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of

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by

Jay Loren Strom

In Partial Fulfillment of the

Requirements for the Degree

of

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Graduate School

This is to certify that the thesis prepared

JAY LOREN STROM

By \_\_\_\_\_

Entitled SIMULATION OF A SWINE BREEDING HERD

Complies with the University regulations and that it meets the accepted standards of the Graduate School with respect to originality and quality

For the degree of:

DOCTOR OF PHILOSOPHY

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## TABLE OF CONTENTS

	Page
LIST OF TABLES . . . . .	vi
LIST OF FIGURES . . . . .	vii
ABSTRACT . . . . .	viii
CHAPTER 1. INTRODUCTION AND THESIS GUIDE . . . . .	1
1.1 Modeling Swine Production. . . . .	2
1.1.1 Definitions . . . . .	3
1.1.2 Nature of the Production Problem . . . . .	4
1.1.3 Management Practices. . . . .	6
1.2 Objectives of the Study. . . . .	7
1.2.1 Discussion of the Objectives. . . . .	8
1.3 Thesis Guide . . . . .	9
CHAPTER 2. MODELING ALTERNATIVES AND PREVIOUS STUDIES . . . . .	10
2.1 Variables Required in the Model. . . . .	10
2.1.1 Control Variables . . . . .	12
2.1.2 Stochastic Variables. . . . .	13
2.1.3 Variables Not Included. . . . .	14
2.2 Modeling Alternatives. . . . .	16
2.2.1 Discrete Stochastic Programming . . . . .	18
2.2.2 Markov Chain Analysis . . . . .	25
2.2.3 Simulation. . . . .	30
2.3 Review of Previous Studies . . . . .	35
2.3.1 Marten. . . . .	35
2.3.2 Schroder. . . . .	37
2.3.3 Sonntag . . . . .	38
CHAPTER 3. CONCEPTUAL AND DEMONSTRATION MODELS . . . . .	41
3.1 Conceptual Models. . . . .	41
3.1.1 Simple Binary Mechanistic Model of a Swine Herd . . . . .	41
3.1.2 The Conceptual Model and Markov Analysis. . . . .	53

	Page
3.2 Demonstration Models and Transition to the Research Model . . . . .	54
3.2.1 Markov Chain Model of a Swine Herd. . . . .	55
3.2.2 Modified Markov Chain Model . . . . .	67
3.2.2.1 Individual Randomized Simulation . . . . .	67
3.2.3 Shortcomings of the Demonstration Models. . . . .	77
3.2.3.1 Limitations Which Could Have Been Overcome in a Monthly Model. . . . .	79
3.2.3.2 Limitations Which Require a Daily Model. . . . .	87
3.2.4 Transition to the Research Model. . . . .	88
CHAPTER 4. THE MODEL . . . . .	89
4.1 Statement of the Model . . . . .	90
4.1.1 Animal States . . . . .	90
4.1.2 Auxiliary Animal Characteristics. . . . .	94
4.1.3 Auxiliary Characteristics of the System . . . . .	96
4.1.3.1 Buildings. . . . .	100
4.2 Computer Implementation. . . . .	101
4.2.1 The Skipping Process. . . . .	102
4.2.2 Packed Attribute Storage and Filing System. . . . .	103
4.2.3 Random Number Sources . . . . .	106
4.2.4 Input-Output Forms. . . . .	106
CHAPTER 5. ILLUSTRATIVE RESULTS. . . . .	108
5.1 Building Utilization With Standard Control Values. . . . .	108
5.2 Production With Standard Control Values. . . . .	113
5.3 Costs and Return With Standard Control Values. . . . .	114
5.4 A Comparison of Synchronized and Nearly Continuous Breeding. . . . .	116
5.5 Use of This Model In Its Present Form. . . . .	121
CHAPTER 6. IMPLICATIONS OF THE STUDY. . . . .	124
6.1 Limitations of the Model . . . . .	124
6.1.1 Execution Time Problems . . . . .	125
6.1.2 Size and Degree of Detail . . . . .	126
6.1.3 Input-Output Limitations. . . . .	126
6.2 Suggestions For An Extension Model . . . . .	128
6.2.1 Farrowing Systems . . . . .	128
6.2.2 Minimum Time Unit . . . . .	129
6.2.3 Means of Obtaining Faster Execution . . . . .	130
6.2.4 Other Husbandry Practices . . . . .	130
6.3 Conclusions. . . . .	131

	Page
LIST OF REFERENCES . . . . .	133
APPENDICES	
Appendix A. A Comparison of Alternative Ways of Calculating Binomial Results - Appendix to Chapter 3 . . . . .	137
Appendix B. Input-Output Forms and Instructions . . . . .	141
Appendix C. The FORTRAN Program . . . . .	164
Appendix D. Input Data. . . . .	232
VITA . . . . .	238

## LIST OF TABLES

Table	Page
2.1 Zero Deaths Example . . . . .	22
2.2 Death Loss Example . . . . .	23
2.3 Discrete Stochastic Programming Illustration . . . . .	24
3.1 Number of Possible Daily Binary States . . . . .	46
3.2 Daily Binary State Transformation Probabilities. . . . .	48
3.3 Monthly Markov Chain Inventories . . . . .	56
3.4 Monthly Markov Chain Transition Matrix . . . . .	58
3.5 Monthly Markov Chain Simulation.... . . . . .	63
3.6 Randomized Markov Chain Simulation . . . . .	68
4.1 Standard Gain Parameters . . . . .	95
5.1 Periodic Reports . . . . .	109
5.2 Periodic Reports for Nearly Continuous Breeding. . . . .	118

## Appendix

## Table

A.1 Computation Method Results . . . . .	139
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## LIST OF FIGURES

Figure	Page
3.1 Flow Chart of Subroutine Row I-Loop . . . . .	74

## ABSTRACT

Strom, Jay Loren, Ph.D., Purdue University, May, 1973, Simulation of a Swine Breeding Herd. Major Professor: W. V. Candler.

While very important to Indiana farmers, swine production is a complex and uncertain economic and technical enterprise. Uncertainty complicates farmers' management decisions, yet computer models for extension have largely ignored the stochastic nature of production. An objective of this study was to provide a model to aid in analysis of swine management decisions which involve stochastic outcomes.

Swine producers are faced with stochastic outcomes for survival, estrus, conception, litter size and growth rates which affect the scheduling of the herd for breeding, culling, and sales as well as for the use of buildings and equipment.

Stochastic and integer elements in swine planning models either cannot be incorporated in traditional modeling techniques or expand them beyond the capacity of currently existing computing technology.

A Markov type model was developed and demonstrated by implementing a small scale monthly example model of a swine herd. The full scale research model was implemented as a computer program (simulation). Central emphasis of the model is the problem of scheduling the herd through buildings. Control variables include farrowing, breeding, culling, and sales dates and criteria along with the parameters

which define the random variables of production and survival. A six farrowings per year system was modeled.

An input-output form is used to facilitate use of the model by research workers and to define those control parameters which are optional to the user of the computer program.

The primary disadvantages to the modeling procedures chosen were those of implementation which resulted in a relatively large and complex computer program requiring long run times. The simulator, despite its high cost of operation, may be both a cheaper and faster method than experimentation with live animals.

Illustrative examples of the output of computer runs are presented. The program will be most useful when used to test the feasibility of swine management strategies or to generate production outcomes as in an experimental setting.

## CHAPTER 1

## INTRODUCTION AND THESIS GUIDE

Swine production is one of the most important livestock industries. In Indiana, farmers consistently market 6.5 to 7.0 million head of hogs annually, contributing over 300 million dollars to annual cash farm income. During the period 1965-1970, swine production accounted for 45% of all livestock sales and over 24% of sales from all commodities marketed from Indiana farms.<sup>1/</sup>

While very important to Indiana farmers, swine production is a complex and uncertain economic and technical enterprise. The complexity is due in part to the uncertainty involved in the production process, where uncertainty reveals itself in the stochastic nature of conception, litter size, survival, growth, etc. The complexity of technical production is evident when breeding, farrowing, weaning, culling, and sales must be scheduled. Both technical complexity and uncertainty complicate economic decision making.

Knowledge about the outcomes of management decisions can be gained by experimenting with real herds. This method of learning is, however, a slow and tedious process, and involves a relatively high cost. Experiments which require the sacrifice of a large number of animals can be prohibitive, yet the importance of the swine enterprise indicates the need for knowledgeable decisions on the part of the swine producer.

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<sup>1/</sup> Based on United States Department of Agriculture Statistics for the years 1965-1970 [38].

Computer modeling has been used as an alternative to experimenting with real herds. Previous computer models have abstracted from the risk and uncertainty involved in swine production even though this aspect is central to the swine producers planning problem. Extension models for swine production decision making have assumed non-stochastic performance rates without giving attention to stochastic elements operating in the swine herd. These models are most appropriate for finishing, the least uncertain and most routine aspect of the production process.

Given the stochastic nature of the problem, can computer models be used to help researchers in their analysis? Can they be used in extension work with farmers? Is it technically possible to build an appropriate computer program and is such a computer program even economical for use in research or extension? These questions motivated development of a research model appropriate to at least some of the most important planning problems of the swine producer. This model may ultimately lead to further development of research and extension models for analysis of swine producers problems.

### 1.1 Modeling Swine Production

This section first presents a discussion of the terminology revolving around the use of the words "model" and "simulation" as used in this study. The nature of the production problem is then presented, followed by a discussion of the management practices used in a swine breeding herd.

### 1.1.1 Definitions

A model is an abstract representation of the real world. The art of model building is built upon the appropriate degree of abstraction. For example, abstraction which may be legitimate for extension purposes may be quite inappropriate for research purposes. A model includes important elements so that it can provide a useful representation without containing the great many details of the real world.

A Conceptual model ideally defines all the significant relationships of a system in a logical and concise manner. Its purpose is to define and clarify (conceptualize) the relationships of the system under investigation. A researcher may be able to express a set of mathematical equations which define all the important relationships of a simple system, but more often he must turn to summarization and abstraction by making only the more important relationships explicit in abstract graphical, narrative or mathematical expressions.

A mathematical programming model at once connotes both the well known structural framework of the programming procedure (model) and the solution procedures (algorithms) of that type of mathematical problem, if they are known.<sup>1/</sup>

An algorithm is a computational method for deriving numerical solutions to a model [40, p.80]. In particular for this study, an algorithm is the solution procedures and techniques organized in computer program form.

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1/ Linear Programming, for example, defines a mathematical programming problem (accepted structure and assumptions) for which the Simplex method is one of the solution techniques (algorithms).

A research model contains the essential structure and those variables chosen as necessary to adequately represent the problem being modeled, yet permit implementation as a computer program to permit experimentation with the model.

An extension model as opposed to a research model, must permit routine use by farmers or extension personnel. A notable characteristic is the importance of computer efficiency and Input-Output forms.

Simulation is use of a computer program (simulator) to study a quantitative model. Given an objective function it may, or may not, involve procedures aimed at finding a "good" solution to the model. Obviously, if there is no objective function, as in this study, such procedures are irrelevant. It is assumed the model being studied is stochastic.

An experiment consists of repeated runs of the simulation (where a run refers to one pass through the simulation from input to output) with given parameter values of interest. Repeated runs are required because outcomes are stochastic. An experiment allows evaluation of if ... then statements, i.e., if the parameters are at level X then we can expect an outcome with an associated Mean, Range, and Variance.

#### 1.1.2 Nature of the Production Problem

If a producer has decided to produce hogs with a breeding herd, has a given herd inventory, has a set of facilities and labor committed to swine production, then his problem is to economically schedule those committed resources and carry out his production plan.

The results from given production plans are subject to major uncertainties. Physical uncertainty is recognized by the producer in expecting disease to strike sometime, in recognizing that a whole group of sows may be relatively infertile, and that virtually a whole farrowing of pigs may be lost if an epidemic baby pig disease should strike.

Other uncertainties are less drastic to the execution of a management plan. Most of these involve risk in the traditional sense that a statistical mean and probability distribution can be estimated which may be useful in a decision model. For example, the length of the estrus cycle, the likelihood of pregnancy if serviced, the likelihood of farrowing if in gestation, and the number of pigs farrowed are all stochastic variables which are often explicitly modeled as non-stochastic variables, possibly at their mean values, for planning purposes. This simplifies the modeling process but ignores important questions in the breeding and scheduling of the herd for given facilities.

Stochastic and integer elements in swine production need to be incorporated into decision models to increase their usefulness.<sup>1/</sup> These elements either cannot be incorporated into traditional modeling techniques, and/or expand the traditional models beyond the capacity of currently existing algorithms and computing technology. Linear programming cannot be used to handle uncertain or integer aspects of the swine production problem. Therefore, application of other modeling methods seems appropriate.

---

1/ Section 1.1.3 discusses management practices which lead to the need for recognizing integer aspects of the problem. Objectives of the study appear in section 1.2. Section 2.1 includes a discussion of the stochastic nature of swine production. Section 2.3 is a review of previous studies. See section 1.3 for a guide to the thesis.

### 1.1.3 Management Practices

The manager's major scheduling decisions revolve around conflicting goals. His problem is a dynamic one, characterized by the changing structure of the herd, and imperfect knowledge as to outcomes of his production plans. The production manager's job involves a large number of scheduling decisions; number of animals and dates must be chosen for breeding, farrowing, moving animals, culling, and selling.

Popular management practices aimed at controlling the incidence of disease, require emptying and cleaning farrowing buildings after periodic farrowing. In addition, producers can tightly group farrowing dates with the goal of a uniform group of baby pigs which can be grown to sale weights in relatively uniform pen lots. Weaning dates also can be adjusted to make sows available for breeding for tightly grouped target farrowing dates, but this competes with the nursing requirements of the baby pig.

The swine herd is usually housed in several specialized buildings. A sow maintenance, breeding, and handling area or building is one such facility. Farrowing and nursery buildings or some combination comprise a second major category with finishing facilities constituting a third.

Reduction of the number of sows maintained, and hence reduction of feed, housing, and labor cost, is an objective in conflict with the requirement of a large pool of sows available for breeding to fill facilities on target farrowing dates.

Culling practices reflect a conflict between revenue from and productivity of butcher hogs, gilts, and sows. A large number of

gilts and sows in the breeding herd delays recovery of their market value as well as resulting in high maintenance costs. Income tax considerations, especially the possibility of capital gains for the sale of sows may also influence culling policy.

Disruptions of the social order among animals in any one pen is avoided by starting animals of similar size and age together; then further intermixing is avoided when possible. Few animals in any one pen, and hence better pig performance, is an objective in conflict with the goal of maximum utilization of available facilities. Housing few animals in each building as a precaution against disease, conflicts with the need for efficient labor and building utilization.

In addition, the manager must decide on ration composition, feeding rates, health care, genetic improvement, investment in facilities, etc. As the above discussion has shown, production scheduling is a vital part of over-all swine management decision making.

### 1.2 Objectives of the Study

The objective of this study was to explore the feasibility of modeling the stochastic and integer elements of swine production in a way which would be helpful for the study of at least one swine production system. Emphasis was on the scheduling problems of a swine breeding and finishing herd as opposed to an operation involved exclusively in finishing purchased feeder pigs.

The Specific Objectives of this study were:

1. To identify stochastic, uncertain, and integer elements which are of importance in modeling swine production,

2. To search for an appropriate approximating<sup>1/</sup> model,
3. To implement that model in the form of an operational computer program for use by research workers, and
4. To demonstrate solutions to the approximating model.

#### 1.2.1 Discussion of the Objectives

Identification of stochastic, uncertain, and integer elements is a process which continued throughout the study. These elements were hypothesized and included as attributes of the model, however, their relative importance in modeling the swine breeding herd cannot be answered until some experience is gained from use of the model as an experimental tool.

The results of the search for modeling alternatives are discussed in Chapters 2 and 3.

The third objective involved the construction of a research model,<sup>2/</sup> and its implementation by simulation. The model constructed was a non-adaptive management system simulator which tested the feasibility of scheduled mating strategies, estrus control and the like.

---

1/ Approximating in the sense that modeling approximates by excluding variables to permit analysis. For a discussion of variables required and those excluded from this model, see section 2.1 of the following Chapter.

2/ The term "research model" places emphasis upon structural flexibility and the ability to experiment with the model as opposed to the requirements of a model which is for routine use by extension personnel. Computer software, as well as modeling objectives, may be quite distinct for an extension model as compared to a research model. See Candler, Boehlje, and Saathoff [6, pp. 71-80].

### 1.3 Thesis Guide

In accordance with the second objective listed above, Chapter 2 explores alternative model types which could be used, and reviews previous studies.

Chapter 3 reports the work which led up to the research model. A conceptual model was constructed and then demonstrated by making it operational in small scale examples. Shortcomings of the demonstration models led to Chapter 4 which shifts attention to the full scale research model by presenting a statement of the model, and its implementation as a computer program.

Chapter 5 demonstrates use of the model by presenting illustrative results.

Over-all summary, limitations and implications are given in Chapter 6.

The Appendices contain FORTRAN IV coded listings of the model, and a copy of the Input-Output forms.

## CHAPTER 2

### MODELING ALTERNATIVES AND PREVIOUS STUDIES

Chapter 2 first presents a discussion of the variables required in a model of a swine breeding herd. Attention is then turned to the modeling alternatives available for handling these variables and finally presents a review of some previous studies of swine production.

#### 2.1 Variables Required in the Model

A swine production scheduling model must be able to handle the time dimension of swine production, perhaps in discrete time intervals of hours, days, weeks or months. In addition, the uncertain nature of swine production dictates that the model include stochastic variables. This is discussed further in section 2.1.2.

The need to clean out facilities completely, for disease control, dictates integer variables in the model: either the facility is cleaned out, or it is not. From the disease control viewpoint, a half cleaned out building, is still dirty.

The following management practices were incorporated in the model: (a) periodic building emptying and cleaning, (b) grouping of animals for housing assignment, (c) planning of breeding, culling and replacement for target farrowings, and (d) movement of animals from building to building.

Ideally, this thesis would have produced an adaptive research model <sup>1/</sup> in which management strategies would be defined for all possible outcomes. At the present stage of our knowledge of swine herd scheduling, this was felt to be too ambitious an objective. Accordingly, a non-adaptive model was developed.<sup>2/</sup> In the present model, animals survive and space is either exceeded or is not, there are sufficient sows in the herd for breeding the target number of litters for each farrowing or there are not, and so on. A non-adaptive model carries out a management plan and notes the results. In particular, it notes the types of infeasibilities that occurred and their frequency. It does not consider the wide range of alternative management strategies open to a farmer who perceives the danger of infeasibility.<sup>3/</sup>

#### Control variables permitted experimenting with management

---

- 1/ An adaptive model is defined for the purposes of this study to mean a model which adapts by choosing among classes of strategies, the action to be taken in response to improved information. For example, an adaptive model would determine sow replacements by first making an inventory of those expected to be available for breeding, and comparing this with the expected number required, to determine the number of gilts selected for replacement. The non-adaptive model developed here selects a predetermined number of replacements without regard to the condition of the breeding herd.
- 2/ The computer program implementing the model did, however, permit inclusion of simple adaptive techniques. These included restricted weaning and moving of pigs when buildings became full, and altered conception rates when boars were found to be in short supply. For a discussion of these and other features of the research model implemented in the form of a computer program, see Chapters 4 and 5.
- 3/ At worst, the farmer can usually sell stock to correct building overflow, albeit at a discount.

policies,<sup>1/</sup> these are discussed in the following section.

### 2.1.1 Control Variables

Control variables are necessary to allow the researcher to perform experiments with the model and to define management policies. The more important control variables for a swine management policy might be defined as:

1. Gilt and boar selection for the breeding herd
  - 1.1 Number to select,
  - 1.2 Time at which new gilts and boars are brought into the herd, and
  - 1.3 Criteria for selection.
2. Farrowings and their target dates
  - 2.1 Number of farrowings per year and their intervals,
  - 2.2 Target number of days or weeks continuation, and
  - 2.3 Relative proportion of sows and gilts.
3. Target number of litters
  - 3.1 Percent "over breeding" to obtain enough litters to fill the farrowing house, and
  - 3.2 Disposition if over filled.

---

<sup>1/</sup> In this thesis a strategy was used as in the literature on decision theory: Brown [4], Fishburn [9], Schlaifer [32], and Wagner [40]. "A strategy is a rule which prescribes exactly what act shall be chosen in every situation in which a choice may have to be made...," Schlaifer[32, p.60]. A strategy involves an appropriate decision for each possible state of nature. A management policy is defined as an ex ante set of objectives for the performance of the system. Thus, a policy may prove to be feasible or infeasible while a strategy is always feasible.

4. Selection and culling rules

    4.1 Selection and culling of the breeding herd, and

    4.2 Criteria for sales of butchers, old sows, and boars.

5. Space assignments

    5.1 Age and/or weight variables to define space  
        assignment,

    5.2 Maximum number of sows or pigs per building.

2.1.2 Stochastic Variables

Stochastic variables,<sup>1/</sup> proposed as both random variables and of major importance in swine production, include (a) survival, (b) rate of gain, and (c) variables associated with the breeding-gestation of sows and farrowing of baby pigs.

Survival is an attribute of all animal categories throughout all time periods. However, survival has a specific probability distribution according to the age of the animal, and productive classification. Survival can be represented by a 0, 1 variable, i.e., there is survival to the next time period or not.

Rate of gain is also an attribute of all animals and has a specific probability distribution according to productive classification, and age.

Stochastic variables associated with breeding, gestation, and farrowing include (a) the uncertainty of detection of heat in the sow, (b) boar availability at a particular time, (c) conception rate,

---

<sup>1/</sup> These are also "control variables" from the point of view of the research model in the sense that the researcher specifies the distribution from which these values are drawn to run an experiment.

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( )  
     (d) embryonic mortality, (e) abortion, (f) stillbirths, and (g) the number of pigs born alive. Emphasis is placed on the stochastic elements of sow productivity because this is considered a most uncertain aspect of swine production. It is vital to model these important variables when modeling the stochastic nature of swine production.

#### 2.1.3 Variables Not Included

Some other important features of swine production have been modeled by animal scientists and extension workers using traditional budgeting techniques. Labor requirements, and feed utilization are two aspects of swine production which have been included in deterministic budgets. A major part of the stochastic nature of feed utilization is directly associated with the incidence of disease. The day-to-day scheduling and handling of feed is primarily dependent upon the number and kinds of animals in the herd. For the purposes of this study, however, feed was assumed available but accounted for only as a simple cost of production based on weight gain. This simplification permitted the stochastic features of other variables to be modeled in more detail.

Labor available and the labor requirements of swine are major decision variables in the choice of enterprises for a farm plan. Labor requirements in swine production are stochastic as a result of the stochastic nature of the production processes. Labor was accounted for as a simple calculation of variable labor based on daily building inventories.

Contagious disease has repercussions on a swine breeding herd. The incidence of disease is a stochastic variable which greatly

affects the payoff of management strategies.. However, this aspect of the swine producer's problem was judged to be too complicated for a first attempt at modeling the swine breeding herd with stochastic variables. At best, inclusion of contagious disease would greatly complicate evaluation of the model because of its unpredictable and low incidence of occurrence.

Variables which would have allowed alternative farrowing systems were not included. Modeling of additional farrowing systems would have greatly expanded the size and complexity of the model. Each farrowing system considered would have required rearrangement of the opening inventory configuration. Each farrowing system would also have required a unique set of culling and selection rules to properly time breedings for target farrowing dates. Modeling a single system reflects a producers short term planning problem once a farrowing schedule has been decided. Comparison of systems would have involved many of the aspects of a unique model for each system.

A continuous time variable is another feature not investigated. One choice of time interval thought to provide sufficient realism is one day. A shorter interval would constitute more realistic modeling, i.e., be closer to the reality of continuous time. However, modeling hour by hour as compared to day by day would expand the size of model considerably. The number of states of nature are increased drastically, as well as the computations necessary to run the model, for a given experience interval of several years. These two factors combined would appear to be likely to have an exponential effect on the computer run time required for solution and at least a multiplicative effect on

the number of relationships (complexity) in the model.<sup>1/</sup> It is expected that more comprehensive extension models would use a day as the minimum and possibly a week or month as the basic time interval in a model of a swine production system.

Genetic inheritance as well as some environmental factors such as temperature, humidity and others considered under the title "stress" are significant determining factors of swine production. Many of these factors have been ignored or modeled in simplified, indirect or abstract ways in this study. It is hoped that experience gained in modeling stochastic variables may lead to more realistic treatment when comprehensive swine production models are constructed.

## 2.2 Modeling Alternatives

Exploring possible modeling techniques to discover the relative merits of some types that might be used is the general objective of this section. This study assumes there exists the motivation to model a swine breeding herd as part of the extension-research objective of developing computer models for farm planning decisions. Modeling is an accepted part of the scientific method, and computer modeling is already in use as an extension tool<sup>2/</sup> to aid in decision

---

<sup>1/</sup> A vivid picture of this point can be seen by comparing the simplified 6-month models presented in section 2.2.1 and 2.2.2 with the monthly models in Chapter 3.

<sup>2/</sup> Purdue University has several models operational as extension tools in the Top Farmer series of workshops. One of these: "Simulated Near-Optimal Growth Paths for Hog-Corn Farms Under Alternative Resource, Price and Efficiency Situations," is reviewed in section 2.3.3. Many other universities report operational computer programs in farm management [20].

making for the farmer. Model building is an integrated part of scientific philosophy: Naylor [25, p.5]

"In its present day form scientific philosophy or the scientific method, as it is frequently called, consists of four well-known steps,

1. Observation of a physical system.
2. Formulation of a hypothesis (or in our case a mathematical model) that attempts to explain the observation of the system.
3. Prediction of the behavior of the system on the basis of the hypothesis by using mathematical or logical deduction, i.e., by obtaining solutions to the mathematical model or models.
4. Performance of experiments to test the validity of the hypothesis or mathematical model."

According to Naylor [25], it may not always be plausible to follow these four steps for a particular problem. An appropriate model may be a satisfactory substitute for steps in the procedure which cannot be expedited otherwise. It would surely have been too expensive to experiment with a swine breeding herd over the extended period of time required to generate the data desired for analysis in this study.

The complexity of the problem puts a severe restriction on the solution algorithm. One cause of this complexity is the large number of classifications of animals in the herd. It may be impossible to describe all the interrelationships with a relatively small set of mathematical equations. It is virtually impossible to describe the many probabilistic interactions necessary to obtain an analytical solution mathematically.<sup>1/</sup>

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<sup>1/</sup> An attempt at describing a herd as a binary model of 0, 1 variables with various subscripts for animal characteristics grows into a huge number of combinations for all but the simplest of models. See section 3.1.1.

Alternative models must be judged on the basis of the type of problem and objectives of the study. As will be seen, a Markov chain 1/ type model structure was selected. Modeling procedures of the following types will be discussed: (a) Models that lead in principle to known analytical algorithmic solutions.2/ (b) Models useful for demonstration of the nature of the problem and the type of modeling procedures which will handle a problem of this nature, and (c) Simulation. The choice of a modeling technique is influenced by two levels of research: ultimate operational decision models for extension use and the more basic research of this study. For a research model it may be useful to go beyond the level of detail appropriate for an applied model. Simplifications can be made after obtaining basic experience with a research model.3/

### 2.2.1 Discrete Stochastic Programming

Discrete stochastic programming relaxes the single valued coefficients assumption of linear programming. Cocks [8] presents a method for solving linear programming problems where the objective function, restraints, and/or input-output coefficients are subject

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- 1/ Section 2.2.2 Markov Chain Analysis contains a definition and discussion of Markov Chain type models.
  - 2/ Unfortunately, these models are too large to be solved on available computer facilities.
  - 3/ The reverse strategy of building a simple model for extension, and later adding complexity for a research model, is less likely to be efficient since it is not until we have sensitivity analysis of the complex model, that we can tell which simplifications can safely be made in an extension model.

to discrete probability distributions.<sup>1/</sup>

The problem could conceivably have been modeled as a discrete stochastic program.<sup>2/</sup> The stochastic nature of production is properly reflected by probability distributions on input-output coefficients. Management options for breeding sows, assigning buildings, creating newborn pigs, etc., could have been modeled by the proper configuration of restraints and activities. A suitable objective function, such as maximizing expected profit could have been defined.

Discrete stochastic programming is well suited to multiple period production problems. Information comes forth to the manager as his production plan is executed, making it possible to decide issues as information becomes available, i.e., as the states of nature actually materialize. This method is especially well suited to handle a problem where timing of information is of the essence. Timing of information is important in scheduling of breeding for a target farrowing. The number of gilts or sows available would be known at a point in time but the actual number that can be successfully bred would not be known.

The problem modeled in this study is a discrete stochastic integer programming problem. However, an extremely large operational model results as evidenced by the following simple example.<sup>3/</sup>

- 
- 1/ The introduction to this method is based on Cocks [8] with altered notation. For some other discussions and applications see Rae [30], Johnson, et al. [16], and Arnoff and Sengupta [2].
  - 2/ Classed among mathematical programming problems, the problem under study here is a discrete stochastic integer programming problem.
  - 3/ Cocks and others generally recognize that unmanageable working models may result, for an example, see Hutton [15, p. 1, 402].

The nonstochastic linear programming problem is

$$(2.1) \quad \max Z = \underline{c}' \underline{x}$$

$$(2.2) \quad \text{subject to } A \underline{x} \leq \underline{b}$$

$$(2.3) \quad \text{and } \underline{x} \geq 0$$

where

$A = m \times n$  matrix of input-output constants

$\underline{b}$  = a column vector of resource restraint constants

$\underline{c}$  = a column vector of pay-off constants, and

$\underline{x}$  = a column vector of activity levels to be determined

Introduce stochastic elements by defining the probability distribution for a total of  $K$  states of nature, one of which will materialize.

$$(2.4) \quad \text{Prob. } \{ (A, \underline{b}, \underline{c}) = (A_k, \underline{b}_k, \underline{c}_k) \} = p_k; \quad k = 1, 2, \dots, K$$

$$(2.5) \quad \sum_{k=1}^K p_k = 1$$

The activity vector  $\underline{x}$  is now dependent on the state of nature  $k$  that turns up. The value of the program  $Z$  is a random variable.

$$(2.6) \quad \text{Prob. } \{ Z = z_k \mid (A, \underline{b}, \underline{c}) = (A, \underline{b}, \underline{c})_k \} = 1$$

The example introduced below has a discrete probability distribution on elements of  $A$ . The discrete stochastic programming problem is

$$(2.7) \quad \max Z^* = E(Z) = \sum_k p_k z_k$$

$$(2.8) \quad \text{subject to } A_k \underline{x}_k \leq \underline{b}; \quad k = 1, \dots, K$$

$$(2.9) \quad \text{and } \underline{x}_k \geq 0; \quad k = 1, \dots, K$$

Where  $E(Z)$  is the expected value of  $Z$ . Consider a very small scale illustration which will show the way in which the problem under study here could have been modeled if it were not for the size of the matrix which results. Assume that it is desired to know the number of sows to mate and the number of their offspring to retain for replacement in a subsequent reproductive period. Let survival be considered the only stochastic variable. The outcomes of survival include: no deaths, or death of one sow and no pigs, or death of 2 sows and no pigs, etc.; or death of no sows but death of one pig, 2 pigs, 3 pigs, etc. etc., until an example herd of 50 sows with 8 pigs each would define 20,451 outcomes due to survival.

If the outcome which was to materialize was known before mating decisions were made, the problem would be a deterministic one. It would then be relatively easy to model as a nonstochastic linear programming problem. Let the following example (see Table 2.1) represent a portion of the system for a simplified case when it is known that no deaths will occur.

The simple example represented in Table 2.1 assumes there were 4 sows at the beginning of the first reproductive period. Column 1 allows for mating of sows, creation of their offspring and disposition of the sows themselves at the end of the period either as ending inventory or sows sold. Exactly 8 pigs are raised (see row 2 of column 1). Sows sold (.2) and ending inventory (.8) represent a 20% cull with no death loss. Costs of production have been ignored for simplicity but a Revenue row is included to account for generation of sales revenue.

Table 2.1 Zero Deaths Example

Column:	1 Mate Sows	2 Hold and Sell	3 Hold Over	4 Save Replace- ments	5 Sell Hogs	6 Ending Inventory	7 Sell Sows
Row:							
1. Open Sows	4>		1	1	1		
2. Pigs Raised	0>		-8		1	1	
3. Sows Sold	0>	-.2	-1	-.3			1
4. Ending Sows	10>	-.8		-.7	-1		1
5. Revenue max					-50	100	-70

Column 2 allows the decision to sell sows rather than mate or hold them over to the next period. The sale of each sow generates \$70 of revenue for the system. Column 3 accounts for open sows held over and provides for culling. Columns 4 and 5 provide for saving pigs for use as replacements, or for their sale as hogs. Sales of hogs generate \$50 of revenue per hog sold. Column 6 provides for transfer of open sows to the following period. The value of an open sow to the next period (next section of the matrix, not shown) was assumed to be \$100, a value which could be determined by a complete model.

There are many possible survival outcomes. Table 2.2 is an example which assumes a death loss of 2 pigs and 1 sow. Column 1 of Table 2.2 reflects the results of mating one sow which farrows, say,

8 live pigs of which only 6 survive to be sold. Of the sows which are mated 20% are assumed culled but death loss results in only 15% available for sale. Likewise 60% remain as open sows. Columns 2 through 6 have an interpretation similar to the same columns in Table 2.1 except that death loss has been added.

Table 2.2 Death Loss Example

Column:	1 Mate Sows and Sell	2 Hold Sows Over	3 Hold Replace- ments	4 Save Replace- ments	5 Sell Hogs	6 Ending Inventory Sows	7 Sell Sows
<u>Row:</u>							
1. Open Sows	4>		1	1	1		
2. Pigs Raised	0>	-6			1	1	
3. Sows Sold	0>	-.15	-.75	-.225			1
4. Ending Sows	10>	-.6		-.525	-1		1
5. Revenue max					-50	100	-70

If the forthcoming state of nature (death loss) were known before the decision to mate sows was made, a complete linear programming model could be used to find a solution. However, the forthcoming state of nature is not known except in a probability sense. It is possible to incorporate this probability information for the discrete survival outcomes in the form of a discrete stochastic programming model. Such a model is illustrated in Table 2.3 where the two hypothetical survival outcomes are represented as part of a discrete stochastic programming matrix.

Table 2.3 Discrete Stochastic Programming Illustration

		State of Nature 1			State of Nature k		
		Mate Sows	Sell Sows	Hold Sows	Sell Hogs	End Inv.	Sell Hogs
				Over	Gilts	Sows	Gilts
Open Sows	4>		1	1	1		
State of Nature 1							
Pigs Raised	0>	-8			1	1	
Sows Sold	0>	-.2	-1	-.3			
Ending Sows	10>	-.8	-.7	-.7	-1	1	
State of Nature 2							
Pigs Raised	0>	-6					
Sows Sold	0>	-.15	-.75	-.225			
Ending Sows	10>	-.6	-.525				
State of Nature K							
Revenue	0>		R <sub>2</sub> <sup>1</sup>	R <sub>3</sub> <sup>1</sup>	...	R <sub>2</sub> <sup>k</sup>	R <sub>3</sub> <sup>k</sup>
						R <sub>4</sub> <sup>k</sup>	...

Sections of the partial matrix of Table 2.3 represent two of the total possible outcomes K (see equation 2.4). Each outcome has some probability  $p_k$  of occurrence. The value of the program is directly related to the probability of the occurrence of the states of nature. For this example, the revenue generated would be:

$$(2.10) \quad z^* = p_1 z_1 + \dots + p_k z_k + \dots; \quad k = 1, 2, \dots, K$$

Where

$p_1$  = the probability of state of nature 1

$z_1$  = revenue generated by  $R_2^1 + R_3^1 + R_4^1$

$p_k$  = the probability of state of nature k

$z_k$  = revenue generated by  $R_2^k + R_3^k + R_4^k$

Modeling as a discrete stochastic program requires a very large matrix to represent even the simplest of examples. It is obvious that inclusion of a realistic number of states of nature, additional stochastic variables, and completing the model by including a full set of time periods along with other necessary relationships would make such a model totally impractical to solve.

### 2.2.2 Markov Chain Analysis

"A finite Markov chain is a stochastic process which moves through a finite number of states, and for which the probability of entering a certain state depends only on the last state occupied," Kemeny and Snell [18, p. 207]. A swine herd can be cast as an operational system as has been done in section 2.2.1. The simplified

example given there describes the herd as a set of state of nature outcomes. A complete set of states can be used to describe the herd at a given point in time.<sup>1/</sup>

True Markov processes<sup>2/</sup> are defined for a system which has mutually exclusive system states. The system can be in one and only one of these states at a given time. Successive moves from one state to another (or back to the same) state at the end of a time unit is called a step.

For a Markov process a transition is defined as a change from state  $i$  to state  $j$ . The probability of a transition is called a transition probability:  $p_{ij}$ . These transition probabilities form an  $n \times n$  matrix called the transition matrix for a system described by  $n$  mutually exclusive states.

$$(2.11) \quad P = (p_{ij}) ; i, j = 1, 2, \dots, n$$

where  $p_{ij}$  is the conditional probability of a change from state  $i$  to state  $j$  at time  $t+1$ , given that it is in state  $i$  at time  $t$ . Equation 2.11 defines a transition matrix if

$$(2.12) \quad p_{ij} \geq 0 \quad \text{for all } i, j$$

$$(2.13) \quad \sum_{j=1}^n p_{ij} = 1 \quad \text{for each } i=1, 2, \dots, n$$

1/ Our interest will be limited to discrete time, finite processes. Markov theory has been developed for continuous time processes as well as for discrete time units. See Howard [14], Chapter 8.

2/ Kemeny, Snell, and Thompson [19, pp. 171-177] present a general introduction to Markov processes. Reilly has reviewed some applications to economic problems [31].

A particular row ( $i$ ) of a transition matrix is called a probability vector. If we assume that a process begins in some particular state,  $a_i$ , then we can calculate the probability of being in every possible state at some future date. A process which has a specific beginning state, and refers to an entire sequence of transitions is known as a Markov chain.

Markov analysis is used to answer the following question: Suppose that a system is in state  $i$ . What is the probability that after a defined number of steps, it will be in state  $j$ ?

Define a probability vector  $p_t$  for the starting time <sup>1/</sup>  
 $t = 0$  and for any other future date as

$$(2.14) \quad p_t = (p_{tj}) ; \quad j = 1, 2, \dots, n$$

Then the above question can be readily answered by matrix multiplication. The probability vector  $p_t$  where  $t = T$ , the future date of interest, contains the respective probabilities of being in one of the  $n$  possible states of the system after  $T$  steps. This is given by

$$(2.15) \quad p_T = p_{(T-1)} P$$

implying step-by-step multiplication from the starting point  $t = 0$ . <sup>2/</sup>

Application of Markov analysis would require definition of the swine herd into system states where, for example, state number 1 is a herd of: 2 open sows, and 6 bred sows, and 60 pigs of all ages.

- 1/ A probability vector contains non-negative elements which sum to 1. A starting state may be given by assigning a particular state  $a_i$  the probability  $p_{tj} = 1$ ;  $i=j$  and all other  $p_{tj}=0$ , or the vector may describe the respective probabilities of being in states  $a_i$ ;  $i=1, 2, \dots, n$ .
- 2/ Kemeny, Snell and Thompson [19, p.218]. An equivalent result is obtained by first finding the  $T^{\text{th}}$  power of the transition matrix  $P$ , i.e.,  $p_T = p_0 P^T$ , p. 218.

Then state number 2 is a herd of 1 open sow, and 7 bred sows, and 60 pigs of all ages, etc., etc. This would have the advantage of making it possible to calculate the probability of each state in any time period. It would also have the advantage of allowing for management policies. For example, modeling an overfilled building would simply require additional states of the system representing over filled buildings. Forced sale of some animals, with a probability of 1 that animals are sold when this state is reached, would return the system to a normal condition. However, operationally the problem modeled in this way would be huge.

Fortunately useful information is obtainable from a much smaller configuration of the model. Define an inventory vector

$$(2.16) \quad \underline{y}_t = (y_{tj}) ; \quad j = 1, 2, \dots, n$$

where respective elements  $j$  for a given time  $t$  make up the set of states which can describe any animal in the herd. Inventory values  $y_{tj}$  are the number of animals in each state  $j$  at time  $t$ . The vector  $\underline{y}_t$ , for  $t = 0$ , is a beginning inventory distribution showing the number of animals in each category. Subsequent inventory vectors are

$$(2.17) \quad \underline{y}_{t+1} = \underline{y}_t P$$

and contain the expected number in each inventory category.

This inventory vector-transition matrix approach can be used as demonstrated in the simple example below.<sup>1/</sup> Let  $P$  represent a  $4 \times 4$  transition matrix for a swine herd, 6-month model.

<sup>1/</sup> For examples of this approach as used in research on the size distribution of firms, see Hallberg [10], or Padberg [29].

$$(2.18) \quad P = \begin{bmatrix} 0 & .7 & 0 & .3 \\ 0 & .8 & 8.0 & .2 \\ .1 & 0 & 0 & .9 \\ 0 & 0 & 0 & 1.0 \end{bmatrix}$$

and the initial inventory contains 4 open sows, 6 bred sows, 60 pigs of all ages and 0 total sales

$$(2.19) \quad y_0 = [ 4 \quad 6 \quad 60 \quad 0 ]$$

The creation of pigs is provided for by the element  $p_{2,3}$  of the transition matrix  $P$ . Upon matrix multiplication, each bred sow in the inventory,  $y_{t,2}$ , will in effect create 8 pigs in the inventory  $y_{t+1,3}$ . This is similar to the effect of Howard's reward matrix <sup>1/</sup> which associates a "reward" with a particular transition from state i to j. For simplicity, the single "reward" has been added to the transition matrix.

The solution to this simplified model is calculated by matrix multiplication. The expected inventory at the end of the first 6-month period  $y_1$  is:

$$(2.20) \quad y_1 = y_0 P$$

$$(2.21) \quad y_1 = [ 6.0 \quad 7.6 \quad 48.0 \quad 56.4 ]$$

and expected inventory at the end of the second 6 month period  $y_2$  is:

$$(2.22) \quad y_2 = y_1 P = y_0 P^2$$

$$(2.23) \quad y_2 = [ 4.8 \quad 10.28 \quad 60.8 \quad 102.92 ]$$

and so on.

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<sup>1/</sup> There is a one period lag as compared to Howard's "reward" in which the reward is paid only if the state j is reached [14, p. 17].

The use of the inventory vector  $\underline{y}$  approach has permitted calculation of expected numbers in inventory categories at future dates. Note, however, that this approach does not permit estimation of the variance of the numbers in each state as would the larger Markov chain of equation 2.15.

Some aspects of the problem with which this study is concerned can be modeled as a Markov type problem. The Markov type model is appropriate to demonstrate the role of probabilities in transitions from state to state of the individual (or groups of) animals in a swine herd. The model is flexible in that the length of a time unit can be appropriately chosen, stochastic variables are incorporated, and it is a simple, clear and concise framework to demonstrate these essential problem characteristics.

The next Chapter will further develop a model in the Markov context and bring in other adaptations to make it suitable for modeling a swine breeding herd.

