zero it is set at zero. The amount of each crop or commodity used each month is maintained as an array. As the final quantity used is calculated for each crop that quantity is added to the appropriate "_____used" array element.

14.9 The pounds of supplement fed to steers is calculated as the number of "steers on feed" multiplied by FEDBEF(5,Q.42(e), Part I). This quantity is converted to tons and added to the supplement requirement for cows. If STORED(12,14) is greater than or equal to the total requirement, the requirement is subtracted from STORED(12,14). If STORED(12,14) is less than the quantity required, STORED(12,14) is subtracted from the quantity, STORED(12,14) is set to zero and the remaining quantity is added to "supplement purchase."

If STORED(5,14) is greater than or equal to the ear corn required, the amount required is subtracted from STORED(5,14). If STORED(5,14) is less than the ear corn required, STORED(5,14) is subtracted from the ear corn requirement, STORED(5,14) is set equal to zero and the program moves to STORED(6,14). The bushels of ear corn required is converted to shelled corn requirement by dividing by 2. This converted quantity is added to the corn grain requirement calculated above.

The pounds of shelled corn fed to steers on feed is calculated as

the number of "steers on feed" multiplied by FEDBEF(4, Q.42(e), Part I). This is divided by 56 to get the bushels required. The bushels required is added to the shelled corn required by the dairy to determine the total amount required. If STORED(6,14) is greater than or equal to the calculated shelled corn requirement, the requirement is subtracted from STORED(6,14). If STORED(6,14) is less than the requirement, STORED(6,14) is subtracted from the requirement, STORED(6,14) is set equal to zero and the remaining requirement is added to the "corn purchase" variable.

If STORED(8,14) is greater than or equal to the bushels of oats required, the quantity is subtracted from STORED(8,14). If STORED(8,14) is less than the quantity required, STORED(8,14) is subtracted from the quantity required, STORED(8,14) is set equal to zero and the variable "oats purchased" is increased by the quantity remaining.

If STORED(7,14) is greater than or equal to the bushels of wheat required, the quantity of wheat required is subtracted from STORED(7,14). If STORED(7,14) is less than the quantity required, the quantity required is reduced by the value of STORED(7,14), STORED(7,14) is set equal to zero and the program moves to consider STORED(6,14). If STORED(6,14) is greater than or equal to the remaining quantity, that quantity is subtracted from STORED(6,14). If STORED(6,14) is less than the remaining quantity, STORED(6,14) is subtracted from the remaining quantity, STORED(6,14) is set equal to zero and the then remaining quantity is added to the variable "corn purchase."

<u>14.10</u> The total hay equivalent requirement for the month for the dairy herd is taken from the dairy routine. The amount of hay equivalent produced by the pastured acreage is taken from the hay routine. The

pasture hay equivalent is subtracted from the total hay equivalent requirement to get the quantity required from other forages. If the pasture hay equivalent exceeds the total hay equivalent requirement, the quantity required from other forages equals zero.

14.10.1 The tons of hay used by the dairy herd this month is calculated as the quantity of hay equivalent required from non-pasture sources multiplied by the ratio of the figure from row 1, Q.14, Part I from the column corresponding to the correct month to the sum of that column.

The pounds of hay fed to steers on feed is calculated as the number of "steers on feed" multiplied by FEDBEF(3, Q.42(e), Part I). This is divided by 2,000 to get tons of hay required for the steers on feed. This is added to the hay required by the dairy to get total hay required.

If STORED(3,14) is greater than or equal to this quantity, it is subtracted from STORED(3,14). If STORED(3,14) is less than this quantity, STORED(3,14) is subtracted from this quantity, STORED(3,14) is set equal to zero and the variable "hay purchase" is increased by the remaining amount.

14.10.2 Tons of hay crop silage required for the diary herd is calculated by multiplying the non-pasture hay equivalent required by the ratio of the figure in row 2 of Q.14, Part I, from the column corresponding to the proper month, to the sum of that column and multiplying the result by 3. NOTE: The ratio is used to protect against totals other than 100.

The pounds of hay crop silage used by the steers is calculated as the number of "steers on feed" multiplied by FEDBEF(2, Q.42(e), Part I). This is divided by 2,000 to get the tons of hay crop silage required

for the steers on feed. This is added to the hay crop silage required for the cows as calculated in the paragraph above.

If the available quantity of hay crop silage, STORED(1,14), is greater than or equal to the quantity of hay crop silage required, the quantity is subtracted from STORED(1,14). If STORED(1,14) is less than the quantity required, STORED(1,14) is subtracted from the quantity, STORED(1,14) is set equal to zero and the program moves to consider STORED(2,14).

If the available quantity of corn silage, STORED(2,14) is greater than or equal to the remaining quantity required, the quantity is subtracted from STORED(2,14). If STORED(2,14) is less than the quantity remaining, STORED(2,14) is subtracted from the quantity, STORED(2,14) is set equal to zero and the program moves to consider STORED(3,14).

If the available quantity of hay, STORED(3), is greater than or equal to one-third of the now remaining quantity, one-third of the quantity is subtracted from STORED(3,14). If STORED(3,14) is less than that quantity, 3 times STORED(3,14) is subtracted from the quantity, STORED(3,14) is set equal to zero and "hay purchase" is increased by one-third of the now remaining quantity.

14,10,3 The tons of corn silage used by the dairy herd is calculated by multiplying the total tons of non-pasture hay equivalent by the ratio of the element from row 3 in the column representing the present month to the sum of that column.

The pounds of corn silage used by the steers is calculated as the number of "steers on feed" multiplied by FEDBEF(1, Q.42(e), Part I). This is divided by 2,000 to get tons of corn silage required for the steers on feed. The calculated quantity is added to the corn silage

required for the cows to get total corn silage required.

If the available quantity of corn silage, STORED(2,14) is greater than or equal to the required amount, that amount is subtracted from STORED(2,14). If STORED(2,14) is less than that amount, STORED(2,14) is subtracted from that amount, STORED(2,14) is set equal to zero and the program moves on to consider hay crop silage.

If STORED(1,14) is greater than or equal to the now remaining quantity, the quantity is subtracted from STORED(1,14). If STORED(1,14) is less than the quantity, STORED(1,14) is subtracted from the quantity, STORED(1,14) is set equal to zero and the program moves to consider STORED(3,14).

If the available quantity of hay, STORED(3), is greater than or equal to one-third the now remaining quantity, one-third of the quantity is subtracted from STORED(3,14). If STORED(3,14) is less than that quantity, STORED(3,14) is subtracted from the quantity, STORED(3,14) is set equal to zero and "hay purchase" is increased by one-third the now remaining quantity.

14,11 The straw requirement is taken from the dairy routine and if STORED(11,14) is greater than or equal to the total requirement, the quantity is subtracted from STORED(11,14). If STORED(11,14) is less than the quantity required, STORED(11,14) is subtracted from the quantity required, STORED(11,14) is set to zero and the "straw purchase" variable is increased by the now remaining quantity.

14,12 If the present month equals the month in which hay is to be sold, SELMOH, the difference between STORED(3,14) and the product of the quantity of hay to be kept per cow (Q.4, Part II) and the number of cows is added to "hay sale" and that same amount is subtracted from STORED(3,14).

If the present month equals SELMOC (Q.5, Part II), STORED(6,14) minus the product of EXSC (Q.5, Part II) and the quantity of corn used this month as calculated above is added to "corn grain sale" and the same amount is subtracted from STORED(6,14).

If the present month equals SELMOO (Q.6, Part II), STORED(8,14) minus the product of EXSO (Q.6, Part II) and "oats used" as calculated above is added to "oats sale" and the same amount is subtracted from STORED(8,14). If this month

| equals | add | | and set |
|---|---|---|---|
| SELMO(1) | STORED(7,14) | to "wheat sale" | STORED(7,14) = 0 |
| SELMO(2) | STORED(6,14) | to "corn grain sale" | STORED(6,14) = 0 |
| SELMO(3) | STORED(8,14) | to "oats sale" | STORED(8,14) = 0 |
| SELMO(4) | STORED(9,14) | to "soybeans sale" | STORED(9,14) = 0 |
| SELMO(5) | STORED(10,14) | to "field beans sale" | STORED(10,14) = 0 |

If this month equals the month in which corn grain is purchased, BTMOC (Q.8, Part II), the amount of corn bought, CORNBT, is added to STORED(6,14) and to "corn grain purchase." If this month equals the month in which high moisture corn is purchased, BTMHMC (Q.9, Part II), the amount of high moisture corn bought, HMCBT, is added to STORED(4,14) and to "corn grain purchase."

14.13 The income from the sale of each crop is calculated as the amount of that commodity sold multiplied by its price. The price for commodity j is calculated as PRICE(MONTH,j) multiplied by PRICE(13,j). The quantity of each commodity sold is indicated by the following variables:

(1) Wheat sale
(2) Corn grain sale
(3) Oats sale
(4) Soybeans sale
(5) Field Beans sale
(6) Hay sale
(7) Straw sale
(8) Ear Corn sale

The income from the sale of each crop is maintained as a monthly array except that hay and straw sales are combined into the hay income variable and ear corn sales are added to corn income. The sum of all these crop sales is "crop sales." This is maintained as a value for this month and a corresponding variable for the sum to date.

14.14 The amount spent for each crop purchased is the amount purchased multiplied by the sum of the price of the commodity from Q.53, Part II and a hauling charge per unit from Q.34, Part II. The quantities purchased are indicated by:

(1) Hay purchase (tons)
(2) Corn grain purchase (bu.)
(3) Oats purchase (bu.)
(4) Wheat purchase (bu.)
(5) Straw purchase (tons)

Feed purchased is the sum of the amounts spent for the first four items listed plus the amount of supplement purchased multiplied by its price. Price is taken from Q.53, Part II and is the product of the average annual price and the monthly coefficient.

If there is no large truck (machinery item code number 10), hauling costs are calculated as the quantity indicated as sold (as used to calculate income from crops) multiplied by the selling (hauling) costs indicated in Q.34, Part II, i.e. hay selling cost is "hay sale" multiplied by the first item in Q.34, Part II. Total selling cost is calculated as the sum of the costs for each commodity. Accumulated selling cost is also maintained as a variable.

14.15 Storage costs for off-farm storage are calculated as the quantity stored in off-farm storage multiplied by the price from Q.35, Part II. The costs are calculated for:

(1) Corn
(2) Oats
(3) Wheat
(4) Soybeans
(5) Field Beans

The sum of these is maintained as two variables, one for this month total and one for the accumulated amount this year.

Milk sold (lbs.) is taken from the dairy routine and multiplied by the price of milk from Q.53, Part II. The amount received for the sale of dairy cows, cows sold for beef, bred heifers, open heifers, calves and steers sold is also calculated. The quantities sold are indicated by the respective "sale" variables calculated in the Dairy subroutine. Price for dairy cows comes from Q.53, Part II. Price of bred heifers, open heifers and heifers under one year of age are calculated as the price of dairy cows from Q.53, Part II multiplied by the ratio of the price of each respective group of animals in Q.9, Part I to the price of cows in Q.9, Part I. The prices of calves, cows sold for beef and steers is taken from Q.53, Part II in the manner indicated in section 14.13. These items are summed to calculate income from "livestock sold."

In a similar manner the value of purchased livestock is calculated as livestock purchases from the input routine plus bred heifers purchase, fresh cows purchase, open heifers purchase and heifers under 1 year of age purchase multiplifed by their respective prices as determined above. The value of the last four items is added to cash livestock investment.

The value of the inventory of crops is calculated at the end of the last month of the year (after calculations). This is calculated as the quantity in storage (STORED(i,14)) multiplied by the price from Q.53, Part II for each commodity, summed over all crops. The end inventory for one year becomes the beginning inventory for the next.

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Hay purchase | HPUR | (13) |
| 2. Corn purchase (bu.) | CPUR | (13) |
| 3. Oats purchase (bu.) | OPUR | (13) |
| 4. Wheat purchase (bu.) | WPUR | (13) |
| 5. Straw purchase (tons) | STPUR | (13) |
| 6. Supplement purchase | SUPPUR | (13) |
| 7. Corn silage fed | CSFED | (13) |
| 8. Hay crop silage fed | HCSFED | (13) |
| 9. Straw used | STUSE | (13) |
| 10. Corn grain used | CUSE | (13) |
| 11. Oats used | OUSE | (13) |
| 12. Wheat used | WUSE | (13) |
| 13. Ear Corn used | ECUSE | (13) |
| 14. HMC used | HMCUSE | (13) |
| 15. Hay sold (tons) | HSLD | (13) |
| 16. Corn sold (bu.) | CSLD | (13) |
| 17. Oats sold (bu.) | OSLD | (13) |
| 18. Wheat sold (bu.) | WSLD | (13) |
| 19. Soybeans sold (bu.) | SSLD | (13) |
| 20. Field beans sold (bu.) | FSLD | (13) |
| 21. Crop sales ($) | CRPSAL | ( 2) |
| 22. Livestock sales ($) | XLVSAL | (13) |
| 23. Feed purchases ($) | FEDPUR | (13) |
| 24. Livestock purchases ($) | XLVPUR | (13) |
| 25. Hauling costs | HAUL1 | ( 2) |
| 26. Milk sold ($) | XMKSLD | (13) |
| 27. High moisture corn purchase | HMCPUR | (13) |
| 28. Ear Corn sold | ECSLD | (13) |
| 29. Straw sold | STWSLD | (13) |
| 30. Hay crop silage produced (tons) | HCSPRO | (13) |
| 31. Corn silage produced (tons) | CSPRO | (13) |
| 32. Hay produced (tons) | HPRO | (13) |
| 33. High moisture corn produced (bu.) | HMCPRO | (13) |
| 34. Earn Corn produced (bu.) | ECPRO | (13) |
| 35. Shelled Corn produced (bu.) | CPRO | (13) |
| 36. Wheat produced (bu.) | WPRO | (13) |
| 37. Oats produced (bu.) | OPRO | (13) |
| 38. Soybeans produced (bu.) | SPRO | (13) |
| 39. Field beans produced (CWT.) | FPRO | (13) |
| 40. Straw produced (tons) | STPRO | (13) |

| Variable Definition (Cont'd.) | Name | Dimension Code |
|---|---|---|
| 41. Supplies and produce insurance | SUPI | ( 1) |
| 42. Inventory value of crops (a) beg. | CROPVB | ( 1) |
| (b) end | CROPVE | ( 1) |
| 43. Hay fed (tons) | HAYFED | (13) |
| 44. Supplement used (tons) | SUPUSE | (13) |
| 45. Corn sales income | CINC | (13) |
| 46. Field beans sales income | FINC | (13) |
| 47. Hay (and Straw) sales income | HINC | (13) |
| 48. Oat sales income | OINC | (13) |
| 49. Soybean sales income | SINC | (13) |
| 50. Wheat sales income | WINC | (13) |
| 51. Off-farm storage cost | OFCOST | ( 2) |
| 52. Quantities stored off farm (bu.) | OFSTOR | ( 5) |
| 53. Straw purchase cost | STCOST | ( 2) |
| 54. Cash investment in livestock | CASHLS | (13) |

SUBROUTINE BUILDINGS

This subroutine makes the calculations required for the purchase of buildings, determines building depreciation and calculates other building costs. Section 15.1 is carried out by an entry point, BUILDO, which is called by the READI Routine during the first month.

15.1 In the first simulated month the buildings presently owned as indicated in Q.24, Part I are entered in the building set matrix (BSTM(i,j)). The building set matrix is of the following form:

| i \ j | Type Code | Purchase Value | Age | Depreciated Value | Life |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| . | | | | | |
| . | | | | | |
| . | | | | | |
| . | | | | | |
| 15? | | | | | |

In the first empty row the buildings indicated in row one of Q.24, Part I are entered. To do this (1) type code is set at 1, (2) depreciated value is set at the present value from input, (3) age and life are taken directly from input and (4) a "purchase value" is calculated as

$$(\text{depreciated value}) \left(\frac{\text{life}}{\text{life-age}}\right)$$

This is repeated for rows 2 and 3 of Q.24, Part I.