### 2.2.3 Simulation<sup>1/</sup>

This section provides a brief summary of general simulation techniques as they are presented in the literature. Attention is then turned to the definition of simulation as it will be used in this study.<sup>2/</sup> Some of the advantages and pitfalls of simulation techniques are then discussed.

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1/ Two useful bibliographies on simulation in business management and models in managerial economics are: Johnsson and Eisgruber, [17] and Vincent[39].

2/ See previous definition, page 4.

Simulation as generally used, describes a general approach to modeling, and has been applied to many diverse forms of model building.<sup>1/</sup> Morgenthaler [24, pp.366-371] discusses numerous applications in the engineering sciences and gives other examples such as military gaming. Orcutt[27], Shubik [35], and Clarkson et al. [7 ]review the use of simulation in micro and macro economic contexts.

There may have been an expanding use of simulation techniques in agricultural economics research since Burt's comment [5, p. 1, 425] in 1965 that simulation "...is looked upon more as a method of gaining general understanding of complex decision processes than an optimization model." Several substantial studies have been done in the interim using simulation techniques which seek to optimize an objective function. These include several examples of farm planning models,<sup>2/</sup> and farm management games.<sup>3/</sup> Most recently, policy decision models have been solved with simulation.<sup>4/</sup>

Simulation techniques provide a flexible method to overcome many of the difficulties of straight forward execution of the scientific method: duplication of the environment, of mathematical formulation, of lack of analytical solution techniques, or of experimental

---

1/ Orcutt's review of the use of simulation is comprehensive, [27, pp. 893-897].

2/ Some of those which have come to this author's attention are: Sonntag [36], Lee [21], Anderson [1], Zusman and Amiad [41], and Halter and Dean [11].

3/ Babb and Eisgruber [3].

4/ Schechter and Heady [34], Halter, Hayenga and Manetsch [12], Naylor [26], Tyner and Tweetan [37], and Hayenga, Manetsch and Halter [13].

impossibilities.<sup>1/</sup>

An important advantage in the use of simulation is that there are practically no limits dictated by structural form to hamper description of the problem in mathematical form.<sup>2/</sup> The model may contain as many variables and relationships as needed to describe the problem realistically. Nor is there restriction as to the form the mathematical equations can take. Variables can be deterministic or be specified by random selection from probability distributions; equations can be linear, or non-linear; variables can be continuous or integer, and so on.

Simulation techniques provide a very convenient method of incorporating time into the model. Dynamic modeling is natural because of the ease of using output from a run or loop in a computer language program to feed into the next time period as data input.

"In extremely complex problems, particularly those of a stochastic nature, simulation...is about the only recourse we have for quantitative analysis."<sup>3/</sup>

Some of the advantages of simulation techniques mentioned above can also turn into pitfalls. Simulation techniques imply that a model is constructed by the researcher that has no a priori set pattern or structure so that the pitfalls are not so well known nor widely publicized as they are for mathematical programming models.

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1/ Morganthaler [24, p. 372].

2/ Although model size is as significant a limitation to simulation as it is to analytical algorithmic procedures.

3/ Burt, in a discussion of the merits of simulation [5, p. 1, 426].

Some errors are obvious because they result in nonsense answers. Events out of sequence, most syntax errors in computer language statements, and major errors of parameter specification are of this type and usually will turn up as impossible results when comparison is made to real world production possibilities. There are far more subtle (and therefore dangerous) errors that are difficult to recognize.

One problem common to any modeling procedure; omitted variables, can lead to unreliable experiments. If the variables omitted are significant to the model, the model is a poor representation of the real world. Omitting relatively unimportant variables is part of the abstraction of modeling; some variables should be left out.

Discrete time approximations of a continuous time process presents a pitfall for simulation techniques. Certain events in the real process happen simultaneously. An exaggerated example of this problem was encountered in the monthly model of section 2.2.2 where all sows in the state "bred sows" were assumed to produce pigs whereas those reaching the end of a 11 $\frac{1}{4}$  day pregnancy could more realistically be considered to have produced pigs at the end of gestation.

Morganthaler [24, p. 384] warns of problems that the model builder should be aware of. Transient decay <sup>1/</sup> may extend for longer simulation time than realized by the researcher.

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<sup>1/</sup> The effect of starting time values on subsequent results. See the preliminary model examples of section 3.2.1, and 3.2.2, where a lumpy opening inventory is gradually smoothed during simulation.

The use of expected values in place of random variables at intermediate stages should be suspect. Morganthaler warns against their use <sup>1/</sup> [24, p. 385].

The use of the computer for computation means that calculation accuracy should be excellent for most purposes. However, possible machine errors, rounding errors and random number generator errors should be kept in mind.

Simulation involves constructing a model and using that model ("running" it) to conduct experiments.<sup>2/</sup> This study was concerned with a specific application. A complex farm management problem was modeled, giving particular attention to stochastic variables. Given the type of problem involved, a Markov type model was developed. The conceptual model and small scale examples to demonstrate the model are found in chapter 3.

Simulation (use of a computer program to study the model) was chosen as the means to implement the model for quantitative study. The model does not include an objective function. Therefore the simulation does not include optimum seeking techniques. The simulation facilitated implementation of the stochastic nature of the model by generation of random variables, by convenient definition of daily time periods, and by providing a means of defining animal attributes and storing and

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1/ Wagner has called this the fallacy of averages [40, p. 350].

2/ See section 1.1.1 for a definition of simulation as used in this study. There is no such thing as "the simulation model." The term "simulation" in the context of this study means the procedures which are used to study the model.

summarizing results. Illustrative results of runs of the simulation are found in Chapter 4.

### 2.3 Review of Previous Studies

The use of operational computer decision models in extension work in swine production is a relatively new endeavor. Consequently, research experience in development of models specific to swine production is not extensive.

Three studies which give detailed emphasis to swine production problems are reviewed in the following three sections. Marten [23] modeled the finishing of purchased feeder pigs. Schroder [33] compared application of dynamic programming and linear programming to budgeting methods, and Sonntag [36] modeled the alternatives in growth of the swine enterprise.

#### 2.3.1 Marten

The objective of the Marten study [23] was to construct a computer software program for a hog feedlot scheduling problem. Multiple period feedlot scheduling is emphasized with linkage to other farm management decisions by consideration of labor cost and availability, as well as corn production.

Marten chose a linear programming model. He states [23, p. 28], "The single-value expectation assumption is, theoretically, the most limiting assumption of linear programming as applied to the hog feedlot scheduling problem... In the final analysis, trade-offs existed between 'theoretical correctness' and 'practical availability' (of other solution algorithms)...". He has recognized that stochastic elements enter biological processes such as swine production.

Features of the model include the following user defined options: (a) length of time period, (b) number of periods, (c) availability and type of feeder pigs, and (d) building and management system options. The optimum results computed by the linear programming algorithm are presented in an easy to understand form usable by farmers and extension personnel.

The Marten study provides an operational extension tool for a particular swine production problem.<sup>1/</sup> The model has the advantage of optimizing return above variable costs, and is flexible, allowing the user to define his specific hog feeding problem. However, the user is tempted by the nature of the input form to define a very large linear programming problem which is impractical to solve.<sup>2/</sup> Thus, Marten's program is fully operational only for a sub-set of the alternatives available in the input form; and, in practice, has zero acceptance by farmers and extension agents.

The problem modeled in this study, as compared to the Marten study, includes the breeding of sows and raising of baby pigs, i.e., a farrow to finish problem. The nature of the scheduling problem (section 1.1) includes stochastic elements which are an important aspect of managing baby pig production and only enter into feedlot management to a lesser degree. Marten's choice of the linear programming structure excludes modeling the breeding herd both because of stochastic

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<sup>1/</sup> Feeding of purchased feeder pigs is analogous to the finishing part of a farrow to finish operation.

<sup>2/</sup> If all options are used, then 19,887 real activities and 197 restraints are defined. Moreover, the density of this matrix is relatively high. Marten suggests methods by which this program could be reduced in size, but these suggestions have not yet been implemented.

elements and the management practices required.

### 2.3.2 Schroder

Schroder [33] investigated the applicability of operations research models for swine management decision making. He studies two types of swine management problems: (a) scheduling sales and purchases for a hog feedlot and (b) selection of a housing-management system for the farrowing, nursery, and finishing stages of swine production. No input form or report writer was written to make the model applicable for extension use.

The feedlot problem is modeled using a dynamic programming approach. A FORTRAN IV computer program was written to solve the dynamic programming model. Results are compared to those obtained from budgeting procedures under several feeder pig buying policies and two knowledge situations. The model effectively handles the multiple decision periods nature of the problem. There are no stochastic variables in the model.

Turning to the problem of selection of a housing-management system for the farrowing, nursery, and finishing stages of swine production, Schroder chooses to model with linear programming and compare results with those obtained from traditional budgeting methods. Housing systems compared ranged from all pasture to complete confinement for each of the farrowing, nursery, and finishing buildings considered.

The linear programming formulation of the housing-management selection problem optimizes profit by selecting from all possible combinations of buildings and management systems. There are no integer requirements imposed and, therefore, solutions can turn out embarrassing.

singly unrealistic. Results can contain certain linear combinations of management systems such as farrowing both 4 times per year and 6 times per year. This is analogous to optimizing a student's course scheduling problem by recommending he take 0.2 of Math. 223 and 0.8 of Math. 163.

Other limitations of the study which, given the problem definition and objectives of the present study, limit its usefulness include: (a) the model is static, there is no consideration of the timing of important details of the production process, and (b) no account is taken of stochastic elements in either prices or the production process.

Schroder [33, p. 100] points out that including stochastic variables such as "sow gestation time" may result in the necessity of having greater building capacities than when these stochastic variables are modeled with zero variance.

### 2.3.3 Sonntag

Sonntag [36] developed an operational extension model<sup>1/</sup> of the long run planning problems of corn-hog farmers. The growth process was emphasized in an examination of size, combination of production alternatives, techniques of production, and investments over time.

The model features a wide range of hog production-management alternatives. Combinations of farrow to finish, finished purchased feeder pigs, and producing feeder pigs for sale are offered. The

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1/ "Planning Growth of the Swine Farm," the title of the input form for extension use [36, pp. 306-328], is a "Top Farmer" extension model developed for use in Purdue University extension work.

alternatives over which the model must be solved are narrowed by the beginning situation and the user prerogative to exclude management systems, and/or building combinations from consideration. A few corn production alternatives are available on the input form to link hogs to corn production. Maximum terminal net worth is the objective of this decision model.

The production process contains no stochastic elements. The herd manager's scheduling problem of getting sows bred, pigs raised, and buildings and labor efficiently utilized are modeled with traditional, average coefficients of production and costs per unit. This model is solved for "near-optimal" plans by a simulation searching procedure. Integer solutions are realistically imposed on buildings, and on enterprise units (10 sows, 100 feeders, etc.). A complete, usable input form as well as easily interpretable output for extension use, were developed; and the program has been well accepted by farmers.

For the purpose of this study, the Sonntag approach had several limitations which made it inappropriate for the problem under investigation here. His modeling of biological production is deterministic. No stochastic elements are included to represent the effect of shocks on the system. The modeling of open and bred sow pools and the variability of the gestation-breeding process is excluded by statements such as: "10 percent more sows are maintained than needed for farrowing." The scheduling problems of breeding sows, and assigning housing are passed off as average capacity of building concepts, etc.

This abstract modeling of the production process is an acceptable first representation for long term planning of growth of

the swine farm. For short term swine scheduling problems, however, much more detail of the nature of the production process is needed. It should be emphasized that the Sonntag model has been widely used in a workshop setting with hog farmers, and has been well accepted under these conditions.

As compared to the Marten, Schroder, and Sonntag studies, this thesis aims to add to the array of available hog production models, a first exploration of the implications of modeling the stochastic aspect of swine production. In particular, it should throw some light on the "average building capacities" which can reasonably be included in deterministic models such as those discussed above.

## CHAPTER 3

### CONCEPTUAL AND DEMONSTRATION MODELS

The nature of the modeling problem (sections 1.1 and 1.2) and the objectives of this study dictated the particular swine production features modeled. The characteristics of the modeling problem led to a special set of well known modeling alternatives (section 2.2). The purpose of this Chapter is to further conceptualize the modeling problem by constructing a more realistic demonstration of the nature of the problem and showing how these characteristics are represented by the modeling procedures chosen.

#### 3.1 Conceptual Models

A simple binary mechanistic model is first presented and then the nature of a monthly Markov chain model is explored. Demonstration of these models follows in later sections of Chapter 3.

##### 3.1.1 Simple Binary Mechanistic Model of a Swine Herd

The simple binary mechanistic model of a swine herd serves to illustrate the size and complexity of the modeling problem in relatively realistic detail. It presents the interrelationships between reproductive animals in a typical herd, using a daily time interval with each animal assigned an identity number. Essential animal attributes and transition probabilities are defined.

The binary mechanistic model is most simply stated as: given an initial state vector  $x_0$  of the herd at time  $t=0$ , calculate the

resulting state vector of the herd  $\underline{x}_t$ ;  $t=1,2,\dots,T$  in each of  $T$  subsequent periods, subject to appropriate transformation probabilities,  $P$ , where

$$(3.1) \quad \underline{x}_t = P \underline{x}_{t-1} ; \quad t=1,2,\dots,T$$

The elements of  $\underline{x}_t$  can be written:  $x_t = (x_{ijklm})$ , where

$$(3.2) \quad x_{ijklmt} = 0 \text{ or } 1$$

It is the characteristic of having 0 or 1 elements of the state variable  $\underline{x}_t$  which leads to the term binary model, -- either there is an animal in this state, or there is not. The term mechanistic refers to the fact that the transition probabilities  $P$  are non-adaptive; they do not reflect changing husbandry practices in light of the levels of the state variables. An animal with the characteristics  $i, j, k, L, m, t$ , is equal to zero or one since herd numbers,  $m$ , are unique for individual animals.<sup>1/</sup> The following classification scheme defines equation (3.1) as a binary sexual state:

$i = \text{Age in days}$ ,  $i = N_{jk}^*, N_{jk}^* + 1, \dots, N_{jk}^*$ ;  $j=1,2,3$ . Where  $N_{jk}^*$  and

$N_{jk}$  are defined in connection with subscripts  $j$  and  $k$  below.<sup>2/</sup>

$j = \text{Sex: } = 1,2,3$

1/ Note: (a)  $x_{ijklmt} = 0 \text{ or } 1$ , and (b)  $\sum_{ijklmt} x_{ijklmt} = 0 \text{ or } 1$ ;  
where  $i, j, k$ , and  $L$  describe attribute classifications,  $m$  is a unique herd number, and  $t$  is the day of simulation time.

2/ Birth on day  $t$  implies  $i = 1$ , if the animal survived to the end of day  $t$ .

Where

$$1 = \text{purchased boars}; \quad N_{1k}^* = 150 \leq i \leq 1825 = N_{1k}$$

$$2 = \text{female}; \quad N_{2k}^* = 1 \leq i \leq 1825 = N_{2k}$$

$$3 = \text{barrow}; \quad N_{3k}^* = 1 \leq i \leq 365 = N_{3k}$$

$k = \text{Sex Subclass:}$

for  $j = 1: k = 1,2,3$

Where

$$1 = \text{newly purchased}; \quad N_{11}^* = 150 \leq i \leq 395 = N_{11}$$

$$2 = \text{young boar}; \quad N_{12}^* = 195 \leq i \leq 365 = N_{12}$$

$$3 = \text{mature boar}; \quad N_{13}^* = 366 \leq i \leq 1825 = N_{13}$$

for  $j = 2: k = 1,2,3,4$

Where

$$1 = \text{never ovulated}; \quad N_{21}^* = 1 \leq i \leq 365 = N_{21}$$

$$2 = \text{ovulating, open}; \quad N_{22}^* = 150 \leq i \leq 1825 = N_{22}$$

$$3 = \text{gestation}; \quad N_{23}^* = 171 \leq i \leq 1825 = N_{23}$$

$$4 = \text{lactating}; \quad N_{24}^* = 281 \leq i \leq 1825 = N_{24}$$

for  $j = 3: k = 0; L = 0$

$L = \text{Day Tally:}$

for  $j = 1; k = 1;$

$L = 0,1,2,\dots Z_k; Z_1 = 30 \text{ days adjustment period.}$

for  $j = 1; k = 2;$

$L = 0,1,2,\dots, Z_k; = \text{number of fertile days}; L = Z_2 \text{ if at}$

least  $Z_2$  days since use,  $Z_2 \leq 10.$

for j = 1; k = 3;

L = 0,1,2,...,Z<sub>k</sub> = number of fertile days; L = Z<sub>3</sub> if at least Z<sub>3</sub> days since use, Z<sub>3</sub> ≤ 5.

for j = 2; k = 1;

L = 0

for j = 2; k > 1;

L = 1,2,...,Z<sub>k</sub> = day in cycle, Z<sub>2</sub> ≤ 90, Z<sub>3</sub> ≤ 122, and Z<sub>4</sub> ≤ 60.

m = herd number, unique to each animal.

t = day of simulation = 0,1,2,...,T

T = number of days from initialization time (t=0) to T, the number of days to be simulated.

This classification provides a unique animal description  $x_{ijkLmt}$ . For example, if  $x_{201,2,3,4,50,60} = 1$ , then we know that there was an animal alive of age i=201; it was a female j=2; in gestation k=3; at the 4th day L=4; with a herd number m=50, at time t=60 days.

The above limitations placed on attribute subscripts defined a finite set of binary states. These biological characteristics highlight the reproductive attributes of swine. Accounting for days into gestation, day of the estrus cycle, days of lactation, and the age of the animal rapidly expands a daily model. A much larger set of binary states would have been conceived if one were to model in more detail and include other attributes such as inherited traits, environmental history, physical characteristics, or spacial characteristics such as location by building.

There are 450,756 daily binary state classifications outlined in Table 3.1. These are the number of states which can be taken by any one animal under the various reproductive attributes  $i$ ,  $j$ ,  $k$ , and  $L$ .<sup>1/</sup> The greatest cause of the large number of binary states is the day of age attribute  $i$ . Age cannot be ignored since it is the primary delineator of reproductive ability.<sup>2/</sup>

Simulation of a swine breeding herd involves solving the conceptual model, equation (3.1), by calculating the state to state transformations of animals through time. Transformation always involves at least the stochastic nature of survival. If  $x_{ijkLmt} = 1$  then the daily binary state transformation probability is given by:

$$(3.3) \quad \Pr \{ x_{i+1,j'k'L'm',t+1} = 1 \} = Q: \quad m=1,2,\dots,M; \quad t=0,1,2,\dots,T-1$$

Where

$j'$  = value of  $j$  in  $t+1$

$k'$  = value of  $k$  in  $t+1$

$L'$  = value of  $L$  in  $t+1$

$M$  = maximum number of animals in the herd

$T$  = total simulation time in days.

- 1/ The number of state classifications is large because of the multiplicative effect of accounting for both age in days,  $i$ , and number of days in the specific reproductive class,  $L$ . For example, if  $j=2$ ;  $k=3$  (female in gestation), the animal may be of any age, 171-1825 days, and will be in one of the days of gestation,  $L=1-122$ . These include 1655 and 122 integer states respectively. The number of combinations ( $1655 \times 122$ ) is equal to 201,910. However, gilts of minimum age for pregnancy cannot be in the latter stages of the gestation tally which excludes 7,381 for a net total of 194,529 feasible combinations. See Table 3.1 and its footnote number 2.

- 2/ Weight, a continuous variable, is a less useful alternative for the purposes of the conceptual model because reproduction ability is being modeled largely as a function of age.

Table 3.1 Number of Possible Daily Binary States

Feasible Subscript Values				Number of States for j, k, L, i Combinations <sup>1/</sup>
j (sex)	k (Sub-class)	L (day tally)	i (day of age)	
1	1	0-30	150-395	( 7,626 - 465 <sup>2/</sup> ) = 7,161
1	2	0-10	195-365	( 1,881 - 55 <sup>2/</sup> ) = 1,826
1	3	0-5	366-1825	( 8,760 - 15 <sup>2/</sup> ) = 8,745
2	1	0	1-365	= 365
2	2	1-90	150-1825	(150,840 - 4,005 <sup>2/</sup> ) = 146,835
2	3	1-122	171-1825	(201,910 - 7,381 <sup>2/</sup> ) = 194,529
2	4	1-60	281-1825	( 92,700 - 1,770 <sup>2/</sup> ) = 90,930
3	0	0	1-365	= 365
				Grand Total = 450,756

- 1/ Number of possible states which can be taken by an individual animal with a given herd number  $m^*$  at time  $t^*$  in  $x_{ijklm^*t^*}$ .
- 2/ Certain combinations in the multiplicative calculation of L and i are not feasible over the respective ranges of i,j,k and L. In general, if an animal is entering a classification at the minimum age, it cannot be more advanced than the beginning day tally for that class. Consider the classification: j=1, k=1, when i=150; a new boar of the minimum number of days of age for purchase; L=0 with no freedom to take the values 1-30. If we consider a boar of age i=151, there is freedom to have been purchased 1 day ago (L=1) or on the current day (L=0). A boar of age 152 could have L=1,2, or 3, and so on, to i=169. For i=170,171,...,395; the day tally has full freedom to range 0,1,2,...,30. The formula for calculating these exclusions involves summing the integers  $1,2,\dots,r_L-1$ ; where  $r_L$  is the range of L as given in the table.

There are  $(450,756)^2$  possibilities  $0 \leq Q \leq 1$ ; the probability of transition from every state of  $t$  to every state of  $t+1$ . However, the chronological nature of gestation, lactation, day of heat cycle, etc., results in only a relatively few feasible transformations with nonzero probabilities, i.e.,  $0 < Q \leq 1$ . The number of transformation probabilities are further reduced by grouping them for approximation into ranges as expressed in Table 3.2.<sup>1/</sup> Even though this model allows us to distinguish 450,756 states which an animal taken at random from a herd on any given day could be in, only 17 distinct transition probabilities<sup>2/</sup> need be defined to account for daily transition between states. It is this small number of distinct probabilities which leads to the adjective simple binary mechanistic model.

The symbol  $\alpha_{ijkL}^S$  represents the probability that an animal with the characteristic  $ijkL$  at time  $t$ , will survive with these characteristics to time  $t+1$ . Likewise the symbols  $\alpha_{ijkL}^V$ ,  $\alpha_{ijkL}^C$ ,  $\alpha_{ijkL}^R$ , and  $\alpha_{ijkL}^F$  represent the probabilities of ovulation, conception, premature termination of gestation, and Farrowing-lactation respectively. The symbols for these probabilities are given in the right hand column of Table 3.2. The following summary defines the probabilities associated with survival and reproductive categories:

- 
- 1/ A more realistic alternative is to define the probability  $Q$  as a continuous function of  $i$ ,  $j$ ,  $k$ , and  $L$  to avoid the "lumpiness" of arbitrary grouping. The procedure of Table 3.2 is, however, more useful as a conceptualization.
  - 2/ In addition, however, there are 189 probabilities; or a probability distribution for each litter of pigs born; see equation (3.16) which follows.

Table 3.2 Daily Binary State Transformation Probabilities

Description	Subscript Value in Time t <u>1/</u>				Subscript in Time t+1 <u>2/</u>		<u>Q 3/</u> $\alpha_{ijkl}^S$ :
	<u>r<sub>i</sub></u>	<u>r<sub>j</sub></u>	<u>r<sub>k</sub></u>	<u>r<sub>L</sub></u>	<u>k'</u>	<u>L'</u>	
<u>Survival:</u>							
First week	1-7	2,3	0,1	0	<u>r<sub>k</sub></u>	0	$\alpha_{ijkl}^1$
2-3 weeks	8-21	2,3	0,1	0	<u>r<sub>k</sub></u>	0	$\alpha_{ijkl}^2$
Starting	22-56	2,3	0,1	0	<u>r<sub>k</sub></u>	0	$\alpha_{ijkl}^3$
Market Hogs	57-240	2,3	0,1	0	<u>r<sub>k</sub></u>	0	$\alpha_{ijkl}^4$
Ovulating, open	150-1825	2	2	1-90	2	<u>r<sub>L</sub></u>	$\alpha_{ijkl}^5$
Gestation	150-1825	2	3	1-121	3	<u>r<sub>L</sub></u>	$\alpha_{ijkl}^6$
Farrowing day	262-1825	2	3	110-122	4	1	$\alpha_{ijkl}^7$
Lactating	263-1825	2	4	2-60	4	<u>r<sub>L</sub></u>	$\alpha_{ijkl}^8$
Boars not in use	150-1825	1	1-3	1-10	<u>r<sub>k</sub></u>	<u>r<sub>L</sub></u>	$\alpha_{ijkl}^9$
Boars in use	195-1825	1	2,3	1-10	<u>r<sub>k</sub></u>	<u>r<sub>L</sub></u>	$\alpha_{ijkl}^{10}$
<u>Ovulation:</u>							
Before 5 months	1-149	2	1	0	2	1	$\alpha_{ijkl}^V$
5 mo.-5 years	150-1825	2	1,2	0-90	2	<u>r<sub>L</sub></u>	$\alpha_{ijkl}^2$
<u>Conception:</u>							
Gilts	150-365	2	2,3	1-63	3	1	$\alpha_{ijkl}^C$
Sows	366-1825	2	2,3	1-63	3	1	$\alpha_{ijkl}^2$

Table 3.2 (continued)

Description	Subscript Value in Time t <sub>1</sub> /				Subscript in Time t+1 2/			$\alpha_{ijkl}^3/$
	$r_i$	$r_j$	$r_k$	$r_L$	$k'$	$L'$		
<u>Premature Termination:</u>								
Gilts or Sows	151-1825	2	3	1-22	2	1	$\alpha_{ijkl}^1$	$\alpha_{ijkl}^R$ :
<u>Farrowing-Lactation:</u>								
Gilts	262-449	2	3,4	1-121	4	1	$\alpha_{ijkl}^1$	$\alpha_{ijkl}^F$ :
Sows	450-1825	2	3,4	1-121	4	1	$\alpha_{ijkl}^2$	$\alpha_{ijkl}^C$ :

1/  $r_i$ ,  $r_j$ ,  $r_k$ , and  $r_L$  indicate full range of integer subscripts within the range r.

2/  $k'$  and  $L'$  indicate any interger in  $r_k$ ,  $r_L$ , or first appearance of the attribute, e.g.,  $k'=4$ , when  $L'=1$  is first day of the suckling period, i.e., the day of farrowing.

3/ Probabilities  $\alpha_{ijkl}^S$ ,  $\alpha_{ijkl}^V$ ,  $\alpha_{ijkl}^C$ ,  $\alpha_{ijkl}^R$ , or  $\alpha_{ijkl}^F$  where i, j, k and L have values as defined in the Table.

Allowance for Death Loss

If  $x_{ijklmt} = 1$ ;  $i = 1, 2, 3, \dots, 1825$   
 $j = 1, 2, 3;$   
 $k = 0, 1, 2, 3, 4$   
 $L = 1, 2, 3, \dots, Z_k;$   
 $m \leq M;$   
 $t = 1, 2, 3, \dots, T-1$

then

$$(3.4) \quad \Pr \{ x_{i+1,jklm,t+1} = 1 \} = \alpha_{jkl}^S \leq 1 \text{ for survival, and}$$

$$(3.5) \quad \Pr \{ x_{i+1,jklm,t+1} = 0 \} = 1 - \alpha_{jkl}^S \leq 1 \text{ for death}$$

where  $S = 1, 2, \dots, 10$ .

Onset of Ovulation

If  $x_{i,2,l,0,m,t} = 1$ ;  $i = 1, 2, \dots, 365$ ;  
 $m \leq M$ ;  
 $t = 1, 2, \dots, T-1$

then

$$(3.6) \quad \Pr \{ x_{i+1,2,l,0,m,t+1} = 1 \} = \alpha_{ijkl}^S (1 - \alpha_{ijkl}^V) \leq 1$$

for survival and no ovulation and

$$(3.7) \quad \Pr \{ x_{i+1,2,2,l,m,t+1} = 1 \} = \alpha_{ijkl}^S \alpha_{ijkl}^V \leq 1$$

for survival and ovulation where  $S = 4$  or  $5$ ;  $V = 1$  or  $2$ .

Gestation, first day is conception

If  $x_{i,2,2,L,m,t} = 1$ ;  $i = 151, 152, \dots, 1825$   
 $L = 1, 2, \dots, 89$ ;  
 $m \leq M$ ;  
 $t = 1, 2, \dots, T=1$

then

$$(3.8) \quad \Pr \{ x_{i+1,2,2,L+1,m,t+1} = 1 \} = \alpha_{ijkl}^S (1 - \alpha_{ijkl}^C) \leq 1$$

for survival without conception and

$$(3.9) \quad \Pr \{ x_{i+1,2,3,1,m,t+1} = 1 \} = \alpha_{ijkl}^S \alpha_{ijkl}^C \leq 1$$

for survival and conception where  $S = 5$ ;  $C = 1$  or  $2$ .

#### Continued Gestation

If  $x_{i,2,3,L,m,t} = 1$ ;  $i = 151, 152, \dots, 1825$   
 $L = 1, 2, \dots, 121$ ;  
 $m \leq M$ ;  
 $t = 1, 2, \dots, T-1$

then

$$(3.10) \quad \Pr \{ x_{i+1,2,3,L+1,m,t+1} = 1 \} = \alpha_{ijkl}^S (1 - \alpha_{ijkl}^R) \leq 1$$

for survival and continuing gestation and

$$(3.11) \quad \Pr \{ x_{i+1,2,2,1,m,t+1} = 1 \} = \alpha_{ijkl}^S \alpha_{ijkl}^R \leq 1$$

for survival and premature termination where  $S = 6$ ;  $R = 1$ .

#### Lactation, first day is day of farrowing

If  $x_{i,2,3,L,m,t} = 1$ ;  $i = 262, 263, \dots, 1825$   
 $L = 1, 2, \dots, 121$ ;  
 $m \leq M$ ;  
 $t = 1, 2, \dots, T-1$

then

$$(3.12) \quad \Pr \{ x_{i+1,2,3,L+1,m,t+1} = 1 \} = \alpha_{ijkl}^S (1 - \alpha_{ijkl}^R) \leq 1$$

for survival and continuing gestation and

$$(3.13) \quad \Pr \{ x_{i+1,2,4,1,m,t+1} = 1 \} = \alpha_{ijkl}^S \alpha_{ijkl}^F \leq 1$$

for survival and farrowing where  $S = 7$ ;  $R = 1$ ;  $F = 1$  or  $2$ .

If  $x_{i,2,4,L,m,t} = 1$ ;  $i = 281, 282, \dots, 1825$ ;  
 $L = 1, 2, \dots, 59$ ;  
 $m \leq M$ ;  
 $t = 1, 2, \dots, T=1$

then

$$(3.14) \quad \Pr \{ x_{i+1,2,4,L+1,m,t+1} = 1 \} = \alpha_{ijkL}^S \alpha_{ijkL}^F \leq 1$$

for survival and continuing lactation and

$$(3.15) \quad \Pr \{ x_{i+1,2,2,l,m,t+1} = 1 \} = \alpha_{ijkL}^S (1 - \alpha_{ijkL}^F) \leq 1$$

for survival and discontinued lactation and

$$(3.16)^1/ \quad \Pr \{ u(x_{1,2,1,0,m,t} = 1) \text{ and } v(x_{1,3,0,0,m,t} = 1) \} = \beta_{uv} \leq 1;$$

for  $u + v \leq 18$  newborn pigs;

where  $u =$  number of female, and

$v =$  number of male (barrow) pigs born alive

$S = 7$  or  $8$

$F = 1$  or  $2$

The simple binary mechanistic model would be an appropriate description of a herd under non-adaptive husbandry conditions where transformation probabilities are independent of the current state of the system. Such a system assumes of course no building, target farrowing, or other restraints which require strategies in the model. The simple binary mechanistic model of a swine herd has the advantages of (a)

- 1/ Provision for creating baby pigs. Note that  $\beta_{uv}$  refers to the probability of farrowing various combinations of male and female pigs totaling  $1, 2, \dots, 18$ . There are 189 male and female combinations resulting in 189 probabilities associated with creating live pigs at farrowing. These probabilities are in addition to the transition probabilities listed in Table 3.2.

placing emphasis on reproductive functions, (b) being a daily model, and (c) defining probabilities associated with transformation from state to state. This model incorporates probability data.

### 3.1.2 The Conceptual Model and Markov Analysis

The binary model presented in the previous section recognizes the stochastic and integer attributes of reproductive animals. Implementation of the model requires solution procedures which are capable of simulating the reproductive process through time. The transformation probabilities of the previous section define transformations from day  $t$  to  $t+1$ . These are the transition probabilities of a Markov process. All attributes of a given animal<sup>1/</sup> are described by the state classifications in time  $t$ .

The transition probabilities sum to one. The probability of finding any individual animal in a given state at time  $t$  depends upon the state which it occupied in  $t-1$ , and not how it got to this state. The history of the herd previous to  $t-1$  is given by the number of animals in each state at  $t-1$  and the transition probabilities. Thus the simple binary mechanistic model fulfills the requirements of a Markov process.<sup>2/</sup>

While especially useful to conceptualize the nature of stochastic relationships, the simple binary mechanistic model is too

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1/ Including death of the animal, the zero binary state.

2/ See section 2.2.2, Markov Chain Analysis and the simple example given there.

simple to be useful as a research model. The rapid expansion of the model by including the creation and raising of baby pigs, as well as other animal attributes and management decision variables, suggests some exploration of the characteristics of a simple demonstration model before specification of the complete research model.

As discussed previously the model presented above is a Markov type model which provides a convenient solution procedure. Subsequent adaptations of the Markov chain simulation procedure are suggested later to incorporate other elements of the research model.

The simple daily binary mechanistic model conforms to Markov analysis<sup>1/</sup> as a solution procedure. However, for a practical demonstration of the solution procedure, the size of this model is reduced by presenting a monthly example. Management rules, spacial considerations (building occupation), and economic measures of production are deferred until attention is returned to the daily research model of Chapter 4.

### 3.2 Demonstration Models and Transition to the Research Model

A monthly Markov chain process of a swine breeding herd is presented as a demonstration of solution procedures. The Markov process illustrates the simulation methods which are used to evaluate the research model. Example numerical probability data and an opening inventory are presented in Markov context. First, a monthly model is solved yielding expected number of animals in each inventory state classification. The multiplication process is then modified in recognition of integer requirements for individual animals. Short-

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<sup>1/</sup> The Markov process transition matrix is 450,756 X 450,756.

comings of the demonstration models are discussed (section 3.2.3) as an indication of the additional features required in the research model.

### 3.2.1 Markov Chain Model of a Swine Herd<sup>1/</sup>

A monthly model of a swine breeding herd is defined by an inventory vector of 30 states. The inventory includes (a) two boar categories, (b) sixteen classes of growing-finishing by age in months, (c) three states for open sows, (d) four monthly gestation states, (e) lactation states for months 1 and 2, (f) states for total deaths, and (g) sales of butcher hogs and sows. The beginning inventory vector is

$$(3.17) \quad \mathbf{y}_t = (y_{tj}); \quad j = 1, 2, \dots, 30; \quad t=0$$

where the elements  $j$ , known with certainty, are described in Table 3.3 together with the opening inventory values. The monthly transition matrix is

$$(3.18) \quad P = (p_{ij}) ; \quad i, j = 1, 2, \dots, 30$$

Where the elements of  $P$  are given in Table 3.4, the monthly Markov chain transition matrix.

The rows and columns of  $P$ , the  $30 \times 30$  transition matrix are given coded state names "S" which correspond exactly to the 30 inventory states  $j$  with code names "Y", in Table 3.3. All elements of the matrix  $P$  conform to a transition matrix<sup>2/</sup> except  $p_{17,3}$  and  $p_{17,20}$  which provide

1/ Markov theory and examples of Markov multiplication are given in section 2.2.2.

2/ For a transition matrix all elements  $\leq 1$ , and rows sum to 1, see equations 2.11, and 2.12 of section 2.2.2.

Table 3.3 Monthly Markov Chain Inventories

Element No.	$J = 1/$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Code Name	=	$y_{110}$	$y_{120}$	$y_{211}$	$y_{212}$	$y_{213}$	$y_{214}$	$y_{215}$	$y_{216}$	$y_{217}$	$y_{218}$	$y_{221}$	$y_{222}$	$y_{223}$	$y_{231}$	$y_{232}$
Opening Inventory Value <sub>2</sub> /	2	4	50	50	0	0	50	45	10	0	15	10	5	25	0	
<u>End of Year Inventories</u>																
<u>1. Markov Simulation<sup>3/</sup></u>																
Year 1	0.0	5.7	43.0	96.4	73.6	12.2	16.6	63.5	2.9	.9	9.3	1.0	1.6	15.1	8.6	
Year 2	0.0	5.4	57.7	77.7	56.8	50.0	50.0	44.0	4.6	.8	6.8	2.3	1.9	14.8	15.1	
Year 3	0.0	5.2	65.1	68.2	62.1	64.5	56.6	50.4	5.7	.6	7.6	2.9	1.8	16.7	17.0	
Year 4	0.0	4.9	69.7	69.8	69.2	69.5	64.0	60.1	6.1	.6	8.7	3.1	1.8	18.3	18.2	
Year 5	0.0	4.7	75.9	75.6	75.3	74.5	72.2	67.4	6.6	.7	9.7	3.3	2.0	19.9	19.7	
Year 6	0.0	4.5	83.2	82.5	81.8	81.1	79.9	73.9	7.2	.7	10.5	3.6	2.2	21.6	21.5	
<u>2. Randomized Markov Simulation</u>																
Year 1	0	6	20	87	59	0	20	63	3	0	7	1	0	13	4	
Year 2	0	6	48	76	44	44	87	51	3	0	9	2	0	9	15	
Year 3	0	6	104	76	56	67	66	52	3	2	5	3	0	19	21	
Year 4	0	6	108	67	88	110	48	71	16	0	13	3	3	20	24	
Year 5	0	5	84	95	95	130	100	90	7	1	17	4	3	27	30	
Year 6	0	5	104	123	86	120	116	99	7	2	10	5	1	34	28	

Table 3.3 (continued)

Element No. j = 1/	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Code Name =	y233	y234	y241	y242	y301	y302	y303	y304	y305	y306	y307	y308	y400	y500	y600
Opening Inventory Value2/	0	25	0	15	50	0	0	50	45	10	0	0	0	0	0
End of Year Inventories															
1. Markov Simulation3/															
Year 1	10.3	13.4	10.4	23.5	43.0	96.4	73.6	12.2	16.6	68.2	6.3	1.9	18.8	1,011.8	38.4
Year 2	13.6	12.5	14.0	18.9	57.7	77.7	56.8	50.0	50.0	47.3	10.0	1.7	39.0	2,225.9	73.2
Year 3	15.2	15.1	15.7	16.6	65.1	68.2	62.1	64.5	56.6	54.3	12.2	1.4	61.1	3,554.7	111.7
Year 4	17.3	17.4	16.9	17.0	69.7	69.8	69.2	69.5	64.0	64.7	13.2	1.3	85.4	5,010.5	153.6
Year 5	19.3	19.2	18.3	18.4	75.9	75.6	75.3	74.5	72.2	72.5	14.3	1.4	111.9	6,608.1	199.2
Year 6	21.2	21.0	20.1	20.1	83.2	82.5	81.8	81.1	79.9	79.4	15.6	1.5	140.9	8,357.8	249.2
2. Randomized Markov Simulation															
Year 1	18	15	5	19	20	88	59	0	20	68	6	3	21	989	41
Year 2	23	12	12	19	48	76	44	44	88	56	4	3	33	2,054	65
Year 3	16	18	25	18	104	76	56	67	67	56	15	2	50	3,509	96
Year 4	20	20	25	17	108	68	87	111	47	79	20	0	76	5,165	147
Year 5	29	22	21	22	84	96	94	132	98	99	16	2	107	7,068	197
Year 6	31	28	23	31	104	123	87	119	116	105	16	3	150	9,395	272

1/ The j classifications are: 1 = young boars, 2 = mature boars, 3 = females 1 month of age, 4 = females 2 months age, 5 = females 3 months age, 6 = females 4 months age, 7 = females 5 months of age, 8 = females 6 months age, 9 = females 7 months age, 10 = females 8 months age, 11 = open sows, first month, 12 = open sows second month, 13 = open sows third month, 14 = gestation month 1, 15 = gestation month 2, 16 = gestation month 3, 17 = gestation month 4, 18 = lactating month 1, 19 = lactating month 2, 20 = males 1 month age, 21 = males 2 months age, 22 = males 3 months age, 23 = males 4 months age, 24 = males 5 months age, 25 = males 6 months age, 26 = males 7 months age, 27 = males 8 months age, 28 = total died, all ages, 29 = total sold, butchers: 1-8 months age, 30 = total sold, sows 9 months age and older.

2/ Also reported as "full inventory at time t=0" in Tables 3.5 and 3.6.

3/ End of the year inventory reported as "full inventory at time t=12" in Tables 3.5 and 3.6.

Table 3.4 Monthly Markov Chain Transition Matrix

Table 3.4 (continued)

$t+1$	$t$	Code:	Code:	$t-1$
3	SS 211	...	...	3 SS 211
11	S 221	...	...	11 S 221
12	S 222	...	...	12 S 222
13	S 223	...	...	13 S 223
14	S 224	...	...	14 S 224
15	S 225	...	...	15 S 225
16	S 226	...	...	16 S 226
17	S 227	...	...	17 S 227
18	S 228	...	...	18 S 228
19	S 229	...	...	19 S 229
20	S 230	...	...	20 S 230
21	S 231	...	...	21 S 231
22	S 232	...	...	22 S 232
23	S 233	...	...	23 S 233
24	S 234	...	...	24 S 234
25	S 235	...	...	25 S 235
26	S 236	...	...	26 S 236
27	S 237	...	...	27 S 237
28	S 238	...	...	28 S 238
29	S 239	...	...	29 S 239
30	S 240	...	...	30 S 240
31	S 241	...	...	31 S 241
32	S 242	...	...	32 S 242
33	S 243	...	...	33 S 243
34	S 244	...	...	34 S 244
35	S 245	...	...	35 S 245
36	S 246	...	...	36 S 246
37	S 247	...	...	37 S 247
38	S 248	...	...	38 S 248
39	S 249	...	...	39 S 249
40	S 250	...	...	40 S 250
41	S 251	...	...	41 S 251
42	S 252	...	...	42 S 252
43	S 253	...	...	43 S 253
44	S 254	...	...	44 S 254
45	S 255	...	...	45 S 255
46	S 256	...	...	46 S 256
47	S 257	...	...	47 S 257
48	S 258	...	...	48 S 258
49	S 259	...	...	49 S 259
50	S 260	...	...	50 S 260

Table 3.4 (continued)

<u>t</u>	<u>t+1</u>	<u>Code:</u>	<u>t</u>	<u>t+1</u>	<u>Code:</u>
20	S 301	....	.992		.008
21	S 302			.998	.002
22	S 303			.999	.001
23	S 304			.999	.001
24	S 305			.999	.001
25	S 306			.199	.8
26	S 307				.099
27	S 308				.001
28	S 400				.999
29	S 500				.1.
30	S 600	....			1.

for the creation of 4 female ( $j=3$ ) and 4 male pigs ( $j=20$ ) of age one month from every sow in month four of gestation ( $i=17$ ).

Probability data in matrix P and the opening inventory vector  $y$  are chosen to demonstrate the model for a fictitious herd. The element  $p_{7,11}$  of the matrix P (with a value of .18 in Table 3.4) is considered the only decision variable in this model. This element,  $p_{7,11}$ , is the proportion of gilts selected. Females are taken from the inventory of 5 month old butcher hogs ( $i=7$ ) and "selected" for the "open sow, first month" state ( $j=11$ ). This variable directly affects the growth of the sow herd over time.

Solutions are found by Markov chain multiplication.

$$(3.19) \quad y_{t+1} = P y_t$$

where  $y_t$  = an inventory vector of expected numbers in each state category  $y_{tj}$ .<sup>1/</sup>

Results of six years' simulation with a "gilts selection proportion" of 7 percent is given in yearly blocks in Table 3.5. Monthly inventory

- 1/ Known with certainty for  $t=0$ . For  $t>0$ , the expected number of an individual state category  $y_j$  is:

$$E[y_{tj}] = \sum_{m=0}^M m(\Pr \{ y_{tj} = m \}) ; \text{ any } j=1,2,\dots, \text{ or } 30;$$

where  $y_{tj}$  = inventory state  $j$  of time  $t$ ,

$m = 0,1,2,\dots,M$  the number of animals in state  $y_{t-1,j}$ .

The probability,  $\Pr \{ y_{tj} = m \}$ , can be found by binomial formula if the probability vector (row of matrix P) contains two non-zero values, by multinomial formula if it contains more than two non-zero values. Expected values are reviewed by Wagner [40, p. 341].

values are summarized in seven sow and pig type categories<sup>1/</sup> and are also given yearly as the expected number in each inventory state.<sup>2/</sup>

Markov multiplication yields expected values, and as such provides a first useful analysis of the properties of the husbandry practices being modeled. It does not however, allow us to examine individual feasible time paths for the herd, nor does it provide estimates of variances around the expected values. Note that the solution procedure smooths the expected inventory values through time, i.e., sow and pig groupings are not maintained as identifiable groups after the opening inventory state. The effect is to simulate a herd breeding freely for continuous farrowing as if there were no target farrowing dates, or sow and pig groups. This is evidenced by the annual summary statistics. Note that the variance reported as a summary item each year is variance of the 12 expected inventory values, not an average of monthly variances. The variance of the expected values declines year-by-year and tends toward zero.

The following sections of this Chapter discuss modification of the multiplication procedure to allow variance estimates on inventory

- 
- 1/ Open sows, and lactating sows are sums of more than one inventory state.
  - 2/ Labeled "full inventory" at time T=12" in Table 3.5, they also appear in Table 3.3. These numbers appear as a series of 30 values printed in the order indicated as "identification for inventory states," also see the y code list in Table 3.3 where the 30 inventory states were first defined. The rather inconvenient summary arrangement of the full inventory reflects the fact that this program was developed simply to provide an example of the modeling procedures for exposition purposes in this thesis. The research model developed has considerably more readable reports.

Table 3.5 Monthly Markov Chain Simulation

MARKOV CHAIN MULTIPLICATION WILL BE USED TO SOLVE. INVENTORIES ARE TRUE EXPECTED NUMBERS.  
 GILTS SELECTED PROPORTION = .070  
 RANDOM NUMBER SOURCE IS CDC FUNCTION RANF(0)  
 T IMPLIES SIMULATION TIME AT THE END OF A MONTHLY TIME PERIOD

IDENTIFICATION FOR INVENTORY STATES.									
BOARS-		FEMALES-		GESTATING SOWS-		PIGS WITH PIGS-		YOUNG BARRONS-	
Y110	Y120	Y211	Y212	Y231	Y232	Y233	Y234	Y216	Y217
OVULATING, OPEN-	Y221	Y222	Y223	Y231	Y232	Y233	Y234	Y241	Y242
BARROWS (CONTINUED)-	Y302	Y303	Y304	Y305	Y306	Y307	Y308	T*DIED T.SOLD1-B MO	T*SOLD9-MO
FULL INVENTORY AT TIME T= 0 IS-								Y400	Y500
2.0	4.0	50.0	50.0	0.0	0.0	0.0	0.0	45.0	10.0
15.0	10.0	5.0	25.0	0.0	0.0	25.0	0.0	15.0	50.0
50.0	.0.0	0.0	50.0	45.0	10.0	0.0	0.0	0.0	0.0

START YEAR= 1	INVENTORY AT T=				THIS MONTH			
	OPEN SOWS	LACTATING SOWS	PIGS MO.1	PIGS MO.3	TOT. DIED	SOLD-U.MO.	SOLD 9-MO.	
T= 1	14.5	24.2	200.0	99.8	1.4	94.5	6.2	
T= 2	5.7	24.2	0.0	99.0	2.1	95.6	4.8	
T= 3	7.5	0.0	0.0	198.0	0.7	14.4	4.9	
T= 4	5.6	24.1	199.4	0.0	0.6	1.4	2.0	
T= 5	5.9	47.7	195.4	0.0	2.1	81.4	*7	
T= 6	14.8	31.3	63.8	197.4	2.4	93.8	3.7	
T= 7	11.1	24.4	136.3	193.5	1.4	175.9	3.5	
T= 8	6.7	20.8	-33.6	63.1	1.8	27.3	1.5	
T= 9	13.0	7.0	24.6	136.9	1.1	2.8	3.9	
T= 10	12.0	21.0	148.6	33.3	1.0	161.1	1.9	
T= 11	8.0	41.0	194.3	24.5	1.8	183.6	1.3	
T= 12	11.9	33.8	85.9	147.2	2.3	79.6	4.0	
			SUMMARY ITEM	TOTAL FOR YEAR	AVE MONTH	VARIANCE		
			LACTATING SOWS	1286.05	24.991	171.564		
			PIGS MO.1	1011.82	107.004	6006.917		
			HNGS SOLD -8 MO.		84.318	4196.203		
			FULL INVENTORY AT TIME T=12 IS-					
0.0	5.7	43.0	66.4	73.6	12.2	63.5	2.9	*9
9.3	1.0	1.6	15.1	8.6	10.3	10.4	23.5	43.0
96.4	73.6	12.2	16.6	68.8	6.3	1.9	1011.8	38.4

Table 3.5.(continued)

START YEAR= 2		INVENTORY AT T=			THIS MONTH			SOLD 9-MO.		
		OPEN SOWS	LACTATING SOWS	PIGS MO.1	PIGS MO.3	TOT.	DIED	SOLD-8MO.	SOLD 9-MO.	
T= 1	10.8	23.3	107.3	192.3	1.6	122.7	4.0			
T= 2	7.8	22.9	82.4	25.1	1.6	45.9	1.8			
T= 3	11.0	18.3	68.7	106.3	1.5	26.3	3.1			
T= 4	12.8	22.9	120.7	81.6	1.4	123.8	2.6			
T= 5	10.0	35.8	175.5	66.0	1.7	176.5	2.1			
T= 6	11.0	33.4	101.4	119.5	2.2	96.2	3.2			
T= 7	11.7	23.8	95.7	173.7	1.7	100.6	4.0			
T= 8	9.8	23.8	101.2	100.4	1.6	61.7	2.4			
T= 9	10.6	24.4	101.2	95.0	1.6	67.7	2.6			
T= 10	12.7	26.1	114.7	100.1	1.6	107.6	3.0			
T= 11	11.2	32.8	156.6	113.6	1.8	158.3	2.7			
T= 12	11.0	32.9	115.4	100.2	2.0	106.3	3.4			
SUMMARY ITEM		TOTAL FOR YEAR			AVE MONTH			VARIANCE		
LACTATING SOWS		1341.01			26.705			30.561		
PIGS MO.1		1214.05			111.750			662.325		
HOGS SOLD -8 MO.					101.171			1833.250		
FULL INVENTORY AT TIME T=12 IS=		T=12 IS=			T=12 IS=			T=12 IS=		
0.0	5.4	57.7	77.7	56.8	50.0	44.0	4.6	57.7	57.7	
6.8	2.3	1.9	14.8	15.1	12.5	14.0	18.9			
77.7	56.8	50.0	50.0	47.3	10.0	1.7	39.0	2225.9	73.2	
START YEAR= 3		INVENTORY AT T=			THIS MONTH			SOLD 9-MO.		
		OPEN SOWS	LACTATING SOWS	PIGS MO.1	PIGS MO.3	TOT.	DIED	SOLD-8MO.	SOLD 9-MO.	
T= 1	11.9	26.0	99.7	155.0	1.8	93.1	3.8			
T= 2	11.2	25.2	103.7	114.3	1.7	95.6	2.9			
T= 3	11.1	27.7	120.2	98.7	1.7	96.2	2.6			
T= 4	12.6	28.8	118.3	107.6	1.8	107.2	3.1			
T= 5	12.1	31.6	143.4	116.0	1.8	142.8	3.2			
T= 6	11.5	32.4	124.5	117.1	2.0	115.1	3.1			
T= 7	12.1	28.3	109.9	142.0	1.9	97.7	3.6			
T= 8	12.2	27.1	114.6	123.3	1.8	102.3	3.2			
T= 9	11.9	29.6	130.4	108.8	1.8	112.6	3.0			
T= 10	12.6	30.9	125.5	113.5	1.9	112.6	3.2			
T= 11	12.7	31.8	137.5	129.1	1.9	132.9	3.4			
T= 12	12.2	32.3	130.1	124.2	2.0	120.8	3.2			
SUMMARY ITEM		TOTAL FOR YEAR			AVE MONTH			VARIANCE		
LACTATING SOWS		1462.76			29.306			6.306		
PIGS MO.1		1328.81			121.890			158.794		
HOGS SOLD -8 MO.					110.134			241.123		
FULL INVENTORY AT TIME T=12 IS=		T=12 IS=			T=12 IS=			T=12 IS=		
0.0	5.2	65.1	68.2	62.1	64.5	56.6	50.4	56.7	56.1	
7.6	2.9	1.8	16.7	17.0	15.2	15.1	15.7	16.6	16.1	
68.2	62.1	66.5	56.6	54.3	12.2	1.4	61.1	3554.7	111.7	

Table 3.5 (continued)

START YEAR = 4		INVENTORY AT T			THIS MONTH			
		OPEN SOWS	LACTATING SOWS	PIGS MO.1	PIGS MO.3	TOT. DIED	SOLD -8 MO.	SOLD 9+PC.
T= 1	12.5	30.4	121.1	136.1	1.9	106.9	3.4	
T= 2	12.8	20.3	121.6	128.6	1.9	106.6	3.4	
T= 3	12.6	31.1	136.1	119.9	1.9	121.7	3.2	
T= 4	13.0	32.5	133.0	120.4	2.0	119.8	3.3	
T= 5	13.2	32.7	137.3	136.7	2.0	129.1	3.6	
T= 6	12.9	35.9	134.6	131.7	2.0	121.7	3.4	
T= 7	13.0	32.1	131.0	135.9	2.0	116.6	3.6	
T= 8	13.4	31.5	129.6	133.3	2.0	115.7	3.5	
T= 9	13.3	32.6	140.5	129.7	2.0	127.4	3.5	
T= 10	13.5	33.9	139.8	128.3	2.1	126.8	3.5	
T= 11	13.7	33.9	160.8	139.1	2.1	133.0	3.7	
T= 12	13.6	33.9	139.5	138.4	2.1	128.4	3.6	
SUMMARY ITEM		TOTAL FOR YEAR			AVE MONTH	VARIANCE		
LACTATING SOWS		-----			32.220	-----		
PIGS MO.1		1604.81			133.734	2.002		
HOGS SOLD -8 MO.		1455.79			121.316	46.911		
HOGS SOLD		-----			62.658	-----		
FULL INVENTORY AT TIME T=12 IS-		-----				-----		
0.0	4.9	69.7	69.8	69.2	60.1	-----		
8.7	3.1	1.8	18.3	18.2	16.9	-----		
69.8	69.2	69.5	64.0	64.7	65.4	-----		
OPEN SOWS		-----			150.5	-----		
START YEAR = 5		INVENTORY AT T			THIS MONTH			
		OPEN SOWS	LACTATING SOWS	PIGS MO.1	PIGS MO.3	TOT. DIED	SOLD -8 MO.	SOLD 9+PC.
T= 1	13.6	33.7	119.4	139.4	2.1	125.2	3.7	
T= 2	13.9	33.5	137.9	138.1	2.1	123.5	3.7	
T= 3	14.0	34.2	145.2	138.0	2.1	132.1	3.7	
T= 4	14.1	35.2	146.1	136.5	2.2	133.0	3.7	
T= 5	14.2	35.3	146.2	143.7	2.2	133.8	3.8	
T= 6	14.3	35.2	145.2	144.6	2.2	132.9	3.8	
T= 7	14.3	35.3	146.8	144.7	2.2	132.7	3.8	
T= 8	14.5	35.4	146.1	143.7	2.2	131.4	3.8	
T= 9	14.5	35.9	150.7	145.3	2.2	137.1	3.9	
T= 10	14.7	36.6	152.1	144.7	2.3	138.7	3.9	
T= 11	14.8	36.8	152.5	149.2	2.3	139.0	4.0	
T= 12	15.0	36.8	151.7	150.6	2.3	138.3	4.0	
SUMMARY ITEM		TOTAL FOR YEAR			AVE MONTH	VARIANCE		
LACTATING SOWS		-----			35.313	1.217		
PIGS MO.1		1759.87			146.656	21.065		
HOGS SOLD -8 MO.		1537.61			133.135	24.567		
FULL INVENTORY AT TIME T=12 IS-		-----				-----		
0.0	4.7	75.9	75.6	75.3	74.5	72.2	6.6	.7
9.7	3.3	2.0	19.9	19.7	19.3	19.2	18.3	75.9
75.6	75.3	74.5	72.2	72.5	14.3	14.4	11.9	6608.1

Table 3.5 (continued)

START YEAR = 6	INVENTORY AT				THIS MONTH		SOLD 9-MO.	
	OPEN SOWS	LACTATING SOWS	PIGS MO.1	PIGS MU.3	TOT. DIED			
T= 1	15.0	26.9	153.8	151.0	2.3	139.5	4.0	
T= 2	15.2	37.2	154.1	150.2	2.3	139.1	4.0	
T= 3	15.3	37.6	157.0	155.3	2.3	142.7	4.1	
T= 4	15.4	38.1	158.4	152.5	2.4	144.4	4.1	
T= 5	15.5	38.4	159.3	155.4	2.4	145.0	4.1	
T= 6	15.6	38.4	158.9	156.6	2.4	144.4	4.2	
T= 7	15.7	38.6	160.9	157.7	2.4	146.1	4.2	
T= 8	15.8	39.0	161.8	157.3	2.4	146.5	4.2	
T= 9	16.0	39.3	163.9	159.3	2.5	148.9	4.2	
T= 10	16.1	39.8	165.2	160.2	2.5	150.5	4.3	
T= 11	16.2	40.1	166.4	162.3	2.5	151.4	4.3	
T= 12	16.3	40.2	166.5	163.5	2.5	151.2	4.3	
					AVE MONTH			
					SUMMARY ITEM			VARIANCE
					LACTATING SOWS	38.637		1.176
					PIGS MO.1	160.516	19.306	
					HOGS SOLD -8 MO.	145.812	17.443	
					FULL INVENTORY AT TIME T=12 IS			
0.0	4.5	83.2	82.5	81.8	81.1	73.9	7.2	.7
10.5	3.6	2.2	21.6	21.5	21.0	20.1	83.2	
82.5	81.8	81.1	79.9	79.4	15.6	140.9	249.2	

values, and to study feasible time paths for given inventory situations.

### 3.2.2 Modified Markov Chain Model

The Markov chain multiplication procedure of the previous section was modified to solve the model with the use of random numbers in the selection of transition paths. Individual animals are transformed from state to state resulting in stochastic integer results.

#### 3.2.2.1 Individual Randomized Simulation

Consider a row vector  $\underline{p}^*$  made up of a single row  $i^*$  of the transition matrix  $P$ . Positive elements  $p_{ij}^*$ ;  $j=1,2,\dots,30$  of this probability vector<sup>1/</sup> prescribe the probability of an individual animal of inventory state  $i^*$  transferring to state  $j$  in time  $t+1$  given that it was in state  $i^*$  in time  $t$ . A single random number is drawn for each animal of each inventory state in time  $t$  to randomly select, with probability defined by the probability row vector  $\underline{p}^*$ , the state  $j$ , into which this animal will move in time  $t+1$ .

This solution procedure was carried out by three Subroutines of a FORTRAN program. It is this general flow of the computer program that has generated the results reported in Table 3.6.<sup>2/</sup> These Subroutines are:

```

Subroutine EXECUTIVE
    ↓
Subroutine ROW I-LOOP
    ↓
Subroutine REPORT

```

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1/ For a definition of a probability vector see equation (2.14).

2/ Additional features of the FORTRAN program, ignored here for clarity of presentation, include statistical calculating operations.

Table 3.6 Randomized Markov Chain Simulation

ROUTE FORCE SPINS OF RANDOM NUMBER GENERATOR WILL SOLVE, INVENTORIES ARE FREE TO RANGE STOCHASTICALLY.  
 GILTS SELECTED PROPORTION = .070  
 RANDOM NUMBER SOURCE IS CDC FUNCTION RANF(0)  
 T IMPLIES SIMULATION TIME AT THE END OF A MONTHLY TIME PERIOD

IDENTIFICATION FOR INVENTORY STATES.									
ROARS-	FEMALE'S-	Y211	Y212	Y213	Y214	Y215	Y216	Y217	Y218
Y110	Y120								
OVULATING, OPEN-									
Y221	Y222	Y231	Y232	Y233	Y234	Y241	Y242	BARRIGHS-	
BARRIGHS (CONTINUED)-	Y223					T.DIED	T.SOLD1-8	Y301	
Y302	Y303	Y304	Y305	Y306	Y307	Y308	Y400	Y600	T.SOLD9-MO
FULL INVENTORY AT TIME T= 0 IS=									
2.0	6.0	50.0	50.0	0.0	0.0	50.0	45.0	10.0	0.0
15.0	10.0	5.0	25.0	0.0	0.0	25.0	0.0	15.0	50.0
50.0	0.0	50.0	45.0	10.0	0.0	0.0	0.0	0.0	0.0

START YEAR= 1									
INVENTORY AT T=				THIS MONTH					
OPEN SOWS	LACTATING SOWS	PIGS MO.1	PIGS MO.3	TOT. DIED	SOLD	9-MO.	SOLD	9-MO.	SOLD
T= 1	17.0	24.0	200.0	100.0	2.0	92.0	0.0	0.0	0.0
T= 2	4.0	24.0	0.0	97.0	5.0	103.0	0.0	0.0	6.0
T= 3	7.0	0.0	0.0	197.0	0.0	0.0	11.0	4.0	4.0
T= 4	4.0	24.0	200.0	0.0	0.0	0.0	0.0	2.0	2.0
T= 5	5.0	45.0	176.0	0.0	1.0	62.0	1.0	1.0	1.0
T= 6	16.0	28.0	56.0	199.0	2.0	96.0	4.0	4.0	4.0
T= 7	9.0	23.0	136.0	172.0	3.0	171.0	6.0	6.0	6.0
T= 8	9.0	21.0	40.0	56.0	3.0	32.0	2.0	4.0	4.0
T= 9	15.0	5.0	0.0	136.0	2.0	2.0	0.0	0.0	0.0
T= 10	5.0	14.0	120.0	40.0	0.0	161.0	1.0	1.0	1.0
T= 11	5.0	33.0	176.0	0.0	2.0	171.0	3.0	3.0	3.0
T= 12	8.0	40.0	113.0	0.0	1.0	66.0	1.0	1.0	1.0
SUMMARY ITEM TOTAL FOR YEAR									
LACTATING SOWS				AVE MONTH				VARIANCE	
PIGS MO.1				1144.00				140.063	
HOGS SOLD -8 MO.				989.00				656.616	
				82.477				3984.265	
FULL INVENTORY AT TIME T=12 IS=									
0.0	6.0	20.0	87.0	59.0	0.0	20.0	63.0	3.0	0.0
7.0	1.0	0.0	13.0	4.0	18.0	15.0	5.0	19.0	20.0
88.0	59.0	0.0	20.0	6.0	3.0	21.0	9.0	41.0	41.0

Table 3.6 (continued)

START YEAR= 2		INVENTORY AT T=			THIS MONTH		
		OPEN SOWS	LACTAT'G SOWS	PIGS MO.1	PIGS MO.3	TOT. DIED	SOLD -H.M.
T= 1		8.0	19.0	120.0	175.0	2.0	120.0
T= 2		6.0	32.0	144.0	39.0	6.0	54.0
T= 3		11.0	22.0	32.0	120.0	1.0	6.0
T= 4		12.0	16.0	104.0	144.0	1.0	96.0
T= 5		5.0	12.0	152.0	32.0	2.0	152.0
T= 6		9.0	25.0	56.0	104.0	1.0	58.0
T= 7		16.0	20.0	112.0	152.0	1.0	105.0
T= 8		13.0	35.0	176.0	56.0	0.0	138.0
T= 9		15.0	32.0	80.0	112.0	3.0	36.0
T= 10		14.0	22.0	88.0	175.0	0.0	101.0
T= 11		8.0	30.0	152.0	88.0	0.0	127.0
T= 12		11.0	31.0	96.0	88.0	1.0	70.0
							VARIANCE 39,659
							1758,545
							1932,750
FULL INVENTORY AT TIME T=12 IS=		THIS MONTH			THIS MONTH		
		OPEN SOWS	LACTAT'G SOWS	PIGS MO.1	PIGS MO.3	TOT. DIED	SOLD -H.M.
0.0		6.0	48.0	76.0	44.0	47.0	0.0
9.0		2.0	0.0	9.0	15.0	12.0	19.0
		44.0	44.0	56.0	4.0	3.0	2054.0
START YEAR= 3		INVENTORY AT T=			THIS MONTH		
		OPEN SOWS	LACTAT'G SOWS	PIGS MO.1	PIGS MO.3	TOT. DIED	SOLD -H.M.
T= 1		16.0	24.0	96.0	152.0	2.0	104.0
T= 2		8.0	34.0	184.0	94.0	0.0	157.0
T= 3		5.0	37.0	120.0	95.0	2.0	93.0
T= 4		15.0	24.0	72.0	184.0	1.0	68.0
T= 5		14.0	29.0	176.0	119.0	0.0	134.0
T= 6		14.0	41.0	176.0	72.0	1.0	99.0
T= 7		16.0	35.0	112.0	174.0	2.0	95.0
T= 8		13.0	31.0	136.0	111.0	4.0	154.0
T= 9		12.0	33.0	136.0	111.0	4.0	126.0
T= 10		12.0	29.0	112.0	133.0	2.0	84.0
T= 11		13.0	31.0	152.0	135.0	0.0	151.0
T= 12		8.0	43.0	204.0	112.0	1.0	168.0
							VARIANCE 34,992
							1623,273
							954,750
FULL INVENTORY AT TIME T=12 IS=		THIS MONTH			THIS MONTH		
		OPEN SOWS	LACTAT'G SOWS	PIGS MO.1	PIGS MO.3	TOT. DIED	SOLD -H.M.
0.0		6.0	104.0	76.0	26.0	67.0	52.0
5.0		3.0	0.0	19.0	21.0	16.0	25.0
		56.0	67.0	56.0	15.0	2.0	3509.0

Table 3.6 (continued)

Table 3.6 (continued)

START YEAR = 6	INVENTORY AT T=			THIS MONTH		
	OPEN SOWS	LACTATING SOWS	PIGS MO.1	PIGS MO.3	TOT. DIED	SOLD 9-MO.
T= 1	21.0	42.0	176.0	190.0	5.0	183.0
T= 2	25.0	49.0	232.0	165.0	4.0	192.0
T= 3	18.0	57.0	240.0	174.0	4.0	241.0
T= 4	19.0	56.0	216.0	230.0	3.0	189.0
T= 5	19.0	53.0	224.0	439.0	4.0	184.0
T= 6	23.0	46.0	160.0	210.0	7.0	160.0
T= 7	17.0	46.0	216.0	222.0	3.0	172.0
T= 8	20.0	54.0	232.0	157.0	2.0	203.0
T= 9	18.0	57.0	240.0	214.0	2.0	225.0
T= 10	19.0	51.0	176.0	252.0	3.0	212.0
T= 11	22.0	53.0	248.0	239.0	2.0	202.0
T= 12	16.0	54.0	208.0	173.0	4.0	164.0
SUMMARY ITEM						
		LACTATING SOWS			AVE MONTH	VARIANCE
		PIGS MO.1	2568.00	4.0	51.500	23.182
		HOGS SOLD -8 MO.	2327.00		214.000	827.636
					193.917	584.447
FULL INVENTORY AT TIME T=12 IS =						
0.0	5.0	104.0	123.0	86.0	120.0	99.0
10.0	5.0	1.0	34.0	28.0	31.0	7.0
123.0	87.0	119.0	116.0	105.0	16.0	2.0
					150.0	104.0
						272.0

Subroutine EXECUTIVE reads in data and prepares the problem for execution. Subroutine ROW I-LOOP accepts the prepared problem from Subroutine EXECUTIVE and executes it for a single time period. Subroutine REPORT writes the results of the execution and returns control to the EXECUTIVE for preparation of the next single period problem.

Subroutine EXECUTIVE notes the number of periods to be simulated, the total number of elements (total = J) in the opening inventory vector  $y_0$ ; and the size of the transition matrix P (J rows and J columns). Initialization of variables includes setting the vector  $y_{t+1} = 0$  and the counting variable  $i = 0$ .  $y_0$  and P are read in as data. Individual rows  $i; i=1,2,\dots,J$ ; of the transition matrix P are then converted to a matrix of cumulative probabilities <sup>1/</sup> C, containing zeros, positive elements  $0 < c_{ij} \leq 1$ , and deterministic variables ( $>1$ ). The cumulative probability elements are calculated by summing probability elements of P from left to right on rows while maintaining their positions as found in the original matrix P. Therefore, the probability elements of C indicate feasible transitions as they did in P.

Consider the  $J=4$  example of Chapter 2 where equation (2.18)  
was presented:<sup>2/</sup>

$$(3.20) \quad P = \begin{bmatrix} 0 & .7 & 0 & .3 \\ 0 & .8 & 8.0 & .2 \\ .1 & 0 & 0 & .9 \\ 0 & 0 & 0 & 1.0 \end{bmatrix}$$

1/ Conversion to cumulative probabilities was not required for the matrix multiplication of ordinary Markov Chain analysis.

2/ Recall from Chapter 2 that the four states of this example are: 1=open sows, 2=bred sows, 3=pigs of all ages, and 4=total sales.

Converted to a cumulative probability matrix, P becomes<sup>1/</sup>

$$(3.21) \quad C = \begin{bmatrix} 0 & .7 & 0 & 1.0 \\ 0 & .8 & 8.0 & 1.0 \\ .1 & 0 & 0 & 1.0 \\ 0 & 0 & 0 & 1.0 \end{bmatrix}$$

Matrix C facilitates comparison of feasible transitions with the random number selected for each animal in the Subroutine ROW I-LOOP. Note that the deterministic element<sup>2/</sup>  $c_{2,3}$  remains equal to 8.0, resulting in the creation of 8 pigs from each sow farrowing.

The opening inventory vector  $y_0$  as used for ordinary Markov multiplication is:

$$(3.22) \quad y_0 = [4 \quad 6 \quad 60 \quad 0] .$$

After preparation of matrix C by Subroutine EXECUTIVE, control is passed to Subroutine ROW I-LOOP for execution. One row i at a time is used in an "I-LOOP" thereby accommodating transition of all animals contained in a single state i of  $y_t^3/$  before turning to the animals in the next inventory state.

Consider the above example problem (equation 3.21 and 3.22) as it was solved by the FORTRAN program. Subroutine EXECUTIVE reads in matrix P and  $y_0$ , converts P to C, recognizes the deterministic value

<sup>1/</sup> Elements  $c_{ij}$  are the cumulative probability of transferring to respective states. Each individual row vector  $c^*$  made up of a single row  $i^*$  of the cumulative probability matrix C fulfills the function of a row vector  $p^*$  described in the opening statement of this section.

<sup>2/</sup> This coefficient need not be deterministic. If it were stochastic, an extra random number loop would be needed to draw litter size from a probability distribution for this particular run, or particular sow as was done for this type variable in the research model presented in Chapter 4.

<sup>3/</sup>  $y_{it}$  is used to refer to elements of  $y_t$  while  $y_{jt+1}$  is used to refer to elements of  $y_{t+1}$ . See figure 3.1 Flow Chart of Subroutine ROW I-LOOP.

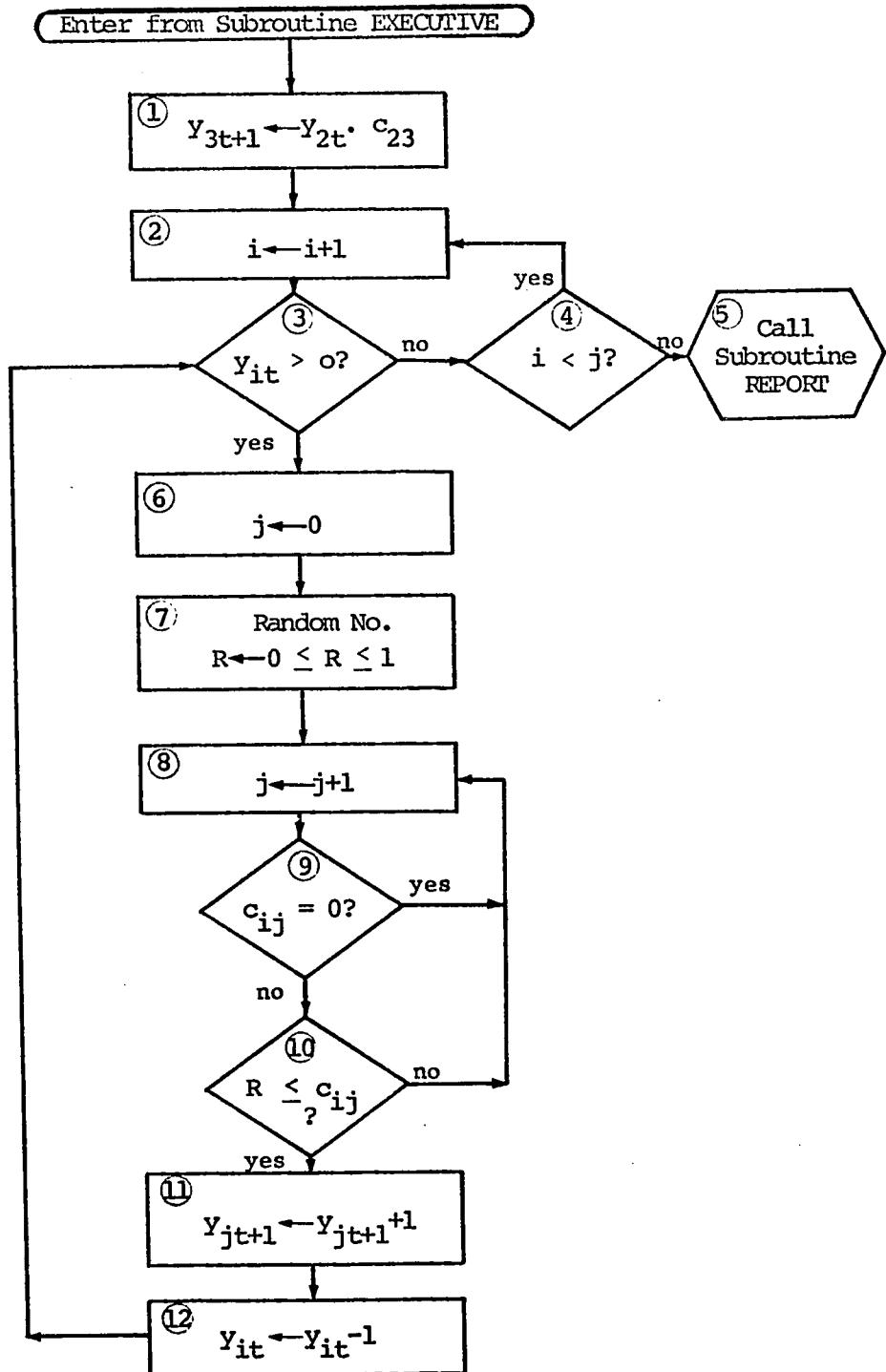


Figure 3.1 Flow Chart of Subroutine ROW I-LOOP

in  $c_{2,3}$ , and notes that there are 4 states ( $J = 4$ ). Subroutine ROW I-LOOP then executes the transition from  $t$  to  $t+1$  according to the Flow Chart in Figure 3.1. First, pigs are created by multiplication, box 1, and stored as the first addition to the inventory vector  $\underline{y}_{t+1}$ . In this example problem, eight pigs are added to state 3 for each bred sow of state 2 in the original inventory vector  $\underline{y}_t$ .<sup>1/</sup> The value of the counter  $i$  is then incremented: box 2, Figure 3.1. If state  $i$ , of  $\underline{y}_0$  ( $y_{1,0}$  of box 3) contains more than zero animals, the counter  $j$  (corresponding to states of the inventory vector for time  $t+1$ ) is set to zero in box 6, and a random number is drawn in box 7. At this point an individual animal of state classification  $i$ , is to be transferred to one of its feasible transition states  $j$  in  $t+1$ .

The value of the counter  $j$  is incremented by one in box 8, to consider disposition of the animal to state  $l$  of  $\underline{y}_{t+1}$ . The model allows two possibilities: (a) that  $c_{ij} = 0$  in box 9, and is not a feasible transition or; (b) that  $0 < c_{ij} \leq 1$  and is therefore a feasible transition for comparison with the random number  $R$ , from box 7. If there is not a successful match of  $R \leq c_{ij}$  in box 10, control is returned to box 8 where the value of  $j$  is incremented by one<sup>2/</sup> and the immediately succeeding state  $j$ , (succeeding  $c_{ij}$ ), is considered for transition.

<sup>1/</sup> This side calculation could have involved a random variable for litter size as was used in the research model of Chapter 4.

<sup>2/</sup> A successful match will be found on or before  $j$  takes the value  $J$  since a  $c_{ij} = 1$  will be found on or before the point where  $j=J$ . See the matrix  $C$ , equation (3.21).

A successful match of  $R \leq c_{ij}$  allows transfer of the animal to state  $j$  of the inventory vector  $y_{t+1}$  from state  $i$  of  $y_t$  by operation of boxes 11 and 12 respectively.<sup>1/</sup> Control now returns to box 2 where state  $i$  ( $y_{it}$ ) is compared to determine if additional animals require disposition.

One animal at a time is thus transferred to one of its feasible states via operation of boxes 3-12. When all animals of any one state have been transferred,  $i$  is incremented so that succeeding states can be transferred in turn.

When all animals of all 4 example inventory states have been transferred, control is passed to Subroutine REPORT where the  $t+1$  inventory vector is written. Control then returns to Subroutine EXECUTIVE and the process repeated for each additional period to be simulated.

Individual randomized simulation for the 30 state modified Markov chain model was carried out by similar operations of the Subroutines EXECUTIVE, ROW I-LOOP, and REPORT.

Solution of this modified model in a FORTRAN language computer program is relatively fast.<sup>2/</sup> Solutions were restricted to integer values since each animal was transformed to one and only one

- <sup>1/</sup> In the example problem for  $i=1$  a successful match would result if the random number drawn were say  $R=.3$ . The box 10 match would occur when  $j$  was equal to 2, since  $.3 \leq .7$ . The result is one open sow deleted from inventory  $t$  and one bred sow incremented for  $t+1$ .
- <sup>2/</sup> A total of 60 sec. of Central Processing time was required for this monthly model containing 30 inventory states, with 500 animals in opening inventory, and simulating 6 years of production. A random number is drawn for each animal and its disposition decided according to the probability of attaining each feasible state. A less efficient alternative computational procedure is discussed in Appendix A.

feasible state. Simulation results were free to range stochastically. Results from solution of the modified Markov chain model, designated "Model No. 2", are given in Table 3.6. Results are reported for a simulation run covering six years. Note that while inventory numbers in each state category are held to integer values, the grouping of sows and pigs is also smoothed through time as was the result of Markov multiplication.<sup>1/</sup>

Repetitive solution of this model would provide information for estimation of the probability distribution of results. Repeated runs would yield fully stochastic results simulating many of the important features of a breeding herd.

### 3.2.3 Shortcomings of the Demonstration Models

The conceptual model presented above defines the important features of the reproductive process of the swine breeding herd, with a daily time interval, and highlights the stochastic and integer nature of the productive animal.

The demonstration models reveal the operational nature of the modeling problem. Markov process models have demonstrated how probability data can be incorporated. The individual randomized simulation (Table 3.6), in particular, provides a general procedural pattern for studying the research model.

There are however, a number of important limitations of the demonstration models. These shortcomings are of two types: (a)

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1/ This was evidenced by the decline in the month-to-month variance statistics over the 6 years of simulated results. Variance was greater than that of the Markov multiplication model and did not tend toward zero. End of the year inventories also appear for comparison purposes in Table 3.3.

limitations which can be overcome by improvement of the monthly individual randomized simulation, and (b) those which require a more complex and detailed model.

Major shortcomings under (a) are:

1. The number of pigs born alive per litter should have been a stochastic variable.
2. Baby pig survival should have depended on the survival of the nursing mother.
3. Number of sows bred should have depended on the number of boars as well as the number of sows available.
4. There should be synchronization of farrowings.
5. There should be provision for breeding policy to get a target number of sows bred for each farrowing, subject to the number of open sows and gilts as well as boar availability.
6. There should be grouping of pigs for housing assignment to confront housing availability.
7. Rules should be included for selection of gilts for breeding stock, weight to sell, maximum age to keep sows, etc.
8. There should be provision for conditional probabilities of conception, farrowing, etc., related to earlier events.<sup>1/</sup>

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1/ Note that this modification would take us away from a simple Markov type structure and/or increase the size of the problem by several orders of magnitude.

The above limitations were overcome by reprogramming the three Subroutines detailed in the previous section and described in the Flow Chart of Figure 3.1. The changes required are discussed in section 3.2.3.1 below.

Major shortcomings which would require a substantially more complex model include:

1. A model which would allow experiments with heat synchronization, length of heat cycles, gestation, estrus cycles or other characteristics requiring the detail of a daily model.
2. A model which would allow adaptive behavior in the allocation of space or other scarce resources.

The latter shortcomings required a model with daily transformation.<sup>1/</sup> A daily model is required to answer questions related to: (a) scheduling of farrowing, (b) gilt versus sow production, (c) boar availability, (d) female fertility, etc. In short, the monthly model is too aggregate for modeling many stochastic aspects of production.

### 3.2.3.1 Limitations Which Could Have Been Overcome in a Monthly Model

Limitations which could have been incorporated into the monthly demonstrational model include those that require a simple development of the model, and management strategies which require a different type of model. In the list, 1-8 above, shortcomings 1-3 indicate a simple development of the model. Shortcomings 4-8 however, require

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<sup>1/</sup> For a biological study of epidemic disease, an hourly, or even shorter time period, might be required.

greater modification of the structure of the model.

The number of pigs farrowed (shortcoming number 1) could have been made a stochastic variable by inserting a few FORTRAN statements. This would have made the number of pigs farrowed dependent upon a sow reaching the end of gestation. The number of pigs farrowed could then become a random variable, replacing the deterministic calculation in the demonstration model. When a deterministic value was encountered in the matrix of transition probabilities, this could be noted, and operations with bred sows carried out before pigs were created. This would result in a known number of sows surviving and farrowing, i.e., moving from state 17 (bred sows) to state 18 (first month of lactation).<sup>1/</sup> An additional subroutine could then be used to create baby pigs for each of the surviving mothers which have farrowed and appear in state 18. This new subroutine would use the deterministic value discovered in the transition matrix as the mean, of say a truncated normal distribution, in conjunction with the random number generator to assign baby pigs stochastically to individual nursing mothers.

Herd numbers could be stored in an additional matrix M managed in parallel with the vector  $y$ . For say 12 bred sows in the herd, matrix M would contain 12 unique herd numbers identified as block 17, i.e.,  $y_{17,t} = 12$ . Matrix M for time  $t + 1$  would then reflect those bred sows surviving and farrowing to become first month lactating sows of state 18. A herd numbering system is essential for assignment of a

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<sup>1/</sup> States coded  $S_{234}$  and  $S_{241}$ , Table 3.4 Monthly Markov Chain Transition Matrix.

particular litter to an individual sow.<sup>1/</sup>

Baby pig survival could be dependent upon the survival of the nursing mother (shortcoming number 2) by inserting FORTRAN statements which make a check for survival of the nursing sow and only then allows survival of individual litters.<sup>2/</sup> Litters of pigs could be identified by a coded herd number which links the individual pig as offspring of a particular sow.<sup>3/</sup> A subroutine would be called, subject to the

- 1/ The opening inventory  $y_0$  for the example problem (equation 3.22) for the four state model containing 4, 6, 60 and 0 animals respectively would be:

M =	1	0001
	1	0002
	1	0003
	1	0004
	2	0001
	2	0002
	..	..
	2	0006
	3	0001
	3	0002
	..	..
	3	0060
	4	0000

M is an array of flexible sized blocks containing J rows, one for each of the J total number of states in the model; and 2 columns, one for the associated block (state i) to which the animal belongs and the other the herd number m.

- 2/ Baby pigs were assumed lost if the mother dies. In a very detailed model, pigs would realistically have a chance for survival dependent on transfer to other litters, and their age and stage of consumption of milk replacer or dry feeds at the time of the mother's death.
- 3/ A computer word of storage which allows 18 integer digits permits coding of several pieces of information into a herd number. For example, the number 01800090053 can represent a first month lactating sow (state 018), nine baby pigs in her litter (0009), and an individual chronological herd number of 0053. An individual pig in this sow's litter might have the herd number 00300530198 indicating a barrow in its first month (state 003), born to sow number 0053, which has a unique herd number 0198. The number of attributes which can be stored in one computer word is limited by the 18 integer digits storage capacity of the CDC 6500 at Purdue University. Ordinary FORTRAN statements using integer multiplication and division were used to interpret numbers "packed" in this way.

event that a nursing sow dies, which locates the dead sow's pigs and "kills" them. Other operations of the model would not change implying that the baby pig transition probabilities would then be defined as conditional probabilities, i.e., survival given that the nursing mother survived.

Interaction of boars and sows (shortcoming number 3) could be overcome by a check for boar availability. For the monthly model, a subroutine would be required which makes a check on the number of boars available (values of  $y_{1t}$  and  $y_{2t}$ ) before the usual transitions for rows  $i = 11, 12, 13$ , and  $19$  are made.<sup>1/</sup> This subroutine would adjust the appropriate transition probabilities of conception if boars were found to be in short supply.

The above adaptations of the monthly demonstration model could have been accomplished by adding FORTRAN statements or subroutines to check for biological feasibility and carry out appropriate adjustments.