The initial number of one and two-man parlors is calculated from Q.25(c), Part I. If Q.25(c), Part I is odd there is one one-man parlor.

If that number is greater than one, it is divided by two and truncated. This gives the number of two-man parlors.

15.2 If Q.26(a), Part I equals zero, sections 15.2.1 and 15.2.2 are skipped.

15.2.1 A variable called EXCED1 is initially set to zero and each month that COWEXD equals 1 (set to 1 by the dairy routine) EXCED1 is increased by 1 and COWEXD is set to zero. When EXCED1 equals DELAY (Q.59, Part II) buildings for the dairy herd are built if the maximum of 25(a), Part I and 25(b), Part I is less than Q.17(a), Part I. The capacity (amount) of new dairy facilities to build is calculated as the maximum of: (1) the minimum quantity allowed (Q.59, Part II), (2) AMTBLD (Q.59, Part II) multiplied by 25(b), Part I if Q.19(1), Part I is one or 25(a), Part I if Q.19(1), Part I is 2 through 7, or (3) the present number of cows minus either 25(a) if Q.19(1), Part I is 2 through 7 or 25(b), Part I if Q.19(1) is 1. However it must not be greater than Q.17, Part I minus the maximum of Q.25(a), Part I, or Q.25(b), Part I. The cost and handling of the purchase is identical to INPUT subroutine section 3.1.3A.

When dairy buildings are constructed as above, silage storage capacity equal to STORAG(1,1) (Q.60, Part II) multiplied by the capacity (amount) of new dairy facilities calculated above is constructed. If Q.25(g), Part I has a positive value horizontal storage is built and the cost and financial calculations are the same as INPUT subroutine part 3.1.3F. If Q.25(g), Part I has a zero value then upright storage is built and the cost and financial calculations are those indicated in INPUT subroutine part 3.1.3E.

Also when dairy buildings are built dry hay storage equal to

STORAG(1,2), (Q.60, Part II), multiplied by the capacity of new facilities is built. Cost and financial calculations made are identical to those in the INPUT routine part 3.1.3G.

If Q.19(1), Part I is 2 through 7, the parlor facility size is checked. The number of "one-man parlors" multiplied by PARLR1 (Q.61, Part II) plus the number of "two-man parlors" multiplied by PARLR2 is subtracted from the new stall capacity to determine the number of cows for which milking parlor capacity is required. The number of "one-man parlors" and "two-man parlors" are initialized in section 15.1. If this capacity required exceeds 20 percent of PARLR1 (Q.13(c), Part II), then additional parlor capacity is built.

The number of two-man parlors to be built is the increased capacity divided by PARLR2 and rounded down to an integer. If the capacity required exceeds the new two-man parlor capacity by more than 20 percent of PARLR1, one one-man parlor is constructed. The cost and handling of financial calculations are identical to INPUT subroutine part 3.1.3B. This size of parlor check is also carried out whenever the herd size increases by more than 20 percent.

15.2.2 A variable called EXCED2 is initially set at zero and each month that HEFEXD equals 1 this is increased by one and HEFEXD is set back to zero. When EXCED2 $\geq$ DELAY (Q.59, Part II), heifer buildings are built if Q.25(d), Part I is less than Q.17(b), Part I and the number of heifers over one year of age minus Q.25(d), Part I is positive. The quantity to be built is the maximum of (1) the number of heifers over one year of age minus Q.25(d), Part I and (2) the minimum quantity of heifer building capacity allowed (BMIN2(1)). The cost is calculated and financial considerations handled as in INPUT routine 3.1.3C.

A variable called EXCED3 is initially set at zero and each month that CAFEXD equals 1, this is increased by one and CAFEXD is set back to zero. When EXCED3 DELAY, calf (heifer under 1 year) buildings are built if Q.25(e), Part I is less than Q.17(c), Part I and the number of heifers under one year of age minus Q.25(e), Part I is positive. The quantity to be built is the maximum of (1) the number of heifers under 1 year of age minus Q.25(e), Part I and (2) the minimum quantity of heifer building capacity allowed (BMIN2(2)). The cost calculations and financial considerations are handled the same as INPUT routine part 3.1.3D.

15.3 If Q.26(c), Part I equals zero skip section 5.3.1.

15.3.1 If HAYEXD = 1, hay storage capacity equal to the maximum of (1) the sum of STORED(3,14) plus STORED(11,14) minus Q.25(h), Part I and (2) the minimum quantity of hay storage allowed to be constructed (BMIN2(3)), is constructed. The cost and financial calculations are the same as INPUT subroutine section 3.1.3G.

15.4 If Q.26(b), Part I equals zero skip sections 15.4.1, 15.4.2 and 15.4.3.

15.4.1 If ECNEXD = 1, ear corn storage capacity is built. The quantity built is the maximum of STORED(5,14) minus Q.25(i), Part I and the minimum quantity allowed to be constructed (BMIN2(4)). The cost and financial calculations are the same as INPUT subroutine section 3.1.3H.

15.4.2 If GRNEXD = 1, grain storage capacity is built. The quantity to be built is the maximum of (1) the amount by which the farm stored quantity of grain exceeds capacity

$$\left[\sum_{i=6}^{10} \text{STORED}(i,14) - \sum_{i=1}^{10} \text{OFSTOR}(i) - \text{Q.25}(j), \text{ Part I}\right]$$

and (2) the minimum quantity allowed to be built (BMIN2(5)). The cost and financial calculations are handled as in INPUT subroutine section 3.1.3I.

15.4.3 If HMCEXD = 1, high moisture corn storage is purchased. The required capacity to be built is calculated as the maximum of STORED(4, 14) minus Q.25(K), Part I and the minimum quantity allowed to be constructed (BMIN2(6)). The size of silo, cost and financing are handled as shown in INPUT routine section 3.1.3J.

15.5 The building repair costs for this month are calculated as

$$\sum_{\text{all } i} \text{BSTM}(i,2)\ (\text{Q.41(b), Part II})\ (\text{BLDRD(month)})$$

where BLDRD is from Q.41(a), Part II.

The building insurance cost for the year is

$$\sum_{\text{all } i} \text{BSTM}(i,2)\ (\text{Q.38(a), Part II})\ (\text{Q.38(b), Part II}).$$

This is calculated in the month indicated by Q.38(c), Part II.

15.6 Each year in the month of December, the amount of depreciation for the year is calculated and the present value, age, etc. of the building set is brought up to date. The age is increased by 1. Depreciation is calculated as $\left(\frac{\text{purchase value}}{\text{life}}\right)$ and this amount is subtracted from the depreciated value to get the new depreciated value. The depreciation calculated is accumulated in a variable called "building depreciation."

The inventory value of buildings and improvements is calculated as the sum of the depreciated value column of the building set matrix, i.e. building value = $\Sigma$BSTM(i,4). This calculation is made at the end of each year. The end inventory value for one year is the beginning inventory value for the next.

Building sale value can be calculated as the sum of the depreciated

value of buildings with a code value of 1. I.e.

$$\text{building sale value} = \sum_{\substack{i \\ BSTM(i,1)=1}} BSTM(i,4)$$

15.6 The variables calculated and maintained by this subroutine are listed below.

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Buildings & improvements value | | |
| a) Beg. | BLDIVB | ( 1) |
| b) End | BLDIVE | ( 1) |
| 2. Building depreciation | DEPRB | ( 2) |
| 3. Building insurance | BLDI | ( 1) |
| 4. Building repair costs | BLDRP | (13) |
| 5. Building sales value | BLDV | ( 1) |

SUBROUTINE MACH

This subroutine determines machinery requirements, purchases required machines, sells unused machines, replaces machines and calculates machinery costs.

16.1 In Q.19, Part I the systems to be used are chosen. In Q.20(b), Part I the user indicates whether he wants to input his machinery or not. Regardless of whether he enters his machinery or not he may change the definition of a system by changing the position of the 1's in the three systems matrices and/or he may change the variable cost of operating a particular machinery cost system by changing the values in the variable machinery cost matrix, Q.69, Part II). The fixed costs are influenced by adjusting the coefficients in Q.68, Part II.

If the user inputs the machine items using input code 10 as indicated in Part III, the input items are placed in the machinery inventory matrix directly from input. The machinery inventory matrix format is shown below.

MACHINERY INVENTORY MATRIX

| Machine Code No. | New Value | Life | Age | Depreciated Value |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 2 | | | | |
| 4 | | | | |
| 10 | | | | |
| . | | | | |
| . | | | | |
| . | | | | |
| . | | | | |

If the user desires to put in only the machines on the farm and not their life, age and value, he uses input code 11. The values for

life, age and depreciated value are assigned. The new cost and life are taken from Q.68, Part II. Machines are divided into 3 investment classes (1) new cost greater than $5,000, (2) new cost $2,000-$5,000 and (3) under $2,000. The first item in each category is given an age of 1 year, the second 2 years, etc. If at any point the age exceeds the life, the series for that class starts at one again. The present value of the machines is the depreciated value assuming 10 percent salvage value and straight line depreciation. This is calculated as

$$\text{new value} - \left(\frac{\text{90\% new value}}{\text{life}}\right) \text{ (age)}$$

After the machines are entered the number of each machine (M(i)) is calculated by searching machine code numbers in the machinery set.

If the answer to Q.20(a), Part I is 0, no machines are entered by the user and a representative set of machinery is assigned. This is done by setting all M(i) = 0 and completing the machinery check algorithm which follows.

16.2 For each machine, the program first checks to see if the machine is used at all. Machine code numbers are found in Q.68, Part II. The equations used for this are:

$$\sum_{j=1}^{10} XLS(j)LSM(i,j) + \sum_{j=1}^{42} GS(j)JGSM(i,j) = \sum_{j=1}^{35} HS(j)JHSM(i,j)$$

for machines 1 through 13 (i.e. i=1...,13)

$$\sum_{j=1}^{10} XLS(j)LSM(i,j)$$

for machines 14 through 38 (i=14...,38)

$$\sum_{j=1}^{42} GS(j)JGSM(i-25,j) + \sum_{j=1}^{35} HS(j)JHSM(i-25,j)$$

for machines 39 through 43 (i=39...,43)

$$\sum_{j=1}^{42} GS(j)JGSM(i-25,j)$$

for machines 44 through 75 (i=44...,75)

$$\sum_{j=1}^{35} HS(j)JHSM(i-57,j)$$

for machines 76 through 110 (i=76...,110)

If, for any machine, the value of this equation = 0, and

A. M(i) > 0, then M(i) of the machines are sold. This is done by searching the machinery set to find M(i) machines with machine code (i) and adding Q.44, Part II percent of the depreciated value to "machinery sales" and adding (100 - Q.44, Part II) percent of the depreciated value to accumulated machinery depreciation.

B. M(i) = 0, no immediate change is made.

Following sale of unused machines, the following list of equations is used to determine the number of each machine required and to indicate when machines are to be purchased. If an equation calculates the number of machines required, that number is rounded up and the number of machines on hand (M(i)) is subtracted from it. This gives the number of machines to purchase. If the equation does not calculate the number of machines required, the discussion with the equation indicates when purchases are to be made.

When a machine is to be purchased, the code number of that machine is added to an empty cell of the first column of the machinery inventory

matrix. If this is the first month simulated and the answer to Q.20(a), Part I is 0, the new cost and life are taken from Q.68, Part II, machines are divided into 3 investment classes and age and depreciated value are calculated in the same way as is done if input code 11 is used in input (spelled out above). If this is not the first month or the answer to Q.20(a), Part I is 1, only the machinery code number is entered. The remaining elements of the row in which the new machine is entered are left blank.

16.3 The equations listed below require the total number of acres handled by each harvest system. Because the HS array indicates only the number of acres harvested this month, an array called TT is used to indicate the total acres harvested by each harvest system. For oats, wheat, field beans and soybeans the number of acres harvested equals the acreage planted. For corn, a variable called CSACRE is calculated by the corn subroutine which indicates most recent calculation of acres of corn silage harvested or to be harvested. CSACRE is originally estimated for the first year and input by the user (Q.23(b), Part I). Thus the TT variable for the corn silage harvest system in use is set equal to CSACRE. The TT variable for corn grain equals the total corn acreage minus CSACRE.

A similar variable, HSACRE, is maintained for hay crop silage. This is initialized by Q.23(b), Part I. Thereafter it is calculated in the hay routine as the sum of (1) the acreage of first cutting hay crop silage, (2) the acreage of second cutting hay crop silage multiplied by the appropriate coefficient from Q.18, Part II, and (3) the acreage of third cutting hay crop silage multiplied by the appropriate coefficient from Q.18, Part II. The TT variable for hay is calculated

in similar fashion using the hay coefficient from Q.18, Part II. Acreage of first cutting hay is calculated as the total hay acreage minus first cutting pasture and first cutting hay crop silage. Acreage of second and third cutting hay are calculated in similar fashion using second and third cutting pasture and hay crop silage.

16.3.1 For machines 1 through 6, 9, and 10, the number of machine i's required equals the maximum of (Di + Fi) and (Di + Si) where

$$Di = \sum_{j=1}^{10} \left[ LSM(i,j)XLS(j) \frac{1}{TCR(i,j)} \right]$$

$$Si = [(GS(1)JGSM(i,1) + GS(5)JGSM(i,5) + GS(9)JGSM(i,9) + TT(20)JHSM(i,20) + TT(25)JHSM(i,25)) \left(\frac{1}{TCR(i,11)}\right)]$$

$$+ [(GS(2)JGSM(i,2) + GS(6)JGSM(i,6) + GS(10)JGSM(i,10) + GS(19)JGSM(i,19) + GS(22)JGSM(i,22) + GS(16)JGSM(i,16) + TT(21JGSM(i,21) + TT(23)JGSM(i,23) + GS(31)JGSM(i,31) + GS(37)JGSM(i,37) + GS(13)JGSM(i,13) + GS(40)JGSM(i,40) + TT(26)JGSM(i,26) + GS(34)JGSM(i,34)) \left(\frac{1}{TCR(i,12)}\right)]$$

$$+ [(GS(3)JGSM(i,3) + GS(7)JGSM(i,7) + GS(11)JGSM(i,11) + GS(20)JGSM(i,2) + GS(23)JGSM(i,23) + GS(17)JGSM(i,17) + TT(22)JHSM(i,22) + GS(32JGSM(i,32) + GS(35)JGSM(i,35) + GS(38)JGSM(i,38) + GS(14)JGSM(i,14) + GS(41)JGSM(i,41) + TT(27)JGSM(i,27)) \left(\frac{1}{TCR(i,13)}\right)]$$

$$+ [(GS(4)JGSM(i,4) + GS(8)JGSM(i,8) + GS(12)JGSM(i,12) + GS(24)JGSM(i,24) + TT(24)JHSM(i,24) + GS(15)JGSM(i,15) + GS(33)JGSM(i,33) + GS(36)JGSM(i,36) + GS(39)JGSM(i,39) + GS(42)JGSM(i,42) + TT(28)JGSM(i,28) + GS(21)JGSM(i,21) + GS(18)JGSM(i,18)) \left(\frac{1}{TCR(i,14)}\right)]$$

$$+ \left[\left(\sum_{j=25}^{30} GS(j)JGSM(i,j)\right) \left(\frac{1}{2000}\right)\right]$$

$$FI = [(TT(2)JHSM(i,2) + TT(7)JHSM(i,7)) \left(\frac{1}{TCR(i,15)}\right)] + [TT(3)JHSM(i,3)$$

$$+ TT(8)JHSM(i,8) + TT(9)JHSM(i,9) + TT(30)JHSM(i,30) + TT(34)JHSM(i,34)) \left(\frac{1}{TCR(i,16)}\right)\Bigg]$$

$$+ \left[(TT(4)JHSM(i,4) + TT(10)JHSM(i,10) + TT(31)JHSM(i,31)) \left(\frac{1}{TCR(i,17)}\right)\right]$$

$$+ \left[(TT(5)JHSM(i,5) + TT(11)JHSM(i,11) + TT(32)JHSM(i,32) + TT(35)JHSM(i,35) \left(\frac{1}{TCR(i,18)}\right)\right]$$

$$+ \left[\left(\frac{1}{2000}\right) \left(\sum_{j=12}^{15} TT(j)JHSM(i,j) + \sum_{j=16}^{19} TT(j)JHSM(i,j) + TT(1)JHSM(1,1)\right.\right.$$

$$\left.\left. + TT(6)JHSM(i,6) + TT(29)JHSM(i,29) + TT(33)JHSM(i,33)\right)\right]$$

This algorithm essentially assumes that the number of machines required depends on the dairy requirements plus the Fall crop requirements or the dairy requirements plus the Spring crop labor. Of these time periods the one with the peak load determines the number of machines required.