Shortcomings which require management strategies demand rather major changes in the model and its flow of solution procedures. This type of shortcoming has to be overcome by writing a more complicated FORTRAN program<sup>2/</sup> which is capable of carrying out management

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<sup>1/</sup> See Table 3.4 column 14 showing transitions to the month-one bred sow state of the Monthly Markov Chain Transition Matrix.

<sup>2/</sup> Such as the research model itself which was designed to overcome the limitations under discussion here.

strategies according to predetermined rules.. The following discussion of how shortcomings 4-8(in the list 1-8 above) were overcome mainly involves the nature of the additional programming required to overcome those shortcomings.<sup>1/</sup>

Synchronization of farrowing was overcome by designing a model which operates a particular kind of management system. Synchronization was accomplished by weaning sows to synchronize their heat periods. Gilts cannot be grouped in this way. The management system may demand say, a 3 week weaning season in an attempt to schedule breeding and farrowing in approximately three weeks. Using a very simple approach, the model was made to follow a calendar of breeding schedules so that breeding was allowed over appropriate dates with no breeding at other times. For the monthly model this would have meant a check for dates by Subroutine EXECUTIVE. If breeding were not allowed, transition probabilities would be altered to reflect the no breeding policy. These adjustments would have been made before Subroutine ROW I-LOOP executed the program.

Provision for a breeding policy to get a target number of sows bred required limiting exposure of sows to boars. The breeding season was closed when the target number of sows had been exposed. Building design capacity of the farrowing house provided a target number of sows to farrow (number of farrowing crates). The farrowing

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<sup>1/</sup> Note that introduction of herd numbers, location codes, etc., required to overcome shortcomings 4-8, changes the complexion of the model. Attention is being given to simulation of the production path for individual animals and away from total number of animals in broadly defined states.

house is the most rigid space bottleneck in the production process.

Modern farrowing facilities contain a given number of farrowing crates with no flexibility for adding crates or crowding more than one sow into one crate.<sup>1/</sup> The farrowing house is a high investment building, and requires emptying and cleaning after each farrowing season. Although in practice, as well as in the research model, breeding policy needed to focus primarily on farrowing capacity and the size of target farrowings.

Open sows are available from (a) the supply of female butcher hogs being finished (gilts), (b) from the stock of open sows being maintained in anticipation of an upcoming breeding season, and (c) from sows which were lactating in the immediate preceding period and could be weaned and bred before the end of the breeding season. Breeding strategy demands noting the number available from b and c, and selecting the number to be culled from five month old butcher lots and assigning them to the open sow state, two periods<sup>2/</sup> prior to the beginning of the breeding season. Subroutine EXECUTIVE needed to be reprogrammed to carry out these operations and start and stop the breeding season.

#### Grouping of pigs for housing assignment (shortcoming number 6)

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- 1/ Early weaning, removal of the sow to maintenance and the pigs to a growing house, allows double use of the crate in a single farrowing season but not double occupancy. There are of course, associated influences on the number of pigs in the nursery, the number of sows being maintained and/or available for breeding. These effects were incorporated into the daily research model.
  - 2/ Removal from finishing rations and conditioning for two months is required to complete sexual maturity and enhance reproductive ability.

was overcome by adding a housing subroutine to the monthly model. A housing code number was added to the individual animal herd number to reflect the building in which the animal is housed.<sup>1/</sup> In addition, an inventory of building space must be maintained to evaluate occupancy rates for study of the model. This inventory requirement took the form of an array with accounting of subfiles to reflect coded housing types, their capacities and occupancy as the model was executed.

A set of production management options were provided for selection of gilts for breeding, weight to sell, maximum age to keep sows, etc. This took the form of additional computer program where a rather complete review of the inventory vector would first be made to determine qualifying animals and then appropriate disposition made in light of the criteria for gilt selection, selling weight, maximum ages, etc. For example, sales were handled as a search of all animals located in the finishing building. Those animals meeting the weight criteria, greater than or equal to say 215 pounds, are declared sold and removed from array storage. Production management strategies were much the same as the culling jobs the herdsman must execute.

Conditional probabilities, related to earlier events were accomplished by including key probabilities in the list of attributes throughout simulation for each individual animal entity. These are of two types: (a) those which are lifetime characteristics of the animal such as date of birth, litter size and length of estrus, and (b)

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<sup>1/</sup> A very detailed model could have included crate and pen numbers in this code.

those which cause a multiple period effect but are determined by a random event during simulation such as the availability of boar services and building space, and the length of a pregnancy.

Conditional probabilities of type (a) are incorporated by the Markov Chain approach to a solution procedure where previous history is summed up by the description of the current state occupied by an animal. The probability of transition to another state is a conditional probability (probability of transition given that earlier events placed the animal in the current state). Conditional probabilities of type (b) suggest a major departure from the Markov Chain solution procedures exemplified by an effects calendar. These operate as adjustments of transition probabilities and attribute values.<sup>1/</sup> Suppose Subroutine EXECUTIVE determines that the number of boars available results in only one boar service rather than the normal two services. The effect of reduced boar services would be carried out over the period in which they are in short supply. The severity and length of time over which conceptions were reduced could occur over several time periods. The resulting probabilities are conditional upon previous events and the duration of the effects of such events.

Accommodation of the above shortcomings 4-8 have been shown to require more and more attention to the individual animal as an

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1/ This is for computer efficiency. Note that attaching attribute values to individual animal entities is not a conceptual departure from the "state" definition of the Markov process, in that the "state" implied a well defined set of attributes. Given no practical limit on the number of "states," all stages of any condition could be represented by some series of states and the probability of transition one to another.

entity, turning away from the use of generalized "States". This is necessitated by the incorporation of the detail desired in the model. It was found necessary to identify individual animals and attach attributes<sup>1/</sup> for expedient operation of the FORTRAN program. Note that definition of these attributes is suggested by the Simple Binary Mechanistic Model of a Swine Herd of section 3.1.1. The characteristics i, j, k, L, m, and t (subscripts of the individual animal x) in equation (3.2), are the reproductive attributes of swine. The conceptual model demands daily considerations as suggested by the second major category of shortcomings.

The monthly model and its solution procedures provided the building block for a more complex research model. Limitations which required a more complex model are discussed in the following section.

### 3.2.3.2 Limitations Which Require a Daily Model

Even if the monthly individual randomized model were developed as suggested above, it would not have been detailed enough to allow experiments with characteristics of swine which require a model with a shorter time unit. A more complex daily model was required to incorporate the features of the reproductive animal.

A daily research model allowed experiments with heat synchronization, length of heat cycles, gestation, and estrus cycles by providing a time unit short enough to allow additional attributes as random variables. Allocation of space experiments were possible once the

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<sup>1/</sup> Attributes already introduced above include: weight, building location, litter and dam identification.

daily model was developed. Many of the space bottlenecks may appear critical when modeled daily, even though they would not seem to be problems under the abstraction of a monthly model. The daily time interval allowed calculation of daily gains as well as many of the reproductive attributes of swine.

The strategy rules, adjustments to the transition matrix, and other operational aspects of the model suggested a flexible model which is more comprehensive than the demonstration models but at the same time includes the features of the inventory vector and transition probabilities of those models.

#### 3.2.4 Transition to the Research Model

The demonstration models and the above discussion of their shortcomings indicate the way in which the stochastic nature of the swine breeding herd problem was visualized. Limitations of the demonstration models were overcome by the use of a daily time interval and the incorporation of greater detail and features in the research model beyond those of the demonstration models. These developments are discussed in greater detail in the next chapter.

## CHAPTER 4

## THE MODEL

Conceptual models have been developed and demonstrated in the form of a simplified monthly model in Chapter 3. The limitations of this monthly model led to the requirements of the research model. These limitations, and the modifications required to overcome them, have already been discussed. It is the purpose of this chapter to define the research model and discuss its implementation in accordance with the third objective of the study: to implement the model in the form of an operational computer program for use by research workers.

The research model provides for definition of all possible states which an animal can take at any point in simulation time, and for the transition mechanisms for all state to state transformations. Some of these mechanisms have been presented and demonstrated in Chapter 3. Additions to them are discussed in this chapter. Limits to transformations are set by specification of control parameters which define management practices and housing restrictions. The complete list of control parameters takes the form of an Input-Output Form which is included as Appendix B.

Section 4.1 defines the limits to animal attributes, combinations of which define animal states, as well as auxiliary characteristics of animals and the system.

Animal and building attributes characterize the model and facilitate its evaluation. Section 4.2 presents the computer

implementation of the model and reviews the more important control parameters incorporated into the computer program.

#### 4.1 Statement of the Model

The statement of the model defines states and characteristics of all animals and of the system as a whole. Animals have attribute values which define their productive state at any point in time. Attributes and their permissible ranges were defined following the notation of the conceptual model of Chapter 3. Whereas the conceptual model of Chapter 3 served to conceptualize the complexity of the interrelationships between reproductive animals, this statement of the research model has as its emphasis definition of all productive states of all animals. The research model also provides for evaluation of the condition of the herd at any point in time as well as measures of the use of building resources.

Permissible animal states are first defined. Then the auxiliary animal characteristics dictated by the limitations to the monthly models found in Chapter 3 are discussed. The auxiliary characteristics of the system itself are then presented.

##### 4.1.1 Animal States

For the purposes of the research model, animals were conveniently classified into productive classes as (a) boars, (b) sows, or (c) market hogs. Let

$$(4.1) \quad B_{iklmhuvstwg} = \text{a unique boar state, where:}$$

$i = \text{age in days} = 150, 151, 152, \dots, 730^{\frac{1}{1}}$

$k = \text{subclass} = 1 = \text{newly purchased}; 150 \leq i \leq 395$

$= 2 = \text{young boar}; \quad 195 \leq i \leq 365$

$= 3 = \text{mature boar}; \quad 366 \leq i \leq 730^{\frac{1}{1}}$

$L = \text{number of days in the herd}$

$m = \text{a unique herd number}$

$h = \text{boar building (file) number}$

$u = \text{daily use} = 0 \text{ for } k = 1, L \leq 30$

$= 0, 1, 2, 3^{\frac{1}{1}} \text{ for } k = 1, 2, 3, L > 30$

$v = \text{weekly use} = 0, 1, 2, \dots, 10^{\frac{1}{1}} \text{ for } k = 1$

$= 0, 1, 2, \dots, 15^{\frac{1}{1}} \text{ for } k = 2$

$s = \text{total services count}$

$t = \text{simulation time in days}$

$w = \text{current weight in pounds}$

$g = \text{daily gain in pounds}^{\frac{2}{2}}$

If boar  $B_{iklmhuvstwg}$  survives  $^{\frac{3}{3}}$  to time  $t$  he is available for service only if  $u$  and  $v$  do not exceed their respective ranges, unavailable otherwise.

1/ A control variable set optionally by the user of the computer implementation, see section 4.3.4. Optional control variables will be simply footnoted as "optional value" in the remainder of this chapter.

2/ A random deviate discussed in section 4.1.2.

3/ Survival is stochastic as defined in Chapter 3.

Let

(4.2)  $S_{ikLmhp eqstw g}$  = a unique sow state, where:

$i$  = age in days - 160,161,162,...,1600<sup>1/</sup>

$k$  = subclass = 1 = never ovulated;  $160 \leq i \leq 209$

= 2 = open sows;  $210 \leq i \leq 1600$

= 3 = in gestation;  $226^{2/} \leq i \leq 175^{43/}$

= 4 = in lactation;  $336 \leq i \leq 175^{43/}$

$L$  = days in  $k$  subclass.

$m$  = unique herd number

$h$  = building file number = 4 = farrowing

= 6 = maintenance

= 9 = cull pen

$p$  = number of pigs born alive<sup>4/</sup> = 4,5,6,...,or 16

$e$  = estrus cycle length, days<sup>5/</sup> = 16,17,18,...,25

$q$  = gestation length, days<sup>4/</sup> = 110,111,112,...,118

$s$  = maximum exposures without conception = 0,1,<sup>6/</sup>2

- 1/ Maximum age to keep a sow is waived if the sow is in gestation or lactation when reaching this age. This is a control variable: optional value.
- 2/ Age at first start of estrus cycle plus minimum 16 days estrus.
- 3/ Maximum age of 1600 plus maximum length of gestation and lactation, since producing sows are never culled because of age.
- 4/ Random deviate drawn for each farrowing, optional value.
- 5/ Random deviate drawn once for the life of the sow.
- 6/ Optional value.

t = simulation time in days  
w = current weight in pounds  
g = daily gain in pounds

Surviving sows gestate, farrow, and lactate within the limits of the management strategies defined for the herd. See sections 4.1.2 and 4.1.3 which discuss auxiliary characteristics of animals and the system.

Let

(4.3)  $H_{ikmhdbtwg}$  = a unique market hog, where:

i = age in days; = 1,2,3,...240  
k = subclass = 1 = female  
= 2 = male  
m = unique herd number  
h = building file number = 4 = farrowing  
= 5 = nursery  
= 7 = finishing  
d = dams herd number  
b = birth weight;  $\frac{1}{2}$   $1.25 \leq b \leq 5.0$   
t = simulation time in days  
w = current weight in pounds  
g = daily gain in pounds

Surviving hogs of all ages occupy building space until sold as butcher hogs or selected as female replacements for the sow herd.

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1/ Optimal value.

See auxiliary management strategies: section 4.1.3 Auxiliary Characteristics of the System.

#### 4.1.2 Auxiliary Animal Characteristics

Auxiliary characteristics of animals include those attributes added to the reproductive attributes to facilitate evaluation of the model. These include weight,  $w$ , daily gain,  $g$ , and the associated age categories used to select daily gain values as random normal deviates. Animal weights were a necessary addition to provide a realistic sales criteria and to permit cost of gain calculations. Sows experience a weight loss at parturition based upon number of pigs born alive.

Table 4.1 Standard Gain Parameters, presents the standard parameters which define the random normal distribution from which daily gains are drawn. Parameter values for gain are optional to the user of the model, see Appendix B Input-Output Forms and Instructions.

Daily gain is constant throughout the time period of each age or productive classification. For example, an individual sow receives a daily gain (drawn as a random deviate) at the beginning of her lactation period and gains at that rate throughout lactation.

She then receives another at the beginning of her maintenance period. Pigs likewise grow at constant rates within their age classifications. A new random deviate for the value of  $g$  is drawn as the pig enters each age class.

In general, the features necessary to overcome the limitations of section 3.2.3.1 which could have been overcome in a monthly model

Table 4.1 Standard Gain Parameters

<u>Productive Class</u>	<u>Mean</u>	<u>Standard Deviation</u>	<u>Minimum</u>	<u>Maximum</u>
All boars:	0.5	0.2	-5.0	10.0
Sows:				
Maintenance	1.0	0.2	-5.0	10.0
Lactation	-0.5	1.0	-5.0	10.0
Weight Loss per pig at parturition	5.0	0.5	-10.0	10.0
Market Hogs of age:				
1-7	0.45	0.07	-5.0	10.0
8-21	0.58	0.09	-5.0	10.0
22-56	0.75	0.11	-5.0	10.0
57-149	1.25	0.15	-5.0	10.0
150-sale <sup>1/</sup>	1.70	0.26	-5.0	10.0

were incorporated in the daily research model.<sup>2/</sup> The number of pigs farrowed was made a stochastic variable, as shown in equation (4.2). The number of pigs farrowed was made to reflect the productivity of gilts versus sows by adding an attribute which is obtained by drawing a random normal deviate with the Mean a function of the age of the sow. This was accompanied by the addition of a stochastic variable for

1/ Or in the case of a female, until selection as a sow herd replacement.

2/ For a complete list of optional parameters, see Appendix B.

length of gestation. Individual herd numbers were added to the model to link sows with their baby pigs which permitted making baby pig survival dependent upon survival of the nursing mother. If a lactating sow dies during the first week of lactation, all her pigs also die. If death takes place after the first week her pigs die with a probability of 50 percent.

The probability of pregnancy was made dependent upon the availability of boar services facilitated by the daily and weekly availability scheme defined by equations (4.1) and (4.2). Attributes  $u$  and  $v$  define daily and weekly limits on the number of services available from a boar. Boar services either are or are not available. Users of the computer implementation have the opportunity to make the number of pigs born as well as the probability of conception dependent upon there being 1 or 2 boar services available.

#### 4.1.3 Auxiliary Characteristics of the System

The auxiliary characteristics of the system were necessary to correct the limitations of the monthly models and to incorporate the management strategies which required a different type of model.

The main feature required of the system was a schedule of events to control breeding, weaning, gilt selection, culling, and sales according to management policy. Let  $f$  represent farrowing season 1, 2, ..., or 6 in a six farrowing per year-blocked<sup>1/</sup> system.

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1/ Blocked refers to blocking out of farrowings during Spring and Fall planting and harvesting seasons.

Then beginning dates of target farrowings<sup>1/</sup> within any one year can be represented as:  $t_f = 15$  (January 15), 60 (March 1), 152 (June 1), 198 (July 17), 244 (September 1), or 355 (December 1). Corresponding times to begin breedings  $t_b$  are:

$$(4.4) \quad t_b = t_f - q + D_q$$

Where

$t_b$  = day to begin breeding for target farrowing f;  
 $b, f = 1, 2, \dots, 6.$

$t_f$  = target day for first farrowing in season  $f=b$ .

$q$  = Mean length of gestation in days.

$D_q$  = Standard Deviation of  $q$ .

The Standard breeding season of 21 days defines a breeding season from:  $t_b$  to  $t_b + 21$ . The length of the breeding season; and the value of  $q$ , and  $D_q$  are all optional control parameters to the computer implementation.

Sows and gilts are available for breeding as they come into heat during the time the system is in a breeding season  $t_b$  to  $t_b + 21$ , if the count of the number exposed to boar services has not exceeded the target number of sows to be exposed.

If the target number exposed<sup>2/</sup> is reached, exposure to boars is terminated until the following breeding season. A 21 day breeding season accomplishes a moderate synchronization of farrowing subject to

1/ The stochastic nature of farrowing leads to the use of the term target farrowing.

2/ Optional value.

the stochastic nature of the length of gestation and to the availability of sows and boars during the breeding season.

Let  $w$  represent weaning season 1, 2, ..., or 6 for pigs born during the farrowing season  $f=w$ . Beginning days of weaning seasons  $t_w$  are:

$$(4.5) \quad t_w = t_f + A$$

Where

$t_w$  = day to begin the weaning season  $w$ .

$t_f$  = Target day for first farrowing in season  $f, w=1, 2, \dots, 6$ .

$A$  = Target age of pigs at weaning.<sup>1/</sup>

The Standard length of the weaning period<sup>1/</sup> is 18 days. The actual weaning schedule (number of litters weaned on given days) provides for inspection of the inventory of litters at the beginning of the weaning season and a subschedule to uniformly wean all litters within days  $t_w$  and  $t_w + 18$ . The schedule consists of an assigned number of litters to be weaned each day of the weaning season.<sup>2/</sup>

1/ Optional value.

2/ The schedule is a subscripted array with one element for each of the days in the weaning period. It is constructed by adding to an empty array a digit 1 for each litter to be weaned. Additions to positions are in the order:  $t_w+18, t_w+17, \dots, t_w, t_w+18, t_w+17, \dots, t_w$ , etc., etc., until all litters have been assigned. The distribution over the weaning period is therefore relatively uniform; but lumped toward the end of the season by at most 1 litter per day, unless by chance the number to be weaned is exactly divisible by the number of days in the weaning period.

Let  $g$  represent gilt selection day 1,2,..., or 6. Gilt selection occurs on day  $t_g$  where:

$$(4.6) \quad t_g = t_b - 101$$

when gilts are approximately 5 months of age. Minimum age is the only gilt selection criteria. The first  $10^{1/}$  gilts encountered which met this criteria are selected prior to each breeding season, i.e. on day  $t_g$ .

Culling occurs as the result of routine probability culling at weaning time or as the result of reaching the maximum number of times permitted failure to conceive when exposed to boars. Twenty percent  $^{1/}$  of first litter gilts and sows are routinely culled after weaning. Those culled are sold at the next regularly scheduled market hog sale.

Culling for nonconception follows when the sow attribute  $s$  exceeds two  $^{1/}$  exposures to the boar without conception. Detection of nonconception for culling purposes is assumed to take place  $60^{1/}$  days after this limit is reached. Culled sows are eligible for sale.

Sales were scheduled every two weeks. $^{1/}$  Selling implies clearing the system of an animal entity after recording weight and value for reporting purposes. A market hog was sold if it met the minimum weight criteria of  $215^{2/}$  pounds. All sows located in the cull pen are also sold at that time.

1/ Optional value.

2/ Optional value. Special sales can take place when the finishing building becomes overfilled, see section 4.2.4.

A complete cleaning was performed on the farrowing house before each farrowing. During this cleaning period the farrowing house remains idle for seven<sup>1/</sup> days.

#### 4.1.3.1 Buildings

Buildings were added to the research model. Permissible building occupation by animals has been defined by equations (4.1), (4.2) and (4.3). Building design capacities assumed were:

<u>Building Type</u>	<u>Capacity<sup>1/</sup> and Target Age Limits</u>	<u>Absolute Age Limits for Occupancy</u>
Farrowing	15 sows; $k = 4$ , and 15 litters of pigs; $1 \leq i \leq 36$	$i \leq 44$
Nursery	125 head of pigs $37 \leq i \leq 82$	$28 \leq i \leq 150$
Maintenance	80 sows; $k = 1,2$ , or 3; $160 \leq i \leq 1600$	none
Finishing	240 hogs; $83 \leq i \leq 180$	$i \geq 58$
Boars	no limit to number of head	none
Culls	no limit to number of head	none

Capacities of buildings are simple accounting values in the research model. These values are used to evaluate the use of buildings by simple arithmetic calculation of the percentage occupancy in each building.

Management strategies were required for movement of animals from building to building. At farrowing a sow and her litter enter

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1/ Optional value.

the farrowing house ( $n = 4$  in equations 4.2 and 4.3) and remain there throughout lactation. Actual age at weaning is stochastic with a target age of  $36\frac{1}{4}$  days. The program allows early weaning, up to a point,<sup>1/</sup> if the farrowing house is overfilled.

Transfer of pigs from the farrowing house to the nursery is mandatory at weaning. Sows return to the maintenance building or go to the cull pen at weaning time.

Transfer from the nursery to finishing building occurs as the individual pig becomes 82 days of age.<sup>1/</sup> The program allows animals to remain in the nursery, up to a point,<sup>1/</sup> if the finishing house is full.

#### 4.2 Computer Implementation

The research model was implemented in the form of a computer program written in FORTRAN IV for the CDC 6500 computer at Purdue University. Various features of the computer program are discussed as subsections of this final portion of Chapter 4.

A skipping process was developed to improve run time. This is the subject of section 4.2.1. Next, the system of filing animal attributes by packing 3 to 5 attributes into a single word of computer storage is discussed in section 4.2.2.

Optional sources of random numbers were provided by a subroutine. This is discussed in section 4.2.3 followed by section 4.2.4, a discussion of the Input-Output Form which was developed to define those parameters which are user options in the computer program.

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<sup>1/</sup> Optional value.

#### 4.2.1 The Skipping Process

The models' emphasis upon scheduling of reproductive activities and housing bottlenecks led to the belief that for some purposes, the daily nature of the model was less important than at other parts of the production process. This allowed consideration of a longer time unit than one day at some points to improve computational efficiency. It was found that animals could be skipped forward while preserving the daily nature of the simulation process. Skipping saved time consuming calculations by reducing the number of times that an animal was required to be removed from a file, considered for survival, and updated for daily attributes such as age or weight and returned to a file. This was accomplished by skipping an animal forward in simulation time whenever it was appropriate to do so. Once skipped forward, an animal was counted as part of the inventory class and building in which he was located and could be skipped with regard to other calculations until simulation time caught up to him.

Skipping required multiplication of daily transition probabilities to reflect transition probabilities over the period being skipped. Animals were skipped various lengths of time but could not be skipped beyond dates for events which might affect them or beyond reporting dates requested on the input form. Application of a single random number for the time period skipped replaced use of a random number for each day, reducing computer time spent generating random numbers.

Primary candidates for skipping were the nursery and finishing stages of hog growth, sow gestation, open sows when breeding

seasons were not in effect, and lactation after the first week and before the beginning of weaning. The skipping process was halted for finishing hogs prior to gilt selection from the finishing building and was halted before scheduled sales. Skipping was also halted for all sows during breeding seasons. Boars were never skipped forward because of the small number of animals involved.

#### 4.2.2 Packed Attribute Storage and Filing System

Packing of more than one attribute into a single word of computer storage permitted the storage of up to 12 integer values (attributes of animals) in three computer words of 14 integer digits each. This reduced the computer memory requirements for storage of animal entities by approximately  $\frac{1}{4}$   $\frac{3}{4}$ .

Packing involves splitting a word of storage into parts. Consider as an example, for the purpose of exposition, splitting a 14 digit word into 4 rightmost and 10 leftmost digits. Assignment is made to the rightmost section by simple FORTRAN assignment taking care that the resulting integer value of the rightmost 4 places will always be a value IR such that  $0 \leq IR \leq 9999$ .

Unpacking the rightmost digits involves remaindering to discover their value. For a 14 digit value N, the rightmost 4 digits are  $IR = N - N / 10000 * 10000$ . The hierarchy of FORTRAN arithmetic operations insures that multiplication and division have equal precedence but are done before subtraction. The number N is first divided by 10000,

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1/ Approximately since some memory was required for those machine language statements which did the packing or unpacking operations.

truncating the rightmost 4 digits. Then multiplication by 10000 has the effect of moving the decimal point 4 places to the right, i.e. completing a two step replacement of the original 4 rightmost digits with zeros. The remaining arithmetic operation is to subtract the result from the original 14 digit value N. The value assigned to IR by this procedure is the value equal to the rightmost 4 digits of N.

Assignment of the leftmost portion IL involves simple set-over by integer multiplication of the digits IL before assignment:  $N = IL * 10000$ . IL is then unpacked by division:  $IL = N/10000$ , where division has removed the unwanted rightmost 4 digits by integer truncation.

Three to five attributes were packed into one word of computer storage by using combinations of the above techniques. While efficiency of use of computer memory was improved, access and reassignment of attribute values required several multiplication and/or division operations at a cost of increased computer run time.

Packed storage of attributes is accomplished only at the cost of the additional execution time required for their packing and unpacking before and after their manipulation as animal attributes in whole word variable names. Note that for packed storage with four integer attributes packed into one word of computer memory, a leftmost, two middle, and a rightmost attribute must be unpacked to provide access to all four attributes. A savings in get operations is traded for the time required to divide, multiply, and subtract the integer values as required to unpack the four attributes after a single get operation.

The leftmost attribute is unpacked in about 135 time units<sup>1/</sup> by an integer division. Each middle attribute requires both leftmost and rightmost type unpacking for a total of 422 units. The rightmost attribute is unpacked with an integer division (135 units), multiplication (112 units), and a subtraction (40 units) as discussed above. Unpacking the four attributes involves a total of about 1305 time units as compared to 156 for getting four separately stored integer attributes. Packing also involves a similar trade off of time spent in packing for that saved in the put operation.

A convenient filing system was used to store animal attributes as rows in one integer and one real array. Column subscripts were used to correspond to individual animals. Since the columnwise dimensioned size of a doubly dimensioned array is not used to find memory locations, the columnwise dimensioned size need be declared only in the main program. This made changing the size of the filing arrays a matter of changing their dimensioned size in the main program only.

Filing arrays were organized into subfiles corresponding to buildings to facilitate the terminology of writing subroutines to place animals in and to remove animals from buildings (files).<sup>2/</sup> Comment cards

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- 1/ The time unit used here is the minor cycle = 100 nanoseconds where 1 nanosecond =  $10^{-9}$  seconds. Based on units requirement for arithmetic operations from information obtained in personal communication and from unpublished estimates by the Agricultural Economics Computer Laboratory, Purdue University.
  - 2/ See Appendix C for a list of the computer program used to implement the research model.

found in the main program give an outline of the general organization of the program. Comment cards are used in the main program and in subroutines to indicate the purpose and use of major sections of the program should attention need be given to FORTRAN statements in the program itself. The Input-Output Forms have been designed to facilitate use of the model by providing a means to specify control parameters (see section 4.2.4).

#### 4.2.3 Random Number Sources

Computer implementation of the research model provides a means of using alternative sources of random numbers. All random numbers used in the program are supplied in the program by calls to FUNCTION RANUM.

The standard source used in this study was the CDC 6500 FUNCTION RANF(0). The program FUNCTION RANUM (D) is also prepared to alternatively supply random numbers from a tape of random numbers  $R: 0.0 \leq R \leq 1.0$ . Instructions for this alternative are given in the Input-Output Form, Appendix B.

#### 4.2.4 Input-Output Forms

The use of a model is highly dependent on its structure. The choice of a Markov Chain type model permitted running the model as a computer program (simulation). Sensitivity analysis by running experiments to evaluate the model was further facilitated by provision of convenient input forms and easily read output.

The Input-Output Forms define those parameters of the computer implementation which are user options. Use of the computer program by

research workers is further facilitated by providing optional report requests. These reports may take the form of a short report of production and costs incurred or they may extend to reporting of individual animal attribute values on a daily basis.

The Input-Output Forms are contained in Appendix B. Chapter 4 has presented the research model, including definition of the states which animals are permitted to take. Characteristics of the system and the attributes permitted for buildings were also discussed. A discussion of the computer implementation of the research model dealt with the more important features of the computer program. Chapter 5 will present the kind of results obtainable by running the program.

## CHAPTER 5

## ILLUSTRATIVE RESULTS

This chapter is intended to illustrate the capability of the implemented model. The results of a single run of one years' simulated swine production is presented, Table 5.1, to illustrate the information provided by the computer program.<sup>1/</sup> Section 5.1 discusses the use of buildings. The topic of section 5.2 is production information. Section 5.3 discusses costs and returns followed by a review of the financial results of synchronized (standard control values) as compared to nearly continuous breeding in section 5.4. Section 5.5 then presents some possible uses of the model in its present form as an experimental tool.

## 5.1 Building Utilization With Standard Control Values

Table 5.1 contains the report of a simulation run using standard values as defined on the input-output forms.<sup>2/</sup> The subsections of Table 5.1 all report some combination of building use, breeding results, farrowing results, weight gains, or costs and returns which were obtained from the simulation of a 365 day period.

- 
- 1/ This portion of optional computer output is termed "periodic reports" because it was available covering any length period from 1 to 1600 days. Seasonal reporting is also available on farrowing, breeding, and sales. Other more voluminous reports and messages are provided as optional diagnostic aids. For a complete list of available output see Appendix B Input-Output Forms and Instructions.
  - 2/ See Appendix B for a complete list of the optional control variables on building occupancy.

Table 5.1. Periodic Reports

## SWINE BREEDING HERD SIMULATOR

REQUEST IS FOR 365 DAYS,  
YOUR IDENTIFICATION CARD.  
TODAY'S DATE IS 12/16/72

## STANDARD CONTROL PARAMETERS FOR A PRODUCTION AND BUILDING UTILIZATION EXAMPLE.

BUILDING USE PERIODIC REPORT ON DAY= 365  
PREVIOUS REPORT WOULD HAVE BEEN DUE ON DAY= 0, TODAY IS DAY 365 OF YEAR 1

(IND.TODAY) PERCENT OF MAXIMUM CAPACITY OVER 365 DAYS

ITEM	MEAN	ST. DEV.	MINIMUM	MAXIMUM
NURSERY { 0}#	66.54	32.99	0.00	123.20
CAPACITY= 125				
FINISHING {182}#	78.65	17.27	40.42	100.00
CAPACITY= 240				
MAINTENANCE { 62}#	60.42	12.24	37.50	81.25
CAPACITY= 80				
FARRY CRATES{ 11}#	67.16	27.12	0.00	100.00
CAPACITY= 15				
***END BUILDING USE REPORT***				

PERIODIC BREEDING REPORT ON DAY= 365  
TODAY IS DAY 365 OF YEAR 1

## BREEDINGS RESULTED IN 93 CONCEPTIONS!

ITEM	MEAN	ST. DEV.	MINIMUM	MAXIMUM
AGE OF SOW AT FARROWING= 755.183	371.385	360.000	1564.000	16
ASSIGNED LITTER SIZE= 9.828	2.958			

SOWS IN HEAT BUT NOT BRED  
DUE TO- TARGET PREVIOUSLY REACHED  
LACK OF BOARS  
FAILING PROBABILITY OF CONCEPTION TEST  
SEASON CLOSED

## END PERIODIC BREEDING REPORT\*\*\*

Table 5.1 (continued)

FARROWING PERIODIC REPORT ON DAY# 365  
 TODAY IS DAY 365 OF YEAR 1  
 -----ITEM----- ---MEAN--- ---ST. DEV.--- ---MINIMUM--- ---MAXIMUM---

FARROWED 75 LITTERS IN FARROW BLD.

LITTER SIZE ALIVE= 9.893      3.069      6.667      100.000  
 PCT. CRATES FULL AT BIRTH= 45.689      25.296      1.272      4.717  
 BIRTH WEIGHT OF PIGS= 3.129      .534

LOST 0 LITTERS, BLD. NOT CLEANED

LOST 0 LITTERS, DUE TO BLD. OVERFLOW

END PERIODIC FARROWING REPORT-----

WEIGHT GAINS PERIODIC REPORT ON DAY# 365

TODAY IS DAY 365 OF YEAR 1

PRODUCTION NET OF INVENTORY CHANGE-

-----NUMBER----- ---WEIGHT LBS.----- ---VALUE DOL.-----  
 HOGS UNDER 240 DAYS = 517      132211.1      27103.3  
 SOWS(ALL 240 AND UP)= 28      11284.8      1908.6

ENDING INVENTORY-

HOGS UNDER 240 DAYS = 303      32859.3      6736.2  
 SOWS(ALL 240 AND UP)= 58      26446.4      4495.9

END WEIGHT GAINS PERIODIC REPORT-----

Table 5.1 (continued)

COSTS AND RETURNS PERIODIC REPORT ON DAY# 365			
TODAY IS DAY 365 OF YEAR 1 PERIOD COVERED 365 DAYS			
FEED COSTS SOWS= 3018.82 DOL. AT .14 PER DAY PER SOW			
FEED COSTS HOGS=15634.80 DOL. AT 11.75 PER 100 LBS. PRODUCED			
LABOR COSTS BY BUILDING INCLUDING CULL PEN AT 3.00 DOL. PER HOUR FARRONING			
1198.27			
NURSERY# 323.71			
SOWS MAINT. & CULLS# 715.04			
FINISHING# 1001.73			
SOWS PRODUCED# 112.8 CWT. AT VALUE OF 1918.42 DOL.			
HOGS PRODUCED# 1322.1 CWT. AT VALUE OF 27103.27 DOL.			
COSTS AND RETURNS SUMMARY OVER A 365 DAY PERIOD.			
TODAY IS DAY 365 OF YEAR 1			
-----SOWS----- HOGS----- TOTAL HERD-----			
-----(\$ ) ----- (\$ ) ----- (\$ ) -----			
PRODUCTION NET OF INVENTORY CHANGE {1} 1918.42			
{2} 27103.27 29021.70			
FEED COST {3} 15534.80 18553.62			
LABOR COST {3} 1913.31 1325.45 3238.76			
RETURN OVER FEED AND LABOR			
-3013.71 10243.02 7229.31			
-----			
(1) SOWS INCLUDE ANIMALS 240 DAYS OF AGE AND OVER, OTHERWISE CLASSED AS HOGS AND PIGS.			
(2) FEED COST FOR SOWS BASED ON DAYS OF MAINTENANCE (INC CULL PEN) AND LACTATION.			
(3) LABOR COST BASED ON BUILDING OCCUPANCY, ALL FARRROWING HOUSE LABOR WAS ASSIGNED TO SOWS.			
END COSTS AND RETURNS SUMMARIES-----			

Building utilization reports; including the Mean, Standard Deviation, Minimum, and Maximum percent of capacity; were calculated from daily observations. The number of head in each building was reported for the final day and the total capacity of the building noted.

On the last day of simulation the nursery building contained no animals, but on the average it was utilized to 66.5 percent of its 125 head capacity with a Standard Deviation of 33 percent. At least at one point, the building contained 123.2 percent of its 125 head capacity as reported in the Maximum column. Standard control parameters do not allow pigs to move from the nursery to the finishing building until they are 82 days of age.<sup>1/</sup> Overfilling of the nursery is an infeasibility which would, in practice, require some adaptive procedure. Moving pigs to the finishing building at an earlier age<sup>2/</sup> or housing pigs in the nursery under overcrowded conditions would be two possible adaptive strategies which could be used by the manager when the nursery building is overfilled.

The finishing building, with 182 head at the end of the year, was utilized to an average of 78.7 percent of its 240 head capacity. During the period, occupancy was as low as 40.4 percent and as high as 100 percent. This indicates that at some time the building was assigned to full capacity. Special sales can be held to reduce the number in the finishing building to maximum capacity. Special sales

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<sup>1/</sup> See Appendix B for a complete list of the optional control variables on building occupancy.

<sup>2/</sup> A user option, see Appendix B.

are made when the finishing building is overfilled, reducing numbers until no hogs over 190 pounds remain, or the building is no longer overfilled. A detailed report of these special sales may be requested as a user option.

The maintenance building with 62 head at the end of the period had been used to 60.4 percent of its 80 head capacity but never reached more than 81.3 percent at any time during the year.

At the end of the year the 15 farrowing crates in the farrowing building contained 11 Litters and had been used up to 67 percent. The farrowing building is empty for cleaning before each farrowing season and this results in a reported Minimum occupancy of zero. The farrowing house did not overflow. Overflow results in loss of litters when Standard control options are in effect. A check for this loss is made by inspecting the section of Table 5.1 entitled: "Farrowing Periodic Report on day = 365".<sup>1/</sup>

## 5.2 Production With Standard Control Variables

The portion of Table 5.1 entitled "Periodic Breeding Report on Day = 365" reveals that the six breeding seasons included in the reporting period resulted in a total of 93 sows conceived. Conceiving sows were estimated to average 755 days of age at farrowing time and the average litter size assigned (actual number born alive if the sow farrows) was equal to 9.8. A count shows that 206 sows were on heat but not bred, due either to the number exposed having been previously reached (30 cases), lack of boars (1 case), failing to conceive when exposed (3 cases), or the season being closed (172 cases).

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<sup>1/</sup> See the second page of Table 5.1.

The farrowing periodic report indicates 75 litters farrowed during the year. Single use of the 15 crates in 6 farrowings could have accommodated 90 litters. Note that crate occupancy observations include litters in the crates at opening inventory as well as those litters farrowed during the year. Average litter size born during the year was 9.9 live pigs. Building capacity, calculated from one observation per litter upon its first entry to the farrowing house, ranged from 6.67 to 100 percent. Average birth weight was 3.1 pounds. No litters were lost due to the farrowing house not being cleaned or due to building overflow as indicated by the messages at the conclusion of the farrowing report.

The report called "weight gains periodic report on day = 365" indicates the number of head, weight, and value produced net of inventory changes. These are allocated between hogs and sows for use in calculation of the financial results in the final portion of Table 5.1.

### 5.3 Costs and Returns With Standard Control Values

The costs and returns portion of Table 5.1 reconciles the variable costs of feed and labor with the net value of production. Cost options are intended to be an approximation of variable costs for feed and labor. Cost calculations are made daily based on inventories in buildings using Standard costs or user supplied rates. No fixed costs were included in the costs and returns calculations.

Feed cost for sows was based on an average day of maintenance and lactation at a rate of 14 cents per day.<sup>1/</sup> The \$3,018. cost of

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<sup>1/</sup> Standard value, at the users' option.

feed reported for sows was a simple summation over all sows in the maintenance and farrowing buildings. Feed costs of \$15,535. for butcher hogs was calculated at the rate of \$11.75 per 100 pounds<sup>1/</sup> of gain produced net of inventory.

Labor was assumed to cost \$3 per hour<sup>1/</sup> regardless of the building in which it was incurred. Labor in minutes per litter, or per head, per day was calculated for each building. For the specific labor requirements and the variable cost options available, see Appendix B.

The cost and returns summary groups all animals into sows or hogs. For convenience of calculation, sows are defined as all animals 240 days of age and over, otherwise they are classed as hogs. The value of production net of inventory change was: sows = \$1,918., hogs = \$27,103. for a total herd value of \$29,021. Feed costs at \$3,019. for sows and \$15,535. for all hogs totaled \$18,553. for the herd. Labor costs for sows includes all farrowing house labor plus sow maintenance building and cull pen labor. This amounted to \$1,913. and labor for hogs was \$1,325., making the total herd labor charge \$3,239.

The results called "return over feed and labor" shows a net return over variable feed and labor for sows of \$3,014. but a gain of \$10,243. for hogs. Return to the whole herd was calculated at \$7,229. Note that this is a measure of return above those variable feed and labor costs included in the 14¢ per day per sow, the \$11.75 per 100 lbs. of hog produced, and the \$3 per hour labor charge. While

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<sup>1/</sup> Standard value, at the users' option.

inventory changes are accounted for, fixed costs and other variable costs are not accounted for in any way.

#### 5.4 A Comparison of Synchronized and Nearly Continuous Breeding

A limited number of runs were made to demonstrate how the model can be used as a research tool and how the results would be interpreted to compare synchronized with continuous breeding.<sup>1/</sup> Six runs were made using standard data as found on the input form. The output given in Table 5.1 and reviewed above was chosen to represent the results of synchronized breedings.

Six comparative runs were then made to demonstrate the results obtainable for a nearly continuous breeding (farrowing) schedule. In these runs the breeding season was scheduled over 44 days<sup>2/</sup> rather than 21 days, and weaning over 44 days<sup>2/</sup> rather than 18 days as prescribed by the standard values. The outstanding difference between these two breeding policies is that the longer breeding season permits some sows to be exposed to boars over two heat periods. Some second occupancy of farrowing stalls over the longer farrowing season can also be expected.

The results of six runs made under each of these breeding policies demonstrates the stochastic nature of the outcomes. The expected returns (calculated Mean of 6 observations) were: \$7,497 for standard-synchronized breeding<sup>3/</sup> and \$7,663 for the continuous breeding

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<sup>1/</sup> The following section contains additional suggestions for use of the model as an experimental tool.

<sup>2/</sup> Maximum values allowed by the computer program, see section 4.3 of Appendix B.

<sup>3/</sup> Returns over feed and labor were \$7,229, \$7,687, \$7,065, \$7424, \$8,066, and \$7,514.

policy<sup>1/</sup>. Standard Deviations were calculated at \$353 and \$414 respectively.

This small number of runs is not sufficient to permit a conclusion as to whether these policies give significantly different financial results. However, for the purpose of exposition, the results for one of the runs will be considered typical of those obtained under the nearly continuous breeding policy. This report, shown in Table 5.2, reveals that continuous breeding resulted in more sows conceiving and greater total production for a larger return over feed and labor than was obtained with the standard-synchronized breeding policy.

The modest improvement in return over feed and labor apparently was gained through more efficient use of the sows maintained. A comparison of the number of sows (including boars and culls) maintained shows that the standard-synchronized policy required maintaining about 1.6 sows for each one farrowed while only 1.4 were maintained for each one farrowed under the continuous breeding policy.<sup>2/</sup>

Double use of some farrowing stalls occurred at least during one farrowing as indicated by the 120 percent reported as maximum capacity in the building use report of 5.2. The continuous breeding policy resulted in an infeasible farrowing house bottleneck during the first two farrowings of the year.<sup>3/</sup> A total of 5 litters were lost due to lack of farrowing crates at birth.

1/ Returns over feed and labor were \$7,333, \$7,625, \$8,100, \$7,222, \$7,468, and \$8,232.

2/ Based on a "normal" 182 days of maintenance per sow farrowed: calculated from the "costs and returns periodic report" of Tables 5.1 and 5.2.

3/ This information is taken from detailed diagnostic reports not shown in Table 5.2.

Table 5-2 Periodic Reports for Nearly Continuous Breeding

## SWINE BREEDING HERD SIMULATOR

REQUEST IS FOR 365 YRS.  
YOUR IDENTIFICATION CARD#

CONTINUOUS FARROWING EXAMPLE WITH STANDARD PARAMETERS OTHERWISE.

## BUILDING USE PERIODIC REPORT ON DAY# 365

PREVIOUS REPORT WOULD HAVE BEEN DUE ON DAY 0, TODAY IS DAY 365 OF YEAR 1

PERCENT OF MAXIMUM CAPACITY OVER 365 DAYS

(IND.TODAY)	ITEM	MEAN	ST. DEV.	MINIMUM	MAXIMUM
NURSERY ( 0 )=	67.05	37.12	0.00	183.20	
CAPACITY= 125					
FINISHING (1185)=	86.00	15.24	45.42	125.83	
CAPACITY= 240					
Maintenance ( 52 )=	59.85	11.00	38.75	80.00	
CAPACITY= 80					
FARROW CRATES( 13 )=	61.66	37.93	0.00	120.00	
CAPACITY= 15					
END BUILDING USE REPORT					

## PERIODIC BREEDING REPORT ON DAY# 365

TODAY IS DAY 365 OF YEAR 1

BREEDINGS RESULTED IN 105 CONCEPTIONS.

ITEM	MEAN	ST. DEV.	MINIMUM	MAXIMUM
AGE OF SOW AT FARROWING= 743.724	369.872	344.000	4	1490.000
ASSIGNED LITTER SIZE= 9.610	2.973			
SOWS IN HEAT BUT NOT BRED DUE TO-TARGET PREVIOUSLY REACHED	143			
LACK OF BOARS FAILING PROBABILITY OF CONCEPTION TEST	72	0	5	
SEASON CLOSED	66			
END PERIODIC BREEDING REPORT				

Table 5.2 (continued)

FARRING PERIODIC REPORT ON DAY= 365  
TODAY IS DAY 365 OF YEAR 1

ITEM ----- MEAN ----- ST. DEV. ----- EXPENSES -----

FARRING 78 LITTERS IN FARRING PLC.

LITTER SIZE ALIVE= 5.546  
PLC. CRATES FULL AT BIRTH= 52.137  
BIRTH WEIGHT CF FIGS= 3.115

LCST 0 LITTERS, PLC. ACT CLEARED

LCST 5 LITTERS, CLE TC PLC. OVERFLCH  
LITTER SIZE LCST= 6.116

END PERIODIC FARRING REPORT

WEIGHT GAINS PERIODIC REPORT ON DAY= 265

TODAY IS DAY 365 OF YEAR 1

FACELCTION NET OF INVENTORY CHANGE-

	NUMBER	WEIGHT LBS.	VALUE LCL.
PCGS LACER 24C DAYS = SCS(ALL 24C ANC LPI)=	545 16	147111.5 5372.1	20157.7 654.0

ENDING INVENTORY

	PCGS LACER 24C DAYS = SCS(ALL 24C ANC LPI)=	308 52	24664.5 22036.1	7104.3 3515.8
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END WEIGHT GAINS PERIODIC REPORT

Table 5-2 (continued)

COSTS AND RETURNS PERIODIC REPORT ON DAY= 365			
TODAY IS DAY 365 OF YEAR 1 PERIOD COVERED= 365 DAYS			
FEED COSTS SOWS=	2939.02 DOL.	AT .14 PER DAY PER SOW	
FEED COSTS HOGS=	17285.54 DOL.	AT 11.75 PER 100 LBS. PRODUCED	
LABOR COSTS BY BUILDING INCLUDING CULL PEN AT 3.00 DOL. PER HOUR			
FARROWING=	1100.12		
NURSERY=	324.66		
SOWS MAINT. + CULLS=	704.32		
FINISHING=	1092.17		
SOWS PRODUCED=	53.7 CWT.	AT VALUE OF	913.26 DOL.
HOGS PRODUCED=	1471.1 CWT.	AT VALUE OF	30157.75 DOL.

COSTS AND RETURNS SUMMARY OVER A 365 DAY PERIOD.  
TODAY IS DAY 365 OF YEAR 1

	SOWS (\$)	HOGS (\$)	TOTAL HERD (\$)
PRODUCTION NET OF INVENTORY CHANGE (1)	913.26	30157.75	31071.01
FEED COST (2)	2939.02	17285.54	20224.56
LABOR COST (3)	1804.44	1416.83	3221.27

RETURN OVER FEED AND LABOR	-3830.21	11455.38	7625.17
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(1) SOWS INCLUDE ANIMALS 240 DAYS OF AGE AND OVER, OTHERWISE CLASSED AS HOGS AND PIGS.  
 (2) FEED COST FOR SOWS BASED ON DAYS OF MAINTENANCE (INC. CULL PEN) AND LACTATION.  
 (3) LABOR COST BASED ON BUILDING OCCUPANCY, ALL FARROWING HOUSE LABOR WAS ASSIGNED TO SOWS.

END COSTS AND RETURNS SUMMARIES

Inspection of the representative reports shown in Table 5.1 and Table 5.2 reveal that the policy of continuous farrowing resulted in more sows conceived, more litters farrowed, and in a higher return than that obtained with the Standard control values i.e. moderately synchronized breeding and farrowing.

### 5.5 Use of This Model In Its Present Form

One of the objectives of this study was to discover and implement a model for use by researchers. The model will be most useful when used to test the feasibility of management policies, or to generate the outcomes of production when control variables are specified as in an experimental setting.

Testing of the feasibility of management policies for a given herd and set of building capacities permits evaluation of the stochastic nature of swine production. The variability of breeding performance, conception rates, and farrowing can be observed. Production, its value, the variable cost incurred, and the building utilization realized can be reported.

Use of the model as an experimental tool has a large number of possibilities because of the flexibility built into the computer program as presented in the input-output forms. Parameter values which could be varied with respective runs tracing out stochastic outcomes include (a) conception rates, (b) length of estrus and gestation cycles, (c) survival rates, (d) litter size, (e) rates of gain, and (f) culling-replacement rates, (g) opening inventory herd size, and (h) building capacities.

Two breeding policies were considered by making comparative runs as reported in section 5.4 above. Many similar experiments can be made to compare management policies. The procedure required is to carefully select those control parameters which should be changed to represent the desired management policy, building capacities, or productive ability of animals. For example, the question of the importance of large litters versus more sows versus rate of conception could be compared by incrementing the litter size and/or conception rate parameters and comparing results with those obtained by maintaining a larger number of sows to produce a similar number of market hogs. Number of sows are controlled by parameters of the opening inventory and culling-replacement rates.

The question of gilts versus sows can be handled by making runs which compare culling-replacement policies. The parameters involved are the maximum age to keep a sow and the number of gilt replacements selected periodically. The relative litter size parameters for gilts and sows may also be adjusted on the input form.

Boar power can be experimented with by making runs with various numbers of boars for a given sow herd size as well as with boar maturity parameters.

The management policy questions of building size involve setting the building size parameters as well as growth rate parameters for the particular experiments desired. The rate of gain attained by growing-finishing pigs affects the amount of time spent in the nursery and finishing buildings and therefore the capacity requirements for a given production, or alternatively the number that can be produced for a given building size.

Use of the model permits economic analysis and/or analysis of the productivity of husbandry practices. Although the model itself is not an extension tool, it is capable of facilitating analyses for that type of application. The use of this model as a facilitating tool for further analysis in other projects agrees with the objectives under which it was developed.

## CHAPTER 6

### IMPLICATIONS OF THE STUDY

The experience gained in the preparation of this dissertation suggests implications for other research or extension oriented models. A discussion of these implications is the subject of the sections which follow.

Section 6.1 discusses several of the important limitations of the model including execution time, size and detail, and input-output. Section 6.2 makes suggestions for an extension model based on experience gained in the study, and section 6.3 presents some conclusions drawn from the knowledge gained in model development and the study as a whole.

#### 6.1 Limitations of the Model

The complexity and stochastic nature of swine production dictated inclusion of mechanisms to represent probabilistic aspects of animals such as survival, conception, gestation, farrowing, and weight gains. Inclusion of only the most important attributes expanded the size of the model and its computer implementation beyond original expectations, excluding other details. Use of the model is limited by computer execution time and by the computer memory readily accessible for internal storage of the program and the relatively large arrays required to represent animal attributes.

### 6.1.1 Execution Time Problems

Execution of the program with the standard control values for one year of simulation required 1370 seconds of Central Processing time on the CDC 6500 at Purdue University. Seasonal reports were generated in addition to those shown in Table 5.1. The continuous farrowing example and other similar problems, run with the simple three page output requires 900-1100 seconds. Other problems either with greater amounts of output, more animals, and/or larger simulation times have used much greater amounts of execution time.

There is an initial block of time used to read data and build the opening inventory (approximately 50 seconds) after which execution time is proportional to the number of days of simulation requested. Time required to execute is also highly dependent upon the size of the herd being simulated. This is somewhat less than arithmetically proportional to the number of animals in the herd because the time spent writing reports is fixed for any optional set of reports. Execution time spent collecting the information for those reports is however, proportional to the number of animals in the herd, the number of sows farrowed, the number of days simulated, etc.

Experimental repetitions (repeated runs of the same control data but with a unique random number series) will be essential to the use of the model for experimental work. The cost of execution time required may limit use of the model to those experiments where a relatively small number of repetitions can be judged sufficient or to those where a relatively moderate sized herd is involved, say 1,000--1,200 total animals at any one time. Simulation of a large herd over

a large number of days is feasible but may be too expensive. Nevertheless, while a real biological experiment would in most cases provide better data than the simulation, the simulator, despite its apparently high cost, might be both cheaper and faster than a biological experiment.

#### 6.1.2 Size and Degree of Detail

The computer program contains approximately 3600 card images of source program and 300 data cards. The computer memory required to load was 102,000<sub>8</sub> and to run was 63,600<sub>8</sub> words. These requirements are for the Standard control values which provide for 1,500 total animals as an absolute maximum. A simulation run representing additional animals would require that the animal filing arrays be dimensioned larger, with correspondingly higher memory requirements.

The relatively large program was the results of including a large number of animal attributes and the associated statements needed by the daily model for checking, sorting, filing, and report writing.

#### 6.1.3 Input-Output Limitations

Input to the model includes a data deck of 249 cards representing the attributes of 30 sows and 219 market hogs found on the Purdue Swine Farm on March 2, 1972. These animal attributes are used in building the opening inventory. A deck of 26 standard control values, as well as those optional control cards supplied by the user, complete the input data for each computer run.<sup>1/</sup>

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<sup>1/</sup> Appendix D Input Data is a list of herd and Standard control data required to run the program.

The basic herd at opening inventory is assembled from information from the control cards (schedules, weight gains, litter size, etc.) and the Purdue herd data. There is some influence of the basic herd data after opening inventory time, especially during the simulation startup in the first breeding and farrowing seasons. This is most pronounced with regard to the age distribution of sows in the herd, their initial weights, and day of farrowing within the time period allotted for the first farrowing and weaning seasons. Specifically, the model does not guarantee that these initial distributions will closely resemble those generated by the simulator at some later simulation time.

While designed to facilitate specification of control parameters by the research worker, the Input-Output Forms and Instructions require contemplation and care in preparation of experimental runs. No experimental design is built into the model or given in the Input Forms. The Input-Output Forms were not prepared for use with farmers and would have limited value in communicating with a farmer-producer.

Standard output from the simulator in its most concise form consists of the printed output in Table 5.1. However, the seasonal reports and other diagnostic aids optional to the user can become voluminous. This is true when a long series of seasons or daily information must be printed. Partial estimates of the volume of output were given as footnotes to the output options in Appendix B Input-Output Forms and Instructions.

The more obviously important information necessary to the evaluation of a simulation run has been programmed as optional output, in table format, where practical. However, all specific information

required for every experimental purpose could not be anticipated and may not be available without some reprogramming of the FORTRAN statements. Should this be necessary, Appendix C contains a copy of the computer program in its final form as used in this study.

An input-output bottleneck was experienced in debugging and running test runs with the program. Built-in error messages indicated that unanticipated errors were occurring late in simulation time. A means of saving a partially completed run for a rerun from that point in simulation time would have facilitated debugging and reduced the amount of time used in debugging the program.

## 6.2 Suggestions for an Extension Model

There have been many management practices and biological relationships omitted from this model which should have attention given to them for other modeling purposes. Suggestions for an extension model provides a framework in which to cast one possible modeling purpose which might grow out of the experience gained from this study. The topics of this section are grouped under the heading of: 6.2.1 Farrowing Systems, 6.2.2 Minimum Time Unit, 6.2.3 Means of Obtaining Faster Execution, and 6.2.4 Other Husbandry Practices.

### 6.2.1 Farrowing Systems

The ability to consider alternative farrowing systems was thought to be an important part of a model which is to aid in analysis of production intensity. It was excluded from this model because of time limitations. Consideration of alternative farrowing systems would be particularly important to an extension model where the intensity

decision revolved around the economics of swine production and the competitive nature of the enterprise in whole farm planning.

Given more time for the study, additional size and less costly execution for the computer program, this model could have been adapted to consider alternative farrowing systems. This would however, require reprogramming of the opening inventory subroutines and a substantial reprogramming of the scheduling mechanisms for breeding, farrowing, weaning, gilt selection, and sow culling.

#### 6.2.2 Minimum Time Unit

A minimum time unit greater than one day would make the model more practical for research and would be essential to an extension model. Execution time would be reduced as well as the number of animal states which would need to be programmed for sorting and updating during each time period.

The development of a hybrid model which has aspects of both, say, a daily and a monthly model is possible. For the model used here, such a scheme would consider the breeding, farrowing, lactation and weaning strategies daily. Growth of market hogs after, say, their first month would be modeled monthly, replacing the skipping process used in this model. Such a procedure would, however, limit collection of data and reporting to monthly options unless intermonth estimates were acceptable. Such a hybrid model would likely have been more efficient with respect to execution time than the present model since checking for feasible skipping negated a significant portion of the time saved by the skipping process itself.

### 6.2.3 Means of Obtaining Faster Execution

A larger minimum time unit can be judged to be the most effective change for reduction of execution time. A week versus one day literally reduces to one-seventh the amount of transition calculations and updating of attributes required to run a model. This kind of execution activity represents a large part of the total execution time experienced with this program.

The research model developed here has nearly duplicated collection of data for preparation of reports: periodic and seasonal. Independence of the two reporting methods was necessary to offer the user a flexible range of time periods over which the periodic reports could be requested. A choice between seasonal and periodic reporting would reduce computer execution time to that required for the single reporting method.

Some FORTRAN statements are more efficient than other statements which can be made to do the same work. Attention to those which are relatively efficient with respect to execution time can save considerable time over the large number of programming statements in a simulator of this type.

### 6.2.4 Other Husbandry Practices

Some other possibilities for a research or extension model include (a) the effect of overcrowding on weight gains and health of the herd, (b) strategies for reaction to expected future prices, (c) more sophisticated timing and purchases of boars based on those in the herd and a predicted need for boar services, (d) optional

replacement strategies to reflect more realistic culling practices, (e) additional cost calculations for labor involved in moving hogs and cleaning pens, (f) the effect of stress from moving and regrouping animals, and (g) provisions for pen versus field breeding.

A modeling decision as to the relative importance of the inclusion of these practices versus that of the time unit should be made with the purpose for modeling well in mind. For a research model, the execution time criteria may not be as important as it would be for an extension model.

### 6.3 Conclusions

A model was developed and implemented which successfully demonstrated that important stochastic elements of swine production can be modeled for research use. The primary disadvantages to the modeling procedures chosen were those of implementation which resulted in a relatively large and complex computer program requiring long run times.

Fortunately a simulator need be developed only for those problems or parts of problems where it is essential to model stochastic or very complex elements involving a large number of states of nature. Close attention should be given to deciding those aspects of a model which are required to contain these elements. Simulation techniques have useful possibilities for application in research, but this study has shown that they can be used to the point where they tax the limits of even present day computing equipment.

The usefulness of a simulator of the type developed in this study would be much more restrained for extension modeling than for research work. It appears that the very complex nature of daily swine production cannot be represented realistically in a sufficiently abstract way to run such a model in less than, say, 100 seconds for use in a routine extension application.

The experience of this study has also pointed up the importance of keen judgement as to what is important for inclusion in a model and what could be excluded or modeled in more efficient ways.

**LIST OF REFERENCES**

## LIST OF REFERENCES

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**APPENDICES**

APPENDIX A

A COMPARISON OF ALTERNATIVE WAYS OF CALCULATING BINOMIAL RESULTS

APPENDIX TO CHAPTER 3

APPENDIX A: A COMPARISON OF  
ALTERNATIVE WAYS OF CALCULATING BINOMIAL RESULTS-  
APPENDIX TO CHAPTER 3

The basic transition transformation in the model involved n animals in state i at time t, each having the probability p of being in state j in time t+1 and the probability 1-p of being in some other state k in time t+1. This is exemplified by a survival-nonsurvival situation.

The probability of having 0,1,2,...,or n of these animals in state j in time t+1 is given by the well known binomial formula. The computer programming required to implement the binomial method involved calculating the probability of each outcome 0,1,2,...,n; conversion to cumulative probabilities; and finally comparison to a random number to decide an outcome. This procedure was suspected of requiring a relatively long time to execute as a simulation computer program.

An alternative method <sup>1/</sup> which was given the name "brute force spins" uses a random number to decide the outcome for animals one at a time. This method compares the probability of survival with the random number drawn for an individual animal, adds the animal to either the survival or nonsurvival category of time t+1, and turns to the next animal until all n have undergone transition from time t to t+1.

The two methods of calculating binomial results can be expected to yield the same results. Note in particular that the expected value

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<sup>1/</sup> Yet another method: storage of a table of binomial (and multinomial) coefficients was rejected out of hand because of the amount of storage required to accommodate the many possible probability situations of the problem under study here.

of each method is equal to the expected number obtained directly by Markov type inventory multiplication as previously shown in Chapter 3.

A FORTRAN computer program was written which solves by (a) computing the binomial formula and (b) the "brute force spins" of the random number generator in respective subroutines. Calculation of the Markov "true" expected number serves as a check on these two methods. The binomial procedure involves drawing a random number R, where  $0 \leq R \leq 1$ , for each inventory state and then comparing R with the cumulative probability of having  $n, n-1, n-2, \dots, 0$  survivors; calculated by binomial formula. Successful comparison implies a solution for that state and terminates the calculation loop.<sup>1/</sup> The next state is then considered in turn.

These subroutines were solved 100 times for each of three different set of data: with the opening inventory and probabilities as indicated in Table A.1 Computation Method Results. Statistics were generated for 100 repetitions so that the Mean, Range, and Variance of the methods could be compared. Resulting ratios of Means are close to 1.0, <sup>2/</sup> as expected.

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1/ This is a procedure adopted to cut computation time. More calculations are required (approaching twice as many for most problems) if the probability of all feasible results are calculated before comparison is made with the random number. Other schemes to gain efficiencies could be incorporated such as a heuristic for starting at an advantageous location or partitioning the series to reduce the number of binomials calculated.

2/ This was further substantiated by 20 additional runs of the above experiment using both function RANF and a tape of random numbers as the source of the random number series.

Table A.1 COMPUTATION METHOD RESULTS.

INVENTORY AND PROBABILITY VALUES FOR DATA:	<u>Set 1</u>	<u>Set 2</u>	<u>Set 3</u>
<b>Opening Inventory Values</b>			
State 1	4	5	6
State 2	6	7	8
<b>Probability of Survival</b>			
From State 1 to State 2	.776	.816	.866
From State 2 to State 2	.566	.616	.666
<b>RESULTS FROM 100 REPETITIONS<sup>1/</sup></b>			
<b>True Markov Expected Value</b>	6.46	8.39	10.52
<b>Brute Force Spins Method</b>			
Mean	6.38	8.24	10.61
Range	10	12	13
Variance	2.3	2.4	2.4
Ratio of Mean/True Markov	.9876	.9819	1.0082
<b>Binomial Method</b>			
Mean	6.51	8.38	10.66
Range	10	12	13
Variance	2.1	2.3	2.1
Ratio of Mean/True Markov	1.0077	.9986	1.0129

1/ The problem was solved 100 times for each of the data sets 1, 2, and 3 using a unique series of random numbers for each repetition.

The relative computation efficiency of the two methods was tested by solving the two subroutines separately and noting the computer run time required for each. Three data sets were used and each was repeated 999 times to exaggerate the computer time spent calculating solutions as opposed to time spent reading input data and writing output. The number of animals in each state was actually increased by 100 over those shown in Table A.1 to represent a more realistic problem situation.

The brute force spins method required 44 seconds of Central Processing (CP) computer time. The binomial method required more than 6 times as much time as compared to the brute force spins method. <sup>1/</sup> In addition, the binomial subroutine has approximately six times as many FORTRAN language statements as does the brute force spins subroutine. The individual brute force spins method was chosen for implementation of the model because of its relative efficiency.

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<sup>1/</sup> Only two of three data sets were completed when a time limit stopped execution of the binomial method. This indicates the binomial method required from 6-9 times as much CP time.

**APPENDIX B**

**INPUT-OUTPUT FORMS AND INSTRUCTIONS**

**TABLE OF CONTENTS**

	<u>Page</u>	Card No.
<b>I. INTRODUCTION</b>	101	
1.1 Objectives	101	
1.2 Identification and Punching Instructions	104	
1.3 Simulation Control	106	
<b>II. OPENING INVENTORY</b>	201	
2.1 Opening Inventory Options	1,10	
<b>III. BUILDING ATTRIBUTES</b>	301	
3.1 Building Options	14,15,16,17	
<b>IV. MANAGEMENT OPTIONS</b>	401	
4.1 Sales and Cost Options	8,13	
4.2 Boar Management Options	20	
4.3 Breeding, Weaning, and Nursery Options	2	
4.4 Gilt Selection and Sow Culling	11	
<b>V. TRANSITION PROBABILITIES</b>	501	
5.1 Survival Probabilities	3	
5.2 Estrus and Conception	4,12	
5.3 Gestation	5	
5.4 Pigs Farrowed	6	
5.5 Rate of Gains	7,9	
<b>VI. OUTPUT OPTIONS</b>	601	
6.1 Summary Reports	53,54	
6.2 Event and Daily Reports	55,56	
6.3 Diagnostic Reports	57,58,"Last"	

**SIMULATION OF A SWINE BREEDING HERD**

INPUT-OUTPUT FORMS  
and  
INSTRUCTIONS

**SIMULATION OF A SWINE BREEDING HERD**

INPUT-OUTPUT FORMS  
and  
INSTRUCTIONS

August, 1972  
Jay Strom

### I. Introduction

The swine producer is faced with short run planning problems once he has committed buildings, equipment, and a basic herd to swine production. Short and intermediate term decisions in management of the swine herd determine the profitability of the herd given that buildings and equipment are fixed. Yet these short term planning decisions must be made for a complex production enterprise in the light of stochastic and uncertain elements.

It is this complexity and the stochastic nature of swine production, together with the severe economic penalty and/or gains which result, that makes this a ripe area for economic analysis. Analysis of management decisions related to scheduling of breeding, farrowing, culling, and sales should be particularly valuable for extension use as swine production continues to become more intensive on the farm. Yet it is these kinds of decisions which seem to be some of the most complex to analyze.

Unfortunately this same variability and complexity faced by the producer very much complicates an economic analysis. Experiments would contribute to our knowledge of these outcomes yet, experimentation with a real herd is impractical. Lack of operational models which permit experimentation with the swine herd are thought to be a key to analysis of the swine producers short term planning problems.

#### Objectives of this project:

1. To provide a model for experimentation with scheduling of breeding, farrowing, culling, and sales, within a simulated swine breeding

### herd.

2. To implement that model in the form of an operational computer program.

3. To make use of the computer program relatively easy and trouble free by providing an appropriate input-output form for use by research workers.

The exploration of the type of model which is appropriate and the logic of that model is best presented in the thesis text, especially Chapters 2 and 3. The model is intended for use by the research analyst. The user should be familiar with the model before undertaking to use the computer implementation which is hopefully facilitated by these forms.

#### Purpose of this Input-Output Form

1. To make explicit those parameters of the model which the computer program permits to be user options.
2. To provide notes and reminders of the effect of settings of optional parameters of the model as well as to provide one feasible set of data in the form of "Standard" default values.
3. To facilitate communication between researcher and computer laboratory personnel.

Neither the model nor the computer program is designed to do an analysis, only to give the research worker a tool with which to make such analyses.

The model includes the effect of variability of: (a) conception rate, (b) number of pigs farrowed, (c) length of estrus and gestation cycles, (d) survival rates, and (e) the availability of animals for

## 1.2 Identification and Punching Instructions

**breeding.**

The effects of alternative management policies can be measured by production realized and by the building utilization obtained. These effects are also reflected by the value of output and a measure of variable costs required to produce that value.

This input form describes the data required to run the swine breeding herd simulator. The attributes of individual animals in an initial herd are the starting point of simulation. This is called the opening inventory. The determinants of transition define day-to-day and group-to-group changes in attribute values. Attribute values represent the status of the herd permitting evaluation of the model.

Characteristics of the opening inventory are described in section II, "Opening Inventory", then the computer program updates daily the animal attributes and the building attributes of section III. This is carried out according to the Management Policy information given in section IV, "Management Options". Probability of Transition Data is given in section V, and output options are specified in section VI.

Name: \_\_\_\_\_ Date: \_\_\_\_\_

First Card: 1 \_\_\_\_\_ Col. No.: 1 \_\_\_\_\_ 20  
21 \_\_\_\_\_ 40  
41 \_\_\_\_\_ 60  
61 \_\_\_\_\_ 80

The detailed instructions for filling in this input form are found on the left hand page with respect to each table of the form. Note the footnote number and consult the specific instruction on the preceding open page.

The first data card (above this page) is punched column by column according to the indicated column numbers. All following cards must conform to 10F7.0 format.<sup>1/</sup> The first field of each data card is the card number. In general, underlined spaces may be filled with any integer digit. Recognize the typed in decimal point. Some values will be automatically converted to integer numbers by the computer program. "Standard" values (following pages) default when the users option is blank. Therefore, punch only those cards which contain at least one "Users Option" value.

<sup>1/</sup> The first field is the card number. Decimals must be punched since the punched location overrides the F7.0 FORMAT. Punch the card number in field one, followed by data from the table (going down the page) until the next card number is encountered. Not all cards will have 10 fields. Following the first (title) card, data cards may be scrambled. If data cards are duplicated, only the first one is effective. The last data card must contain 999., in place of the card number, followed by blanks. The first data card (identifier card above) and the terminal card (999.1b,...) are mandatory data cards.

**Instructions for Simulation Control Options, Next Page**

**1.3 Simulation Control Card**

	<u>Standard<sup>1/</sup></u>	<u>Range<sup>2/</sup></u>	<u>Users Option</u>
(a) Length of simulation			Card No. <u>Σ1.</u>
Total Number of Days <sup>3/</sup>	365.	1.-1460. -----	
(b) Random Number Seed <sup>4/</sup>	1.	1.-9999. -----	
(c) Skipping process <sup>5/</sup>			
Maximum Skip, value of "MAXSKP"	14.	1.-1825. -----	
(d) Source of Random Numbers			
= 1 for CDC Function RANF,			
= 2 for Tape Source <sup>6/</sup>			
(e) Maximum seconds of Execution	1950.	1.-99999. -----	

<sup>1/</sup> Fill in the blanks under "Users Option" for any values that you

desire to change from the "Standard" value. "Users Option" values left blank, automatically default to "Standard" values.

**Footnotes:**

<sup>1/</sup> Standard values are given for the users reference and are used in computing whenever the users option column is left blank.

<sup>2/</sup> Range is the feasible range over which the computer program will operate with respect to individual user option values. All user options set to maximize levels would exceed computer storage capacity as well as require an extremely long execution-time.

<sup>3/</sup> Total number of days for a single repetition of the simulation. Days 1-365, 366-731, 732-1097, etc. are automatically reported as year 1, 2, 3, etc., respectively. Computer execution time is approximately proportional to the number of days specified here.

<sup>4/</sup> A number used to start the random number series in the routine called RANF. A unique number here implies a unique series of random numbers for the run.

<sup>5/</sup> See thesis text, Chapter 4, sec. 4.2.1 for explanation of the skipping mechanism used to improve computer execution time. MAXSKP set equal to 1, eliminates "skipping", while a setting of 1825, implies full reliance on the automatic protection built into the program.

<sup>6/</sup> The tape source option requires a previously prepared tape of 0.,1. random numbers, while the RANF source does not.

### III. Opening Inventory

The opening inventory consists of an inventory of animals in their respective buildings as of January 1. This inventory is generated automatically, based on the size of the herd defined by the user in this section. In addition, the user defines the boars available, in detail. The user must specify opening inventory herd size in terms of number of sows in each of the 3 herd groups. One group is located in the farrowing house with their suckling pigs. The second group is in gestation for the first upcoming farrowing. Appropriate finishing hogs of 5-6 months of age correspond to an earlier farrowing of this group. The third group (open sows, available for breeding) has finishing pigs from a previous farrowing that are about 4 months of age. The number of pigs and finishing hogs which are related to these herd groups will depend upon litter size and other values specified in other sections of the input form.

"Herd group" is an opening inventory concept. After opening inventory the sow herd is treated as a pool of individuals with unique gestation and estrus attributes. Depending upon the control variables specified in other sections of this input form, a sow may turn up eligible for farrowing on any of the 6 times per year at some future date.

Generation of the opening inventory is based on the animal attributes which were available from a herd of 30 sows and 219 finishing hogs on the Purdue Swine Farm March 2, 1972. From this basic herd and other data required from this input form, the program generates a typical opening inventory for a herd which has farrowed beginning July 17 (sows rebred and

in gestation), September 1 (sows are rebred and in gestation, hogs are in the finishing house), and December 1 (sows and pigs are in the farrowing house).

Farrowings are planned for dates beginning January 15 (day 15), and March 1 (day 60). Continuation is automatic for farrowings scheduled for June 1 (day 152), July 17 (day 198), September 1 (day 244), and December 1 (day 335). This 6 times per year schedule is continued automatically, year after year. Options in other sections of this form permit specification of a range of farrowing plans from short, tightly grouped farrowings to continuous farrowing except for the extra break between Spring (March and June) and between Fall (September and December) farrowings.

## Instructions for Opening Inventory Options, Next Page

## 1.2. Opening Inventory Options

Users  
Option:Range:Standard:Card No.:

Specify the size of the sow groups, and the number of boars on the opening inventory. These are assumed known with certainty.

Card 1 has only two entries: the card number, and number of sows per group. Card 10, boars for the opening inventory, contains a full set of entries.

## Footnotes:

<sup>1/</sup>The number of sows in each of the three herd groups at opening inventory. Sows are automatically given appropriate attributes for upcoming farrowings beginning January 15th and March 1st. The program sets up breeding dates for subsequent farrowings from data elsewhere in this input form. Baby pigs and older hogs are generated as if a herd of this size had been in production the previous year. The number specified should not exceed farrowing house size, see Building Options, page 303.

<sup>2/</sup>Boars are created for opening inventory from attribute information supplied here. Boar purchases are allowed, see section 4.2 (b). For a discussion of individual boar attributes, see thesis text pp.

<sup>3/</sup>Newly purchased boars are not used for 30 days even if they are of minimum service age of 195 days.

<sup>4/</sup>A young boar is defined by age as 195-365 days.

<sup>5/</sup>A mature boar is defined by age as 366 days-1825 days. If a boar reaches the maximum age to keep a boar as specified in the Selection and Culling section page 409, he is sold.

<sup>6/</sup>Zero is required if the intention is to exclude this type boar in the opening inventory.

## Herd Size:

Card No. 1.

-- --

Card No. 15.

-- --

Range:Standard:Card No.:

Card No. 1.

-- --

Range:Standard:Card No.:

## II. Building Attributes

This group of forms requires listing of quantitative aspects of housing. All animals will be assumed to require some kind of housing space which is to be described here.

Buildings represent the housing and equipment restraint in swine production. Buildings have design capacities expressed in number of animals per unit space. The effect of overcrowding (housing more than the design capacity) may have adverse growth and survival implications. Overflow is optional for certain buildings (see p. 303), but it's effect on growth and survival rates is not included in this model.

Building capacities are to be specified in this section for Farrowing, Nursery, Sow Maintenance, and Finishing. The computer program treats these buildings as files. Additional files for boars and for call sows are assumed to have unlimited capacity.

## Instructions for Building Options, Next Page

## 3.1 Building Options

	User Option	
	Standard	Range
1.	Farrowing House	Cd. No. 1-99.
(a)	Total number of crates for sows and litters <sup>1/</sup>	15.
(b)	Number of days idle for cleaning prior to expected beginning farrowing date <sup>2/</sup>	7.
(c)	Number of days early litters may be weaned to prevent exceeding capacity <sup>3/</sup>	0.
2.	Nursery Building	Cd. No. 1-14.
(a)	Number of starting-growing pigs capacity/ head <sup>4/</sup>	125.
(b)	Overflow factor: permitted before forced to finishing <sup>5/</sup>	1.
3.	Sow Maintenance Building	Cd. No. 1-99.
(a)	Number of sows housed, head <sup>6/</sup>	80.
4.	Finishing Building	Cd. No. 1-2.
(a)	Finishing building capacity, head <sup>7/</sup>	240.
(b)	Overflow factor: permitted before forced sale at lighter weights	1.

Some positive capacity is required in all buildings. Appropriate moving of animals, premature sale and/or diagnostic messages result when any individual house is overstocked.

Footnotes:

1/ One building containing the number of farrowing crates specified here is assumed available only after a cleaning period (Next line, see footnote number 2). Overflow results in loss of newborn litters and the sow returning to the open state in the sow maintenance building (see footnote no. 3).

2/ Litters are reported lost (diagnostic written) if farrowing occurs before house no. 4 is cleaned. Cleaning will wean any sows and litters in the farrowing house on the cleaning date whether the regularly scheduled weaning process is completed or not, see "weaning policy," section 4.3, page 407.

3/ If all crates are full, a litter is weaned early (maximum number of days early specified here) to make room for the sow about to farrow. If no litter is old enough newborn litters will be lost as a result of overflow.

4/ Capacity in number of head regardless of the size or age of animal. Overflow moves to the finishing house.

5/ Nursery pigs are normally moved to finishing at option age specified in section 4.3, page 407. However, if the finishing house is full the overflow factor permits their remaining in the nursery. When the overflow factor space is also full they are forced into the finishing building.

6/ Overflow results in a diagnostic but no change in animal location or attribute values. Culls are assumed to have a cull pen of unlimited capacity apart from the maintenance building.

7/ Total capacity in number of head. Overflow results in sale of those animals required to make room for incoming individuals. Heaviest animals are sold first.

401

IV. Management Options

In this section the user specifies the control variables which define the management policy for sales, mating, culling and building use.

The total number of animals in the herd is highly dependent upon the values specified in this section. A large herd requires both a large amount of computer storage and long execution time.

**Instructions for Sales and Cost Options, Next Page**

Sales are conducted regularly. If there are not animals meeting the specifications given here, none are sold. Costs are calculated and reported over the length of time specified in the Output Options section IV, pages 601-607.

**Footnotes:**

<sup>1/</sup>A sale is conducted on the first day of simulation and repeated regularly after each period, the length of which is specified here.

<sup>2/</sup>All butcher hogs greater than or equal to the weight specified are sold.

<sup>3/</sup>Price for all butchers sold. However, sale weight of animals sold prematurely due to overflow is unpredictable. Heaviest animals are sold first to clear capacity for incoming animals.

<sup>4/</sup>A "Basic Sow" of 350 pounds or less, farrowed or not. Selling price is discounted for weight over 350 pounds, i.e. according to (e) below.

<sup>5/</sup>Cost options are intended to provide an approximation of variable costs for feed and labor. Any variable cost other than feed or labor may be included as a feed or labor cost if it is appropriate to the method of calculation used.

Cost calculations are made daily based on inventories in buildings. The "skipping" process can cause the number of animals to be slightly understated for daily calculations. See the discussion of the skipping process in the thesis text, chapter 4, section 4.3.1. Standard transition probabilities are thought to result in negligible underestimation of costs.

<sup>6/</sup>An average sow day of maintenance and lactation. Take into consideration the relative length of lactation as a result of the weaning policy you specify in section 4.3 page 407. The standard value is based on two 5 week lactations. See "Planning Growth of the Swine Farm, Input Forms and Instructions," Dept. of Agricultural Economics, Purdue University, July, 1972, pp. 14-19.

<sup>7/</sup>Exclude sow feed. All gain up to sale or inventory weight is classed as butcher hog gain, if the animal is less than 240 days of age.

<sup>8/</sup>Labor in minutes per litter or per head per day. These rates account only for labor which can be based on the number of animals in buildings. Standard values are estimated from information in: Lines, A.E. & D.H. Bach, "Planning Data for Hog Farms," Publication EC-408, January, 1972, page 14. The standard values are intended to represent feeding and routine cleaning labor.

**4.1 Sales and Cost Options**

Sales of Butchers and Sons	Standard	Range	Users Option
Cd. No.	§.	Cd. No.	§.

- (a) Sell butchers every (?) number of days  $\frac{1}{2}$
- (b) Minimum weight for sale of butchers, pounds  $\frac{2}{2}$
- (c) Butcher hog selling price per hundred pounds, \$  $\frac{1}{2}$
- (d) Sow sales price for basic sow<sup>4/</sup> \$ per hundred pounds
- (e) Discounts, \$ per 100 pounds for wt. of sows over 350 pounds \$ .50

**Variable Cost Options<sup>5/</sup>**

Variable Cost Options <sup>5/</sup>	(a) Feed Costs	(b) Variable Labor Costs by Building <sup>8/</sup>
Per sow day of maintenance and lactation $\frac{1}{2}$	\$ .14	\$ 0.01-.99
Per 100 pounds of butcher hog produced $\frac{1}{2}$	\$11.75	\$1.99.
Value of Labor, \$/hour	\$ 3.00	\$0.99.
Parrowing Bld., min./day/litter	6.5	1.99.
Nursery Bld., min./head/day	.21	.01-.99
Sow Maintenance Bld., min./head/day	.8	.1-.99
Finishing Bld., min./head/day	.005	.01-.99

## Instructions for Boar Management Options, Next Page

## 4.2. Boar Management Options

Specify maximum boar capacity and give instructions for replenishing boars by yearly purchase.

<u>Users</u>	<u>Standard</u>	<u>Range</u>	<u>Option</u>
Cd. No. 2	Cd. No.	Cd. No.	Cd. No.
<b>(a) Services Permitted<sup>1/</sup></b>			
Maximum services daily for young boar, no.	3.	1-9.	-
Maximum services weekly for young boar, no.	10.	1-99.	-
Maximum services daily for mature boar, no.	3.	1-9.	-
Maximum services weekly for mature boar, no.	15.	1-99.	-
<b>(b) Purchases of New Boars<sup>2/</sup></b>			
Number purchased once per year, no.	2.	0-99.	-
Date of yearly purchase, day of year	60.	1-365.	-
Age at purchase date, days <sup>3/</sup>	180.	150-395.	-
Weight at purchase date, pounds	260.	200-600.	-

## Footnotes:

<sup>1/</sup> The number of times each boar has serviced a sow is tallied both for daily and weekly totals. If the maximums given here are reached, the boar is no longer available until next day. A diagnostic is printed if a sow is not mated for lack of an available boar.

<sup>2/</sup> Purchase is assumed to take place once yearly.

<sup>3/</sup> Newly purchased boars wait a 30-day adjustment period before being used even if they are of minimum age (195 days) for use.

**Instructions for Breeding, Weaning, and Nursery Options, Next Page**

Specify here the length of breeding season, target numbers of sows and gilts to be served with the boar and the weaning criteria desired for all farrowings.

**Footnotes:**

1/ Breedings are scheduled automatically: planned beginning date = first day of farrowing - Mean length of gestation + one Standard Deviation, where first day of farrowings are respectively: Jan. 15, March 1, June 1, July 1, September 1, and December 1. Length of gestation is an input form option, see section 5.3, page 507.

2/ Number of days over which sows and gilts coming into heat are served by the boar, if a boar is available.

3/ Maximum number to be exposed to boars for breeding. The number of sows and gilts exposed as they come in heat is counted and exposure terminated when this number is reached. The number of sows conceiving is assumed not known by the manager until the immediately following breeding season. At that time non-breeders will be coming in heat and are available for breeding.

4/ A weaning schedule will be automatically followed to wean all the litters in the farrowing house at the time of the beginning of the weaning schedule. Weaning will commence as if the first litter had been born on the beginning date of that farrowing. Litters are weaned over the number of days specified on the following line, see footnote 5.

5/ Specify the number of days over which weaning will take place. The number of litters to be weaned are divided equally among the number of days given here. The oldest litters are weaned first. Scheduled cleaning of the farrowing house will automatically wean those litters remaining in the farrowing house at cleaning time, whether they have reached target weaning age or not. See Cleaning Option, section 3.1, page 303.

**4.3 Breeding, Weaning, and Nursery Options**

Users Options	Standard	Range	Cd. No.	2.
1. Breeding of Sows and Gilts <sup>1/</sup>	21	1.-44.	—	—
(a) Length of Breeding Season, days <sup>2/</sup>	36.	22.-44.	—	—
(b) Target Number to Breed, No. Sows <sup>3/</sup>	17.	1.-999.	—	—
2. Weaning Policy				
(a) Target Age of Pigs at Weaning, days <sup>4/</sup>	36.	22.-44.	—	—
(b) Length of Weaning Period, days <sup>5/</sup>	18.	1.-44.	—	—
3. Nursery				
(a) Age at which pigs are moved from Nursery to Finishing, days	82.	57.-150.	—	—

**Instructions for Gilt Selection and Sow Culling Options, Next Page.**

**Footnotes:**

1/ Gilts are selected, if available, from the finishing building and placed in the reproductive herd. They obtain estrus attributes as defined in Section 5.2, page 505. The number of gilts specified here are selected so that they would be eligible to farrow at one year of age. Minimum age is the only selection criteria.

2/ If the sow or gilt passes this number she is sold at the next regularly scheduled culling date. If the sow does conceive before reaching this maximum, this count is reset to zero. A sow or gilt gets one count toward her maximum each time she comes into heat but fails to conceive either because of lack of boars or because of failing the probability of conception test. The length of breeding season specified, (page 207), will determine the number of times it is possible for a sow to come in heat during any one breeding season.

3/ If bred, the sow will be sold after weaning the current litter.