16.3.2 The quantity of machines number 7's, which is a user defined machine, required is calculated using Q.80(a), Part II to indicate the number of acres or animals that one machine can handle. This same method is used for machines 8, 11, 20, 39, 58, 70, 76, 110.

$$\text{No. Machine } 7 = \left(\frac{1}{URQ(1,1)}\right) \left(\sum_{j=1}^{10} (XLS)j)LSM(7,j)\right) + \left(\frac{1}{URQ(1,2)}\right) \left(\sum_{j=1}^{42} (GS(j)JGSM(j,j))\right) + \left(\frac{1}{URQ(1,3)}\right)\left(\sum_{j=1}^{35} TT(j)JHSM(7,j)\right)$$

No. Machine 8 = same as for 7 except

$$7 = 8$$

$$\text{and } URQ(i,j) = URQ(i + 1,j)$$

No. Machine 11 = same as for 7 except

$$7 = 9$$

$$\text{and } URQ(i,j) = URQ(i+2,j)$$

16.3.3 No. Machine 12 = 1 if $\sum_{j=1}^{10} XLS(j)LSM(12,j) > 0$ and

$$\sum_{j=1}^{35} TT(j)JHSM(12,j) = 0$$

$$= 0 \text{ if both sums above} = 0$$

$$\geq 2 \text{ if } \sum_{j=1}^{35} TT(j)JHSM(12,j) > 0$$

$$= 3 \text{ if } \sum_{j=1}^{35} TT(j)JHSM(12,j) > 150$$

$$= 4 \text{ if } \sum_{j=1}^{35} TT(j)JHSM(12,j) > 400$$

No. Machine 13 = same equation as 12 except

$$12 \text{ is replaced by } 13$$

16.3.4 No. Machine 14 through 19 are calculated as:

$$\text{No. of machine } i = \sum_{j=1}^{10} \left[XLS(j)LSM(i,j) \frac{1}{DMR(i=13,j)}\right]$$

16.3.5 Machine 20 = $\sum_{j=1}^{10} \left[XLS(j)LSM(20,j) \frac{1}{URQ(4,1)}\right]$

16.3.6 Machines 21 through 28 (silo unloaders) is calculated as below:

$$\text{If } [Q.25(f), \text{ Part I minus } \sum_{i=21}^{28} \sum_{j=1}^{10} [XLS(j)LSM(i,j)TONS(i)] = Q \leq 0,$$

where TONS(i) is from Q.80(b), Part II, then the number of each size unloader being used $\left(\sum_{j=1}^{10} XLS(j)LSM(i,j) > 0\right)$ is 1. If these machines are not present in the machinery set, they are purchased and the program

moves on to machine 29.

If Q is > 0 a second calculation is made. T is calculated where

$$T = [Q.25(f), \text{ Part I minus } \sum_{i=21}^{28} \sum_{j=1}^{10} [XLS(j)LSM(i,j)TONS(i)M(i)]$$

where TONS is from Q.80(b), Part II and M(i) is the number of machine i's in the machinery set.

If $T \leq 0$, no additional unloaders are to be purchased.

If $T \geq Q$, an unloader of size i (machine i) is purchased if

$\left[\sum_{j=1}^{10} XLS(j)LSM(i,j)\right] > 0$ and $M(i) = 0$. That is a machine is purchased of each size which is to be used but which is not in the machinery set. Then a new $T^1$ is calculated using the same formula as for T. The additional unloaders to purchase are calculated by searching through the TONS(i) to find the one with the smallest value of i which exceeds $T^1$ and for which $\sum_{j=1}^{10} XLS(j)LSM(i,j) > 0$ (machine i is used). When this is found an additional machine i is purchased. If none is found the largest unloader (with largest TONS(i)) in use is purchased, TONS(i) is subtracted from $T^1$ and the searching process is started again.

If $T < Q$, the number of additional machines is found by searching as above but using T instead of $T^1$.

16.3.7 Machine 29 = 1 if $\sum_{j=1}^{10} XLS(j)LSM(29,j) > 0$

= 0 otherwise

16.3.8 Machines 30 through 35 are calculated as indicated below.

$$12.5(Q.24(b), \text{ Part II}) \left(\sum_{j=1}^{7} XLS(j)\right) = G \text{ (gallons of storage required.}$$

If $Q \leq 0$

where $Q = (G - \sum_{i=30}^{35} B(i)M(i))$ and $B(30) = 400$, $B(31) = 600$, $B(32) = 800$, $B(33) = 1000$, $B(35) = 2000$,

the number of each size for which $\sum_{j=1}^{7} XLS(j)LSM(i,j) \quad 0$ is 1.

If this number of machines is not present, additional machines are purchased and the program moves to machine 36.

If $Q > 0$, then T is calculated where

$$T = (G - \sum_{i=30}^{35} B(i)M(i))$$

and M(i) is the number of machine i's in the machinery set. If $T \leq 0$ no additional bulk tanks need be purchased. The program moves to machine 36.

If $T \geq Q$, a tank is purchased for each size (i) for which $\sum_{j=1}^{7} XLS(j)LSM(i,j) > 0$ and $M(i) = 0$. Then a new $T^1$ is calculated using the same formula as for T (last formula) and the additional bulk tanks to purchase is calculated by searching the B(i) for the smallest value which exceeds $T^1$ and for which $\sum_{j=1}^{7} XLS(j)LSM(i,j) > 0$. When this is found the additional machine (i) is purchased. If none is found the largest bulk tank in use ($\sum_{j=1}^{7} LS(j)LSM(i,j) > 0$) is purchased, B(i) is subtracted from $T^1$ and the searching starts again.

<u>16.3.9</u> Machine 36 = $\sum_{j=1}^{7} [XLS(j)LSM(i,j) \frac{1}{DMR(7,j)}]$

where DMR(i,j) is from Q.80(d), Part II.

Machine 37 = same as 36 except DMR(7,j) is replaced by DMR(8,j).

Machine 38 = same as 36 except DMR(7,j) is replaced by DMR(9,j).

16.3.10 Machine 39 = $\left[\sum_{j=1}^{42} GS(j)JGSM(14,j) \frac{1}{URQ(5,2)} + \sum_{j=1}^{35} TT(j)JHSM(14,j) \frac{1}{URQ(5,3)}\right]$

where URQ(i,j) is from Q.80(a), Part II

16.3.11 Machine 40 through 42:

First check to be sure that at least one cultivator of each size used is on hand. That is if

$$\sum_{j=1}^{42} GS(j)JGSM(14,j) + \sum_{j=1}^{35} TT(j)JHSM(14,j) > 0$$

At least one machine 40 should be in the machinery matrix. If it is not, one is purchased. Machines 41 and 42 are handled similarly except that in the equations 14 is replaced by 15 and 16 respectively.

$$\text{If } \sum_{j=1}^{12} GS(j) + \sum_{j=31}^{42} GS(j) - M(40)XMACP(1) - M(41)XMACP(2) - M(42)XMACP3 = Q$$

where XMACP is from Q.80(e), Part II

is: $\leq 0$ no additional machines need be purchased.

$\geq 0$ purchase one machine of largest size in use (i.e. purchase machine 42 if $\sum_{j=1}^{42} GS(j)JGSM(17,j) + \sum_{j=1}^{35} TT(j)JHSM(17,j) = S > 0$.

If S is not > 0, purchase one machine 41 if $\sum_{j=1}^{42} GS(j)JGSM(16,j) + \sum_{j=1}^{35} TT(j)JHSM(16,j)$ is > 0, similarly for machine 40. After

one machine is purchased recalculate Q and repeat the process.

16.3.12 Machine 43 = the maximum of

$$(1)\ \sum_{j=1}^{42} GS(j)JGSM(18,j)\left(\frac{1}{MACP(4)}\right) \text{ or } (2)\ \sum_{j=1}^{35} TT(j)JHSM(18,j)\left(\frac{1}{XMACP(4)}\right)$$

16.3.13 Machines 44 through 57:

1. If $\sum_{j=1}^{42} GS(j)JGSM(19,j) > 0$, then M(44) should be $\geq 1$.

   If it is not, one is purchased.

   This is repeated for machines 45 through 57 with 19 replaced by 20 through 32 respectively.

2. If [(M(44) + M(45))(2) + (M(46) + M(47))(3) + (M(48)) + M(49))(4) + (M(50) + M(51))(5) + (M(52) + M(53))(6) + (M(54) + M(55))(7) + (M(56) + M(57))(8)][XMACP(5)]

   $$- \left[\sum_{j=1}^{12} GS(j) + \sum_{j=19}^{24} GS(j) + \sum_{j=31}^{42} GS(j)\right] = Q$$

   is $\geq 0$ no additional plows need be purchased.

   $< 0$ purchase an additional plow of the largest size indicated as in use and return to recalculation of Q.

16.3.14 Machine 58:

$$\text{Number required} = \sum_{j=1}^{42} GS(j)JGSM(33,j)\frac{1}{URQ(6,2)}$$

16.3.15 Machines 59 through 64:

1. If $\sum_{j=1}^{42} GS(j)JGSM(34,j) > 0$, then M(59) should be $\geq 1$. If it is not, one is purchased. This is repeated for machines 60 through 64 with 34 replaced by 35 through 39 respectively.

2. If [(M(59)(8) + M(60)(10) + M(61)(12) + M(62)(14) + M(63)(16) +

$$M(64)(18))\ (XMACP(6)] - \sum_{j=1}^{12} GS(j) + \sum_{j=19}^{24} GS(j) + \sum_{j=31}^{42} GS(j)] = Q$$

Is 0 no additional machines in this group need be purchased.

0 purchase an additional disc of the largest size indicated as in use and return to calculation of Q.

16.3.16 Machines 65 through 69:

1. If $\sum_{j=1}^{42} GS(j)JGSM(40,j) > 0$, the number of machine 65's should be $\geq 1$. If it is not, one is purchased. This is repeated for machines 66 through 69 with 40 replaced by 41 through 44 respectively.

2. If $[(M(65)(2.25) + M(66)(3) + M(67)(4) + M(68)(5) + M(69)(6))$

$$(XMACP(7))] - \left[\sum_{j=1}^{12} GS(j) + \sum_{j=19}^{24} GS(j) + \sum_{j=31}^{42} GS(j)\right] = Q$$

is $\geq 0$, no additional machines in this group need be purchased.

$< 0$, purchase an additional harrow of the largest size in use and return to recalculation of Q.

16.3.17 Machine 70 $= \left[\sum_{j=1}^{42} GS(j)JGSM(70,j) \frac{1}{URQ(7,2)}\right]$

16.3.18 Machines 71 through 73:

1. If $\sum_{j=1}^{42} GS(j)JGSM(46,j) > 0$, the number of machine 71's should be $\geq 1$. If it is not, one is purchased. This is repeated for machines 72 and 73 with 46 replaced by 47 and 48 respectively.

2. If $[(M(71) + M(72)(2) + M(73)(3))\ (XMACP(8))] -$

$$\left[\sum_{j=1}^{12} GS(j) + \sum_{j=31}^{42} GS(j)\right] = Q$$

is $\geq$ 0 no additional planters need be purchased.

$<$ 0 purchase an additional planter of the largest size in use and return to calculation of Q.

16.3.19 Machine 74:

1. If $\sum_{j=1}^{42} GS(j)JGSM(49,j) > 0$, the number of machine 74's (i.e. M(74)) should be $\geq$ 1. If it is not one is purchased.

2. If $\left[\left(\sum_{j=1}^{12} GS(j) + \sum_{j=19}^{24} GS(j) + \sum_{j=31}^{42} GS(j)\right)\left(\frac{1}{XMACP(9)}\right)\right]$ is $>$ 1, the number is rounded up to equal the number required.

16.3.20 Machine 75:

1. If $\sum_{j=1}^{42} GS(j)JGSM(50,j) > 0$, the number of machine 75's (M(75) should be $\geq$ 1. If it is not, one is purchased.

2. If $\left[M(75)\ (XMACP(10)) - \sum_{j=13}^{28} GS(j)\right] = Q$

is $\geq$ 0 no additional drills need be purchased.

$<$ 0 purchase 1 drill and return to the calculation of Q.

16.3.21 Machine 76:

$$\text{The number required} = \sum_{j=1}^{35} TT(j)JHSM(19,j)\ \frac{1}{URQ(8,3)}$$

16.3.22 Machines 77 through 79:

1. If $\sum_{j=1}^{35} TT(j)JHSM(20,j) > 0$, then the number of machines 77's is $\geq$ 1. If M(77) is $<$ 1, one is bought.

This is repeated for machine 78 and 79 with 20 replaced by 21 and 22 respectively.

2. If [M(77)XMACP(11) + M(78)XMACP(11)(2) + M(79)XMACP(13)(2) - (acres of corn silage from corn subroutine)] = Q

   is $\geq$ 0 no additional choppers need be purchased.

   $<$ 0 purchase the largest size chopper being used (largest machine no.) and return to recalculation of Q.

3. If [M(77)XMACP(12) + M(78)XMACP(12)(2) + M(79)XMACP(14)(2) - (acres of hay crop silage from the Hay routine = $\sum_{j=20}^{24}$ TT(j))] = Q

   is $\geq$ 0 no additional choppers need be purchased.

   $<$ 0 purchase the largest size chopper being used (largest machine no.) and return to recalculation of Q.

   NOTE: Both 2 and 3 are carried out regardless of the results of the other.

16.3.23 Machine 80:

1. If $\sum_{j=1}^{35}$ TT(j)JHSM(23,j) $>$ 0, the number of machine 80's is $\geq$ 1.

   If that machine is not present, it is purchased.

2. If (Q.25(f), Part I) $\left(\frac{1}{\text{XMACP(15)}}\right)$ = Q is $>$ 1, Q is rounded up to get the number required.

16.3.24 Machine 81:

If $\sum_{j=1}^{35}$ TT(j)JHSM(24,j) $>$ 0, the number of machine 81's = 1.

Otherwise, it equals 0.

16.3.25 Machines 82 through 85:

1. If $\sum_{j=1}^{35}$ TT(j)JHSM(25,j) $>$ 0, the number of machines $\geq$ 1. If the one is not present, it is purchased.

2. If [(acres of corn grain = $\sum_{j=6}^{11}$ TT(j)) - [M(82)XMACP(16) +

M(83)XMACP(16)(2) + M(84)XMACP(17)(2) + M(85)XMACP(17)(3)]] = Q

is $\leq$ 0 no additional machines need be purchased.

$>$ 0 an additional machine of the largest machine code no. (82-85) is purchased and the program returns to recalculate Q.

16.3.26 Machine 86:

1. If $\sum_{j=1}^{35}$ TT(j)JHSM(29,j) $>$ 0 the number required is $\geq$ 2. If they are not present (i.e. if M(86) $<$ 2), the difference between M(86) and 2 are purchased.

2. If $\sum_{j=1}^{35}$ TT(j)JHSM(29,j) $\frac{1}{\text{XMACP(18)}}$ = Q

is $\geq$ 2 no additional wagons need be purchased.

$<$ 2 the number required is the maximum of Q and T where

T = (2)(M(84) + M(85) + M(89) + M(90) + M(91)).

16.3.27 Machine 87:

The number required = 1 if $\sum_{j=1}^{35}$ TT(j)JHSM(30,j) $>$ 0.

= 0 otherwise.

16.3.28 Machine 88:

The number required = 1 if $\sum_{j=1}^{35}$ TT(j)JHSM(31,j) $>$ 0

= 0 otherwise.

16.3.29 Machines 89 through 91:

1. If $\sum_{j=1}^{35}$ TT(j)JHSM(32) $>$ 0, the number of machine 89's required $\geq$ 1.

If that one is not present, purchase it.

2. If $\left[\sum_{j=12}^{19} TT(j) \frac{1}{XMACP(19)}\right] = Q$ and $\left[\left(\sum_{j=6}^{11} TT(j)\right)\begin{pmatrix}0 \text{ if } [M(81)+M(88)] = 0\\ 1 \text{ if } [M(81)+M(88)] > 0\end{pmatrix}\right.$

$\left. + \sum_{j=33}^{35} TT(j)\right] \left(\frac{1}{XMACP(19)}\right) = T$ and $[(M(89)(1)+M(90)(1.2)+M(91)(1.4))]$

- (maximum of Q or T) = S

No additional combine need be purchased if $S \geq 0$.

If $S < 0$ purchase the largest size combine (largest of 89-91)

in use and return to calculation of S.

16.3.30 Machine 92:

If $\sum_{j=1}^{35} TT(j)JHSM(35,j) > 0$ the number of bale throwers required is

the maximum of 1 or M(97).

16.3.31 Machines 93 through 95:

1. If $\sum_{j=1}^{35} TT(j)JHSM(36,j) > 0$, the number of machine 93's is $\geq 1$.

If that one is not present, purchase it. Repeat this for

machine 94 and 95 with 36 replaced by 37 and 38 respectively.

2. If $[(M(93)(1,2) + M(94)(1.2) + M(95)(1.4)) -$

$\left(\sum_{j=20}^{28} TT(j)\right) \left(\frac{1}{XMACP(20)}\right)] = Q$

is $\geq 0$ no additional windrowers need be purchased.

$< 0$ purchase the largest windrower in use and return to

calculation of Q.

16.3.32 Machine 96:

The number required = 1 if $\sum_{j=1}^{35} TT(j)JHSM(39,j) > 0$

= 0 otherwise.

16.3.33 Machine 97:

$$\text{The number} = \sum_{j=25}^{28} TT(j)JHSM(40,j)\ \frac{1}{MACP(21)}$$

16.3.34 Machine 98:

The number required equals the maximum of

$$\sum_{j=1}^{35} TT(j)JHSM(41,j)\ \frac{1}{XMACP(22)}$$ and 2 but cannot exceed 6(M(97)).

16.3.35 Machine 99:

$$\text{The number required} = 1 \text{ if } \sum_{j=1}^{35} TT(j)XHSM(42,j) > 0$$

$$= 0 \text{ otherwise}$$

Machine 100:

$$\text{The number required} = 1 \text{ is } \sum_{j=1}^{35} TT(j)JHSM(43,j) > 0$$

$$= 0 \text{ otherwise}$$

Machines 101 through 103:

Same as 100 except 43 is replaced by 44, 45, and 46 respectively.

16.3.36 Machine 104 and 105:

1. If $\sum_{j=1}^{35} TT(j)JHSM(47,j) > 0$ the number of machine 104's equals

   the maximum of 1 or M(77).

2. Use same procedure for machine 105 replacing 47 with 48 and

   M(77) with M(78).

16.3.37 Machine 106:

1. If $\sum_{j=1}^{35} TT(j)JHSM(49,j) > 0$ the number of machine 106's required

equals the maximum of (1) 1, (2) the minimum of

$$(a)\ \sum_{j=29}^{32} TT(j)\ \frac{1}{XMACP(23)(4)} \quad \text{and (b) } M(41).$$

16.3.38 Machine 107:

If $\sum_{j=1}^{35} TT(j)JHSM(50,j) > 0$ the number of machine 107's required

equals the maximum of (1) 1, (2) the minimum of (a) M(42) and

$$(b)\ \sum_{j=29}^{32} TT(j)\ \frac{1}{XMACP(23)(6)}$$

16.3.39 Machine 108:

If $\sum_{j=1}^{35} TT(i)JHSM(51,j) > 0$ the number required equals

$$\sum_{j=29}^{32} TT(j)\ \frac{1}{XMACP(24)}\ .$$

16.3.40 Machine 109:

If $\sum_{j=1}^{35} TT(j)JHSM(52,j) > 0$ the number required equals the maximum

of (1) $\sum_{j=29}^{32} TT(j)\ \frac{1}{XMACP(24)}$ and (2) (M(89) + M(90) + M(91)).

16.3.41 Machine 110:

The number equals $\sum_{j=1}^{35} TT(j)JHSM(53,j)\ \frac{1}{URQ(93)}\ .$

16.3.42 After all machines have been checked and additional ones purchased where necessary, machine 86 is rechecked. This is necessary because the quantity of other machines on hand enters into the calculations used to determine the number of machines of this type required.

16.4 As is implied by the method of handling machine purchases discussed

in section 16.2, the above equations and procedures are also used to be sure that the machinery on hand is sufficient to handle the livestock and crops being grown and to be sure that the machinery on hand is used. If the answer to Q.20(b), Part I is 1, the subroutine uses the check procedure described in section 16.4.1 to determine whether it is necessary to check the sufficiency and necessity of machines on hand or not. (If Q.20(b), Part I is zero and Q.20(a), Part I is zero, these equations are used only during the first month simulated. If Q.20(b), Part I is zero and Q.20(a), Part I is one, these equations are never used.)

If the system numbers in Q.19, Part I are changed or the machines used within a system are changed, the input subroutine sets variables ICHSYS or MCYSYS equal to one, respectively. If either of these variables equal one and Q.20(b), Part I equals one the machines on hand are checked.

16.4.1 To avoid calculation of the equations listed in section 16.3 when it is unnecessary, the following check procedure is used. A two column array is maintained (PRESET(10,2)). The rows of this array represent the number of acres of each of the six crops, total crop acres, acres of corn silage, acres of hay crop silage and number of cows. The first column represents the value of these items the last time machinery was checked. The second column indicates the present values of these items. In any month when the present value exceeds the column one value by more than the maximum of (1) the column one value plus 25 and (2) the column one value plus 25 percent, the machines on hand are checked.

16.5 Machine codes 111 and 112 indicate milking parlor equipment and dairy building equipment respectively. These are always entered in the

machinery inventory matrix by the BUILDI or INPUT subroutines. This subroutine replaces this equipment as it wears out and calculates depreciation. If age equals life for the milking parlor age is set equal to zero, life is set equal to PLIFE (Q.28(e), Part II) and both new value and depreciated value are set equal to the new price. The new price is calculated as PCOST2 (Q.64(b), Part II) if the new value of the old machine is less than or equal to PCOST2; if it is greater, the new price is PCOST4 (Q.64(b), Part II). The price calculated is added to machinery purchased.

If age equals life for the dairy building equipment, age is set equal to zero, life is set equal to PLIFE and the depreciated value is set equal to the new value existing in the matrix. The new value is added to machinery purchased. For both machines 111 and 112 the undepreciated value at the time age equals life is added to machinery depreciation. Parlors are replaced during month two and building equipment during month eight.

16.6 Each month the program replaces machines for which age equals life and the month of the year being simulated equals the month of replacement for that machine (from Q.68, Part II). When a machine is replaced, the same row of the machinery set is used, the machine code is not changed. The purchase price and life come from Q.68, Part II, age is set at zero and depreciated value equals the new value.

The amount paid to purchase the machinery is the purchase value minus the salvage value of the old machine purchased. This is calculated before the new depreciated value is entered. It is added to the variable indicating the total value of machinery purchased this month.

16.6.1 As part of the search for machines to be replaced, a search is

also made for machine items that are to be purchased this month. This is indicated by rows in the machinery inventory matrix with only a code number entered. Column two (as well as three, four and five) are zero. If the month of purchase from Q.68, Part II equals the month being simulated for any such machine, it is purchased. The purchase price and life are taken from Q.68, Part II. Age is set equal to zero. Depreciated value equals the new value. The total purchase price is added to the variable indicating the total value of machinery purchased this month.

16.6.2 After all machine purchase or replace calculations have been made for the month being simulated, the total value of machinery purchased this month is added to machinery purchase and is entered in the debt array. One row of the debt array is used. The beginning balance equals the total value of machinery purchased this month. Interest rate, number of payments, loan period and type of loan are taken from Q.12, Part II. The term of loan is set to 6.

16.7 Each December, age is advanced one year and depreciation is calculated for each machine.

$$\text{Depreciation} = \frac{\text{90 percent of New Value}}{\text{Life}}$$

If the calculated depreciation exceeds the depreciated value of the machine, depreciation is set equal to the depreciated value. Depreciation is subtracted from the depreciated value to get the new depreciated value. The total amount of depreciation is accumulated for the year.

16.8 After all purchases, sales, depreciation calculations and age changes are made, the value of machinery is calculated by summing the depreciated values of all machines. This is done after machinery is entered during the first month and at the end of the last month of the

first year. The first is the beginning inventory and the second is the ending inventory. Each year a new ending inventory is calculated. The end inventory for one year is the beginning inventory for the next.

16.9 Insurance cost is calculated as the depreciated value of all machines in the machinery inventory matrix multiplied by (Q.37(a), Part II) (Q.37(b), Part II) and the amount is calculated (and paid) in the month indicated in Q.44, Part II.

16.10 The machinery repair costs for each system are calculated each month. This is done by multiplying the total annual machine repair cost per unit (Q.69, Part II) by the percentage of that requirement which occurs this month from Q.70, Part II and then multiplying that total by the number of units of the system for livestock (XLS(j)) and crop grow (GS(j)) systems and by the number of units harvested for the harvest systems (HS(j)).

Thus the equations for livestock would be of the form

$$Q = XMRGO(i,1)XMDMC(month,j)XLS(j)$$

where i = system number

j = correct column for that system from Q.70, Part II

Q = machinery repair cost

XMRGO is from Q.69, Part II

and XMDMC is from Q.70, Part II.

Similar equations for crop grow systems would be of the form

$$Q = XMRGO(i + 10,1)XMDMC(Month,j)GS(j)$$

and equations for harvest systems would be of the form

$$Q = XMRGO(i + 52,1)XMDMC(Month,j)HS(j)$$

These equations are calculated only for the systems indicated in Q.19, Part I. The costs for all other systems are zero. The total machinery

repair costs for the month is the sum of the amount for all systems.

The Gas and Oil costs for each system are calculated by the exact same equations except that the column identification of the XMRGO coefficient is 2 instead of 1. The annual gas and oil costs for each system are used from Q.69, Part II. Gas and oil cost is also accumulated for the month.

16.11 The following list of variables are calculated and maintained by this subroutine.

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Gas and oil cost | CASO | (13) |
| 2. Machinery repair cost | XMCHRP | (13) |
| 3. Machinery insurance cost | XMCHI | ( 1) |
| 4. Machinery depreciation | DEPRM | ( 2) |
| 5. Inventory value of machines | | |
| (a) Beg. | XMCHVB | ( 1) |
| (b) End | XMCHVE | ( 1) |
| 6. Machinery sold | XMSLD | (13) |
| 7. Machinery purchased | XMPUR | (13) |

SUBROUTINE LABOR

This subroutine handles labor requirement and cost calculations for the entire farm business.

17.1 Three matrices of labor requirements per month are maintained. These matrices contain the labor requirements for livestock systems, grow systems and harvest systems and are dimensioned 1x10(XLRL), 1x42(XLRG) and 1x35(XLRH) respectively. The value for each matrix cell is the labor required per unit of that system and is represented by an equation or set of equations with the month of the year as one of the variables. These equations are used to calculate the matrix values at the beginning of each month. Calculations are made only for systems being used (Q.19, Part I).

17.1.1 For the dairy herd, a size of herd group number is first calculated as follows:

JACOW = Herd group no. = 1 if no. of cows is less than 30
2 if no. of cows is 31-49
3 if no. of cows is 50-79.
4 if no. of cows is 80-149
5 if no. of cows is 150 and over

The equations are of the form

$$XLRL(i) = (XMDC(1, \text{month of year}))\left(\frac{DCS(JACOW,i)}{12}\right)$$

where i = dairy system number (i=1,...,7)

DCS is from Q.54, Part II

and XMDC is from Q.55, Part II

The equations for youngstock are

$$XLRL(8) = (XMDC(2,\text{month of year}))\left(\frac{(DRS(1,1))(XX) + (DRS(2,1))(YY)}{ZZ}\right)$$

$$XLRL(9) = (XMDC(2,\text{month of year}))\left(\frac{(DRS(1,2)(XX) + (DRS(2,2))(YY)}{ZZ}\right)$$

$$XLRL(10) = (XMDC(2,\text{month of year})) \left(\frac{(DRS(1,3)(XX) + (DRS(2,3)(YY)}{ZZ}\right)$$

where XX = number of heifers under one year + number of steer calves

YY = number of heifers over one year + number of steers on feed

ZZ = total number of heifers and steers

DRS is from Q.56, Part II

and XMDC is from Q.57, Part II

17.1.2 Equations for calculation of grow and harvest systems labor requirements per acre are listed below. Prior to the list of equations for each crop, a size code indicating the number of acres or units of that crop is calculated.

For Corn

Corn Acres Code = 1 if acres of corn (Q.22, Part I) is less than 25
2 if acres of corn (Q.22, Part I) is 26-50
3 if acres of corn (Q.22, Part I) is 51-75
4 if acres of corn (Q.22, Part I) is 76-100
5 if acres of corn (Q.22, Part I) is 101-150
6 if acres of corn (Q.22, Part I) is 151-200
7 if acres of corn (Q.22, Part I) is greater than 200

and XLRG(1) = [CPS(1)] [CPD(month, 1)] [RLE(corn acres code, 1)]

XLRG(2) = [CPS(2)] [CPD(month, 1)] [RLE(corn acres code, 2)]

XLRG(3) = [CPS(3)] [CPD(month, 1)] [RLE(corn acres code, 3)]

XLRG(4) = [CPS(4)] [CPD(month, 2)] [RLE(corn acres code, 4)]

XLRG(5) = [CPS(5)] [CPD(month, 3)] [RLE(corn acres code, 1)]

XLRG(6) = [CPS(6)] [CPD(month, 3)] [RLE(corn acres code, 1)]

XLRG(7) = [CPS(7)] [CPD(month, 3)] [RLE(corn acres code, 3)]

XLRG(8) = [CPS(8)] [CPD(month, 4)] [RLE(corn acres code, 4)]

XLRG(9) = [CPS(9)] [CPD(month, 5)] [RLE(corn acres code, 1)]

XLRG(10) = [CPS(10)] [CPD(month, 5)] [RLE(corn acres code, 2)]

XLRG(11) = [CPS(11)] [CPD(month, 5)] [RLE(corn acres code, 3)]

XLRG(12) = [CPS(12)] [CPD(month, 6)] [RLE(corn acres code, 4)]

where (1) CPS is the crop system's annual labor requirements from Q.57, Part II

(2) CPD is the crop system's distribution of labor by months (monthly distribution of annual labor) from Q.71, Part II.

and (3) RLE is the relative size efficiency from Q.72, Part II.