4/ Percent routinely culled after weaning. Use this value to simulate culling rate desired (i.e., speed of sow turnover, approximation of sow: gilt ratios, and culling for health reasons). This type of culling is at random, on the surviving individuals (i.e., with the probability taken from the percent specified here). Gilts are assumed to be less than 450 days of age or they are assumed to be sows for this criteria.

A 100% declaration on line (d) implies gilt only production. A 100% declaration on line (e) implies 2 litters per sow at most.

5/ Until detected sows remain in the maintenance building. On the detection date they are moved to the cull pen for sale on the next regularly scheduled sale day.

**4.4 Gilt Selection and Sow Culling**

	Standard	Range	Users Option	Cd. No.	1 1.
(a) Number of new gilts selected prior to each breeding season <sup>1/</sup> , no. gilts	10.	0..999.			
(b) Maximum number of failures to conceive per sow <sup>2/</sup>	2.	1..29.			
(c) Maximum age to keep sow <sup>3/</sup> , days	1600.	1..1825.			
(d) Culled of first litter gilts <sup>4/</sup> , %	20.%	0..100.%			
(e) Culled from sows farrowing <sup>4/</sup> , %	20.%	0..100.%			
(f) Maximum age to keep a boar, days	730.	300..1825.			
(g) Number of days to detection following maximum failures to conceive <sup>5/</sup>	60.	0..999.			

501.

#### V. Transition Probabilities

In this section the user specifies the transition probability data involved with survival, estrus, conception, gestation, litter size, and rates of gain. Probability data are applied where an animal is to change from one state to another.

Daily survival probability determines the chance of becoming one day older. Conception probabilities represent the fertility level of the herd and influence the production obtained. Sows are assigned estrus and gestation cycle lengths as random normal deviates based on specifications given here. The number of pigs farrowed alive is drawn as a random normal deviate based upon probability data of this section. Rate of gain is drawn as a random normal deviate for each growth or sexual category.

Data for this section requires Range and Standard Deviation as well as the Mean value. Mean values are more commonly available than are Standard Deviation and Range. Standard values are based upon referenced publication material in those cases where they were found to be available. Some of the data was calculated from original herd records of the Purdue Swine Farm research projects. Other of the Standard values are judgement values based on the experience of research workers and extension personnel. The Users Option column should be used to change transition probability data found to be unsatisfactory.

## Instructions for Survival Probability Options, Next Page

Death Loss is specified and then the program converts to daily survival probabilities for comparison with random numbers.

## Footnotes:

1/ Daily survival probabilities  $s$  are calculated from the relation:

$$S_N = s^N$$

where:  $N$  = total number of days in the time period,

$S_N$  = probability of survival over the time period of  $N$  days,

$s$  = probability of survival for a single day in the series of days  $1 = 1, 2, 3, \dots, N$ .

Death loss  $(1-S_N)$  values are converted to survival values and then daily survival probabilities are found by taking the  $N$ th root of  $S_N$ .

2/ Suggestion for farm conditions from J. Foster and W. Singleton, Animal Science. Probability of survival of pigs 1-21 days of age also is conditional upon birth weight of the particular pig. This adjustment is made automatically and is based on: N. C. Spoor, "Maximizing the Reproductive Efficiency of the Sow", Feedstuffs, Vol. 42, No. 46, Nov., 1970, pp. 27-28. The linear approximation used is: + Probability of survival of .06 over 21 days (.019 daily) for each 1 pound deviation from the mean birth weight of all pigs.

3/ Lines, A. E., and D. H. Bach, "Planning Data for Hog Farms", Pub. EC-408, p. 13.

4/ Source: EC-408, p. 13, see footnote 3.

5/ Source: EC-408, p. 13, see footnote 3.

6/ A boar in use is assumed to be 5 times as likely to die during days he is used than when not in use (due to fighting, accident, etc.).

## 5.1 Survival Probabilities

Probability of Death Loss<sup>1/</sup>

Category	Days of Age Definition	Probability of Death Loss <sup>1/</sup>	
		Standard	Range
Cd. No.	2.		
Baby Pigs	1-7	.10 2/	.01-.9
2nd-3rd week	8-21	.10 2/	.01-.9
Start, not weaned	22-56	.035 3/	.001-.9
Start, weaned	22-56	.05	.001-.9
Growing-Finishing	57-180	.015 4/	.001-.9
Sow & Gilts	181-1825	.015 5/	.001-.9
Boar not in use	150-1825	.015	.001-.9
Boars in use	195-1825	.075 6/	.001-.9

## Instructions for Estrus and Conception Options, Next Page

## Footnotes:

- 1/ Portion of animals which will never be able to reproduce due to abnormalities. Standard probability for farm conditions suggested by Wayne Singleton.
- 2/ Standard distribution parameters are based on a range of 18-23 including 75% as reported in: Cole, H. H., and P. T. Cupps, Reproduction in Domestic Animals, 2nd edition, Academic Press 1969, p. 221. Standard deviation is approximated from the normal distribution.

- 3/ Number of times sow or gilt is served by the boar is dependent only upon boar availability. If a boar is available which can give two services without passing either his daily or weekly maximum, the sow is assumed to receive two services. Otherwise a boar with one available service is used, if such a boar is available.

- 4/ Specify probability of conception on the second service conditional on not conceiving on the first service. Standard values of  $P_1 = .75$  and  $P_2 = .60$  imply that the total probability,  $P$ , when two services are available, is .90, i.e.,  $P = P_1 + (1-P_1)P_2$ .

- 5/ The mean number of pigs born alive is adjusted by this amount for the number of services from the boar. This value is used to represent the effect of "Boar Power" on litter size. Standard deviation and range are left unchanged.

- 6/ Standard values imply conception is 10% less likely during the months of July, August and September. See the discussion, "Effect of Temperature and Humidity on Reproduction", by H. S. Teague in, "Effect of Disease and Stress on Reproductive Efficiency in Swine - Symposium Proceedings", Animal Science Department, University of Nebraska, 1970, pp. 21-26.

- 7/ If the animal in heat is a gilt (less than 365 days of age at breeding), this additional reduction in probability of conception is applied.

## 5.2 Estrus and Conception

	Standard	Range	Users Option
	Cd. No.	4.	
1. Probability of abnormal reproductive tracts in gilts <sup>1/</sup>	.05	.0-.2	—
2. Length of estrus cycle <sup>2/</sup> for potentially reproductive animals	20.7	10-.30	—
Mean length, days	2.1	0-.9	—
Standard deviation, days	16.0	2.6	—
Minimum length, days	25.0	42.5	—
Maximum length, days			
3. Conception as related to number of services per sow <sup>3/</sup>			
a) Probability of sow conceiving with one service available	.75	.2-.99	—
b) Probability of sow conceiving from the second service if failing to conceive on the first <sup>4/</sup>	.60	.2-.99	—
c) Pigs born adjustment for single service, no. pigs <u>5/</u>	-0.5	0-.7(neq )3:	—
d) Pigs born adjustment for two services, no. pigs <u>5/</u>	0.5	0-.3	—
4. Conception Probability Adjustments	Cd. No. <u>1.2.</u>		
a) Summer season <sup>6/</sup>	-.10	(neq )20 -0.	—
b) If gilt <sup>7/</sup>	-.05	(neq )15 -0.	—

506.

Instructions for Gestation Options, Next Page

507.

**5.3 Gestation**

<u>Footnotes:</u>	<u>Standard</u>	<u>Range</u>	<u>Users Option</u>
	<u>Cd. No.</u>	<u>S.</u>	
<b>(a) Length of gestation 1/</b>			
	Mean length for sows and gilts, days	116.0	110-118.
	Standard deviation length, days	2.0	0-10.
	Minimum length, days	110.0	$\geq 110.$
	Maximum length, days	118.0	$\leq 118.$
<b>(b) Probability of Prenature Termination of Gestation 2/</b>			
	During first week, for 7 days =	.04	.0-.4.
	Weeks 2-15, for 100 days =	.035	.0-.3.
	Final Week, for 7 days =	.02	.0-.2.

1/ Length of gestation is drawn once as a random normal deviate for each pregnancy.

2/ If termination occurs, the animal is returned to the open-cycling state. No pigs survive. Termination is assumed a "natural occurrence", not due to epidemic disease. Standard values suggested by J. Foster and W. Singleton, Animal Science. Conversion is to daily probabilities follows the procedures outlined in footnote 1, Survival Probabilities, section 4.1.

## Instructions for Pigs Farrowed Options, Next Page

The number of pigs farrowed alive is drawn as a Random Normal Deviate after adjustment of the Mean for the age of the sow at farrowing time, as well as for the number of boar services which resulted in pregnancy.

## Footnotes:

1/ Number of pigs farrowed alive to a 545 day old sow (at approximate age for farrowing second litter). The mean is adjusted for age of the sow as defined in footnote 2 below. Standard deviation and range are not adjusted from those given on the input form.

2/ The mean number of pigs born alive to a second litter sow (base age) is adjusted as follows:

$$\text{MEAN} = v + 5.867 + .01A - .00000446A^2 \quad \text{for } A \leq 1300, \text{ or}$$

$$\text{MEAN} = v + 5.867 + .01(1300) - .00000446(1300)^2 - .0036(A-1300)$$

Where:  $v$  = adjustment for number of services from the boar (section 4.2)  
+ the amount the deviation of the specified mean (input form next page) is from 10 pigs per litter born alive.

$A$  = age of sow at farrowing time.

Example actual MEAN values are as follows for the standard specification of 9.5 pigs born alive:

Value of MEAN from the above formula

Age of Sow	8.4
365 (1 year old gilt)	8.4
545 (approx. age and litter)	9.5
725 (2 year old)	10.3
1090 (3 year old)	11.0
1090 days	10.9
1200 days	10.8
1300 days	10.3
1600 days	10.0
1825 days	10.0

The above function is derived from: Urban, W. E., Jr., C. E. Shelby, A. B. Chapman, J. A. Whitley, Jr., and V. A. Garwood, "Genetic and Environmental Aspects of Litter Size in Swine", J. Animal Science, Vol. 26, 1966, pp. 1148-1153. Very few observations were used to estimate this function beyond the maximum number of pigs born (age = 1221 days). To negate the rapid decline of the function value for older sows, the number of pigs born is assumed to decline linearly after the age of 1300 days.

3/ Based on Purdue swine farm herd data: 2.24 in Fall, 1967. 3.46 in Spring, 1968. 42 and 39 litters were farrowed respectively.

## 5.4 Pigs Farrowed

	Users Option	Standard	Range	Cd. No.	6.
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(a) Number of pigs farrowed alive per litter to a flow of base age/<sup>2/</sup>

Mean number of pigs born	9.5	4.-16.	— — —
Standard deviation pigs born	3.0 <sup>3/</sup>	0.-10.	— — —
Minimum number pigs born	4.0	≥ 4.	— — —
Maximum number pigs born	16.0	≤ 16.	— — —

(b) Birth weights<sup>4/</sup>

Mean birth weight, pounds	3.0 <sup>5/</sup>	1.-5.	— — —
Standard deviation, pounds	0.4 <sup>6/</sup>	0.-5.	— — —
Minimum weight, pounds	1.25	≥ 1.	— — —
Maximum weight, pounds	5.0	≤ 5.	— — —

(continued from previous page).

4/ Random Deviates are drawn for individual pigs birth weight after adjusting the Mean for number of pigs born in the litter (.09 pounds per pig born in the litter deviation from the input form "Mean No. of Born" given in section (a) above). Standard deviation and range is not adjusted for size of the litter. For birth weight to number of pigs born relationships see: "Relationship of Gestation Length, Age, and Weight at Breeding, and Gestational Gain to Sow Productivity at Farrowing", J. Animal Science, Vol. 26, No. 2, 1966, an article by Qatsevit, I. T., C. M. Stanislaw, and J. A. Whitley, Jr.

5/ Based on Swine Farm Herd Data, mean was 3.01 in Fall, 1967 and 3.08 spring, 1968.

6/ Approximate mean of the variances calculated for individual litters of Swine Farm Herd in Fall of 1967 and spring of 1968.

510.

**Instructions for Rate of Gain Options, Next Page.**

The Mean rate of gain must be specified on this form. Standard deviations and range is calculated by the program, see the following footnotes.

**Footnotes:**

1/ Standard means result in an expected 200 pound market hog at 6 months of age.

2/ Applies to all 5 age categories. Estimation from experiments conducted on farms by J. Foster. Standard deviation of weight gain is calculated as a percent of the above specified mean in each use. Range is assumed -5 to 10 pounds to allow fully stochastic deviation. Standard deviation of gain in the Foster experiments was approximately 20% from 1-4 weeks; 14% from 1-20 weeks.

3/ Approximate value for confined sow gain during gestation reported from Purdue Housing-Management Systems, see Jones, H. W., V. B. Mayrose, and D. H. Bach, "Confined Sow Management Systems," ID-80, Purdue University Cooperative Extension Service, 1972, p. 2.

4/ If additional loss (in addition to loss at parturition, see part (c) below) a negative sign must be specified. The standard value (-0.5) results in a total loss during lactation as indicated in ID-80, see footnote 3 above.

5/ Range is assumed -10 to 10 pounds.

**5.5 Rate of Gain**

		Standard	Range	User's Option
(a)	Mean daily gain of pigs and hogs by age category <u>1/</u> .			Cd. No. <u>1.</u>
	Age Category	Days of Age Definition		
	1st week	1- 7 mean, pounds	0.45 .1-.1.	
	2-3 weeks	8- 21 mean, pounds	0.58 .1-.1.	
	starting	22- 56 mean, pounds	0.75 .1-.2.	
	growing	57- 149 mean, pounds	1.25 .1-.2.	
	finishing	150-sale mean, pounds	1.70 .1-.3.	
	Standard deviation as % of above means <u>2/</u>	15.0%	0-.99%	
				Cd. No. <u>2.</u>
(b)	Daily gain of sows			
	Mean-sow and gilt in maintenance, pounds	1.0 <u>3/</u> .1-.9.		
	Standard deviation sow and gilt in maintenance, pounds	.2 .0-.9.		
	Mean- sow in lactation, pounds	-0.5 (neg).5-.5.		<u>4/</u>
	Standard deviation, sows in lactation, pounds	1.0 .0-.9.		
(c)	Sow weight loss at Parturition <u>5/</u>			
	per pig farrowed, loss, pounds	5. 0-.9.		
	Standard deviation	.5 0-.5.		

511.

601

#### VI. Output Options.

Output options are provided to enable an evaluation of the model while keeping the computer print volume to a minimum.

There are three general types of reports. The first type, called "Summary Reports", is generated periodically to report the productivity as well as simple cost and return measures. These reports are designed to reflect the productivity of the herd over a planning period of say one year. The length of the period is, however, a user option.

The second type of report, called "Event and Daily Reports", is more detailed and may be used to evaluate seasonal events and daily status of the herd.

The third type of report, called "Diagnostic Reports", is for use in debugging the operation of the program. Attributes of individual animals can be inspected daily by writing them out in this way. However, this type of report results in very large volumes of output and will increase computer execution time significantly.

## Instructions for Summary Report Options, Next Page

## 6.1 Summary Reports

603

	Standard	Name	User's Option	Cd. No.	5.3.
Schedule Summary Reports Every ? days: <sup>1/</sup>	365.	1-9999	-----		
Production Summary					
(a) Building Use <sup>2/</sup>	1yes, Ono	1.	0..1.	-	-
(b) Breeding <sup>3/</sup>	1yes, Ono	1.	0..1.	-	-
(c) Farrowing <sup>4/</sup>	1yes, Ono	1.	0..1.	-	-
(d) Weight Gains <sup>5/</sup>	1yes, Ono	1.	0..1.	-	-
Costs and Returns Summaries					
Omit Switch: zero to omit all (a)-(f)					
(a) Feed Costs Sows	1yes, Ono.	1.	0..1.	-	-
(b) Feed Costs Butcher Hog Gains	1yes, Ono	1.	0..1.	-	-
(c) Labor Costs	1yes, Ono	1.	0..1.	-	-
(d) Value of Sows Sold, Adjusted for Inv.	1yes, Ono	1.	0..1.	-	-
(e) Value of Butchers Sold, Adj. for Inv.	1yes, Ono	1.	0..1.	-	-
(f) Costs and Returns Summary Table	1yes, Ono	1.	0..1.	-	-

Summary reports are made periodically. Specify the length of reporting period and indicate those reports desired. This group of reports appear on the resulting output before those of the next section.

## Footnotes:

1/ Specify the number of days between summary reports. A request made larger than the number of days of simulation will result in no report of either production or cost and returns even if some of the individual items are requested with the 1yes option.

2/ Building use includes current inventory of animals in each building as well as the average occupancy rate over the period. If overflow occurred, it can be reported daily, see the overflow message option of Section 6.2 page 605.

3/ The breeding report is a summary over all breeding completed in this reporting period. Sows bred and those failing to conceive are reported along with the number of services given to reach conception.

4/ The farrowing report is a summary over all farrowing in this reporting period.

5/ Weight gains for the period requested=ending inventory weight + sales weight - opening inventory weight. Ending inventory is used as the subsequent opening inventory for the next periodic report. Number of animals and value of production is also reported.

## Instructions for Event and Daily Report Options, Next Page

## 6.2 Event and Daily Reports

Specify those reports required to clarify the experiment being conducted. Users are warned that seasonal and daily reporting can result in a large volume of output. These reports appear in order by simulation time as generated.

Event Options:

1/ The major events schedule as followed in the simulation run. This includes dates of sales, breeding, selection of gilts, cleansing of the farrowing house, weaning, and boar buying.

2/ Reported at close of the respective session.

3/ Specify starting and ending dates. One report is generated for each day requested. Each building request generates 2 lines of output per report.

4/ Zero specification results in an end of day 0 report i.e., the opening inventory, and is a legal request. The standard value: -1. results in no report of this type.

5/ Building overflow and error message reporting generally results in one or two lines per building per day that is in the overflow condition.

Users	Standard Range	Code No.	Options
Coded Schedule of Major Events <u>1/</u> (1-2 pages)	0=no 1=yes	0. 1.	
Seasonal Events <u>2/</u>			
(a) Sales as they occur ( <u>1</u> page per sale) 1=yes, 0=no	0. 1.		
(b) Parrowings at end of season ( <u>1</u> page per season) 1=yes, 0=no 0.	0. 1.		
(c) Breedings at end of season ( <u>1</u> page per season) 1=yes, 0=no 0.	0. 1.		
Consecutive Daily Inventory by Building <u>3/</u>			
Start Daily Inventory date, day <u>4/</u>	-1. ( <u>neg</u> ) 1-999.		
End Daily Inventory date, day <u>4/</u>	-1. ( <u>neg</u> ) 1-999.		
(a) Nursery Bld. 1=yes, 0=no 0.	0. 1.		
(b) Finishing Bld. 1=yes, 0=no 0.	0. 1.		
(c) Maintenance Bld. 1=yes, 0=no 0.	0. 1.		
(d) Boars 1=yes, 0=no 0.	0. 1.		
(e) Farrowing Bld., Sows and Pigs 1=yes, 0=no 0.	0. 1.		
(f) Misc. births & deaths 1=yes, 0=no 0.	0. 1.		
Building Overflow Messages <u>5/</u> 1=yes, 0=no	0.	0. 1.	

## Instructions for Diagnostic Report Options, Next Page

## 6.3 Diagnostic Reports

Diagnostic Reports are recommended only as a last resort in investigating unexpected results and for debugging errors in the program. Large volumes of output are generated and computer execution time is extended by this type of request. Temporary reduction in herd size at opening inventory and reduced conception and/or birth rates while debugging will reduce execution time required.

## Footnotes:

1/ Computer packed storage (multiple variables in a single word) is decoded and given appropriate labels as to individual animal attributes. This process is simply repeated at the end of each day requested in the string of days from the specified "start" to "end" day for those buildings desired.

2/ Zero specification here results in a day zero, i.e., opening inventory report. The standard value (-1.) results in no report of this type.

3/ A OPTION variable which can be set equal to a subroutine number to trigger those debugging aids built into individual subroutines. Other debugging write statements could be placed in the program to be triggered in this way.

4/ A OPTION variable available for a programmer's use as a switch.

<u>Standard</u>	<u>Range</u>	<u>User Option</u>	<u>Cd. No. 5.7.</u>
Individual	Daily Animal Attributes	1/	
Start Daily Animal Attributes,	day 2/-1.(neg)1.-9999.		
End Daily Animal Attributes,	day 2/-1.(neg)1.-9999.		
(a) Nursery Bld.	l=yes, 0=no	0.	0.1.
(b) Finishing Bld.	l=yes, 0=no	0.	0.1.
(c) Maintenance Bld. l=yes, 0=no	0.	0.1.	
and Cull Pen			
(d) Barns	l=yes, 0=no	0.	0.1.
(e) Parrowing Bld.	l=yes, 0=no	0.	0.1.

## Subroutine Oriented Diagnostic Switches

<u>Individual Subroutine: NS1=</u>	<u>3/</u>	<u>Cd. No. 5.8.</u>
Special Use Switch:	NS2= 4/	0. 0.-25. 0.-9999.

Mandatory Last Data Card, first column:

2 9 2 9.

**APPENDIX C**

**THE FORTRAN PROGRAM**

## EXECUT

PROGRAM EXECUT(INPUT,OUTPUT,TAPE2=157,TAPE5=157,TAPE15=115,  
2TAPE50=335,TAPE60,TAPE6=175,TAPE8=175,TAPE13=175,TAPE7=175)

C THE MAIN PROGRAM EXECUT AND ASSOCIATED SUBROUTINES SET UP AND  
C MANAGE THE SIMULATION RUN(S). SUBROUTINE MGT CONTAINS THE  
C MASTER TIME AND REPORTING CONTROL. SUB. MGT3 CHECKS AND  
C PREPARES REPORTS ON THE SYSTEM. SUB. EVNTS CALLS FOR EXECUTION OF  
C THE UPDATING OF ANIMAL ATTRIBUTES. REPORTS ARE WRITTEN BY THE  
C SUBROUTINES OUT, REPT1, AND REPT2. FILEM, REMOV, AND FIND ARE  
C SUBROUTINES FOR PLACING, REMOVING AND FINDING ANIMALS IN A  
C FILE.

C SUBROUTINES OF SUPPORT GROUP INCLUDE-

C     STATISTICAL -ZROSUM,COLLT,STATS FOR CALCULATION OF MEAN ETC.  
C     RANDOM DEVIATES-

C         FUNCTION RANUM FOR RANDOM NUMBERS  
C         FUNCTION RNORM(RMEAN,STD,RMIN,RMAX) FOR NORMAL DIST.

C ARRAY STORAGE-

C     IN(R,C), VEN(R,C) ARE THE INVENTORY FILING ARRAYS  
C     DIMENSION BOTH TO (R,C) HERE, TO (R,1) IN SUBROUTINES.  
C     SEE PRITSKER -SIMULATION WITH GASPII- PP. 23-24.

C LABELED COMMON IS NAME KEYED, SEE SUBROUTINE USAGE.

COMMON/INIT/NR,NW,ND,NT7,NT8,NDAT,NS1,NS2,NOWD  
2 /RAN/ IRN(54),KРАNUM,RLIMIT,NRNOPT,ITAPE  
3 /STAT/SUM(5,20),SUM2(5,10),SUM3(5,10),SUM4(5,10),SUM5(5,10)  
4 /GEN/ITOT,ISIZE,NOWT,NOWY,NDAYS,NRUNS,IATRIB(18),ATRIB(4)  
5 /HOUSE/NH(6),N1,N2,N3,N4,N5,N6,NXTFAR,MX1,MX2,MX3,MX4,X1,X2,X4  
6 /SALES/ MDSELL,WTS,NXTSAL,NSLD(4),WTSLD(4),VSLD(4),PRIH,PRIS  
7 /SALE2/NSLDP(4),WTSLDP(4),VSLDP(4),DIS  
7 /BRED/LBREED,NBREED,IFAR(6,5),IDB(30),KAGEW,LGTHW,NAGEM  
3 /SCH/KS(2,500),IPT,IEVT,KODE,IWE,IWN(45),NKT  
4 /CULL/NGLTS,MXSrv,MXAGS,PCULG,PCULS,PSR,PRGT,MXBOR,LDP  
8 /BRED2/ ABNORG,GESM,GESS,GMIN,GMAX,ESTM,ESTS,EMIN,EMAX  
9 /BRED3/ PTRM1,PTRM2,PTRM16,PCON1,PCON2,ADJ1,ADJ2  
1 /SKIP/ ISTOP4,ISTOP5,ISTOP6,ISTOP7,MAXSKP  
2 /SURVIV/PW1,PW23,PSRT,PSFIN,PSOWS,PBORS,PBORS1,MDEAD(8),PSRT2  
3 /GAIN/GW1,GW23,GSRT,GFIN1,GFIN2,GSOWM,GSOWL,SDP,SSOWM,SSOWL  
4 /BIRTH/ BRNM,BRNS,BMIN,BMAX,BWTM,BWTS,BWMIN,BWMAX,NOBRN  
5 /CLEAN/NDPREP,NH4CLN,LOSSL,SWTLP,SSL,KL4  
COMMON /BOAR/ MXSDY,MXSWY,MXSDM,MXSWM,NPUR,IPDAT,KAGE,WTPB,IBS  
5/BRED4/KBRD,KSWGT(4),NONB(4),NONBK(4)  
2 /MG3/ NHH(6),MDEADH(8),NHP(6),MDP(6),KCALL,KPRET,KNSLD4,KPREP  
7 /KRS/ KRS1,KRS2,KRS3,KRS4,KRS5,KRS6,KRS7,KRPT  
1 /RPT1/ISMYP,ISM,ISM,ISM,ISM,ISM,ISM,ISM  
2 /RPT2/ISMYC,ISMCS,ISMCH,ISM,ISM,ISM,ISM,ISM  
3 /RPT3/MJEV,ISALS,IFARS,IBRDS  
4 /RPT4/IDCS,IDCE,IDCN,IDCF,IDCM,IDCB,IDCFS,IDCFP,IOFLW  
5 /RPT5/IAAS,IAAE,IAAN,IAAFN,IAAM,IAAB,IAAFR  
3 /COST/FCS,FCB,CLAB,TFAR,TNUR,TSOW,TFIN,VAR(3),COST(30)  
6/WRT1/ KW  
4 /GAIN2/SOP(6),HOP(6),SSL(6),HSL(6),SEND(6),HEND(6)  
DIMENSION IN(3,1500),VEN(2,1500)  
DIMENSION EQARR(1802)  
EQUIVALENCE (NR,EQARR(1))

C  
C  
C ARRAYS IN(3,J), VEN(2,J) OVERLOAD PROTECTION, SEE SUB. FILEM.  
C SET KRS3=J, COLUMN SIZE FOR THE ABOVE DIMENSIONED ARRAYS.  
C ITOT (TOTAL NO. OF ANIMALS) MAY NOT EXCEED KRS3 AT ANYTIME.

I KRS3=1500

165

C  
C  
C INITIATE THE PROGRAM IN SUBROUTINE INITN.  
C ASSIGN READ-WRITE TAPES, READ CONTROL PARAMETERS.  
C CALL INITN(IN, VEN)  
C  
C PREPARE OPENING INVENTORY- READ ORIGINAL HERD DATA  
C CALL OPEN(IN, VEN)  
C  
C  
C SET UP INVENTORY REPORTING IN SUBROUTINE MGT3.  
C CALL MGT3(IN, VEN)  
C  
C LET SUBROUTINE MGT MANAGE THIS SIMULATION RUN.  
2 CALL MGT(IN, VEN, EQARR)  
C  
STOP  
END

## INITN

```

SUBROUTINE INITN(IN, VEN)
COMMON/INIT/NR,NW,ND,NT7,NT8,NDAT,NS1,NS2
2 /RAN/ IRN(54),KРАNUM,RLIMIT,NRNOPT,ITAPE
3 /STAT/ SUM(5,20),SUM2(5,10),SUM3(5,10),SUM4(5,10)
4 /GEN/ ITOT,ISIZE,NOWT,NOWY,NDAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5 /HOUSE/NH(6),N1,N2,N3,N4,N5,N6,NXTFAR,MX1,MX2,MX3,MX4,X1,X2,X4
6 /SALES/ MSELL,WTS,NXTSAL,NSLD(4),WTSLD(4),VSLD(4),PRIH,PRIS
7 /BRED/LBREED,NBREED,IFAR(6,5),IDB(30),KAGEW,LGTHW,NAGEM
8 /BRED2/ ABNORG,GESM,GESSION,GMIN,GMAX,ESTM,ESTS,EMIN,EMAX
9 /BRED3/ PTRM1,PTRM2,PTRM16,PCON1,PCON2,ADJ1,ADJ2
1 /SKIP/ ISTOP4,ISTOP5,ISTOP6,ISTOP7,MAXSKP
2 /SURVIV/PW1,PW23,PSRT,PSFIN,PSOWS,PBORS,PBORS1,MDEAD(8),PSRT2
3 /GAIN/GW1,GW23,GSRT,GFIN1,GFIN2,GSOWM,GSOWL,SDP,SSOWM,SSOWL
4 /BIRTH/ BRNM,BRNS,BMIN,BMAX,BWTM,BWTS,BWMIN,BWMAX,NOBRN
5 /CLEAN/NDPREV,NH4CLN,LOSSL,SWTLP,SSL
4 /CULL/NGLTS,MXSRV,MXAGS,PCULG,PCULS,PSSR,PRGT,MXBOR,LDP
3 /COST/ FCS,FCB,CLAB,TFAR,TNUR,TSOW,TFIN
COMMON /BOAR/ MXSDY,MXSWY,MXSDM,MXSWM,NPUR,IPDAT,KAGE,WTPB,IBS
1 /RPT1/ ISMYP,ISMBC,ISMBCG,ISMF,ISMW,ISMS,ISMM
2 /RPT2/ ISMYC,ISMCS,ISMCH,ISML,ISMSS,ISMCH,ISMGR
3 /RPT3/MJEV,ISALS,IFARS,IBRD
4 /RPT4/IDCS, IDCE, IDCN, IDCFS, IDCDFP, IOFLW
5 /RPT5/ IAAS,IAAE,IAAN,IAAFN,IAAM,IAAB,IAAFR
7 /SALE2/DUMMY(12),DIS
7 /KRS/KRS1,KRS2,KRS3,KRS4,KRS5,KRS6,KRS7,KRPT
DIMENSION RR(10),STRR(10)
INTEGER XMINUS
DATA XMINUS/00000000000000007777/
DIMENSION ISTRR(10)
EQUIVALENCE (ISTRR(1),STRR(1))

C ASSIGN TAPES
C      READ=NR= WRITE=NW, DIAGNOSTIC=ND, BASE HERD DATA TAPE=NDAT,
C      RANDOM NOS. =ITAPE
NR=2
NR5=5
NW=6
ND=13
C MAY SET TO 8 FOR JUNKING VIA CARD 56.
NT7=13
NDAT=15
ITAPE=50
MR=0
C
C
C INITIATE VARIABLES OUTSIDE SUBROUTINES
KРАNUM=0
RLIMIT= 2.*48.-1.0
ITOT=0
DO 90 II=1,6
90 NH(II)=0
NOWY=0

C PRESET STATISTICAL COLLECTION ARRAYS
DO 100 JVARBL=1,20
100 CALL ZROSUM(SUM,JVARBL)
DO 200 IVARBL=1,10
CALL ZROSUM(SUM2,IVARBL)
CALL ZROSUM(SUM3,IVARBL)
200 CALL ZROSUM(SUM4,IVARBL)

```

```

C
C
C PRESET FARROWING DATES FOR FIRST YEAR
C
    IFAR(1,1)=15
    IFAR(2,1)=60
    IFAR(3,1)=152
    IFAR(4,1)=198
    IFAR(5,1)=244
    IFAR(6,1)=335
C
C
C
C MARK BEGINNING OF PRINTED OUTPUT
    WRITE(ND,606)ND
    WRITE(NT7,606)NT7
    WRITE(NW,606)NW
606  FORMAT(*8   BEGIN PRINT TAPE*I4* REPORTS*)
C
C
C READ NR=TAPE5 DATA AND LIST THEM.
    READ(NR,705) RR
705  FORMAT(10A8)
706  FORMAT(///* FREE FORM IDENT CARD FOLLOWED BY*
2 * DEFAULT DATA, USER OPTION CARDS *//* APPEAR AFTER THE *
3 *CORRESPONDING DEFAULT CARD*/5X,10A8)
    READ(NR5,705) RR
    WRITE(ND,706) RR
C
C READ STANDARD 10F7.0, FIRST CELL IS CARD NO., OTHERS
C REPLACE WITH NON-BLANK CELLS IF FIND USER OPTION CARD NO.
C
30    READ(NR,50) RR
    WRITE(ND,60) RR
    IR=RR(1)
    IF(IR.EQ.8888) GO TO 999
355  READ(NR5,50) STRR
    MR = STRR(1)
    IF(MR-999) 301, 354, 354
301  IF(MR-IR) 355, 305, 355
305  WRITE(ND,60) STRR
    DO 353 I=1,10
    IF(I$HFTR(I$TRR(I),48).EQ.XMINUS) STRR(I)=RR(I)
353  RR(I)=STRR(I)
50    FORMAT(10F7.0)
60    FORMAT(5X,10F9.3)
354  REWIND NR5
    READ(NR5,705) ALPHA
    IF(IR.GT.20) GO TO 500
    GO TO(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20) IR
C
C ISIZE OF OPENING INVENTORY HERDS
1    ISIZE=RR(2)
C
    GO TO 30
C FARROWING CONTROL
2    LBREED=RR(2)
    NBREED=RR(3)
    KAGEW=RR(4)
    LGTHW=RR(5)
    NAGEM=RR(6)
    GO TO 30

```

C SURVIVAL PROBABILITIES, CONVERT TO DAILY, PUT INTO /SURVIV/.

3 PW1=(1.-RR(2))\*\*(1./7.)  
PW23=(1.-RR(3))\*\*(1./14.)  
PSRT=(1.-RR(4))\*\*(1./35.)  
PSRT2=(1.-RR(5))\*\*(1./35.)  
PSFIN=(1.-RR(6))\*\*(1./124.)  
PSOWS=(1.-RR(7))\*\*(1./365.)  
PBORS=(1.-RR(8))\*\*(1./365.)  
PBORS1=(1.-RR(9))\*\*(1./365.)  
GO TO 30

C  
C FILL /BRED2/ AND /BRED3/  
C ABNORMAL GILTS, ESTRUS LENGTH, PROBABILITY OF CONCEPTION, ADJ. NO BORN

4 ABNORG=RR(2)  
ESTM=RR(3)  
ESTS=RR(4)  
EMIN=RR(5)  
EMAX=RR(6)  
PCON1=RR(7)  
PCON2=RR(8)  
ADJ1=RR(9)  
ADJ2=RR(10)  
GO TO 30

C GESTATION LENGTH AND PREMATURE TERMINATION.

5 GESM=RR(2)  
GESS=RR(3)  
GMIN=RR(4)  
GMAX=RR(5)  
PTRM1=1.-((1.-RR(6))\*\*(1./7.))  
PTRM2=1.-((1.-RR(7))\*\*(1./100.))  
PTRM16=1.-((1.-RR(8))\*\*(1./7.))  
GO TO 30

C  
C FILL /BIRTH/

6 BRNM=RR(2)  
BRNS=RR(3)  
BMIN=RR(4)  
BMAX=RR(5)

C  
C WEIGHTS FILLED INTO /BIRTH/

BWTM=RR(6)  
BWTS=RR(7)  
BWMIN=RR(8)  
BWMAX=RR(9)  
GO TO 30

C  
C WEIGHT INTO /GAIN/

7 GW1=RR(2)  
GW23=RR(3)  
GSRT=RR(4)  
GFIN1=RR(5)  
GFIN2=RR(6)  
SDP=RR(7)/100.  
GO TO 30

C  
C SALES CONTROL INTO /SALES/

8 MDSELL=RR(2)  
WTS=RR(3)  
PRIH=RR(4)  
PRIS=RR(5)  
DIS=RR(6)/100.

GO TO 30

169

C  
C  
C SOW GAINS  
9     GSOWM=RR(2)  
     SSOWM=RR(3)  
     GSOWL=RR(4)  
     SSOWL=RR(5)  
C       ADD TO /CLEAN/  
     SWTLP=RR(6)  
     SSLP=RR(7)  
     GO TO 30  
C  
C OPENING INVENTORY, BOARS - NEW, YOUNG, THEN MATURE.  
10    NB1=RR(2)  
     IF(NB1.LT.1) GO TO 6200  
     DO 6101 K= 1,NB1  
     IATRIB(1)=RR(3)  
     IATRIB(2)=1  
     IATRIB(3)=1  
     IATRIB(4)=1  
     IATRIB(5)=88\*1000+K  
     ATRIB(1)=RR(4)  
     ATRIB(2)=RNORM(GSOWM,SSOWM,-5.,10.)  
     CALL FILEM(IN,VEN,8)  
6101  CONTINUE  
C  
6200  NB2=RR(5)  
     IF(NB2.LT.1) GO TO 6300  
     DO 6201 K=1,NB2  
     IATRIB(1)=RR(6)  
     IATRIB(2)=1  
     IATRIB(3)=2  
     IATRIB(4)=1  
     IATRIB(5)=88\*1000+NB1+K  
     ATRIB(1)=RR(7)  
     ATRIB(2)=RNORM(GSOWM,SSOWM,-5.,10.)  
     CALL FILEM(IN,VEN,8)  
6201  CONTINUE  
C  
6300  NB3=RR(8)  
     IF(NB3.LT.1) GO TO 30  
     DO 6301 K=1,NB3  
     IATRIB(1)=RR(9)  
     IATRIB(2)=1  
     IATRIB(3)=3  
     IATRIB(4)=1  
     IATRIB(5)=88\*1000+NB2+NB1+K  
     ATRIB(1)=RR(10)  
     CALL FILEM(IN,VEN,8)  
6301  CONTINUE  
     GO TO 30  
C  
C  
C CULLING OF GILTS AND SOWS IN /CULL/  
11    NGLTS=RR(2)  
     MXSRV=RR(3)  
     MXAGS=RR(4)  
     PCULG=RR(5)/100.  
     PCULS=RR(6)/100.  
     MXBOR=RR(7)  
     LDP=RR(8)  
     GO TO 30

C  
C CONCEPTION ADJUSTMENT, ADDED TO /CULL/  
12 PSSR=RR(2)  
PRGT=RR(3)  
GO TO 30

C  
C COST CARD  
13 FCS=RR(2)  
FCB=RR(3)  
CLAB=RR(4)  
TFAR=RR(5)  
TNUR=RR(6)  
TSOW=RR(7)  
TFIN=RR(8)  
GO TO 30

C  
C BUILDING OPTIONS, BUILDINGS ARE NOT IN FILES AS ARE ANIMALS.  
14 MX1=RR(2)  
NDPREV=RR(3)  
X1=RR(4)  
GO TO 30  
15 MX2=RR(2)  
X2=RR(3)  
GO TO 30  
16 MX3=RR(2)  
GO TO 30  
17 MX4=RR(2)  
X4=RR(3)  
GO TO 30

C  
C NO SUCH CARDS  
18 GO TO 1350  
19 GO TO 1350

C  
C BOAR MANAGEMENT OPTIONS  
20 MXSDY=RR(2)  
MXSWY=RR(3)  
MXSDM=RR(4)  
MXSWM=RR(5)  
NPUR=RR(6)  
IPDAT=RR(7)  
KAGE=RR(8)  
WTPB=RR(9)  
GO TO 30

C  
C CARDS 51. AND GREATER

C  
500 IF(IR-51) 1350,51,502  
502 IF(IR-53) 52, 53, 504  
504 IF(IR-55) 54, 55, 506  
506 IF(IR-57) 56, 57, 508  
508 IF(IR-59) 58, 1350, 1350 -

C  
C SIMULATION CONTROL -N DAYS, NRUNS  
51 NDAYS=RR(2)  
SEED=RR(3)  
SEED=RANF(SEED)  
MAXSKP=RR(4)  
NRNOPT=RR(5)  
KRS4=RR(6)  
GO TO 30

C

C NO CARD 52.

52 GO TO 1350

C PRODUCTION SUMMARY REPORT CONTROL

53 ISMYP=RR(2)

ISMB=RR(3)

ISMBG=RR(4)

ISMF=RR(5)

ISMW=RR(6)

ISMM=RR(7)

ISMM=RR(8)

GO TO 30

C

C COSTS AND RETURNS SUMMARY REPORT CONTROL

54 ISMYC=RR(2)

ISMCS=RR(3)

ISMCH=RR(4)

ISML=RR(5)

ISMSS=RR(6)

ISMSH=RR(7)

ISMGR=RR(8)

GO TO 30

C

C EVENTS AS THEY OCCUR REPORT CONTROL

55 MJEV=RR(2)

ISALS=RR(3)

IFARS=RR(4)

IBRDS=RR(5)

GO TO 30

C

C

C DAILY INVENTORY REPORT CONTROL

56 IDC5=RR(2)

IDCE=RR(3)

IDCN=RR(4)

IDCF=RR(5)

IDCM=RR(6)

IDCB=RR(7)

IDCFS=RR(8)

IDCFP=RR(9)

IOFLW=RR(10)

GO TO 30

C

C INDIVIDUAL DAILY ANIMAL ATTRIBUTES CONTROL

57 IAAS=RR(2)

IAAE=RR(3)

IAAN=RR(4)

IAAFN=RR(5)

IAAM=RR(6)

IAAB=RR(7)

IAAFR=RR(8)

GO TO 30

C

C NS1, NS2 DIAGNOSTIC SWITCHES

58 NS1=RR(2)

NS2=RR(3)

GO TO 30

1350 WRITE(ND,1351) RR(1)

1351 FORMAT(\* ERROR SUB. INITN, DATA CARD .GT. PERMITTED,=\*F8.2)

GO TO 30

C

999 DAY=DATE(0)

REWIND NR5  
READ(NR5,705) RR  
WRITE(NW,998)NDAYS,DAY,RR  
998 FORMAT(1H1,//18X\*SWINE BREEDING HERD SIMULATOR\*//7X  
2\*REQUEST IS FOR\*I4\* DAYS,  
3\*DATE IS \*A8/  
37X\*YOUR IDENTIFICATION CARD=\*//17X,10A8)  
C  
RETURN  
END

OPEN

```

SUBROUTINE OPEN(IN, VEN)
CCMNON/INIT/NR,NW,ND,NT7,NT8,NDAT,NS1,NS2
3 /STAT/ SUM(5,20),SUM2(5,10),SUM3(5,10),SUM4(5,10)
4 /GEN/ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5 /HOUSE/ NH(6),N1,N2,N3,N4,N5,N6
5/CLEAN/DLM(5),KL4
4 /BIRTH/ BRNM,BRNS,BMIN,BMAX,BWTM,BWTS,BWMIN,BWMAX,NCBRN
8 /BRED2/ ABNCRG,GESM,GESE,GMIN,GMAX,ESTM,ESTS,EMIN,EMAX
3/GAIN/GW1,GW23,GSRT,GFIN1,GFIN2,GSOWM,GSCWL,SDP,SSCWM,SSCWL'
4/GAIN2/SCP(6),HOP(6),SSL(6),HSLD(6),SEND(6),HEND(6)
6/SALES/DUMMY(15),PRIH,PRIS
DIMENSION IN(3,1),VEN(2,1)

```

C

C

```

C READ IN BASIC HERD DATA FROM TAPE NCAT.
C     BASE HERD IS 30 SCW AND 219 FINISHING HCGS.,
C     SOWS ARE READY TO FARRCW, HCGS ARE 5.5-6.0 MCNTHS.
C CREATE OPENING INVENTCRY FOR 6 FARRCWING SYSTEM, AT T=0.
C     -ADJUST ATTRIBUTES TC T=0 FCR SCWS AND FINISHING, CREATE
C     BABY PIGS FOR HERD GROUP NUMBER THREE.
C     - ADJUSTMENTS FCR 3 HERD GRCUPS TC FARRCW BEGINNING-
C             HERD 1 JANUARY 15(T=15), AND JULY 15(T=196)
C             HERD 2 MARCH 1(T=60), AND SEPTEMBER 1(T=244)
C             HERD 3 JUNE1(T=152), AND DECEMBER 1(T=335)
C
C LET ITOT= TOTAL NUMBER OF ANIMALS AT ANY TIME DURING SIMULATION.
C LET ISIZE= NO. OF SOWS IN EACH HERD GRCUP CREATED.
C ATTRIBUTES ARE CCNTRCL PARAMETER DEPENDENT.
C
C

```

```

SIZE=ISIZE
IFIN=SIZE*(BRNM*.78)+.5
C LCOP 3 HERDS, ID=1 IMPLIES SCW ADJUSTMENT, ID=2 FINISHING .
C

```

```

DC 9999 IHERD=1,3
REWIND NDAT
ID=1
550 READ(NDAT,500) IAGE, JSEX, KLAS, LTAL, LCCA, MNUM, WT
500 FFORMAT(I4,I1,I1,I3,I3,I6,7X,F5.0)
IF(IAGE.NE.6666) GC TC 449
REWIND NDAT
GO TO 550

```

```

449 IF(IAGE.NE.7777) GC TO 551
REWIND NDAT
DC 776 KI=1,31
776 READ(NDAT,6666)
GO TO 550

```

```

551 IF(LOCA.GT.10) LOCA=LOCA/100
GC TC (1001,2001,3001)IHERD
C HERD 1, ADJUST BACK 15 DAYS

```

```

1001 IF(ID.EQ.2) GC TO 1031
LTAL=LTAL-15
WT=WT-12.

```

```

131 IAGE=IAGE-15
MNUM=ITOT+1+10000
3 IATTRIB(1)=IAGE
IATTRIB(2)=JSEX
IATTRIB(3)=KLAS
IATTRIB(4)=LTAL
IATTRIB(5)=MNUM
ATTRIB(1)=WT

```

```

ATRIB(2)=G
CALL FILEM(IN, VEN, LCCA)
IF(IHERD.EQ.2) GC TC 550
IF(NH(3).GE.ISIZE.A.ID.EQ.1) GC TO 77
IF(NHCGS.GE.IFIN) GO TC 9999
GC TC 550
1031 NHOGS=NHCGS+1
IF(IAGE-149) 1032, 1032, 1033
1032 G=RNCRM(GFIN1,GFIN1*SDP,-5.,10.)
GC TC 131
1033 G=RNCRM(GFIN2,GFIN2*SDP,-5.,10.)
GC TO 131
C HERD I, ADJUST BACK 60 DAYS
2001 IF(ID.EQ.2) GO TO 2031
IH2= IH2+1
IF(IH2.GT. ISIZE) GC TO 77
LTAL=LTAL-60
WT=WT-48.
231 IAGE=IAGE-60
MNUM=ITOT+1+20000
G=RNCRM(GFIN1,GFIN1*SDP,-5.,10.)
GC TO 3
2031 NHOGS=NHOGS+1
IF(NHCGS.GT.IFIN)GC TC 9999
WT=WT-107.1
GO TC 231
C HERD 3, ADD 30 DAYS TC AGE, CREATE BABY PIGS FOR EACH SOW.
3001 CC 333 II=1,ISIZE
IAGE=IAGE+30
KLAS=KLAS+1
LTAL=30+LTAL-114
LCCA=LCCA-2
WT=WT-0.8*LTAL
MNUM=ITCT+1+30000
NCSOW=MNUM
AGE=IAGE+GESM
C ADJUST NO. PIGS FOR AGE SCW, DEVIATION OF MEAN -BRNM- FROM 10 INTERCE
C ASSUME NG SCWS CVER 1300 DAYS IN OPENING INVENTCRY.
V=BRNM-10.
BR=V+5.867+.01*AGE-.00000446*AGE**2.
IPIGS=RNCRM(BR,BRNS,BMIN,BMAX)+0.5
IATRIB(1)=IAGE
IATRIB(2)=JSEX
IATRIB(3)=KLAS
IATRIB(4)=LTAL
IATRIB(5)=MNUM
IATRIB(8)=IPIGS
ATRIB(1)=WT
CALL FILEM(IN, VEN, LCCA)
C CREATE BABY PIGS FOR SCW II LOOP
CC 380 IK=1,IPIGS
IAGE=LTAL
IF(RANUM(C).GT.0.5) 101,102
101 JSEX=2
KLAS=1
GO TO 103
102 JSEX=3
KLAS=0
C CALCULATE WEIGHT BY BIRTH WT. + .5 LB. DAY, STD.=3.6
103 BTWT=RNORM(BWTM,BWTS,BWMIN,BWMAX)
WT=BTWT+RNORM(.5*IAGE,3.6,5.0,25.0)
MNUM=ITOT+1+30000

```

IBT=BTWT\*100.  
IATRIB(1)=IAGE  
IATRIB(2)=JSEX  
IATRIB(3)=KLAS  
IATRIB(5)=MNUM  
IATRIB(8)=NOSCW  
IATRIB(11)=IBT  
ATRIB(1)=WT  
CALL FILEM(IN,VEN,4)

380 CCNTINUE  
381 READ(NDAT,500)IAGE,JSEX,KLAS,LTAL,LCCA,MNUM,WT  
IF(IAGE.NE.6666) GO TO 331  
REWIND NDAT  
GO TO 381  
331 LCCA=LCCA/100  
333 CCNTINUE  
GO TO 9999

C  
C DUMMY READ SKIPS SOW DATA RECCRDS  
77 READ(NDAT,6666)NSTOP  
6666 FCRMAT(I4)  
IF(NSTCP.EQ.6666) GO TO 6667  
GO TO 77  
6667 ID=2  
NHOGS=0  
IH2=0  
GO TO 550

C  
C  
C SET FARROWING HOUSE LITTER COUNT KL4.  
9999 KL4=ISIZE  
C ADD ESTRLS CYCLES TO COPENING INVENTCRY SOWS IN PRODUCTION.  
LNH4=NH(1)  
DC 678 K4=1, LNH4  
CALL REMOV(IN, VEN, 1)  
IF(IATRIB(1)-21) 673, 673, 671  
623 ATRIB(2)=RNORM(GW23, GW23\*SDP,-5.,10.)  
GO TO 678  
671 IF(IATRIB(1)-200) 673, 673, 675  
673 ATRIB(2)=RNORM(GSRT, GSRT\*SDP,-5.,10.)  
GO TO 678  
675 IATRIB(10)=RNCRM(ESTM,ESTS,E MIN,E MAX)+0.5  
ATRIB(2)=RNCRM(GSCWL,SSCWL,-5.,10.)  
678 CALL FILEM(IN, VEN, 4)  
LNH6=NH(3)  
DC 567 K6=1, LNH6  
CALL REMCV(IN, VEN, N2+1)  
A=IATRIB(1)  
C=BRNM-10.  
BR=C+5.867+.01\*A-.0000446\*A\*\*2.0  
IATRIB(8)=RNORM(BR, BRNS, B MIN, B MAX)+0.5  
IATRIB(10)=RNCRM(ESTM,ESTS,E MIN,E MAX)+0.5  
IATRIB(11)=RNCRM(GESM,GESS,G MIN,G MAX)+0.5  
ATRIB(2)=RNCRM(GSCWM,SSCWM,-5.,10.)  
567 CALL FILEM(IN, VEN, 6)

C  
C  
C OPENING INVENTORY WEIGHTS AND VALUE  
C SOWS AND HOGS COUNT AND WT ONLY.  
C ARRAYS GAIN2- 1=NC., 2=WT., 3=VALLE OF WT.  
DC 7009 I=1,ITCT  
ICHK=IN(1,I)/10000000000  
IF(ICFK-240) 7001, 7005, 7005

C HOGS AND PIGS .LT. 240 DAYS OF AGE.  
7001 HOP(1)=HOP(1)+1.  
 HOP(2)=HOP(2)+VEN(1,I)  
 HOP(3)=HOP(3)+VEN(1,I)\*PRIH/100.  
 GO TO 7009  
C COVER 240 DAYS OF AGE.  
7005 SCP(1)=SCP(1)+1.  
 SCP(2)=SOP(2)+VEN(1,I)  
 SCP(3)=SOP(3)+VEN(1,I)\*PRIS/100.  
7009 CCNTINUE  
C  
C IF(NS1.EQ.13) CALL CLT(IN,VEN,1,ITOT,131313.9)  
C  
 RETURN  
 END

MGT

```

SUBROUTINE MGT(IN, VEN, EGARR)
CCMMON/INIT/NR,NW,NC,NT7,NT8,NCAT,NS1,NS2,NCWD
2 /RAA/ IRN(54),KRAALM,RLIMIT,ARNCPT,ITAPE
3 /STAT/ SUM(5,20),SUM2(5,10),SUM3(5,10),SUM4(5,10)
4 /GEN/ ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5 /HOUSE/ NH(6),N1,N2,N3,N4,N5,N6,NXTFAR,MX1,MX2,MX3,MX4
6 /SALES/ MDSELL,WTS,NXTSAL,NSLC(4),WTSLC(4),VSLC(4),PRIH,PRIS
7 /BRED/ LBREED,NBREED,IFAR(30),IDB(30),KAGEW,LGTHW,NAGEM
8 /BRED2/ ABNORG,GESM,GESS,GMIN,GMAX,ESTM,ESTS,EMIN,EMAX
9 /BRED3/ PTRM1,PTRM2,PTRM16,PCCN1,PCCN2,ADJ1,ADJ2
1 /SKIP/ ISTOP4,ISTCP5,ISTCP6,ISTOP7,MAXSKP
2 /SLRVIV/ PW1,PW23,PSRT,PSFIN,PSOWS,PBORS,PBCRS1,MCEAC(8)
3 /GAIN/ GW1,GW23,GSRT,GFIN1,GFIN2,GSCWM,GSOWL
4 /BIRTH/ BRNM,BRNS,BMIN,BMAX,BWTM,BWTS,BWMIN,BWMAX,NCBRN
5 /CLEAN/ NDPREV,NH4CLN,LCSSL
7 /KRS/ KRS1,KRS2,KRS3,KRS4,KRS5,KRS6,KRS7,KRPT
CCMMON/RPT5/ IAAS, IAAE
1/RPT1/ISMYP,ISMB,ISMBG,ISMF,ISMW,ISMS,ISM
3 /SCH/KS(2,500),IPT,IEVT,KCDE,IWE,IWN(44),NKT
6/WRT1/KW

```

```

DIMENSION IN(3,1),VEN(2,1)
C GENERAL MANAGEMENT OF THE SIMULATION RUN.
C
C LET MGT2 BUILD EVENTS FILE INTO ARRAY KS(2,500)
C
KCDE=1
CALL MGT2(IN, VEN)
C
C
C
C LLOOP NCAYS OF SIMULATION, INCREMENTING NCWT AND NCWY.
C
C ISTOP4-7 SET TO NCAYS HERE, MAY TEMPORARILY LOWER ELSEWHERE.
    KRS2=ISMYP
    ISTCP4=KRS2
    ISTOP5=KRS2
    ISTOP6=KRS2
    ISTOP7=KRS2
C
    NOWT=0
C
C
C INDIVIDUAL DAILY ANIMAL ATTRIBUTE CALL 7777
    CALL CUT(IN, VEN, 7777)
    IF(NS2-2) 8888,788,8888
788    CALL CUT(IN, VEN, 1, ITCT, 2788.0)
C
C
8888    NCWT=NOWT+1
        NCWY=(NOWT-1)/365+1
        NCWD=NOWT-(NOWY-1)*365
C
C
        CALL EVNTS(IN, VEN)
C
C INDIVIDUAL DAILY ATTRIBUTE REPCRT IN SUB. CUT(,,,7777)
        IF(IAAS-NCWT) 782, 782, 786
782    IF(IAAE-NCWT) 786, 784, 784
784    CALL CUT(IN, VEN, 7777)
        IF(NS2-2) 786, 785, 786

```

785 CALL CUT(IN, VEN, 1, ITCT, 28888.7)  
C CALL MGT3 EVERY DAY, TEST FOR DAILY INVENTORY REPORT THERE.  
C  
C KRS1 SWITCH SENSES CHANGE IN TOTAL INVENTORY  
786 IF(ITCT-KRS1) 787, 789, 787  
787 KRS1=1  
789 CALL MGT3(IN, VEN)  
KRS1=ITOT  
C  
C  
C PRODUCTION SUMMARY REPORTS CALLED  
C KRS2 HOLDS DAY OF NEXT CALL  
IF(NCWT-KRS2) 80C, 4C1, 4C1  
401 KRS2=KRS2+ISMYP  
ISTOP4=KRS2  
ISTOP5=KRS2  
ISTOP6=KRS2  
ISTOP7=KRS2  
IF(ISMB)5 ,5, 404  
404 KW=4  
CALL REPT1(IN, VEN)  
KW=0  
5 IF(ISMBG) 6, 6, 505  
505 KW=5  
CALL REPT1(IN, VEN)  
KW=0  
6 IF(ISMF) 7, 7, 606  
606 KW=6  
CALL REPT1(IN, VEN)  
C  
C PRODUCTION GAINS AND COST SUMMARY REPORTS IN SUB. REPT1,  
C SUB. REPT1 CALLS REPT2 FOR COSTS AND RETURNS  
C  
7 KW=7  
CALL REPT1(IN, VEN)  
KW=0  
800 CCNTINUE  
C  
CALL SECOND(T)  
KT=T  
IF(KT-KRS4) 8C1, 8C1, 999  
999 WRITE(NW, 961) KRS4, ITCT, NCWT  
961 FFORMAT(///\* STOP DUE TO TIME EXCEEDING LIMIT OF\*I6  
2\* SECCNDS, TOTAL NC. ANIMALS=\*I6\* AT DAY=\*I5)  
STOP  
801 CCNTINUE  
C  
C  
88 IF(NOWT.LT.NDAYS) GC TC 8888  
C  
C  
RETURN  
END

MGT2

```

SUBROUTINE MGT2(IN, VEN)
CCMMCN /INIT/NR,NW,NC,NT7,NT8,NCAT,NS1,NS2
4 /GEN/ ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5 /HCUSE/NH(6),N1,N2,N3,N4,N5,N6,NXTFAR,MX1,MX2,MX3,MX4
6/SALES/MSELL,WTS,NXTSAL
7 /BREC/ LBREED,NBREED,IFAR(6,5),ICB(30),KAGEW,LGTHW,NAGEM
8 /BREC2/ ABNCRG,GESM,GESS
1 /SKIP/ ISTOP4,ISTCP5,ISTCP6,ISTOP7,MAXSKP
5 /CLEAN/ NDPREV,NH4CLN,LOSSL
1 /BOAR/ MXSDY,MXSWY,MXSCM,MXSWM,NPUR,IPCAT,KAGE,WTPB,IBS
3 /SCH/ KS(2,500),IPT,IEVT,KCCE,IWE
3/RPT3/ MJEV

```

C

C

C MGT2 SETS UP SCHEDULES IN ARRAY KS(2,500) AND THEN SENDS THEM TO EVM

C

C IFAR(I,1), I=1,6 IS FIRST YEARS FARROWING SCH. FROM S. INIT  
 C IEVT 1=SELECT, NGLTS PRICR TO EACH BREEDING.  
 C 2=BREED, ON FCR LBREED DAYS WITH IBS=1, CFF IBS=2  
 C 3=CLEAN4, PREVIOUS TO FARROWING BY NCPREV DAYS.  
 C 4=WEAN, ON FCR LGTHW DAYS WITH IWE=1, CFF IWE=2  
 C 5=SELL, EVERY MSELL DAYS.  
 C 7=BCAR PURCHASES  
 C 6=UPDATES -CALLED EVERY DAY, NOT INC. IN SCH. IN KS(,)

C

C BRANCH TO 1000 FOR SET UP, TO 2000 FCR USING THE SCHEDULE.

C

```
IF(KCCE-2)1000,2000,1390
```

C

C COMPLETE FARROWING DATES ARRAY.

```
1000 DO 365 I=1,6
```

```
DO 365 K=2,5
```

```
365 IFAR(I,K)=IFAR(I,1)+365*(K-1)
```

C

C CALCULATE BREEDING DATES ARRAY ICB().

```
DO 114 K=1,5
```

```
M=(K-1)*6
```

```
DO 114 I=1,6
```

```
114 ICB(I+M)=IFAR(I,K)-GESM+GESS
```

```
IF(NS1.EQ.3) WRITE(ND,1314) IDB
```

```
1314 FORMAT(/* MGT2 SET UP BREEDING SEASONS=/*10X,15I5/
```

```
2 10X,15I5/)
```

C

C

C FILL DAY TO START BREEDING AND STCP BREEDING, START SET AT CFF

```
IBS=2
```

```
II=0
```

```
DO 101 I=1,60,2
```

```
II=II+1
```

```
KS(1,I)=IDB(II)
```

```
KS(2,I)=2
```

```
KS(1,I+1)=KS(1,I)+LBREED
```

```
101 KS(2,I+1)=2
```

C

C FILL DAY TO SELECT GILTS

```
IAJ=GESM-114
```

```
CC 103 I=61,90
```

```
KS(1,I)=ICB(I-60)-101+IAJ
```

```
103 KS(2,I)=1
```

C

C FILL DAY TO CLEAN HOUSE 4 NDPREV TO FARROWING.

```

IAJ=GESM-GESS-NDPREV
DC 105 I=91,120
KS(1,I)=ICB(I-90)+IAJ
105 KS(2,I)=3
C
C FILL DAY TO BEGIN WEANING PROCESS, SET UP LATER FOR LGTHW DAYS.
IAJ= KAGEW+GESM-GESS
DC 107 I=121,150
KS(1,I)=ICB(I-120)+IAJ
107 KS(2,I)=4
C
C FILL SELL EVENTS, NO. DEPENDING UPON SIZE OF MSELL.
ICG=NDCAYS/MSELL+150
IF(ICG.GT.498) WRITE(ND,1309) IDO
1309 FFORMAT(* ERRCR MGT2, ATTEMPT TO LOAD*I4* ITEMS INTO*
2 * SCHEDULE ARRAY KS(2,500).*)
NXTSAL=1
IDAT=1
DC 109 I=151,IDO
KS(1,I)=IDAT
KS(2,I)=5
109 ICAT=IDAT+MSELL
C
C      ADD ONE FOR LAST DAYS.
KS(1,IDO+1)=NDAYS
KS(2,IDO+1)=5
C
C FILL BOAR PURCHASE DATES CCDE=7
K7=IDC+1
DC 201 I=1,5
K7=K7+1
IDAT=IPDAT+(365*(I-1))
KS(1,K7)=IDAT
201 KS(2,K7)=7
C
C
C SPECIAL WEAN FOR OPENING INVENTORY PIGS, 30 DAY MIN AGE WEAN.
C
IDAT=KAGEW-30
IF(ICAT.LT.1) IDAT=1
KS(1,K7+1)=IDAT
KS(2,K7+1)=4
C
C ORDER THSE EVENTS BY TIME, I.E. ROW 1.
C      BUBBLE SORT
I=1
10 J=I
11 IF(KS(1,I)-KS(1,I+1)) 98, 98, 9
   KTS1=KS(1,I)
   KTS2=KS(2,I)
   KS(1,I)=KS(1,I+1)
   KS(2,I)=KS(2,I+1)
   KS(1,I+1)=KTS1
   KS(2,I+1)=KTS2
   IF(I .EQ. 1) GO TO 98
   I=I-1
   GO TO 11
98 I=J+1
   IF(I.LT.500) GO TO 10
C      FINISHED W. BUBBLE SCRT.
C
C DROP EMPTY COLUMNS AND THESE SCHEDULED BEFORE NCWT=1

```

```
IF(KS(1,1).GT.0) RETURN
DC 117 I=1,500
IF(KS(1,I).LT.1) GC TC 117
CC 118 K=1,I

C
C      PREVENT EXCEEDING DIMENSIONS.
L=I+K-1
IF(L-501)144, 119, 119
144 KS(1,K)=KS(1,L)
118 KS(2,K)=KS(2,L)
117 CCNTINUE
119 IPT=0
C
C
C ND TAPE WRITE SCHEDULE
IF(MJEV) 1306, 1306, 1302
1302 WRITE(ND,1303) NDAYS
1303 FCRMAT(//,3X*SCHECLLE CF EVENTS SET UP FCR A RUN CF*I5
2*DAY$*/,,5X*CCDES FCLLCWING DATES ARE 1=SELECT, 2=*
3 *BREED, 3=CLEAN4, 4=WEAN, 5=SELL, 6=UPDATE, 7=BUY BOARS*)
C
IID0=IDC+1
WRITE(ND,1305)((KS(I,J),I=1,2),J=1,IID0)
1305 FORMAT((3X,12(I6,I2)/))
1306 RETURN
C
C
C KODE 2000 FCR FINDING NEXT EVENTS.
C
2000 IPT=IPT+1
IF(KS(1,IPT)-NOWT) 2000, 300, 400
C
C EXECUTE THE EVENT.
300 IEVT= KS(2,IPT)
RETURN

C
C NEXT DAY ITEM.
400 IPT=IPT-1
IEVT=6
RETURN
1390 WRITE(ND,1391) NCWT,IPT,KODE,IDC
1391 FCRMAT(/* ERRCR MGT2, NCWT=*I6* IPT=*I4* KODE=*/
2 I3* IDC=*I7* RETLRNING*)
C
C
RETURN
END
```

MGT3

```
SUBROUTINE MGT3(IN, VEN)
COMMON /INIT/NR,NH,ND,NT7,NT8,NDAT,NS1,NS2
```

C

```
4 /GEN/ITOT,ISIZE,NCWT,NCHY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5/HOUSE/NH(6),N1,N2,N3,N4,N5,N6,NXTFAR,MX1,MX2,MX3,MX4,X1,X2,X4
2 /SURVIV/DUMY(7),MDEAD(8) /BIRTH/DUM(8),NOBRN
6 /SALES/ MSELL,WTS,NXTSAL,NSLD(4),WTSLD(4),VSLD(4),PRIH,PRIS
2 /MG3/ NHH(6),MDEADH(8),NHP(6),MDP(6),KCALL,KPRET,KNSLD4,KPREB
7 /KRS/ KRS1,KRS2,KRS3,KRS4,KRS5,KRS6,KRS7,KRPT
5 /CLEAN/NDPREV,NH4CLN,LCSSL,SWLTP,SSL,PL,KL4
3 /SCH/ KS(2,500),IPT,IEVT,KCCE,IWE,IWN(45),NKT
7 /BREC/ LBREED,NBREED,IFAR(6,5),ICB(30),KAGEW,LGTHW,NAGEM
3 /CCST/ FCS,FCB,CLAB,TFAR,TNUR,TSCW,TFIN
4 ,VAR(3),COST(30)
4 /RPT4/ IDCS,IDCE,ICCN,ICCF,ICCM,IDCB,ICCF,ICFLW
4 /CULL/NGLTS,MXSRV,MXAGS,PCULG,PCULS,PSSR,PRGT,MXBCR
3 /GAIN/GW1,GW23,GSRT,GFIN1,GFIN2,GSOWM,GSCWL,SCP,SSCWM,SSCWL
3 /STAT/SUM(5,20),SLM2(5,10),SLM3(5,10),SLM4(5,10),SLM5(5,10)
DIMENSION IN(3,1),VEN(2,1)
```

C

```
C KRS1 SWITCH IS SET=1 IN SUB. MGT IF HAS BEEN CHANGE IN INV.
```

C

```
C CALCULATE DIFERENCES
```

```
NSLD4=NSLD(4)-KNSLD4
```

```
NCBR=NOBRN-KPREB
```

```
DC 4K=1,5
```

```
NHP(K)=NH(K)-NHH(K)
```

4

```
MCP(K)=MDEAD(K+3)-MDEADH(K+3)
```

C

```
GO TO 789
```

500

```
WRITE(ND,510) NOBR, NCBRN
```

510

```
FCRMT(27X*PIGS BCRN*13X*==I9,I21/)
```

```
WRITE(ND,512)(MDP(J),MDEAD(J+3),J=1,5)
```

512

```
FCRMT(27X*FARROWING BLD. DEATHS ==I9,I21/
```

```
227X*NURSERY BLD. DEATHS ==I9,I21/
```

```
3 27X*SCW MAINT. BLD. DEATHS==I9,I21/
```

```
4 27X*FINISHING BLD. DEATHS ==I9,I21/
```

```
5 27X*BCAR DEATHS*11X*==I9,I21)
```

```
WRITE(ND,515) NSLD4,NSLD(4)
```

515

```
FCRMT(/27X*SALES CF BUTCHERS ==I9,I21)
```

C

C

```
GO TO 1271
```

C

789

```
KNSLD4=NSLD(4)
```

```
KPREB=NOBRN
```

```
KPRET=NOWT
```

```
DC 7 I=1,6
```

```
7 NHH(I)=NH(I)
```

```
DC 8 II=1,8
```

```
8 MDEADH(II)=MDEAD(II)
```

```
IF(NCWT-ICCS) 2000, 1201, 1201
```

1201

```
IF(NCWT-ICCE) 1203, 1203, 2000
```

C

C

```
C WRITE CONSECUTIVE DAILY INVENTCRY BY BUILDING IF REQUESTED.
```

```
1203 WRITE(ND,1205) NCWT, ITCT
```

```
1205 FORMAT(////5X*DAILY INVENTCRY CN DAY=*I5* TOTAL ANIMALS=*
```

```
216/5X,95(1H=))
```

```
IF(ICCN)1213, 1213, 1207
```

C NURSERY INFORMATION.

1207 NH2=NH(2)  
IF(NH2) 1213, 1213, 1209

1209 WT=0.  
NN1=N1+1  
DC 1210 I=NN1,N2

1210 WT=WT+VEN(1,I)  
AWT=WT/NH2  
WRITE(ND,1212) NH2, AWT

1212 FCRMAT(/6X\*NURSERY HAS\*I6\* PIGS AT\*F5.1\* LBS. AVE. WT.\* )  
C FINISHING BLD.

1213 IF(IDCFC) 1219, 1219, 1215

1215 NH4=NH(4)  
IF(NH4) 1219, 1219, 1216

1216 WT=0.  
NN1=N3+1  
DC 1217 I=NN1,N4

1217 WT=WT+VEN(1,I)  
AWT=WT/NH4  
WRITE(ND,1218) NH4, AWT

1218 FCRMAT(/6X\*FINISHING HAS\*I6\* PIGS AT\*F7.1\* LBS. AVE. WT.\* )  
C MAINTENANCE BUILDING + CULL PEN FOR SALE.

1219 IF(ICCM) 1227, 1227, 1221

1221 NH3=NH(3)  
IF(NH3) 1227, 1227, 1223

1223 LNCNC=0  
LCPEN=0  
LPREG=0  
DC 1225 I=1,NH3  
CALL REMOV(IN,VEN,N2+1)  
IF(IATRIB(3)-2) 1231, 1232, 1233

1231 LNONO=LNCNO+1  
GC TO 1225

1232 LCPEN=LCPEN+1  
GC TO 1225

1233 LPREG=LPREG+1

1225 CALL FILEM(IN,VEN,6)  
WRITE(ND,1226) NH3, LNCNC, LCPEN,LPREG, NH(6)

1226 FCRMAT(/6X\*MAINTENANCE HAS\*I5\* TOTAL SOWS CLASSED AS\*  
2\* FOLLOWS-\* /10X\*NCNOVULATING=\*I3\*, OPEN=\*I3\*, IN GESTATION=\*  
5I3/10X\*IN ADDITION\*I4\* SCWS AWAIT SALE IN THE CULL PEN\*)

1227 IF(IDCDB) 1241, 1241, 1228

1228 NH5=NH(5)  
IF(NH5) 1241, 1241, 1229

1229 WRITE(ND,1230) NH5

1230 FCRMAT(/6X\*BOARS TOTAL= \*I3)  
C FARROWING BLD. KL4= NC SCWS IN FARROWING HOUSE.

1241 IF(IDCFS) 1261, 1261, 1243

1243 IF(N1) 1261, 1261, 1245

1245 LPIGS=N1-KL4  
WRITE(ND,1247) N1, KL4, LPIGS

1247 FCRMAT(/6X\*FARROWING HAS\*I4\* TCTAL WHERE SOWS=\*  
2I3\*, PIGS=\*I4\*)

C SALES, BIRTHS, MORTALITY MISC.

1261 IF(IDCFC) 1271, 1271, 1263

1263 WRITE(ND, 1265)

1265 FORMAT(/6X\*BIRTHS, DEATHS, SALES MISC.\*/  
25CX\*CHANGE=\*10X\*TCTAL TC DATE=\*)

C USE STATEMENTS ABOVE.  
GC TO 500

1271 WRITE(ND,1273)

1273 FCRRFORMAT(/5X\*END DAILY INVENTCRY REPORT\*69(1H=))  
2000 CCNTINUE

C

C

C

C C OVERFLOW CHECKING AND REPCRTING  
C FARRCWING HOUSE CHECKED IN SLB. FAROW.

C

C NURSERY SEND OVERFLOW TO FINISHING.

C IF FINISHING IS FULL, NURSERY MAY BE CVERSTCCKED UP TO MX2\*X2.

C NURSERY PIGS ARE MCVED BY S. UPDATE AT OPTICN AGE.

C CAPACITY CALCULATION FCR PERCENT OCCUPANCY=SUM4( ,1)

RNH=NH(2)

RMX=MX2

CALL CCLLT(SUM4,1,RNH/RMX\*1CO.)

NI5=NH(2)

C IF FINISHING HAS RCOM APPLY MX2, ELSE MX2\*X2

IF(NH(4)-MX4) 251, 251, 253

251 MFLCW=NI5-MX2

GC TO 255

253 RNI5=N15

MFLCW=RNI5-RMX\*X2

255 IF(MFLCW ) 300, 300, 201

201 II=0

DC 203 I=1,MFLCW

205 CALL REMOV(IN,VEN,N1+1)

IF(IATRIB(1)-22) 211, 215, 215

211 CALL FILEM (IN,VEN,5)

GC TC 203

215 CALL FILEM(IN,VEN,7)

II=II+1

203 CCNTINUE

IF(IOFLW) 300, 300, 291

291 WRITE(ND,292) NOWT, II

292 FORMAT(/3X\*NURSERY CVERFLCW DAY=\*I5\*, \*I4

2 \*PIGS MCVED TO FINISHING\*)

C

C MAINTENANCE OVERFLOW CHECK AND REPCRTED ONLY.

C CAPACITY CALCULATION MAINT., SUM4( ,3)

300 RNH=NH(3)

RMX=MX3

CALL CCLLT(SUM4,3,RNH/RMX\*100.)

MFLCW=NH(3)-MX3

IF(MFLOW) 308, 308, 303

303 IF(ICFLW) 308, 308, 333

333 WRITE(ND,304) MFLCW, NCWT

304 FCRRFORMAT(/3X\*MAINTENANCE CVERFLCW BY\*I4\* SOWS, DAY=\*I5\*)

C

C FINISHING -FIRST NORMAL SALE, IF NOT SATISFIED CROP MIN. WEIGHT

C BY 10 LBS. AND SELL MORE UNTIL WITHIN MX4.

C MX4 CVERFLOW REPCRTED, BUT FCRRCE SELL ONLY AT MX4\*X4.

C CAPACITY CALCULATION- FINISHING, SUM4( ,2)

308 RNH=NH(4)

RMX=MX4

CALL CCLLT(SUM4,2,RNH/RMX\*100.)

SAVWTS=WTS

KISTCP7=ISTOP7

CHG=0.

LFLOW=RNH-RMX\*X4

C

C MX4 IS DESIGN CAPCITY, X4 IS CVER FLOW FACTOR ALLCWEQ,

C FORCED SALE TAKES PLACE ONLY IF MX4\*X4 IS EXCEEDED.

401 IF(LFLOW)408, 408, 403  
 403 WTS=WTS-CHG  
 IF(WTS.LT.191.) GO TO 407  
 CALL SELL(IN,VEN)  
 RNH4=NH(4)  
 LFLCW=RNH4-RMX\*X4  
 MFLCW=NH(4)-MX4  
 IF(ICFLW)400, 400, 418  
 418 WRITE(ND,419) WTS, MFLCW, NCWT  
 419 FCRMAT(/3X\*FINISHING OVERFLCW SALE AT MINIMUM WEIGHT=\*  
 2F5.0\* REDUCED CVERFLCW TC\*I4\* AT DAY=\*I5)  
 400 CHG=1C.  
 GO TO 401  
 407 WRITE(ND,406) NOWT, NH(4), MX4, X4  
 406 FCRMAT(/5X\*FINISHING HCLSE CVERFLCW SALES CURTAILED AT 190\*  
 2\* LBS. MINIMUM TO ALLCW HCG GRCWTH.\*/  
 3 10X\*DAY=\*I5\* BLD. HAS\*I6\* ANIMALS WITH CAPACITY=\*I6  
 4\* OVERFLOW FACTOR=\*F5.2)  
 408 WTS=SAVWTS  
 ISTCP7=KISTOP7  
 C  
 C  
 C CAPACITY CALCUL., FARROWING CRATES, OVERFLOW DCNE IN FARROW.  
 RNH=KL4  
 RMX=MX1  
 CALL CCLLT(SUM4,4,RNH/RMX\*100.)  
 C  
 C  
 C WEANING, FCLLCW NC. WEAN IN IWN(NKT).  
 C SCHEDULE MADE IN SUB. EVENTS.  
 C DAILY WEANING DCNE HERE.  
 C SEASCN ENDS WITH CLEANING DAY, SUB. CLEAN4.  
 C  
 IF(IWE-1) 5000, 4000,5000  
 C  
 C WEAN DURING WEANING SEASCN OF LGTHW DAYS.  
 4000 NKT=NKT+1  
 IF(NKT.GT.45) GO TO 5000  
 C  
 C NKT=CURRENT DAY OF SEASCN, IWN(NKT)= NO. TO WEAN.  
 IF(NKT) 4013, 4013, 4002  
 4002 NWN=IWN(NKT)  
 IF(NWN) 5000, 5000, 4005  
 4005 DO 4100 I=1,NWN  
 C  
 C FIND SCW AND REMCVE, THEN HER PIGS  
 FIRST IN FIRST CUT ORDER.  
 CALL FIND(0,1,4,4,KCL,IN,VEN)  
 IF(KCL) 4100, 4100, 4006  
 4006 CALL REMCV(IN,VEN, KCL)  
 IF(IATRIB(1)-200) 4013, 4013, 4008  
 4008 IATRIB(3)=2  
 IATRIB(4)=IATRIB(10)/3\*2+2  
 IATRIB(8)=0  
 IATRIB(11)=0  
 NAME=IATRIB(5)  
 ATRIB(2)=RNCRM(GSCWM,SSCWM,-5.,10.)  
 C  
 C PROBABILITY CULLING HERE AND IN SUB. CLEAN4.  
 C PRCB. PCULG FOR GILTS, PCULS FOR SCWS.  
 C IF CLLLED PUT IN FILE 9 FCR SALE AT NEXT SALE SCHEDULED.  
 RN=RANUM(D)

```
IF(IATRIB(1)-450) 4905, 4901, 4901
4901 PRCB=PCULS
4903 IF(PRCB-RN) 4909, 4909, 4908
4905 PROB=PCULG
GC TC 4903
C GET READY FOR NEXT SALE DATE NXSLAL, GAIN AT MAINT. RATES.
4908 ISKIP=NXSLAL-NOWT
SKIP=ISKIP
IATRIB(9)=IATRIB(9)+ISKIP
IATRIB(1)=IATRIB(1)+ISKIP
ATRIB(1)=ATRIB(1)+SKIP*RNCRM(GSOWM,SSOWM,-5.,10.)
CALL FILEM(IN,VEN,9)
GC TC 4018
4909 CALL FILEM(IN,VEN,6)
C LOOK FOR ABOVE SCWS LITTER.
4018 KCC=0
CALL FIND(NAME,5,4,8,KCC,IN,VEN)
IF(KCC) 4100, 4100, 4009
4009 CALL REMOV(IN,VEN,KCC)
IF(IATRIB(1)-200) 4011, 4100, 4100
4011 CALL FILEM(IN,VEN,5)
GC TC 4018
C
4100 CCNTINUE
GO TO 5000
C      DIAGNOSTIC WRITE.
4013 WRITE(ND,4014) NKT, IATRIB(1), NOWT
4014 FORMAT(/5X*SUBROUTINE MGT3 ERROR, NKT=*I5* AGE=*I5* AT DAY=*I5*)
C
C
5000 CCNTINUE
C
C      GATHER SCW DAYS IN MAINTENANCE AND LABR MINUTES HERE.
C      COST(1)=SCW DAYS, (2)=FARROW BLD. MIN,(3)=NURSERY BLD. MIN,
C      (4)=MAINT. BLD.MIN.,(5)=FINISHING BLD.MIN.
C      REPORT WRITER IS IN SUB. REPT2.
C      SCWS INCLUDE CULLS IN CULL PEN (IGNORES BOARS)
RNH=KL4
CCST(1)=CCST(1)+RNH+NH(3)+NH(6)
C      LABOR IN MINUTES
CCST(2)=CCST(2)+RNH*TFAR
CCST(3)=CCST(3)+NH(2)*TNUR
CCST(4)=COST(4)+(NH(3)+NH(6))*TSOW
CCST(5)=CCST(5)+NH(4)*TFIN
C
C
RETURN
END
```

## EVNTS

```

SUBROUTINE EVNTS(IN, VEN)
COMMON /INIT/NR,NW,NC,NT7,NT8,NCAT,NS1,NS2
4 /GEN/ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5 /HOUSE/NH(6),N1,N2,N3,N4,N5,N6
3/SCH/KS(2,500), IPT,IEVT,KODE,IWE,IWN(45),NKT
7 /BREC/LBREED,NBREED,IFAR(6,5),IDB(3C),KAGEW,LGTHW,NAGEM
1/SKIP/ISTOP4,ISTCP5,ISTCP6,ISTCP7,MAXSKP
4 /CULL/NGLTS,MXSRV,MXAGS,PCULG,PCULS,PSRR,PRGT
6 /SALES/MSELL
5 /CLEAN/DUM(5),KL4
1 /BOAR/MXSDY,MXSWY,MXSDM,MXSHW,NPUR,IPDAT,KAGE,WTPB,IBS
COMMON/WRT1/KW
4/BREC4/KBRD
      DIMENSION IN(3,1), VEN(2,1)

C
C GET EVENTS FROM FILE ONE AT A TIME AND CALL FOR EXECUTION.
C
C
C
      KODE=2
1111 CALL MGT2(IN, VEN)
      IF(IEVT-2) 1, 2, 33
      33 IF(IEVT-4) 3, 4, 55
      55 IF(IEVT-6) 5, 6, 77
      77 IF(IEVT-8) 7, 98,98
C
C
C UPDATE ALL ANIMALS, HOUSE AT TIME.
6   NDO1=NH(1)
      IF(NDC1.LT.1)GO TO 545
      NN=0
      DC 444 M=1,NDO1
      KCL=1+NN
      IF(MOD(IN(2,KCL),1000000).GE.NCWT) GO TO 443
      CALL REMOV(IN, VEN, KCL)
      CALL UPDATE(IN, VEN)
      GO TO 444
443  NN=NN+1
444  CCNTINUE
545  NDO2=NH(2)
      IF(NDC2.LT.1)GO TO 656
      NN=0
      KPN=N1
      DC 555 M=1,NDC2
      KCL=N1+NN+1
      IF(MOD(IN(2,KCL),1000000).GE.NCWT) GO TO 553
      CALL REMOV(IN, VEN, KCL)
      CALL UPDATE(IN, VEN)
      IF(N1.NE.KPN)NN=NN+N1-KPN
      KPN=N1
      GO TO 555
553  NN=NN+1
555  CCNTINUE
656  NDO3=NH(3)
      IF(NDC3.LT.1) GO TO 767
      NN=0
      KPN=N2
      DC 666 M=1,NDO3
      KCL=N2+NN+1
      IF(MOD(IN(2,KCL),1000000).GE.NCWT) GO TO 663
      CALL REMOV(IN, VEN, KCL)

```

```

CALL LUPDATE(IN, VEN)
IF(N2.NE.KPN)NN=NN+N2-KPN
KPN=N2
GO TC 666
663 NN=NN+1
666 CCNTINUE
767 NDO4=NH(4)
IF(NDC4.LT.1) GO TC 878
NN=0
KPN=N3
D0777 M=1,NDO4
KCL=N3+NN+1
IF(MOC(IN(2,KCL),1000000).GE.NCWT) GO TO 773
CALL REMOV(IN, VEN, KCL)
CALL LUPDATE(IN, VEN)
IF(N3.NE.KPN)NN=NN+N3-KPN
KPN=N3
GO TO 777
773 NN=NN+1
777 CCNTINUE
878 NDC5=NH(5)
IF(NDC5.LT.1) GO TC 99
DC 888 M=1,NDC5
CALL REMOV(IN, VEN, N4+1)
888 CALL LUPDATE(IN, VEN)
GC TC 99
C
C
C
C SELECT
C     MINIMUM AGE TARGET=150, 140 ALLOWS FCR VARIANCE.
1     CALL SELECT(IN, VEN, NGLTS, 140)
      GC TC 1111
C
C BREED FLIP SWITCH
2     IF( IBS .EQ. 2) GO TO 22
      IBS=2
C         SET=2 IMPLIES END OF SEASCN, CALL REPT1 WITH KW=3
      KW=3
      CALL REPT1(IN, VEN)
      KW=0
C         SET NC SCWS EXPOSED (TARGET NC.) =0.
      KBRD=0
      GC TC 1111
22    IBS=1
      GC TC 1111
C
C
C CLEAN4, SETS CLEAN FLAG=1.
3     CALL CLEAN4(IN, VEN)
      KL4=0
      GO TO 1111
C
C WEAN, SET HOUSE 4 NOT CLEAN.
4     NH4CLN=2
C
C NO. FARROWING WITHIN YEAR NOWY, STORE IN IFAR(30)
      IFAR(30)=IFAR(30)+1
      IF(IFAR(30)-6) 400, 400, 47
47    IFAR(30)=1
400    CCNTINUE
C

```

C  
C FIRST DAY WEANING, SET UP SCHEDULE HERE IN IWN(45)  
C SET BY SUB. CLEAN4.  
C NKT SET=0 FOR COUNTER START IN SUB. MGT3.  
NKT=0  
IWE=1  
C IF LGTHW=1 DAY, USE CLEAN4 TO WEAN ALL.  
IF(LGTHW-2) 401, 420, 420  
401 CALL CLEAN4(IN, VEN)  
GC TC 1111  
420 IF(KL4) 449, 449, 435  
C  
C SCHECULE -KL4- WEANINGS WITHIN -LGTHW- DAYS.  
C METHOD- ADD DIGITS FRCM RIGHT TO LEFT INTO THE  
C LGTHW WORDS CF IWN().  
435 KNT=0  
DO 437 I=1,45  
437 IWN(I)=0  
439 DO 441 K=1,LGTHW  
KK=LGTHW-K+1  
KNT=KNT+1  
IF(KNT-KL4) 440, 440, 449  
440 IWN(KK)= IWN(KK)+1  
441 CCNTINUE  
IF(KNT-KL4) 439, 449, 449  
C NKT= WEANING SEASCN DAY CCOUNTER FCR SUB. MGT3.  
449 NKT=0  
GC TC 1111  
C  
C SELL  
5 CALL SELL(IN, VEN)  
GC TO 1111  
C  
C BLY BCARS RCUTINE  
7 IF(NPLR) 1111,1111, 701  
701 DO 708 I=1,NPUR  
IATRIB(1)=KAGE  
IATRIB(2)=1  
IATRIB(3)=1  
IATRIB(4)=1  
IATRIB(5)=88\*1000+NCWY\*100+I  
ATRIB(1)=WTPB  
CALL FILEN(IN, VEN, 8)  
708 CCNTINUE  
WRITE(ND,709)NCWY,NCWT,NPUR  
709 FCRRMAT(/3X\*BCAR PLRCHASE FCR YEAR\*I2\* AT DAY=\*I5  
2 \* ACDED\* I3\* NEW BCARS\*)  
GC TC 1111  
98 WRITE(ND,1309)NOWT,IEVT,IPT,KCDE,IWE  
1309 FCRRMAT(//\* ERROR EVNTS, NOWT=\*I6\* IEVT=\*I3\*IPT=\*  
2 I6\* KODE=\*I3\* IWE=\*I2/)  
99 RETURN  
END

UPDATE

```
SUBROUTINE UPDATE(IN, VEN)
COMMON /INIT/NR,NW,NC,NT7,NT8,NCAT,NS1,NS2
4 /GEN/ITOT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5 /HOUSE/NH(6),N1,N2,N3,N4,N5,N6,NXTFAR,MX1,MX2,MX3,MX4
1 /SKIP/ ISTOP4,ISTCP5,ISTCP6,ISTOP7,MAXSKP
2/SURVIV/PW1,PW23,PSRT,PSFIN,PSCWS,PBCRS,PBORS1,MCEAD(8),PSRT2
3/GAIN/ GW1,GW23,GSRT,GFIN1,GFIN2,GSOWM,GSOWL,SDP,SSCWM,SSCWL
4 /BIRTH/ BRNM,BRNS,BMIN,BMAX,BWTM,BWTS,BWMIN,BWMAX,NCBRN
7/BREC/LBREED,NBREED,IFAR(6,5),ICB(30),KAGEW,LGTHW,NAGEM
8 /BREC2/ CUM(3),GMIN
9 /BREC3/ PTRM1,PTRM2,PTRM16
5 /CLEAN/NCPREV,NH4CLN,LOSSL,SWTLP,SSL,PKL4
4 /CULL/ NGLTS,MXSRV,MXAGS,PCULG,PCULS,PSSR,PRGT,MXBCR
COMMON/SALES/MSELL,WTS,NXTSAL
DIMENSION IN(3,1), VEN(2,1)
```

C CALLED FRM SUB. EVNTS, APPLY SKIP TESTS, SURVIVAL PRCB., I.E.  
 C GENERAL UPDATE OF ANIMALS IN FILES. SLB. FARCW IS PART OF  
 C UPDATE.