For Corn Silage, the corn silage acres code (JCSAC) =

1 if acres of corn silage (CSACRE) is < 25
2 if acres of corn silage (CSACRE) is 26-50
3 if acres of corn silage (CSACRE) is 51-75
4 if acres of corn silage (CSACRE) is 76-100
5 if acres of corn silage (CSACRE) is 101-150
6 if acres of corn silage (CSACRE) is 150-200
7 if acres of corn silage (CSACRE) is > 200

and XLRH(1) = [CPS(43)] [RLE(JCSAC, 5)]

XLRH(2) = [CPS(44)] [RLE(JCSAC, 5)]

XLRH(3) = [CPS(45)] [RLE(JCSAC, 6)]

XLRH(4) = [CPS(46)] [RLE(JCSAC, 7)]

XLRH(5) = [CPS(47)] [RLE(JCSAC, 8)]

For Corn Grain, the corn grain acres code (JCGAC) =

1 if acres of corn grain is < 25
2 if acres of corn grain is 26-50
3 if acres of corn grain is 51-75
4 if acres of corn grain is 76-100
5 if acres of corn grain is 101-150
6 if acres of corn grain is 151-200
7 if acres of corn grain is > 200

and XLRH(6) = [CPS(48)] [RLE(JCGAC, 5)]

XLRH(7) = [CPS(49)] [RLE(JCGAC, 5)]

XLRH(8) = [CPS(50)] [RLE(JCGAC, 6)]

XLRH(9) = [CPS(51)] [RLE(JCGAC, 6)]

XLRH(10) = [CPS(52)] [RLE(JCGAC, 7)]

XLRH(11) = [CPS(53)] [RLE(JCGAC, 8)]

For wheat, the wheat acreage code (JWAC) =

1 if acres of wheat (Q.22, Part I) is < 25
2 if acres of wheat (Q.22, Part I) is 26-50
3 if acres of wheat (Q.22, Part I) is 51-75
4 if acres of wheat (Q.22, Part I) is 76-100
5 if acres of wheat (Q.22, Part I) is 101-150
6 if acres of wheat (Q.22, Part I) is 151-200
7 if acres of wheat (Q.22, Part I) is > 200

and XLRG(13) = [CPS(13)] [CPD(month, 7)] [RLE(JWAC, 14)]

XLRG(14) = [CPS(14)] [CPD(month, 7)] [RLE(JWAC, 15)]

XLRG(15) = [CPS(15)] [CPD(month, 8)] [RLE(JWAC, 16)]

XLRG(16) = [CPS(16)] [CPD(month, 9)] [RLE(JWAC, 14)]

XLRG(17) = [CPS(17)] [CPD(month, 9)] [RLE(JWAC, 15)]

XLRG(18) = [CPS(18)] [CPD(month, 10)] [RLE(JWAC, 16)]

XLRH(12) = [CPS(54)] [RLE(JWAC, 27)]

XLRH(13) = [CPS(55)] [RLE(JWAC, 28)]

XLRH(14) = [CPS(56)] [RLE(JWAC, 29)]

XLRH(15) = [CPS(57)] [RLE(JWAC, 30)]

For oats, the oats acreage code (JOAC) =

1 if acres of oats is < 25
2 if acres of oats is 26-50
3 if acres of oats is 51-75
4 if acres of oats is 76-100
5 if acres of oats is 101-150
6 if acres of oats is 151-200
7 if acres of oats is > 200

and XLRG(19) = [CPS(19)] [CPD(month, 11)] [RLE(JOAC, 9)]

XLRG(20) = [CPS(20)] [CPD(month, 11)] [RLE(JOAC, 10)]

XLRG(21) = [CPS(21)] [CPD(month, 12)] [RLE(JOAC, 11)]

XLRG(22) = [CPS(22)] [CPD(month, 13)] [RLE(JOAC, 9)]

XLRG(23) = [CPS(23)] [CPD(month, 13)] [RLE(JOAC, 10)]

XLRG(24) = [CPS(24)] [CPD(month, 14)] [RLE(JOAC, 11)]

XLRH(16) = [CPS(58)] [RLE(JOAC, 31)]

XLRH(17) = [CPS(59)] [RLE(JOAC, 32)]

XLRH(18) = [CPS(60)] [RLE(JOAC, 33)]

XLRH(19) = [CPS(61)] [RLE(JOAC, 34)]

If the acres of hay crop (Q.22 (a), Part I) multiplied by the coefficient in Q.18, Part II = < 25 the hay crop plant code (JHCPC) is 1
26-50 the hay crop plant code (JHCPC) is 2
51-75 the hay crop plant code (JHCPC) is 3
76-100 the hay crop plant code (JHCPC) is 4
101-150 the hay crop plant code (JHCPC) is 5
151-200 the hay crop plant code (JHCPC) is 6
> 200 the hay crop plant code (JHCPC) is 7

and XLRG(25) = [CPS(25)] [CPD(month, 15)] [RLE(JHCPC, 23)]

XLRG(26) = [CPS(26)] [CPD(month, 15)] [RLE(JHCPC, 24)]

XLRG(27) = [CPS(27)] [CPD(month, 16)] [RLE(JHCPC, 25)]

XLRG(28) = [CPS(28)] [CPD(month, 17)] [RLE(JHCPC, 26)]

For Hay Crop silage, the hay crop silage acreage code (JHCSAC) =

1 if the acres of HCS (HSACRE) is < 25
2 if the acres of HCS (HSACRE) is 26-50
3 if the acres of HCS (HSACRE) is 51-75
4 if the acres of HCS (HSACRE) is 76-100
5 if the acres of HCS (HSACRE) is 101-150
6 if the acres of HCS (HSACRE) is 151-200
7 if the acres of HCS (HSACRE) is > 200

and XLRH(20) = [CPS(62)] [RLE(JHCSAC, 39)]

XLRH(21) = [CPS(63)] [RLE(JHCSAC, 40)]

XLRH(22) = [CPS(64)] [RLE(JHCSAC, 41)]

XLRH(23) = [CPS(65)] [RLE(JHCSAC, 42)]

XLRH(24) = [CPS(66)] [RLE(JHCSAC, 43)]

For Hay, the hay crop acres code (JHCAC) =

1 if acres of hay crop is 25
2 if acres of hay crop is 26-50
3 if acres of hay crop is 51-75
4 if acres of hay crop is 76-100
5 if acres of hay crop is 101-150
6 if acres of hay crop is 151-200
7 if acres of hay crop is > 200

and XLRG(29) = [CPS(29)] [CPD(month, 18)] [RLE(JHCAC, 12)]

XLRG(30) = [CPS(30)] [CPD(month, 19)] [RLE(JHCAC, 13)]

Acres of hay equals hay crop acres minus hay crop silage acreage.

Hay harvest acreage code (JHHAC) =

1 if acres of hay is < 25
2 if acres of hay is 26-50
3 if acres of hay is 51-75
4 if acres of hay is 76-100
5 if acres of hay is 101-150
6 if acres of hay is 151-200
7 if acres of hay is > 200

and XLRH(25) = [CPS(67)] [RLE(JHHAC, 44)]

XLRH(26) = [CPS(68)] [RLE(JHHAC, 45)]

XLRH(27) = [CPS(69)] [RLE(JHHAC, 46)]

XLRH(28) = [CPS(70)] [RLE(JHHAC, 47)]

For Field beans, the field bean acreage code (JFBAC) =

1 of acres of field beans (Q.22, Part I) is < 25
2 of acres of field beans (Q.22, Part I) is 26-50
3 of acres of field beans (Q.22, Part I) is 51-75
4 of acres of field beans (Q.22, Part I) is 76-100
5 of acres of field beans (Q.22, Part I) is 101-150
6 of acres of field beans (Q.22, Part I) is 151-200
7 of acres of field beans (Q.22, Part I) is > 200

and XLRG(31) = [CPS(31)] [CPD(month, 20)] [RLE(JFBAC), 17)]

XLRG(32) = [CPS(32)] [CPD(month, 20)] [RLE(JFBAC, 18)]

XLRG(33) = [CPS(33)] [CPD(month, 21)] [RLE(JFBAC, 19)]

XLRG(34) = [CPS(34)] [CPD(month, 22)] [RLE(JFBAC, 17)]

XLRG(35) = [CPS(35)] [CPD(month, 22)] [RLE(JFBAC, 18)]

XLRG(36) = [CPS(36)] [CPD(month, 23)] [RLE(JFBAC, 19)]

XLRH(29) = [CPS(71)] [RLE(FBAC, 35)]

XLRH(30) = [CPS(72)] [RLE(FBAC, 36)]

XLRH(31) = [CPS(73)] [RLE(FBAC, 37)]

XLRH(32) = [CPS(74)] [RLE(FBAC, 38)]

in the hay subroutine and equals HS(SYS(15)). Dairy replacements equals the sum of the number of all heifers plus all steers. This is calculated in the dairy subroutine.

The total hours of livestock labor required is the sum of the requirements for all livestock systems. The crop labor requirements is the sum of the requirements for all crop grow and all crop harvest systems. These two requirements are added to get the total labor required for the month.

17.3 The amount of operator labor is calculated as XLABOR(1, month + 1) multiplied by XLABOR(1,1). The XLABOR(i,j) coefficients indicated come from Q.27, Part I with "number" as the first column and January as the second, etc. The amount of family labor available this month is calculated as XLABOR(2,1) multiplied by XLABOR(2, month + 1). The amount of year hire labor is calculated as:

year hire 1 labor = XLABOR(3,1) XLABOR(3, month + 1)

year hire 2 labor = XLABOR(4,1) XLABOR(4, month + 1)

year hire 3 labor = XLABOR(5,1) XLABOR(5, month + 1)

The "regular labor" available is calculated as the total of the three year hire labor amounts calculated above. The sum of (1) regular labor, (2) operator labor and (3) family labor is subtracted from "labor required" to get "hourly labor used." If "hourly labor used" is less than zero it is set equal to zero.

If "hourly labor used" is greater than zero, the hourly labor row (i) from Q.27(a), Part I with the lowest per hour rate is chosen. The labor available from hourly (i-5) is calculated as

XLABOR(i,1) XLABOR(i, month + 1).

"Labor hired" is set equal to "hourly labor used."

For Soybeans, the soybean acreage code (JSAC) =

1 if acres of soybeans is < 25
2 if acres of soybeans is 26-50
3 if acres of soybeans is 51-75
4 if acres of soybeans is 76-100
5 if acres of soybeans is 101-150
6 if acres of soybeans is 151-200
7 if acres of soybeans is > 200

XLRG(37) = [CPS(37)] [CPD(month, 24)] [RLE(JSAC, 20)]

XLRG(38) = [CPS(38)] [CPD(month, 24)] [RLE(JSAC, 21)]

XLRG(39) = [CPS(39)] [CPD(month, 25)] [RLE(JSAC, 22)]

XLRG(40) = [CPS(40)] [CPD(month, 26)] [RLE(JSAC, 20)]

XLRG(41) = [CPS(41)] [CPD(month, 26)] [RLE(JSAC, 21)]

XLRG(42) = [CPS(42)] [CPD(month, 27)] [RLE(JSAC, 22)]

XLRH(33) = [CPS(75)] [RLE(JSAC, 48)]

XLRH(34) = [CPS(76)] [RLE(JSAC, 49)]

XLRH(35) = [CPS(77)] [RLE(JSAC, 50)]

17.2 Each month the labor requirements for each system in use (Q.19, Part I) are calculated by multiplying the number of units of that system (except for hay and HCS harvest and dairy replacements) as calculated in the systems subroutines, by the labor requirements for that system as calculated above. For hay harvest the number of units harvested is the acres of first cutting plus acres of second cutting multiplied by the coefficient from Q.18, Part II(CUTCOF(1,1)) plus the acres of third cutting hay multiplied by the third cutting coefficient (CUTCOF(2, 1)). This is calculated in the hay subroutine and equals HS(SYS(17)).

For hay crop silage the same calculations using the acreage of hay crop silage for each cutting multiplied by the correct coefficient in Q.18, Part II, i.e. acres first cutting + (acres second cutting) (CUTCOF(1,2)) + acres third cutting (CUTCOF(2,2)). This is calculated

If the "labor hired" is:

(1) less than or equal to hourly (i-5), "labor hired" multiplied by XLABOR(i,1) is added to "hourly labor cost"

(2) greater than the labor available from hourly (i-5), hourly (i-5) multiplied by XLABOR(i,1) is added to "hourly labor cost," labor available from hourly (i-5) is subtracted from "labor hired" and the program moves on to consider the next cheapest source of hourly labor.

This process continues until all the hourly labor indicated in rows 6, 7 and 8 is used or hired labor equals zero. If all the labor from rows 6, 7 and 8 is used and "labor hired" is greater than zero, the value of "labor hired" is multiplied by the cost of all additional hourly labor (Q.27(b), Part I) and that value is added to "hourly labor cost."

17.4 The wages paid year hire (1) regular labor are calculated as shown below. If the frequency of payment is:

(1) monthly (1 is input), the wage indicated is multiplied by XLABOR(3,1) and the result added to "regular wages paid"

(2) weekly (0 is input), the wage indicated multiplied by XLABOR(3, 1) is multiplied by WEEKS and the result added to "regular wages paid" where

WEEKS = 4 if month = 2

= 4 2/7 if month = 4, 6, 9 or 11

= 4 3/7 otherwise.

The wages paid year hire 2 and year hire 3 are calculated in a corresponding manner with XLABOR(3,1) replaced by XLABOR(4,1) and XLABOR(5,1) respectively.

17.5 Hours of surplus labor is calculated as the sum of operator labor, family labor and regular labor minus the total labor required. If this value is less than zero it is set equal to zero. "Hired labor" is the sum of "regular wages paid" and "hourly labor cost."

The values of operator labor and family labor are calculated monthly and accumulated for the year. The equations are:

Value of operator labor (VOPLB) = (XLABOR(1,1))(VOLABR/12)

Value of family labor (VFMLB) = (Family labor hours)(VFLABR)

where VOLABR is from Q.1, Part II

VFLABR is from Q.2, Part II

and family labor hours is from section 17.3

17.6 The variables calculated and maintained by this subroutine are listed below.

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Livestock labor (hrs.) | LIVLB | (13) |
| 2. Crop labor (hrs.) | CRPLB | (13) |
| 3. Total labor (=labor required)(hrs.) | TLB | (13) |
| 4. Operator labor (hrs.) | OPLB | (13) |
| 5. Family labor (hrs.) | FMLB | (13) |
| 6. Regular labor (hrs.) | RGLB | (13) |
| 7. Hourly labor (hrs.) | HRLB | (13) |
| 8. Surplus hours | SURLB | (13) |
| 9. Regular wage paid ($) | RGWAG | (13) |
| 10. Hourly labor cost ($) | HRWAG | (13) |
| 11. Hired labor ($) | HIRDLB | (13) |
| 12. Value of operator labor | VOPLB | ( 1) |
| 13. Value of family labor | VFMLB | ( 1) |

17.7 SUBROUTINE CODES(X,J) is a subroutine called only by the labor subroutine which calculates the acreage or size code for the various crops. The acreage of crop is received as the first parameter (X)

and the code number for that crop is sent back to the labor subroutine as the second parameter (J). The relationship between the code number and the acreage of crop is found in section 17.1.2.

SUBROUTINE ACCOUNT

This subroutine summarizes operating expenses and receipts and makes the accounting calculations required prior to debt repayment.

18.1 Utilities expense for this month is calculated as the number of cows multiplied by the utility expense items in Q.27, Part II.

A first calculation of "cash operating expense" is calculated by summing the following expenses:

1. Utilities expense
2. Total insurance (sum of building, machinery, supplies and livestock insurance)
3. Total fertilizer expense (sum of fertilizer expense from all crop routines)
4. Total seed cost (sum of seed cost from all crop routines)
5. Total pesticide cost (sum of pesticide cost from all crop routines)
6. Gas and oil expense (from machinery routine)
7. Machinery repair expense (from machinery routine)
8. Hired labor expense (from labor routine)
9. Total other crop expense (sum of other grow costs and other harvest costs from the crop routines plus off farm storage cost from the stores routine)
10. Total breeding expense (from dairy routine)
11. Total vet expense (from dairy routine)
12. Total marketing expense (sum of milk marketing expense from dairy and crop sales hauling cost from stores)
13. Other livestock expense (sum of other dairy costs and calf costs from dairy plus straw cost from stores)

14. Rent paid (from land)

15. Taxes (from land)

16. Land, fence and building repair (sum of conservation and fence repair from land and building repair from buildings)

17. Total custom hire (sum of custom hire from all crop routine).

Miscellaneous expense is calculated as the constant from Q.28, Part II plus the percentage figure from Q.28, Part II multiplied by "cash operating expenses" as calculated above. Then true "cash operating expense" is calculated by adding

18. Miscellaneous expense

19. Feed purchases (from stores)

18.2 Cash income is calculated by summing the following income items:

1. Milk sold (from storage and sales)
2. Livestock sold (storage and sales)
3. Government payments income (from land)
4. Crop sales (from storage and sales)

Total withdrawal is calculated by choosing the correct cell in Q.41(a), Part I and adding "income tax" if the month is February. In year 1 the value of "income tax" is from Q.41(c), Part I. In future years "income tax" = TAXI, which was calculated in December of the previous year in the TAXACC subroutine, is used.

18.3 For those variables with a dimension code of 13, the thirteenth value is the total for the year. These thirteenth values for all variables are calculated by this subroutine. This is accomplished by monthly adding the value for this month to the thirteenth value. The equations for each variable are of the form

$$X(13) = X(13) + X(K)$$

where X is the variable name

and K is the number of the present month.

Total land purchases (PURLD) and land sales (TLDSAL) are also accumulated as the sum to date plus the value for this month.

18.4 Total long term assets equals the sum of land value and building sale value. Intermediate term assets equals the sum of depreciated value of machinery plus value of cattle. Short term assets equals the inventory value of feed and supplies (crops). Total capital investment equals the sum of land value, building value, depreciated value of machinery, cattle value and value of feed and supplies. The beginning and ending value of these asset or investment categories is calculated using the beginning and ending inventory value, respectively, of the items that make them up.

Average capital investment in land is calculated as the average of the beginning inventory land value and the end inventory value from the land subroutine. Average investment in machinery, livestock, buildings, feed and supplies (crops), short term assets, intermediate term assets and long term assets is calculated in a similar fashion.

18.5 Increase in land value is calculated as the end land inventory minus the beginning inventory minus "total land purchased" plus total land sales.

Increasein cattle (livestock) inventory is calculated as the ending inventory (at end of last month) minus beginning inventory (at beginning of first month of the year) minus livestock purchases (stores).

Increase in feed inventory is calculated as the value of the inventory of crops from the beginning of the year minus the value at the end of the year (as calculated stores).

18.6 Average crop yields for each crop are calculated in the twelfth month of the year. This is calculated by dividing total production of that crop plus the landlord share by the number of acres. Average milk yield is calculated as the total milk produced divided by the average of the 12 monthly number of cows values.

18.7 Income from the sale of land is distributed over the number of years (TAXYRS) indicated in Q.46(a), Part II. This distribution is carried out so that whenever TAXYRS equals two or more years the sale qualifies as a sales contract. An array, CLDINC(5), is set up to contain the income from the sale of land for each of the next five years. Whenever land is sold (SALELD is positive) the amount of cash income from the sale of the land for each of the next five years is calculated and entered in the array. The interest income that would be earned on that portion of the income to be received in years other than the first is calculated using the long term interest rate from Q.14, Part II. This is added to the value of the land before it is entered in the CLDINC array. That is if TAXYRS,

(a) equals one, the total land sale income (SALELD) is added to CLDINC(1)

(b) greater than one and less than four

$$CLDINC(1) = CLDINC(1) + (0.3)SALELD)$$

$$CLDINC(i) = CLDINC(i) + \frac{(0.7)SALELD}{TAXYRS-1} \quad (1+j)i-1),\ i-2,\ldots,\ TAXYRS$$

(c) greater than or equal to four

$$CLDINC(i) = CLDINC(i) + \frac{SALELD}{TAXYRS}\ [(1+j)(i-1)],\ i=1,\ldots,TAXYRS$$

where j = the rate of interest

If the present month being simulated equals the month in which land income is received (Q.46(b), Part II), CLDINC(1) is added to cash on hand and to the variable "cash land income." The values in the CLDINC array are shifted to the left one cell so that next years income now appears in CLDINC(1), year three income is in CLDINC(2), etc.

18.8 The variables defined and maintained by this subroutine are listed below.

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Total capital invest (a) Beg. | CAPVB | ( 1) |
| (b) End | CAPVE | ( 1) |
| (c) Ave. | CAPVA | ( 1) |
| 2. Increase in land values | VLNDI | ( 2) |
| 3. Increase in cattle value | VCATI | ( 2) |
| 4. Increase in feed inventory | VFEEDI | ( 2) |
| 5. Average Corn silage yield | ACSYLD | ( 1) |
| 6. Average Hay silage yield | AHSYLD | ( 1) |
| 7. Average Corn grain yield | ACYLD | ( 1) |
| 8. Average Oat grain yield | AOYLD | ( 1) |
| 9. Average Wheat grain yield | AWYLD | ( 1) |
| 10. Average Hay grain yield | AHYLD | ( 1) |
| 11. Average Field beans grain yield | AFYLD | ( 1) |
| 12. Average Soybeans grain yield | ASYLD | ( 1) |
| 13. Average Milk yield | AMKYLD | ( 1) |
| 14. Utilities expense | UTIL | (13) |
| 15. Total insurance | TINS | (13) |
| 16. Total fertilizer expense | TFERT | (13) |
| 17. Total seed cost | TSEED | (13) |
| 18. Spray (pesticide) cost total | TPEST | (13) |
| 19. Total other crop expense | TOCRP | (13) |
| 20. Total marketing costs | TMKT | (13) |
| 21. Custom hire total | TCUSTM | (13) |
| 22. Total breeding fees | TBREED | (13) |
| 23. Total vet expenses | TVET | (13) |
| 24. Other livestock expense | OLIVSE | (13) |
| 25. Rent paid | RENT | (13) |
| 26. Taxes | TAX | (13) |
| 27. Land & Fence repair & Build repair | CONSRP | (13) |
| 28. Livestock sold | SLDLIV | (13) |

| Variable Definition (Cont'd.) | | Name | Dimension Code |
|---|---|---|---|
| 29. Crop sold | | SLDCP | (13) |
| 30. Total long term assets | (a) Ave. | ASETLA | ( 1) |
| | (b) Beg. | ASETLB | ( 1) |
| | (c) End | ASETLE | ( 1) |
| 31. Total intermediate term assets | | | |
| | (a) Ave. | ASETIA | ( 1) |
| | (b) Beg. | ASETIB | ( 1) |
| | (c) End | ASETIE | ( 1) |
| 32. Total short term assets | | | |
| | (a) Ave. | ASETSA | ( 1) |
| | (b) Beg. | ASETSB | ( 1) |
| | (c) End | ASETSE | ( 1) |
| 33. Miscellaneous Exp. | | XMISC | (13) |
| 34. Total withdrawal | | TOTW | (13) |
| 35. Average capital investment | | ACAPIV | ( 5) |
| where 1 = land | | | |
| 2 = buildings | | | |
| 3 = machinery | | | |
| 4 = livestock | | | |
| 5 = supplies | | | |
| 36. Annual cash land income | | CLDINC | ( 5) |
| 37. Monthly cash land income | | CLI | (13) |

SUBROUTINE FINCE

This subroutine handles all borrowing, debt repayment and interest calculations.

19.1 This routine maintains the current debt situation matrix. This is a 50x14 matrix (DEBT(i,j), set up as indicated in Q.40(a), Part I. Each row represents a specific loan. The initial debt situation is entered in the matrix by the READI subroutine.

At the beginning of the first month the amount of payment column (column four) is checked to be sure that the amount of payment has been entered for each loan entered from input. If the amount of payment has not been entered, it is calculated using the same equations as is used to calculate the amount of payment when part of a loan is prepaid (section 19.5C).

19.2 The first calculations made each month involve updating the DEBT matrix and calculating principal and interest payments to be made for this month. This is done by individually considering each row of the matrix that contains data.

The age of the loan is increased by 1. If a payment on this loan is to be made this month, principal and interest calculations are made. That is, calculations are made if (1) amount of payment = DEBT(i,r) $\neq$ 0 and (2) DEBT(i,j) equals either zero or the month being simulated where j=7,...,12 and i = the loan row being considered.

19.2.1 The interest due on the loan is calculated as

$$(\text{DEBT}(i,1))\ (\text{DEBT}(i,2))\ \left(\frac{\text{months since last payment}}{12}\right)$$

Months since last payment equals one if DEBT(i,7) equals zero. If DEBT(i,7) is not zero, months since last payment is the number of months

between the present month of the year being simulated and the first previous month in which payment is to be made as indicated by DEBT(i,7),...,DEBT(i,12). That is, if payments are to be made in months three and nine, and the present month is one, months since last payment equals four.

The interest due is added to:

(1) "long term interest" if DEBT(i,6) = 3

(2) intermediate term interest if DEBT(i,6) = 2

(3) short term interest if DEBT(i,6) = 1 or 0

If the "term of loan" (DEBT(i,6), is zero, skip to the next debt row.

19.2.2 If the type of loan (DEBT(i,5)) is:

A. 1, the "interest due" is subtracted from the amount of payment and the result subtracted from the balance due (DEBT(i,1). The result is also added to

(a) long term principal paid if DEBT(i,6) = 3

(b) intermediate term principal paid if DEBT(i,6) = 2

(c) short term principal paid if DEBT(i,6) = 1.

B. 11 through 15, the same calculations as used in A above are used if the product of (1) the type of loan number (DEBT(i,5)) minus 10 and (2) 12 is less than or equal to the age. If age is less than the calculated number, no principal payment is made.

C. 2, the amount of the payment is subtracted from balance due (DEBT(i,1)) and added to one of the three principal paid categories as indicated for type 1 loan.

D. 21 through 25, the same calculations as used in C above are used if the product of (1) the type of loan number minus

20 and (2) 12 is less than or equal to the age. If age is less than the calculated number, no principal payment is made.

19.3 A first total of interest paid for the month is the sum of "long-term interest," "intermediate-term interest" and "short-term interest." A first total of principal paid is the sum of the three corresponding principal paid items. These two totals are subtracted from the "cash surplus" where cash surplus is the total cash income plus machinery sold minus the sum of (1) cash operating expenses, (2) withdrawals, (3) cash livestock expense, (4) cash machinery expense, (5) cash land expense and (6) cash building expense. The resulting "cash surplus" is added to the cash balance (Q.40(b), Part I).

19.4 If the new cash balance is less than Q.16(c), Part II the difference is borrowed (added to the debt situation) by setting up or adding to an operating short term loan. An existing operating short term loan has a value for balance due and interest rate, and the term of loan (DEBT(i,6) is set at zero. If there is an existing short term operating loan, the quantity borrowed is added to the balance due for that loan. If there is no existing short term operating loan, one is established with balance due equal to the quantity borrowed, interest rate equal to Q.15, Part II, and term of loan and age set equal to zero.

The quantity borrowed is added to "borrowed-short term." If the cash balance is greater than or equal to Q.16(a), Part II and less than or equal to Q.16(b), Part II, "cash on hand" is set equal to the present cash balance and the program moves to section 19.6.

19.5 If the checking account balance is greater than Q.16(b), Part II,

the following sequence of actions are taken:

A. The program checks for operating short-term debt (DEBT(i,6)=0). If there is such short-term debt and its balance is

(1) less than the cash balance minus Q.16(b), Part II (called "cash available") the short-term debt is removed (DEBT(i,1) is set equal to zero) and the amount of the debt is subtracted from the cash balance and added to "short-term principal paid."

(2) greater than or equal to "cash available," "cash available" is subtracted from short-term debt balance due and added to "short term principal paid." The cash balance is set equal to Q.16(b), Part II, cash on hand is set equal to Q.16(b), Part II and the program moves to section 19.6.

B. If there is no operating short-term debt or if the cash balance is still greater than Q.16(b), Part II after paying operating short-term debt, the program checks for entries made this month (DEBT(i,4) has no value) and pays off those for which cash is available. A value of "cash available" is calculated as the value of the cash balance minus Q.16(b), Part II. This value (cash available) is subtracted from the cash balance. The program finds and pays off entries made this month in the following order until "cash available" equals zero or all potential loans entered this month are paid off.

(1) Livestock loans (DEBT(i,6) = 7)

(2) Machinery loans (DEBT(i,6) = 6)

(3) Building loans (DEBT(i,6) = 4)

(4) Land investment loans (DEBT(i,6) = 5)

The action taken as each entry or potential loan is considered depends on the quantity of cash available. If cash available is equal to or greater than the amount of the entry (DEBT(i,1)), DEBT(i,1) is subtracted from the cash available, added to the appropriate cash livestock investment, cash machinery investment, cash building investment or cash land investment variable and then set equal to zero.

If the cash available is less than the value of DEBT(i,1), cash available is subtracted from DEBT(i,1) and added to the appropriate cash investment category. Cash on hand is set equal to Q.16(b), Part II and the program moves to section 19.6.

C. If there were no operating short term loans and no entries made this month, or if "cash available" is still greater than zero, debts contracted in previous months are paid until "cash available is expended" or all loans are paid off. These debts are paid off in the following order:

(1) Short-term debt (DEBT(i,6) = 1)

(2) Intermediate-term debt (DEBT(i,6) = 2)

(3) Long-term debt (DEBT(i,6) = 3)

As each loan is considered the interest due since the last payment was made is calculated first. This is a simple interest calculation and is the product of (1) the loan outstanding (DEBT(i,1), (2) the interest rate (DEBT(i,2)) and (3) the number of months since the last payment divided by 12. Months since last payment equals zero if payment has been made this month, i.e. if DEBT(i,7) equals zero or DEBT(i,7),..., DEBT(i,12) equals the present month simulated. If payment has not been made this month, months since last payment equals

the number of months between the month being simulated and the first previous month in which payment is to be made as indicated by DEBT(i,7), ...,DEBT(i.12).

The interest due, as calculated above, is added to the outstanding balance of the loan (DEBT(i,1)). If this sum is less than the cash available the entire loan is paid off. The sum is subtracted from cash available and if the debt is:

1. Short-term, the interest is added to "short-term interest paid," the balance due is added to "short term principal paid" and DEBT(i,1) is set equal to zero.
2. Intermediate-term, the interest is added to "intermediate-term interest paid," the balance due is added to "intermediate-term principal paid," and DEBT(i,1) is set equal to zero.
3. Long-term, the interest due is added to "long-term interest paid," the balance due is added to "long-term principal paid" and DEBT(i,1) is set equal to zero.

If the sum of interest due and balance outstanding exceeds the amount of cash available, the percentage that cash available is of the sum is calculated. This percentage is then multiplied by the interest due to get the actual interest paid and by the balance outstanding to get the amount of principal to be paid. The sum of interest and principal actually paid is subtracted from cash available and "cash on hand" is set equal to the cash balance. The amount of principal paid is subtracted from DEBT(i,1). The actual interest and principal paid are added to the appropriate "_____interest paid" and "_____principal paid" variables (as indicated in the above paragraph) respectively.

When part of a loan is paid off, a new "amount of payment" is

calculated. It is assumed that the same loan period will be used and the amount of payment is reduced to reflect the reduced principal and interest to be paid. The remaining years of the loan is first calculated as the loan period minus one-twelfth of the age (which is in months). The new amount of payment is calculated as indicated below.

If the type of loan (DEBT(i,5)) is 1, the amount of payment equals

$$\left[\frac{\frac{i}{P}}{\left[1-\left(\frac{1}{1+\left(\frac{i}{P}\right)}\right)^{YP}\right]}\right] \quad (K)$$

where i = annual interest rate

P = number of payments per year

Y = remaining years of the loan

K = remaining unpaid principal

If the type of loan is 11 through 15, the amount of payment is calculated using the above equation except that Y equals the minimum of (1) the remaining years of the loan as calculated above and (2) the loan period minus the result of subtracting ten from the type of loan number.

If the loan type is 2, the amount of payment equals the remaining balance divided by the product of the loan period and the number of payments per year. If the loan type is 21 through 25, the payment is calculated by dividing the amount of the remaining balance by

[(loan period) - (loan type code - 20)] (number of payments per year)

If all loans are paid off and "cash available" is still positive, the value of "cash available" is added to the cash balance.

19.6 After "cash available" is expended or if there is not sufficient "cash surplus" to increase the cash balance above Q.16(b), Part II, the months payments are to made, loan term, and the amount of payment are calculated and the amounts borrowed accumulated for entries made this month.

19.6.1 In each case the term of loan is calculated first. If the loan period (L) is such that:

A. $0 \leq L \leq$ STMAX (Q.13, Part II, Coefficient 1), the loan term is set equal to one and the balance due (DEBT(i,1)) is added to "borrowed short term."

B. STMAX $< L \leq$ ITMAX (Q.13, Part II, Coefficient 2), the loan term is set equal to two and the balance due is added to "borrowed intermediate term."

C. ITMAX $< L$, the loan term is set equal to three and the balance due is added to "borrowed long term."

19.6.2 Months payments are to be made are calculated from the number of payments per year entered previously. If payments per year equals:

A. 12, a zero is entered in column seven (DEBT(i,7))

B. 6, the months payments are to be made are this month, this month, plus 2, this month plus 4, this month plus 6, this month plus 8 and this month plus 10.

C. 4, the months payments are to be made are this month, this month plus 3, this month plus 6 and this month plus 9.

D. 3, the month payments are to be made are this month, this month plus 4 and this month plus 8.

E. 2, the months payments are to be made are this month and this month plus 6.

F. 1, payments are made during this month, i.e., the number indicating this month is entered in DEBT(i,7).

19.6.3 The amount of payment is calculated as follows. If the loan type is 1, the payment equals

$$\left[\frac{\frac{i}{P}}{\left[1-\left(\frac{1}{1+\left(\frac{i}{P}\right)}\right)^{YP}\right]}\right] \quad \text{(beginning balance)}$$

where i = annual interest rate

P = number of payments per year

Y = loan period in years

If the type of loan is 11 through 15, the payment is calculated the same as above except that Y = (loan period in years) - (Loan type No. - 10).

If the loan type is 2, the payment equals the beginning balance divided by [(period of loan)(number of payments per year)]. If the loan type is 21 through 25, the payment is calculated by dividing the amount of the beginning balance by

[(loan period) - (loan type code - 20)](number of payments per year)

19.7 The total short term debt is calculated by summing the balance due for all rows in the debt situation matrix that have zero or one the term of loan column. Intermediate term debt and long term debt are calculated in a similar fashion using term of loan values of 2 and 3 respectively. "Total debt" is the sum of these three items.

The long term equity ratio is total long term assets (from accounting) minus long term debt over total long term assets. Intermediate, short term and total equity ratios are calculated in a

corresponding manner using intermediate, short term and total assets respectively.

Total principal paid is the sum of short term principal, intermediate term principal and long term principal paid. Total interest paid is calculated in a corresponding manner. Total cash investments is the sum of cash investments for livestock, machinery, buildings and land.

After all calculations pertaining to the debt array have been made, any debt row which has a zero in DEBT(i,1) is zeroed out and the debts below that row moved up one row. Thus all "X" debts outstanding for the business are placed in the first "X" rows of the matrix. The remaining rows are available for entry of future debts by other subroutines.

19.8 The variables calculated and maintained by this subroutine are listed below.

| Variable Definition | Name | Dimension Code |
|---|---|---|
| 1. Total debt | TDEBT | (12) |
| 2. Total equity ratio | TRATO | ( 1) |
| 3. Intermediate equity ratio | IRATO | ( 1) |
| 4. Long term equity ratio | LRATO | ( 1) |
| 5. Short term equity ratio | SRATO | ( 1) |
| 6. Long term principal paid | LPPD | (13) |
| 7. Intermediate term principal paid | IPPD | (13) |
| 8. Short term principal paid | SPPD | (13) |
| 9. Long term interest paid | LIPD | (13) |
| 10. Intermediate interest paid | IIPD | (13) |
| 11. Short term interest paid | SIPD | (13) |
| 12. Short term debt | SDEBT | ( 2) |
| 13. Intermediate term debt | IDEBT | ( 2) |
| 14. Long term debt | LDEBT | ( 2) |
| 15. Borrowed - short term | BOROWS | (13) |

| Variable Definition (cont'd.) | Name | Dimension Code |
|---|---|---|
| 16. Borrowed - intermediate term | BOROWI | (13) |
| 17. Borrowed - long term | BOROWL | (13) |
| 18. Cash machinery investment | CASHM | (13) |
| 19. Cash livestock investment | CASHLS | (13) |
| 20. Cash land investment | CASHLD | ( 1) |
| 21. Cash buildings investment | CASHB | ( 1) |
| 22. Cash short term investment | CASHST | (13) |
| 23. Cash buildings investment | CASHLB | (13) |
| 24. Total cash investment | CASHT | (13) |
| 25. Total borrowed | BOROWT | (13) |
| 26. Total interest paid | TIPD | (13) |
| 27. Total principal paid | TPPD | (13) |
| 28. Cash on hand | CASHOH | (13) |
| 29. Total cash land investment | CASHML | (13) |

19.9 SUBROUTINE MOAD(TEMP), is a subroutine which is called only by the FINCE routine. It receives a parameter indicating the month of the year in which a loan payment is to be made. If this parameter exceeds twelve the subroutine converts it to the appropriate month number which is less than or equal to twelve.

SUBROUTINE TAXACC

This subroutine makes the accounting calculations required after the financial aspects of the business have been conducted and calculates the income taxes to be paid.

20.1 Total cash operating expense is completed by adding the total interest paid to the cash operating expense calculated in ACOUNT. If this is the last month of the year the final summary calculations are made.

Average equity is calculated as the average investment minus the average debt (sum of the monthly total debt levels divided by 12). To get equity interest or non-cash interest expense, average equity is multiplied by the coefficient from Q.3, Part II.

The annual sum for those variables which were calculated or influenced by the FINCE routine are calculated. These include cash operating expense, cash operating income and all interest, principal, borrowing and cash investment variables. The annual sum is calculated as the sum of the twelve monthly values.

Return on investment is calculated as total cash and non-cash income minus (total cash and non-cash expenses minus all interest payments), the result divided by average total investment.

Return to labor and management is total cash and non-cash income minus the total of all cash and non-cash expenses except operator and family labor.

20.2 Although fiscal year simulation is allowed, income taxes are always calculated on a calendar year basis. Thus, two variables, income (XINCOM) and Expenses (EXP), are maintained to contain the calendar year data. At the end of each simulation year the income and

expenses required for calculation of income taxes for the present year are accumulated and placed in expense and income variables. This would involve the first months of the calendar year. Similarly at the end of the calendar year, the data for the latter months of the year would be added to the income and expense variables. If the simulation year corresponds with the calendar year, only the latter entries need be made.

The income taxes are calculated in December of each year. The tax is calculated under the following assumptions.[1]

A. Eighty percent of livestock sales qualify as capital gains.

B. Land sale is treated as a contract sale if the income is taken over more than one year.

C. Standard deduction of ten percent of taxable income up to $1,000 is taken.

D. A joint return is filed.

E. The per exemption deduction is $650.

F. Gains and losses from machinery sale are handled through depreciation calculation.

G. The number of exemptions is taken from Q.41(b), Part I.

H. Off-farm income is the level indicated in Q.41(b), Part I.

I. The estimated taxable income for the first months of the first year when the simulation starts in some month other than January is Q.41(d), Part I.

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1. The actual tax calculation algorithm is adapted from a Michigan State University Telplan touch-tone program titled Income Tax Management developed by S. B. Harsh and M. Kelsey.

20.3 The variables calculated and maintained by this subroutine are listed below.

| Variable definition | Name | Dimension Code |
|---|---|---|
| 1. Average equity | AEQTY | ( 1) |
| 2. Equity (non-cash interest) | EQTYI | ( 1) |
| 3. Cash operating expense 2 | CASHOP | (13) |
| 4. Cash income | CASHI | (13) |
| 5. Income tax | TAXI | ( 1) |
| 6. Return on Investment | ROI | ( 1) |
| 7. Return to labor and management | RLM | ( 1) |
| 8. Taxable income | TAXIN | ( 1) |
| 9. Calendar year expenses for tax purposes | EXP | ( 1) |
| 10. Calendar year income for tax purposes | XINCOM | ( 1) |

SUBROUTINE PRINTR

This subroutine prints out the summary reports at the end of each year and zero's out all variables which are not to be maintained for use in the following year.[1]

21.1 The summary tables that can be printed out at the end of each or any year are listed on the following pages. The answers to Q.4, Part I determine which tables are to be printed. That is if Q.4(a), Part I equals one, table 1 is printed; if Q.4(b), Part I equals one, table 2 is printed; if Q.4(c), Part I equals one, table 3 is printed;....

Each table heading contains the title "year of mo./yr. to mo./yr." where mo. and yr. are symbolic titles indicating month and year. This indicates the exact year of the summary and will thus change for each successive year's output. That is, for a calendar year summary starting in January 1971, the actual title would be "YEAR OF 1/71 to 12/71.

21.2 After all tables are printed, all variables the present values of which are not required for future calculations are zeroed out. This includes nearly all variables calculated by the individual subroutines except those involving beginning and ending inventory values or numbers. All parameters variables listed in Part I or Part II of the users manual (Appendix A) are excluded.

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1. The limited core capacity of the CDC 3600 made it impossible to handle the entire FABS model as one program. For that reason the PRINTR subroutine of the 3600 program only writes the values of all common blocks on tape and then zeros out the appropriate variables. A second program, called PRINTR, reads the common blocks from the tape and prints out the summaries required. However, because the separation of functions, the use of tape and the use of the second main program are techniques which were forced by the particular computer facility used rather than being an integral part of the model, the following discussion does not differentiate between those parts of the program carried out by SUBROUTINE PRINTR and those carried out by PROGRAM PRINTR.

TABLE 1 LABOR SUMMARY
Year of mo./yr. to mo./yr.

| Month | Hrs. Labor Required | | | Source Labor (Hours) | | | | Surplus Hours | Labor Cost | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Livestock | Crops | Total | Operator | Family | Regular | Hourly | | Regular | Hourly |
| Jan. | | | | | | | | | | |
| Feb. | | | | | | | | | | |
| Mar. | | | | | | | | | | |
| Apr. | | | | | | | | | | |
| May | | | | | | | | | | |
| June | | | | | | | | | | |
| July | | | | | | | | | | |
| Aug. | | | | | | | | | | |
| Sept. | | | | | | | | | | |
| Oct. | | | | | | | | | | |
| Nov. | | | | | | | | | | |
| Dec. | | | | | | | | | | |
| Total | | | | | | | | | | |

TABLE 2 ANNUAL FINANCIAL STATEMENT
Year of mo./yr. to mo./yr.

| Type of Loan | Principal Paid | Interest Paid |
|---|---|---|
| Long Term | | |
| Intermediate Term | | |
| Short Term | | |

DEBTS OUTSTANDING (END OF YEAR)

| | Balance Due | Interest Rate | Loan Period | Age (months) |
|---|---|---|---|---|
| Long Term | | | | |
| Int. Term | | | | |
| Short Term | | | | |

FINANCIAL SITUATION

| Type of Debt or Asset | Total Asset | Total Debt | Equity Ratio |
|---|---|---|---|
| Long Term | | | |
| Int. Term | | | |
| Short Term | | | |
| Total | | | |

TABLE 3 ANNUAL CROP PRODUCTION AND FEED UTILIZATION SUMMARY
Year of mo./yr. to mo./yr.

| Crop | Beginning | Produced | Bought | Fed | Sold | End |
|---|---|---|---|---|---|---|
| Hay Silage (tons) | | | | | | |
| Corn Silage (tons) | | | | | | |
| Hay (tons) | | | | | | |
| High M. Corn (bu.) | | | | | | |
| Ear Corn (bu.) | | | | | | |
| Sh. Corn (bu.) | | | | | | |
| Wheat (bu.) | | | | | | |
| Oats (bu.) | | | | | | |
| Soybeans (bu.) | | | | | | |
| Field beans (cut) | | | | | | |
| Straw (tons) | | | | | | |
| Supplement (tons) | | | | | | |

TABLE 4 ANNUAL DAIRY CATTLE NUMBERS SUMMARY
Year of mo./yr. to mo./yr.

| | Beginning | Born | Bought | Sold | Died | End |
|---|---|---|---|---|---|---|
| Cows | | | | | | |
| Heifers over 1 yr. | | | | | | |
| Heifers under 1 yr. | | | | | | |
| Steer Calves | | | | | | |
| Steers on feed | | | | | | |

TABLE 5 ANNUAL INCOME AND EXPENSE SUMMARY
Year of mo./yr. to mo./yr.

| Item | Value | Item | Value |
|---|---|---|---|
| Capital Investment (Average) | | Cash Expense | |
| Land | | Hired Labor | |
| Buildings | | Gas & Oil | |
| Machinery | | Mach. Repairs | |
| Livestock | | Custom Hire | |
| Feed & Supplies | | Cons. & Repair | |
| Total | | Insurance | |
| Cash Income | | Fertilizer | |
| Milk | | Seed | |
| Cattle | | Spray | |
| Hay | | Other Crop | |
| Corn | | Breeding | |
| Oats | | Vet. | |
| Wheat | | Marketing | |
| Soybeans | | Other Livestock | |
| Field beans | | Rent | |
| Gov't. Payments | | Taxes | |
| Total | | Utilities | |
| Non-Cash Income | | Interest | |
| Increase Land Value | | Miscellaneous | |
| Increase Cattle Inv. | | Feed Purchase | |
| Increase Feed Inv. | | Total | |
| Total | | Non-Cash Expense | |
| Total Income | | Operator Labor | |
| Total Expense | | Family Labor | |
| Return to Mgt. & Labor | | Mach. Depreciation | |
| Return on Investment | | Build. Depreciation | |
| | | Interest | |
| | | Total | |

TABLE 6 ANNUAL PRODUCTION YIELDS SUMMARY
Year of mo./yr. to mo./yr.

| Crop or Animal | No. of Acres | Yield | Landlord Share |
|---|---|---|---|
| Hay (tons) | | | |
| Hay Silage (tons) | | | |
| Corn (bu.) | | | |
| Corn Silage (tons) | | | |
| Oats | | | |
| Wheat | | | |
| Soybeans | | | |
| Field beans | | | |
| Cows | | | |

TABLE 7 BRIEF MONTHLY CASH FLOW SUMMARY
Year of mo./yr. to mo./yr.

| Item | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Income | | | | | | | | | | | | | |
| Expense | | | | | | | | | | | | | |
| Cash Invest. | | | | | | | | | | | | | |
| Withdrawal | | | | | | | | | | | | | |
| Principal | | | | | | | | | | | | | |
| Borrowed | | | | | | | | | | | | | |
| Cash on Hand | | | | | | | | | | | | | |

TABLE 8 MONTHLY CROP PRODUCTION AND UTILIZATION SUMMARY
Year of mo./yr. to mo./yr.

| Crop | Beginning | Produced | Bought | Fed | Sold | End |
|---|---|---|---|---|---|---|
| | | | ---January--- | | | |
| Hay Silage (tons) | | | | | | |
| Corn Silage (tons) | | | | | | |
| Hay (tons) | | | | | | |
| High M. Corn (bu.) | | | | | | |
| Ear Corn (bu.) | | | | | | |
| Sh. Corn (bu.) | | | | | | |
| Wheat (bu.) | | | | | | |
| Oats (bu.) | | | | | | |
| Soybeans (bu.) | | | | | | |
| Field beans (cut.) | | | | | | |
| Straw (tons) | | | | | | |
| Supplement | | | | | | |
| | | | ---February--- | | | |
| Hay Silage (tons) | | | | | | |
| Corn Silage (tons) | | | | | | |
| | | | . | | | |
| | | | . | | | |
| | | | . | | | |
| | | | . | | | |
| | | | for 12 months | | | |

TABLE

| Anim |
| --- |
| Cow |
| Hei |
| Hei |
| Ste |
| Ste |
| Co |
| He |
| He |
| St |
| St |

TABLE 9 MONTHLY DAIRY CATTLE NUMBERS SUMMARY
Year of mo./yr. to mo./yr.

| Animal | Beginning | Born | Bought | Sold | Died | End |
|---|---|---|---|---|---|---|
| | | | ---January--- | | | |
| Cows | | | | | | |
| Heifers over 1 yr. | | | | | | |
| Heifers under 1 yr. | | | | | | |
| Steer Calves | | | | | | |
| Steers on feed | | | | | | |
| | | | ---February-- | | | |
| Cows | | | | | | |
| Heifers over 1 yr. | | | | | | |
| Heifers under 1 yr. | | | | | | |
| Steer Calves | | | | | | |
| Steers on feed | | | | | | |
| | | | . | | | |
| | | | . | | | |
| | | | . | | | |
| | | | . | | | |
| | | | 12 months | | | |

TABLE 10

MONTHLY CASH FLOW STATEMENT
Year of mo./yr. to mo./yr.

| Item | Jan. | Feb. | Mr. | Apr. | May | June. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Income | | | | | | | | | | | | | |
| Milk | | | | | | | | | | | | | |
| Cattle | | | | | | | | | | | | | |
| Hay | | | | | | | | | | | | | |
| Corn | | | | | | | | | | | | | |
| Oats | | | | | | | | | | | | | |
| Wheat | | | | | | | | | | | | | |
| Soybeans | | | | | | | | | | | | | |
| Field beans | | | | | | | | | | | | | |
| Gov't. | | | | | | | | | | | | | |
| Land & Mach. | | | | | | | | | | | | | |
| Expense | | | | | | | | | | | | | |
| Labor | | | | | | | | | | | | | |
| Gas & Oil | | | | | | | | | | | | | |
| Machinery Repair | | | | | | | | | | | | | |
| Build. Repair | | | | | | | | | | | | | |
| Custom Hire | | | | | | | | | | | | | |
| Conservation | | | | | | | | | | | | | |
| Insurance | | | | | | | | | | | | | |
| Fertilizer | | | | | | | | | | | | | |
| Seed | | | | | | | | | | | | | |
| Spray | | | | | | | | | | | | | |
| Other Crop | | | | | | | | | | | | | |
| Breeding | | | | | | | | | | | | | |
| Vet. | | | | | | | | | | | | | |
| Marketing | | | | | | | | | | | | | |
| Other Livestock | | | | | | | | | | | | | |
| Rent | | | | | | | | | | | | | |
| Taxes | | | | | | | | | | | | | |
| Utilities | | | | | | | | | | | | | |
| Miscellaneous | | | | | | | | | | | | | |
| Feed | | | | | | | | | | | | | |

MONTHLY CASH FLOW STATEMENT (Cont.)
Year of mo./yr. to mo./yr.

| Item | Jan. | Feb. | Mar. | Apr. | May | June. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Expense (cont.) | | | | | | | | | | | | | |
| Interest-Short | | | | | | | | | | | | | |
| Interest-Int. | | | | | | | | | | | | | |
| Interest-Long | | | | | | | | | | | | | |
| Capital Sales | | | | | | | | | | | | | |
| Machinery | | | | | | | | | | | | | |
| Land | | | | | | | | | | | | | |
| Cash Investment | | | | | | | | | | | | | |
| Livestock | | | | | | | | | | | | | |
| Machinery | | | | | | | | | | | | | |
| Buildings | | | | | | | | | | | | | |
| Land | | | | | | | | | | | | | |
| Principal | | | | | | | | | | | | | |
| Short | | | | | | | | | | | | | |
| Int. | | | | | | | | | | | | | |
| Long. | | | | | | | | | | | | | |
| Borrowed | | | | | | | | | | | | | |
| Short | | | | | | | | | | | | | |
| Int. | | | | | | | | | | | | | |
| Long | | | | | | | | | | | | | |
| Totals | | | | | | | | | | | | | |
| Income | | | | | | | | | | | | | |
| Expense | | | | | | | | | | | | | |
| Cash Invest. | | | | | | | | | | | | | |
| Withdrawal | | | | | | | | | | | | | |
| Principal | | | | | | | | | | | | | |
| Borrowed | | | | | | | | | | | | | |
| Cash on Hand | | | | | | | | | | | | | |

TABLE 11 BRIEF ANNUAL SUMMARY
Year of mo./yr. to mo./yr.

| Item | Value |
|---|---|
| No. Cows | |
| Total Investment | |
| Cash Income | |
| Cash Expense | |
| Return on Investment | |
| Return to Labor and Management | |
| Total Debt | |
| Total Debt Highest Month | |

# APPENDIX C

# DATA SOURCES FOR MODEL COEFFICIENTS

FARM BUSINESS SIMULATOR (FABS)

Data Sources for Model Coefficients

The following list indicates the sources of coefficients used in the FABS model unless they are changed by the user. The sources listed provided either the numbers used or the basic data for calculation of the numbers used. The list numbers indicated coincide with the question numbers found in Part II of the User's Manual.

1. Connor, L. J., G. L. Benjamin, J. R. Brake and W. F. Lee, Michigan Farm Management Handbook, Agricultural Economics Report Number 36, Michigan State University, October 1967, p. 16.

2. Brown, L. H. and John Speicher, Business Analysis Summary for Specialized Southern Dairy Farms, 1969, Agricultural Economics Report Number 175, Michigan State University, East Lansing, Michigan, August 1970.

3. Chosen to be representative for most farm managers.

4- 7. Chosen to represent sales timing and hold over quantities frequently used by dairymen.

8-11. Arbitrarily chosen values.

12. Chosen to represent present practice.

13. Chosen as typical values for modern lending institutions.

14-15. Chosen to represent present practice.

16. Arbitrarily chosen as reasonable values.

17. Representative of practices on good Michigan farms.

18. Agricultural Planning Data for the Northeastern United States, Agricultural Economics and Rural Sociology Bulletin 51, The Pennsylvania State University, University Park, Pennsylvania, July 1965.

19. Chosen to be representative of a typical dairy situation.

20(a). Estimates assuming good pasture management practices.

20(b). LaDue, E. L. (ed.), Farm Management Handbook, Department of Agricultural Economics, Extension Bulletin 440, Cornell University, October 1966, p. 91.

21. Kearl, C. D. and D. P. Snyder, Field Crops Costs and Returns from Cost Accounts, Department of Agricultural Economics Research Bulletin 380, Cornell University, November 1969.

22. Yields:

Corn Planting - Hildebrand, S. C., E. C. Rossman and L. S. Robertson, Michigan Corn Production, Hybrid Selection and Cultural Practices, Michigan State University, Extension Bulletin 436, September 1964.

Soybean Planting - Hildebrand, S. C., L. S. Robertson, R. G. White, N. A. Smith and H. S. Potter, Soybean Production in Michigan, Michigan State University, Extension Bulletin E-362, July 1969.

Planting Percentages: Estimated to approximate the typical planting pattern on Michigan farms.

23. Connor, Larry J., Costs and Returns for Major Cash Crops in Southern Michigan, Agricultural Economics Report Number 87, Michigan State University, November 1967.

24. Wright, Karl, Department of Agricultural Economics, Michigan State University; and a Michigan milk handler, private communication.

25. Brown, L. H. and John Speicher, Business Analysis Summary for Specialized Southern Dairy Farms, 1968, Agricultural Economics Report 137, Michigan State University, East Lansing, Michigan, June 1969.

26. Hillman, Don, Michigan State University Dairy Department. In Speicher and Brown, A Dairy Budgeting Guide, Dairy and Agricultural Economics Departments, Bulletin Number 211, Michigan State University, August 1969, p. 9; assumes part of mill feed is feed grain and thus included.

27-30. Brown, L. H. and John Speicher, Business Analysis Summary for Specialized Southern Dairy Farms.

31-32. Chosen to be representative.

33. Connor, L. J., Costs and Returns for Major Cash Crops in Southern Michigan; assumes Anhydrous Amonia N and Bulk $P_2O_5$ and $K_2O$.

34. Connor, L. J., Costs and Returns for Major Cash Crops in Southern Michigan.

35. Milligan, Robert, Research and Extension Associate, Department of Agricultural Economics, Michigan State University, private correspondence.

36. Connor, L. J., et. al., Michigan Farm Management Handbook, p. 26.

37. Chosen to be representative of practices on Michigan farms.

38. Connor, L. J., et. al., Michigan Farm Management Handbook, p. 33. Speicher and Brown, The Dairy Budgeting Guide, p. 33.

39. LaDue, E. L. (ed.), Farm Management Handbook.

40. Chosen to represent capital loss frequently experienced by Michigan farmers.

41(a). LaDue, E. L. (ed.), Farm Management Handbook, p. 81.

41(b). Connor, L. J., et. al., Michigan Farm Management Handbook, p. 33.

42. Chosen to represent typical values.

43. Speicher and Brown, A Dairy Budgeting Guide.

44-45. Chosen to be representative of practices on Michigan farms.

46. Arbitrary values.

47. Speicher, J. and L. H. Brown, A Dairy Budgeting Guide, Dairy and Agricultural Economics Departments, Bulletin Number 211, Michigan State University, August 1969, p. 9.

48. Speicher and Brown, A Dairy Budgeting Guide.

49. Hoglund, C. R., Department of Agricultural Economics, Michigan State University, unpublished data.

50(a). Connor, L. J., et. al., Michigan Farm Management Handbook, p. 61, assumes average disappearance of four pounds per day.

50(b). Hillman, Don, Michigan State University, Dairy Department. In Speicher and Brown, A Dairy Budgeting Guide, Dairy and Agricultural Economics Departments, Bulletin Number 211, Michigan State University, August 1969, p. 9.

51. Connor, L. J., et. al., Michigan Farm Management Handbook, p. 73.

52. LaDue, E. L., Farm Management Handbook.

53. Michigan Agricultural Statistics, Michigan Department of Agriculture, 1960-1969, Michigan Farm Economics, Department of Agricultural Economics, Michigan State University.

54. Speicher and Brown, A Dairy Budgeting Guide.

LaDue, E. L., Free-Stall Barn, Herringbone-Parlor, High-Silage Feeding Dairy Chore Systems, Comparison and Analysis, Department of Agricultural Economics, Research Bulletin 188, Cornell University, January 1966.

55. Estimates, assumes year-round barn feeding for cows and corral or pasture feeding of heifers during summer.

56. Connor, L. J., et. al., Farm Management Handbook, p. 54.

Kearl, C. D., Livestock Costs and Returns from Farm Cost Accounts, Department of Agricultural Economics, Research Bulletin 310, Cornell University, November 1969, p. 7.

57. Van Arsdall, Roy N., Labor Requirements, Machinery Investments and Annual Costs for the Production of Selected Field Crops in Illinois, 1965, Agricultural Economics Bulletin 4112, University of Illinois.

Benjamin, G. L. and L. J. Connor, Economies of Size of Machinery Systems on Southern Michigan Cash-Grain Farms, Agricultural Economics Report 112, Michigan State University, September 1968.

58(a). Assumes 15 percent dry that could be housed with heifers.

58(b). Assumes 15 percent dry (= .60 x 25) that could be housed with the heifers plus a possibility of running ten percent more animals than free stalls.

59. Zero months assumes that the farmer plans ahead so that the barn is available when he needs it and that he does not have to pay for it until after it is built, minimum of 20 animals or 50 percent was arbitrarily chosen.

60. Assumes: (a) Six ton hay equivalent required per cow and either (1) hay crop silage and corn silage are used (four months) of summer feeding capacity refilled with corn silage) or (2) hay capacity is available.

(b) Heifers over one year use existing storage capacity made available by a recent change in dairy cow handling (hay or old silos).

(c) Total hay equivalent required is stored as hay.

61. Hoglund, C. R., J. A. Speicher and J. S. Boyd, Milking Efficiency, Investments and Annual Costs for Milking Parlors, Research Report 93, Michigan State University, Agricultural Experiment Station, June 1970.

62. Chosen to avoid construction of facilities that will be largely unused.

63(a). Connor, L. J., et. al., Michigan Farm Management Handbook, p. 32 and 34, assumes machinery shed type of construction.

LaDue, E. L., Farm Management Handbook, p. 51.

63(b)-63(c). LaDue, E. L., Farm Management Handbook.

64(a)-64(b). Hoglund, C. R., J. A. Speicher and J. S. Boyd, Milking Efficiency, Investments and Annual Costs for Milking Parlors, Research Report 93, Michigan State University, Agricultural Experiment Station, June 1970.

64(e). Estimates based on expected physical life and rate of absolescence.

65-67. Hoglund, C. R., in Speicher and Brown, A Dairy Budget Guide.

68. Connor, L. J., et. al., Michigan Farm Management Handbook.

LaDue, E. L., Farm Management Handbook.

Handbook of Agricultural Charts, 1969, Agriculture Handbook, Number 373, USDA, p. 14, used management handbook values (1966) plus 15 percent.

69. Keener, Harold M. and Warren L. Roller, Labor Economics of Milk Production Systems, Paper Number 69-403, presented at annual meeting of the American Society of Agricultural Engineers.

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Benjamin and Connor, Economies of Size of Machinery Systems on Southern Michigan Cash-Grain Farms.

70. Van Arsdall, R. N., Labor Requirements, Machinery Investments and Annual Costs for the Production of Selected Field Crops in Illinois, 1965.

71. Van Arsdall, R. N., Labor Requirements, Machinery Investments and Annual Costs for the Production of Selected Field Crops in Illinois, 1965.

LaDue, E. L., Farm Management Handbook.

72. Speicher and Brown, A Dairy Budget Guide, an effort was made to separate the effect of increasing use of a machinery system from changing machinery systems.

73-74. Hoglund, C. R., Department of Agricultural Economics, Michigan State University, unpublished data.

75. Estimated values.

76. McDaniel, B. T., R. H. Miller, E. L. Corley and R. D. Plowman, D.H.I.A. Age Adjustment Factors for Standardizing Lactations to a Mature Basis, Dairy Herd Improvement Letter, National Cooperative Dairy Herd Improvement Program, ARS44-188, Volume 43, Number 1, March 1967.

77. Estimates based on normal lactation curves.

78. Estimates based on observed freshening pattern.

79. Ibach, D. B. and J. R. Adams, Crop Yield Response to Fertilizer in the United States, Statistical Bulletin Number 431, Economic Research Service and Statistical Reporting Service, United States Department of Agriculture, 1968, August.

80(a). Arbitrary values.

80(b). Assumes unloaders used only in one silo.

80(c). Van Arsdall, R. N., Labor Requirements, Machinery Investments and Annual Costs for the Production of Selected Field Crops in Illinois, 1965.

Hinton, R. A. and R. P. Kesler, Detailed Cost Report for Selected Hog Farms in Central and Western Illinois, 1964 and 1965, Agricultural Economics Research Report 85, Department of Agricultural Economics, University of Illinois, June 1967.

80(d). Keener and Roller, Labor Economics of Milk Production Systems.

81-83. Benjamin and Connor, Economies of Size of Machinery Systems on Michigan Cash-Grain Farms.

Van Arsdall, R. N., Labor Requirements, Machinery Investments and Annual Costs for the Production of Selected Field Crops in Illinois, 1965.