C

C BRANCH TO HOUSE SECTION 4,5,6,7,CR 8.

```
IC=IATTRIB(6)
IF(IC-4) 1380, 4000, 5555
5555 IF(IC-6) 5000, 6000, 7777
7777 IF(IC-8) 7000, 8000, 1380
```

C

C

C GENERAL RETURN TO FILE ACCORDING TO IATTRIB(6)

```
700 CALL FILEM(IN, VEN, IATTRIB(6))
      RETURN
```

C

C BCAR UPDATING, DAY AT A TIME.

```
8000 IAT1=IATTRIB(1)
IAT10=IATTRIB(10)
K=IATTRIB(3)
IAT4=IATTRIB(4)
IF(IATTRIB(2).LE.0.) ATTRIB(2)=RNCRM(GSOWM/2.,SSCWM,-5.,10.)
```

C

C SCRT FOR MAXIMUM AGE TO KEEP BCAR -MXBOR-

```
IF(IAT1-MXBOR) 8005, 8002, 8002
```

```
8002 SKIP=NXTSAL-NCWT
ATTRIB(1)=ATTRIB(1)+ATTRIB(2)*SKIP
CALL FILEM(IN, VEN, 9)
      RETURN
```

```
8005 IF(IAT10) 6081, 6081, 6082
```

```
6081 IF(RANUM(D).GT.PBCRS) GO TO 613
GO TO 6083
```

```
6082 IF(RANUM(D).GT.PBCRS) GO TO 613
```

```
6083 IAT1=IAT1+1
ATTRIB(1)=IAT1
ATTRIB(9)=ATTRIB(9)+1
ATTRIB(1)=ATTRIB(1)+ATTRIB(2)
```

C

C CHECK K SUB-CLASS FOR NEW STATUS

```
IF(K.EQ.1) GO TO 8011
```

C

C

C CONVERT DAILY SERVICES (10) TO 6 DAY PACKED TALLY IN (11).

```
IAT11=IATTRIB(11)
```

```
IATTRIB(11)= MOD(IAT11*10+IAT10,1000000)
```

```
IATTRIB(10)=0
```

C  
C CCNTINUE CHECKING  
IF(IAT1.EG.195) GC TC 8011  
IF(IAT1.EG.366) GC TC 8017

C  
6085 IATRIB(4)=IAT4+1  
GC TO 700

C  
8011 IF(IAT4.GT.29) GC TC 8013  
GC TC 6085

8013 IF(IAT1.GT.194) GC TC 8015  
GO TC 6085

C YOUNG BOAR, START TALLY 4 GAIN LIKE SCW/2, VARIANCE LIKE SCWS

8015 IATRIB(3)=2  
IATRIB(4)=1  
ATRIB(2)=RNORM(GSCWM/2.,SSCWM,-5.,10.)  
GC TC 700

C MATURE BOAR, START TALLY 4, GAIN REDUCED TO ARBITRARY SMALL AMOUNT.

8017 IATRIB(3)=3  
IATRIB(4)=1  
ATRIB(2)=.001

C  
C  
GC TO 700

C SCWS IN LAC. AND SUCKLING PIGS WK 1, WK 2-3, OR STARTING AGE.  
C HOLD SOWS ISKIP CCWN TC HER PIGS AGE CLASSES.

C  
C NH4CLN IS HELD=1 UNTIL WEANING BEGINS THEN SET =2

4000 IF(NH4CLN-1) 4001, 4C02, 4001

4001 ISTOP4=NOWT  
GC TC 4009

4002 IF(ISTOP4-(NOWT+6)) 4003, 4009, 4009

4003 ISTOP4=NOWT+6

4009 ISKIP=ISTCP4-NOWT+1  
IF(ISKIP.GT.MAXSKP) ISKIP=MAXSKP  
IAGE=IATRIB(1)  
LTAL=IATRIB(4)  
IF(IAGE.GT.200) ISKPT=LTAL  
IF(IAGE.LE.200) ISKPT=IAGE  
IF(ISKPT.LT.8) ISKIP=1  
IF(ISKIP.GT.7) ISKIP=7  
SKIP=ISKIP

C PIGS HERE, SOWS IN 4500.  
IF(IAGE.GT.200) GC TC 4500

C  
C BABY PIGS IN HOUSE 4.  
IF(IAGE-56) 4320, 4320, 5000

4320 BW=IATRIB(11)  
BRTHW=BW/100.  
IF(IAGE.LE.7) GO TO 4007  
IF(IAGE.LE.21) GC TC 4021

C PIGS AGE 22, UP TC 56 BLT NCT WEANED.  
P=PSRT\*\*SKIP  
IF(IAGE-22) 4201, 4202, 4201

4202 ATRIB(2)=RNORM(GSRT,SCP\*GSRT,-5.,10.)

4201 G=ATRIB(2)\*SKIP  
GC TO 4050

C BABY PIGS 1, AND 2-3 WKS. ADJ. WT.  
C DAILY SURV. PRCB. ADJ=.C049\*DEVIATION BIRTHWT, SPEER REF.

4021 IF(IAGE+ISKIP-22) 4023, 4023, 4022

4022 ISKIP=22-IAGE  
SKIP=ISKIP

4023 P=(PW23+(.0049\*(BRTHW-BWTH)))\*\*SKIP

```

IF(IAGE-8) 4029, 4027, 4029
4027 ATRIB(2)= RNORM(GW23,SDP*GW23,-.5, 10.)
4029 G=ATRIB(2)*SKIP
GO TO 4050
4007 P=(PW1+(.0049*(BRTHW-BWTM)))*SKIP
IF(ATRIB(2)) 4019, 4008, 4019
4008 ATRIB(2)= RNORM(GW1,SDP*SW1,-5.,10.)
4019 G=ATRIB(2)*SKIP
4050 IF(RANUM(D).GT.P) GO TO 613
C IF SURVIVED, FILE.
4051 IATRIB(1)=IATRIB(1)+ISKIP
IATRIB(9)=IATRIB(9)+ISKIP
ATRIB(1)=ATRIB(1)+G
GO TO 700
C SCWS CF HCUSE 4 I.E. IN LACTATION WITH BABY PIGS
4500 IF(RANUM(D).GT.PSCWS**SKIP)GC TO 4613
C
C SCW WITH 1 PIG OR LESS MCVED VIA TERMINATION TO HCUSE 6
IF(IATRIB(8).GT.1) GC TO 4515
IATRIB(6)=6
GC TO 6355
4515 IATRIB(4)=LTAL+ISKIP
G=ATRIB(2)*SKIP
C SURVIVES, FILE BACK TC HCUSE 4.
GO TO 4051
C
C LACTATING SOW CIES, KILL SCW, CHECK CN BABY PIGS WELFARE.
4613 NPIGS=IATRIB(8)
NUSCW=IATRIB(5)
MCEAD(4)=MDEAD(4)+1
C
C ADJUST LITTER COUNT (KL4) IN FARRCING HOUSE.
KL4=KL4-1
C FIND PIGS, .LT. 7 DAY DIE, 50 PERCENT LIVE AFTER 7 DAYS AGE.
4623 CALL FIND(NUSCW,5,4,8,KKCL,IN,VEN)
IF(KKCL.EQ.0) RETURN
C CALL REMOV(IN,VEN,KKCL)
IF(IATRIB(1).LE.7) GC TO 4623
IF(RANUM(D).GT.0.5) GC TO 4623
IATRIB(8)=0
IATRIB(13)=77
CALL FILEM(IN,VEN,4)
GC TO 4623
C
C STARTING PIG= 22-56 DAYS, GROWING = 57-180
C NURSERY HCUSE PIGS
5000 ISKIP=ISTOP5-NOWT+1
IF(ISKIP.GT.MAXSKP) ISKIP=MAXSKP
IAGE=IATRIB(1)
IF(IAGE.GT.55) GOTO 5500
C PIGS AGE 22-56, ALLOWED TO SKIP TO 57 ONLY.
IF(IAGE+ISKIP-57) 5005, 5005, 5003
5003 ISKIP=57-IAGE
5005 IF(IAGE-22) 5006, 5006, 5007
5006 ATRIB(2)= RNORM(GW23,SDP*GW23,-5.,10.)
5007 SKIP=ISKIP
C PIGS AGE 22, UP TO 56 BLT WEANED.
P=PSRT2**SKIP
RGAIN=ATRIB(2)
C TEST, ADJUST AND FILE VIA 7045
GO TO 7045
C

```

C PIGS AGE 57-150

5500 IF(IAGE-149) 551, 5509, 5509

551 IF(IAGE-57) 5057, 5057, 5058

5057 ATRIB(2) = RNCRM(GFIN1,GFIN1\*SCP,-5.,10.)

5058 IF(IAGE-NAGEM) 552, 5509, 5509

552 IF(IAGE+ISKIP-NAGEM) 558, 558, 5070

5070 ISKIP=NAGEM-IAGE

GC TO 558

C

C MOVE TO HCUSE 7 AND ADD ONE DAY TO ITS UPDATE.

C IF FINISHING HOUSE FULL, STAYS IATRIB(6)=5

C MOVING DECISION IS THEN IN SUB. MGT3. DAILY.

5509 IF(NH(4)-MX4) 5512, 5514, 5514

5512 IATRIB(6)=7

5514 ISKIP=1

558 SKIP=SKIP

P=PSFIN\*\*SKIP

RGAIN=ATRIB(2)

C TEST, ADJUST AND FILE VIA 7045

GO TO 7045

C

C

C SOW AND GILT OF MAINTNACE BUILDING NO. 6.

6000 IAT1=IATRIB(1)

IF(IAT1-MXAGS) 6001, 6001, 6900

C

C AGE CAN BE SET ARTIFICIALLY HIGH IN SUB. BREED FOR CULL FLAG.

C SOW OVER AGE SEND TO FILE 9 FCR SALE AS CULL.

6900 IF(IATRIB(3)-3) 6901, 6001, 6901

6901 ISKIP=NXTSAL-NOWT

SKIP=SKIP

IATRIB(9)=IATRIB(9)+ISKIP

IATRIB(1)=IATRIB(1)+ISKIP

ATRIB(1)=ATRIB(1)+SKIP\*RNCRM(GSCWM,SSCWM,-5.,10.)

CALL FILEM(IN, VEN, 9)

RETURN

6001 ISKIP=ISTOP6-NOWT+1

IF(ISKIP.GT.MAXSKP) ISKIP=MAXSKP

SKIP=SKIP

J=IATRIB(2)

K=IATRIB(3)

IAT10=IATRIB(10)

IAT4=IATRIB(4)

C

C

C GO TO VALUE OF K.

IF(K-2) 6100, 6200, 6300

C

C K=1 YOUNG AND OR ABNORMAL GILTS SET IN SUB. SELECT.

C SUB. SELECT PLTS GILTS INTO HOUSE 6 BEFORE 210 DAYS OF AGE

C

6100 IF(IATRIB(10).EQ.99) GO TO 6204

IF(IAT1 + ISKIP .GT. 209) ISKIP=210-IAT1

IF(IAT1.NE.210) GC TO 6204

IATRIB(3)=2

IATRIB(4)=0

IATRIB(10)= RNCRM(ESTM,ESTS,EMIN,EMAX)+.5

GC TO 6204

C

C

C K=2, OVULATING SOWS AND GILTS.

6200 IF(IAT4-IAT10) 6202, 6201, 6201

C

C ISKIP=1, PUTS SCW IN HEAT, SENDS TO SUB. BREED.

6201 ISKIP=1  
 CALL BREED(IN, VEN)

C TEST FOR K=2,3 AND CONTINUE ITS UPDATE.  
 IF(IATRIB(3)=3) 6204, 6300, 1380

6202 IF(IAT4+ISKIP.GT.IAT10) ISKIP=IAT10-IAT4

6204 SKIP=ISKIP  
 IF(RANUM(D).GT.PSCWS\*\*SKIP) GO TO 613  
 IATRIB(1)=IAT1+ISKIP

C IATRIB(4) CAN BE ZERO FROM SUB. BREED.  
 IATRIB(4)=IATRIB(4)+ISKIP  
 IATRIB(9)=IATRIB(9)+ISKIP  
 ATRIB(1)=ATRIB(1)+ATRIB(2)\*SKIP  
 CALL FILEM(IN, VEN, 6)  
 RETURN

C

C

C

C SCW IN GESTATION, K=3, APPLY PROBABILITY OF SURVIVAL, PREMATURE

6300 IA4=IATRIB(4)  
 IF(IA4+ISKIP.GT.GMIN-2) GO TO 6305  
 IF(IA4.GE.8) GO TO 6325  
 IF(IA4-7) 6301, 6302, 1380

C

C GESTATION SOWS.

C FIRST WEEK PREGNANCY- SURVIV NC PRETERM, SURVIV PRETERM

6301 IF(ISKIP.GT.7-IA4) ISKIP=7-IA4

6302 SKIP=ISKIP  
 RN=RANUM(D)  
 P1=(PSOWS\*(1.-PTRM1)) \*\*SKIP  
 IF(RN.LE.P1) GO TO 6350  
 P2=(PSOWS\*PTRM1)\*\*SKIP

6326 IF(RN.LE.P1+P2) GO TO 6355  
 GO TO 613

C NC PRETERM

6350 IATRIB(1)=IATRIB(1)+ISKIP  
 IATRIB(4)=IATRIB(4)+ISKIP  
 IATRIB(9)=IATRIB(9)+ISKIP  
 ATRIB(1)=ATRIB(1)+ATRIB(2)\*SKIP

C FILE SCWS BACK IN HOUSE 6  
 GO TO 700

C TERMINATION.

6355 IATRIB(3)=2

C SET TO HEAT IN TRUNCATED 1/3 LENGTH ESTRUS-1  
 ISKIP=1  
 SKIP=1.  
 IATRIB(4)=IATRIB(10)/3\*2+1  
 IATRIB(8)=0  
 IATRIB(11)=0  
 GO TO 6350

C FCR 8-107 DAYS OF GESTATION.

6325 RN=RANUM(D)  
 P1=(PSOWS\*(1.-PTRM2)) \*\*SKIP  
 IF(RN.LT.P1) GO TO 6350  
 P2=(PSOWS\*PTRM2)\*\*SKIP  
 GO TO 6326

C

C 108 DAYS TO FULL TERM AT LENGTH=IATRIB(11)

6305 IA11=IATRIB(11)

C BRANCH TO SUBROUTINE FARCH  
 IF(IA11-IA4.LE.1) GO TO 6099  
 IF(ISKIP.GE.IA11-IA4) ISKIP=IA11-IA4-1

```

SKIP=ISKIP
      NOT FARRCING
RN=RANUM(C)
P1=(PSOWS*(1.-PTRM16) )**SKIP
IF(RN.LE.P1) GO TO 6350
P2=(PSOWS*PTRM16) **SKIP
GO TO 6326
C RETURNED OPEN AND SENT TO STATEMENT 6355.
6099 CALL FARCW(IN,VEN)
IF(IATRIB(1).EQ.0) RETURN
ISKIP=1
SKIP=1.
IF(NH4CLN-1) 6355, 6665, 6355
6665 IF(MX1-KL4) 6355, 6666, 6666
6666 RETURN
C
C FINISHING HOUSE PIGS
C
C      MAXSKP=14 DEFAULT, ISTCP7 FIRST SET TO NCAY THEN IN SUB. SELL
7000 ISKIP=ISTCP7-NCWT+1
IF(ISKIP.GT.MAXSKP)ISKIP=MAXSKP
IF(IATRIB(1)-56) 7020,7040,7040
7020 ISKI=56-IATRIB(1)
IF(ISKI-ISKIP) 7021, 7023, 7023
7021 ISKIP=ISKI
7023 SKIP=ISKIP
RGAIN=ATRIB(2)
P=PSRT**SKIP
GO TO 7045
7040 IF(IATRIB(1)-150) 7430, 7041, 7041
7430 IF(IATRIB(1)-56) 7431, 7431, 7433
7431 ATRIB(2)=RNORM(GFIN1,GFIN1*SCP,-5.,10.)
7433 RGAIN=ATRIB(2)
IF(IATRIB(1)+ISKIP-150) 7438, 7437, 7437
7437 ISKIP=150-IATRIB(1)
7438 SKIP=ISKIP
P=PSFIN**SKIP
GC TO 7045
7041 IF(IATRIB(1)-150) 7042, 7042, 7043
7042 ATRIB(2)=RNORM(GFIN2,GFIN2*SCP,-5.,10.)
7043 RGAIN=ATRIB(2)
SKIP=ISKIP
P=PSFIN**SKIP
7045 IF(RANUM(D).GT. P) GC TO 613
IATRIB(1)=IATRIB(1)+ISKIP
IATRIB(9)=IATRIB(9)+ISKIP
C      GAIN ADDED.
ATRIB(1)=ATRIB(1)+RGAIN*SKIP
C FINISHED WITH ONE PIG FROM FINISHING HOUSE.
CALL FILEM(IN,VEN,IATRIB(6))
RETURN
C DEAD TALLY.
613 IAB=IATRIB(6)
MDEAD(IAB)=MDEAD(IAB)+1
RETURN
C ERRCR AND FINISHED WRITES.
1380 WRITE(ND,1378)NCWT,KCL,(IATRIB(M),M=1,15)
1378 FCRMAT(* ERRCR UPDATE, NCWT=*I5*, KCL=*I5*, IATRIB()=/*10X,15I6
RETURN
END

```

FAROW

```

SUBROUTINE FAROW(IN, VEN)
COMMNCN /INIT/NR,NW,NC,NT7,NT8,NCAT,NS1,NS2
4 /GEN/ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATRIB(18),ATRIB(4)
7 /BRED/LBREED,NBREED,IFAR(30),ICB(30),KAGEW,LGTHW,NAGEM
2 /SURVIV/PW1,PW23,PSRT,PSFIN,PSOWS,PBORS,PBCRS1,MCEAC(8)
3 /GAIN/GW1,GW23,GSRT,GFIN1,GFIN2,GSCWM,GSCWL,SCP,SSCWM,SSCWL
4 /BIRTH/BRNM,BRNS,BMIN,BMAX,BWTM,BWTS,BWMIN,BWMAX,NCBRN
5/CLEAN/NDPREV,NH4CLN,LCSSL,SWTLP,SSL,PKL4
5/HOUSE/NH(6),N1,N2,N3,N4,N5,N6,NXTFAR,MX1,MX2,MX3,MX4,X1,X2,X4
4 /RPT4/IDCS, IDCE, IDCN, ICCF, ICCM, IDC8, ICCFS, ICCFP, ICFLW
3/RPT3/MJEV,ISALS,IFARS,IBRDS
3/STAT/SUM(5,20),SUM2(5,10),SUM3(5,10),SUM4(5,10)
1/RPT1/ISMYP,ISMB,ISMBG,ISMF,ISMW,ISMS,ISMN
      DIMENSION IN(3,1),VEN(2,1)

C BRANCH OF SUBROUTINE LUPDATE FROM 6000 S.
C SOW IS TO FARROW AND CREATE PIGS= IATRIB(8)
C
C
C
C WEANING TO MAKE ROOM FOR THIS SCW TO FARROW.
C
18   IF(KL4-MX1) 409, 18, 18
19   IF(NH4CLN) 99, 99, 19
19   JX1=X1
20   IF(JX1) 199, 199, 21
21   KDO= NH(1)
C
C       LOOK FOR LITTER OF LEGEL WEANING AGE= KAGEW-X1.
C       TEMP. STORE SCW IN IDB()
22   CC 22 I=5,18
22   IDB(I)=IATRIB(I-4)
23   XAT1=ATRIB(1)
24   XAT2=ATRIB(2)
25   CC 27 I=1,KDO
26   CALL REMCV(IN, VEN, 1)
26   IF(IATRIB(4)-KAGEW-JX1) 26, 29, 29
26   CALL FILEM(IN, VEN, 4)
27   CCNTINUE
27   GO TO 39
C FOUND SOW WITH LITTER, WEAN HER AND PIGS.
28   IATRIB(3)=2
28   IATRIB(4)=IATRIB(10)/3*2+1
28   IATRIB(8)=0
28   IATRIB(11)=0
28   ATRIB(2)=RNCRM(GSCWM,SSCWM,-5.,10.)
28   CALL FILEM(IN, VEN, 6)
29   IF(VEN(1,1)-100.) 31, 31, 33
C           CVER 100 POUNDS IS NEXT SCW, I.E. HAVE ALL OF LITTER, STCP
30   CALL REMCV(IN, VEN, 1)
31   CALL FILEM(IN, VEN, 5)
31   GO TO 30
C STOP WEANING, ALLOW ORIGINAL SCW TO FARROW.
32   CC 35 I=5,18
33   IATRIB(I-4)=ICB(I)
34   ATRIB(1)=XAT1
35   ATRIB(2)=XAT1
35   GO TO 410
C
C
39   CC 41 I=5,18

```

41 IATRIB(I-4)=ICB(I)  
ATRIB(1)=XAT1  
ATRIB(2)=XAT2  
GC TC 199  
C END SPECIAL HOUSE OVERFLW WEANING PROCEDURE.

197

C  
C  
C IF BUILDING HAS BEEN CLEANED NH4CLN=1  
409 IF(NH4CLN) 99, 99, 410

C  
C  
C SOW IS FARRCING.  
410 NAMDAM=IATRIB(5)  
NP=IATRIB(8)  
IATRIB(1)=IATRIB(1)+1  
IATRIB(3)=4  
IATRIB(4)=1  
IATRIB(9)=IATRIB(9)+1

IF(RANUM(D).GT.PSCWS) GC TC 613

C COUNT OF LITTERS +1  
KL4=KL4+1

C WT. LOSS AT FARRCING.

WTL=NP\*RNCRM(SWTLP,SSLP,-10.,10.)

ATRIB(1)=ATRIB(1)-WTL

ATRIB(2)=RNORM(GSCWL,SSCWL,-5.,10.)

C COLLECT SEASCNL REPRT STATS CN SCW FARRCING.  
C SEASACNL IN SUM2(), TERM REPRTS IN SUM3().

RMX1=MX1

RKL4=KL4

FILL=RKL4/RMX1\*100.

RNP=NP

RNOWT=NOWT

IF(IFARS) 398, 398, 300

300 CALL COLLT(SUM2,1,RNP)  
CALL CCLLT(SUM2,2,RNCWT)  
CALL CCLLT(SUM2,3,FILL)

398 IF(ISMF) 397, 397, 310

310 CALL COLLT(SUM3,1,RNP)  
CALL CCLLT(SUM3,3,FILL)

C

C FILE THE SOW

397 CALL FILEM(IN, VEN, 4)

C CREATE NP PIGS FOR ABOVE SCW, ALSO FILE IN HOUSE 4  
C INCREASE TCTAL BIRTHS -NCBRN- COUNTER.

DC 63 KP=1,NP

NOBRN=NOBRN+1

C FILL ZEROED ATTRIBUTES.

IATRIB(1)=1

IF(ISEX.NE.1) GO TO 8

IATRIB(2)=3

ISEX=C

GC TC 9

8 IATRIB(2)=2

IATRIB(3)=1

ISEX=1

C

C LET IFAR(30)= CURRENT FARRCING 1-6 OF CURRENT YEAR NCWY.  
C SET IN SUBROUTINE EVENTS.

MFAR=IFAR(30)

9 IATRIB(5)=MFAR\*10000+NCBRN

IATRIB(6)=4

IATRIB(8)=NAMDAM

IATRIB(9)=NOWT  
C BIRTH WT) = MEAN ADJUSTED BY -.09 FOR DEVIATION FROM AVERAGE NC.  
C CF PIGS IN THE THE LITTER, OMTVECT, ET. AL.  
RNP=NP  
BWME=BWTM+(RNP-BRNP)\*.09  
BT=RNCRM(BWME,BWTS,BWMIN,BWMAX)  
IATRIB(11)=BT\*100.  
ATRIB(1)=BT  
ATRIB(2)=0.  
C FILE THIS PIG.  
C  
C COLLECT SEASONAL REPORT STATS CN PIG IN SUM2(), TERM IN SUM3().  
IF(IFARS)399, 399, 3C1  
301 CALL CCLLT(SUM2,4,BT)  
399 IF(ISMF) 400, 400, 303  
303 CALL CCLLT(SUM3,4,BT)  
C  
C FILE THIS PIG.  
400 CALL FILEM(IN,VEN,4)  
63 CCNTINUE  
C  
RETURN  
613 IATRIB(1)=0  
MCEAD(6)=MCEAD(6)+1  
RETURN  
99 LCSSL=LOSSL+1  
RNP=IATRIB(8)  
CALL CCLLT(SLM2,5,RNP)  
WRITE(ND,1303)NOWT,NH4CLN,(IATRIB(M),M=1,15)  
1303 FORMAT(\* LCSS NEW LITTER, NOWT=\*15,  
2 \* ,NH4CLN=\*I2\* ,IATRIB()=\*/10X,15I5)  
RETURN  
199 LCSSL=LOSSL+1  
RNP=IATRIB(8)  
CALL CCLLT(SLM2,6,RNP)  
CALL CCLLT(SLM3,6,RNP)  
C TAPE NC CVERFLCW MESSAGE CPTCN.  
IF(ICFLW) 1309, 1309, 1307  
1307 WRITE(ND,1304) MX1,NCWT  
1304 FCRMAT(/3X\*FARROWING CVERFLCW, SOW RETURNED OPEN\*  
2\* AND LITTER LOST. ALL\*I3\* CRATES FULL AT DAY=\*I5)  
1309 RETURN  
END

SELL

```
SUBROUTINE SELL(IN,VEN)
COMMON /INIT/NR,NW,NC,NT7,NT8,NCAT,NS1,NS2
```

C

```
4 /GEN/ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5 /HCUSE/ NH(6),N1,N2,N3,N4,N5,N6
6 /SALES/ MSELL,WTS,NXTSAL,NSLD(4),WTSLD(4),VSLD(4),PRIH,PRIS
4/GAIN2/SCP(6),HOP(6),SSLD(6),PSLD(6),SEND(6),HEND(6)
7/SALE2/NSLDP(4),WTSLCP(4),VSLCP(4),DIS
3 /COST/FCS,FCB,CLAB,TFAR,TNUR,TSOW,TFIN
4 ,VAR(3),FEED(2,5),ABCR(2,10)
1 /SKIP/ ISTOP4,ISTCP5,ISTCP6,ISTOP7,MAXSKP
3 /RPT3/ MJEV,ISALS,IFARS,IBRDS
```

C

```
C SWITCH DIAGNCSTIC
    IF(NS1.NE.8) GO TO 800
```

C

```
CALL CUT(IN,VEN,N3+1,N4,8888.2)
```

```
C SELL FROM HOUSE 7 FIRST
```

C

```
800 CCNTINUE
    NH4=NH(4)
    IF(NH4) 901, 901, 801
801 DC 810 J=1,NH4
    CALL REMOV(IN,VEN,N3+1)
    AT1=ATTRIB(1)
    IF(AT1-WTS) 805, 850, 850
805 CALL FILEM(IN,VEN,7)
    GO TO 810
C     SELL BY RECCRDING SALE.
850 NSLD(4)=NSLD(4)+1
    WTSLD(4)=WTSLD(4)+AT1
    VSLD(4)=VSLD(4)+PRIH/100.*AT1
```

C

```
C RECCRD SALES FOR PRODLCTCN SUMMARY.
    HSLD(1)=HSLD(1)+1.
    HSLD(2)=HSLD(2)+AT1
    HSLD(3)=HSLD(3)+AT1*PRIH/100.
```

C

```
810 CCNTINUE
```

C

```
C SELL CULL SOWS AND GILTS FRM FILE 9, REPRT BELOW.
```

```
901 NH6=NH(6)
    IF(NH6) 811, 811, 900
900 DC 910 J=1,NH6
    CALL REMOV(IN,VEN,N5+1)
```

```
C CULL SOW SALES USE NSLD(3), NSLDP(3), BUT WT6, WS6, ETC.
    NSLD(3)=NSLD(3)+1
    AT1=ATTRIB(1)
    WTSLD(3)=WTSLD(3)+AT1
    PS=PRIS/100.
    IF(AT1-350.) 821, 821, 815
C     DIS IS A DISCOUNT/LB. CVER ALL WT.
```

```
815 PS=PS-DIS
```

```
821 VSLD(3)=VSLD(3)+PS*AT1
```

```
C RECORD SALES FOR PRODUCTION SUMMARY.
```

```
SSLD(1)=SSLD(1)+1.
```

```
SSLD(2)=SSLD(2)+ATTRIB(1)
```

```
SSLD(3)=SSLD(3)+AT1*PS
```

C

C

```

910  CONTINUE
C
C REPORT ON TAPE IJK, SALES MADE
811  IJK=NC
    NSTOT=0
C CALCULATE CHANGE SINCE LAST SALES DATE.
    DC 5 I2=3,4
5    NSTOT=NSTCT+NSLD(I2)
    NS4=NSLD(4)-NSLDP(4)
    WT4=WTSLD(4)-WTSLCDP(4)
    VS4=VSLD(4)-VSLDP(4)
    AVWT=WT4/NS4
    NS6=NSLD(3)-NSLDP(3)
    WT6=WTSLD(3)-WTSLCDP(3)
    VS6=VSLD(3)-VSLDP(3)
    AVWT6=WT6/NS6
    KTCT46=NS6+NS4

C
    IF(ISALS) 1243, 1243, 1201
1201  IF(KTCT46) 1243, 1243, 1202
1202  WRITE(IJK,1203) KTCT46, NCWT
1203  FFORMAT(/////* SALES SEASONAL REPCRT*
    2 /1X,60(1H=)/16X*REPCRT OF*I5* SALE(S) ON DAY*I5)
    IF(NS4) 1903, 1903, 1204
1204  WRITE(IJK,1205) NS4,AVWT, VS4
1205  FFORMAT(/* FRCM FINISHING HOUSE*/7X*SOLD*I3* HCGS AT*
    2F6.1* POUNDS AVERAGE WEIGHT*/7X*SALES VALUE WAS*F10.2* DCL.*)
1903  IF(NS6) 1906, 1906, 1904
1904  WRITE(IJK,1905) NS6, AVWT6, VS6
1905  FORMAT(/* CULL SCWS AND GILTS */7X*SOLD*I3* HEAD AT*
    2F6.1* POUNDS AVERAGE WEIGHT*/7X*SALES VALUE WAS*F7.2*DCL.*)
1906  WRITE(IJK,1210) NSTCT
1210  FFORMAT(/* TOTAL NUMBER SOLD TO DATE=*I5/*====END SALES REPORT*
    2 40(1H=))

C
1243  DC 1245 JK=1,4
    NSLDP(JK)=NSLD(JK)
    WTSLCDP(JK)=WTSLD(JK)
1245  VSLDP(JK)=VSLD(JK)

C
C
C  ISTOP7 SET FOR DATE OF NEXT SALE NXTSAL.
    NXTSAL=NOWT+MDSELL
    ISTOP7=NXTSAL

C
C  DIAGNOSTICS SWITCH CALLS
    IF(NS1.EQ.8)CALL CUT(IN,VEN,N3+1,N4,8888.8)

C
C
C
C
RETURN
END

```

BREED

SUBRCLTINE BREED(IN, VEN)  
 CCMCN/INIT/NR,NW,ND,NT7,NT8,NDAT,NS1,NS2,NCWD  
 4 /GEN/ITOT,ISIZE,NCWT,NCWT,NCWY,NDAYS,NRUNS,IATRIB(18),ATRIB(4)  
 5 /HCUSE/NH(6),A1,A2,A3,N4,A5,A6,NXTFAR,MX1,MX2,MX3,MX4  
 7/BRED/LBREED,NBREED,IFAR(6,5),IDB(30),KAGEW,LGTHW,NAGEM  
 8 /BRED2/ ABNCRG,GESM,GESE,GMIN,GMAX  
 4 /BIRTH/ BRNM,BRNS,BMIN,BMAX,BWT,BWTS,BWMIN,BWMAX,NCBRN  
 9 /BRED3/ D(3),PCCN1,PCCN2,ADJ1,ADJ2  
 4/CULL/NGLTS,MXSRV,MXAGS,PCULG,PCULS,PSSR,PRGT,MXBKR,LDP  
 CCMCN /BCAR/ MXSCY,MXSWY,MXSCM,MXSWM,NPUR,IPCAT,KAGE,WTPB,IBS  
 3/GAIN/GW1,GW23,GSRT,GFIN1,GFIN2,GSCWM,GSCWL,SCP,SSCWM,SSCWL  
 3/STAT/SUM(5,20),SUM2(5,10),SUM3(5,10),SUM4(5,10),SUM5(5,10)  
 4/BRED4/KBRD,KSWG(4),NCNB(4),NCNBK(4)  
 DIMENSION KATRIB(12),BTRIB(2)

C

C SCW OR GILT IN HEAT IS SENT FROM UPDATE.

C IF IN BREEDING SEASCN IBS=1

C SOW RETURNED AS CPEN, K=2, CR IN GESTATION, K=3

C

C

C

C TEST FOR BREEDING SEASCN

IATRIB(4)=0

IF(IBS-1) 127, 28, 127

28 IF(KBRD-NBREED) 29, 27, 27

27 NCNB(1)=NCNB(1)+1

NCNBK(1)=NONBK(1)+1

IF(NCNB(4)) 107, 107, 109

107 NCNB(4)=NCWT

109 RETURN

C COUNT SCWS IN HEAT BUT NOT BREEDING SEASON.

127 NCNBK(4)=NONBK(4)+1

RETURN

C SAVE FEMALES ATTRIBUTES

C COUNT NO. SOWS EXPECTED (TARGET NO.)

29 KBRD=KBRD+1

DC 30 KX=1,12

30 KATRIB(KX)=IATRIB(KX)

DC 32 KX=1,2

32 BTRIB(KX)=ATRIB(KX)

C

C FIND AVAILABLE BOAR IN FILE 8

NSERV=0

NH5=NH(5)

IF(NH5.LT.1) GO TO 9138

C LOOP FOR BOAR SEARCH

DO 777 MK=1,NH5

KUSE=0

CALL REMOV(IN, VEN, N4+1)

K=IATRIB(3)

IF(K-1) 9138, 776, 41

41 IAT10=IATRIB(10)

IAT11=IATRIB(11)

IF(IAT11.LT.1) GC TO 47

C SUM WEEK SERVICES TALLY

IT=IAT11/100000

IT=IAT11/10000-IT\*10+IT

IT=IAT11/1000-(IAT11/10000\*10)+IT

IT=IAT11/100-(IAT11/1000\*10)+IT

IT=IAT11/10-(IAT11/100\*10)+IT

IT=IAT11-(IAT11/100\*10)+IT

47 IT=0  
49 IF(K-2) 9138, 5, 50

C  
C YOUNG BOARS CHECK MAX. DAILY AND WEEKLY SERVICES AVAILABLE.  
5 IF(IT+IAT10-MXSWY) 6, 776, 776  
6 IF(IAT10+1-MXSDY) 149, 148, 776

C  
C MATURE BOARS CHECK MAX. DAILY AND WEEKLY SERVICES.  
50 IF(IT+IAT10-MXSWM) 52, 776, 776  
52 IF(IAT10-MXSDM) 149, 148, 776

C  
C ASSIGN KUSE TC SERVICES USED FCR THIS BOAR.  
148 KUSE=1  
      GC TC 150  
149 KUSE=2  
      GC TC 150  
776 CALL FILEM(IN, VEN, 8)  
777 CCNTINUE  
      IF(NSERV-1) 1377, 161, 161

C  
C DROP THROUGH 777 LCOP IMPLIES NO SERVICES AVAILABLE IF NSERV .EQ. 0.  
1377 GO TO 161

C  
C ADJUST BOAR USE ATTRIBUTES AND RE-ENTER LCOP OR RETURN SCW AND QUIT.

C  
C NSERV BECOMES 1,2, CR 3(1 FRCM 1 BOAR+2 FRCM SECCNC).  
150 NSERV=NSERV+KUSE  
153 IATRIB(10)=IAT10+KUSE  
      IATRIB(12)=IATRIB(12)+KUSE  
      IF(NSERV-2) 776, 151, 151

C  
C FILE BOAR, BRING BACK SCW ATTRIBUTES.  
151 CALL FILEM(IN, VEN, 8)  
161 DO 35 KX=1,12  
35 IATRIB(KX)=KATRIB(KX)  
      DO 37 KX=1,2  
37 ATRIB(KX)=BTRIB(KX)  
      IF(NSERV) 152, 152, 155

C  
C LACK BOARS NCN CONCEPTION COUNT FCR NCNB(2).  
C CHECK FAILS TC CONCEIVE IN BREEDING SEASCN COUNT.  
152 IATRIB(12)=IATRIB(12)+1  
      IF(IATRIB(12)-MXSRV) 154, 154, 159  
.C SET AGE UP TO AUTOMATICALLY CULL IN LDP DAYS.  
159 IATRIB(1)=MXAGS-LDP  
      IATRIB(10)=99  
154 NCNB(2)=NCNB(2)+1  
      NCNBK(2)=NCNBK(2)+1  
      RETURN

C  
C CONCEPTION TEST  
155 IF(NSERV.GT.1) GC TC 175  
C PROB. OF CONCEPTION WHEN 1 SERVICE GIVEN.  
      PC=PCCN1

C  
C ADJUSTMENT FOR SUMMER DAYS 183-243  
173 IF(NCWD-183) 183, 184, 184  
184 IF(NCWD-243) 185, 185, 183  
185 PC=PC+PSSR  
C ADJUSTMENT IF GILT.  
183 IF(IATRIB(1)-365) 190, 193, 193

190 PC=PC+PRGT  
193 RN=RANUM(D)  
IF(RN-PC) 205, 205, 9300  
C PROB. OF CONCEPTION WHEN 2 SERVICES= PRCB. CN FIRST+  
C PRCB. CN SECND IF NOT CONCEIVED ON FIRST.  
175 PC=PCCN1+(1.-PCCN2)\*PCON2  
GO TO 173  
C  
C BRED SOW RETURNED WITH GESTATION ATTRIBUTES.  
205 IATRIB(3)=3  
IATRIB(12)=0  
C  
C NC. PIGS ATTRIBUTE ADJUSTED FOR AGE SCW AND NO. SERVICES.  
AGE=IATRIB(1)+GESM  
V=BRNM-10.  
IF(AGE.GT.1300.) GC TC 207  
BRM=V+5.867+.01\*AGE-.00000446\*AGE\*\*2.  
GC TC 209  
207 BRM=V+5.867+.01\*1300.-.00000446\*1690000.-.0016\*(AGE-1300.)  
IF(NSERV.GT.1) GC TC 708  
BRM=BRM+ADJ1  
GC TO 209  
708 BRM=BRM+ADJ2  
209 NPIGS=RNORM(BRM,BRNS,BMIN,BMAX) +0.5  
IATRIB(8)=NPIGS  
IATRIB(11)=RNCRM(GESM,GESS,GMIN,GMAX)+0.5  
C  
C  
C STATS FOR SEASONAL BREEDING REPORT.  
C SUM2( ,7)=AGE AT FARRCING (APPRCX.)  
C SUM2( ,8)= LITTER SIZE IF SCW FARROWS.  
CALL CCOLLT(SUM2,7,AGE)  
CALL CCOLLT(SUM3,7,AGE)  
RNPIGS=NPIGS  
CALL CCOLLT(SUM2,8,RNPIGS)  
CALL CCOLLT(SUM3,8,RNPIGS)  
RNCWT=NCWT  
CALL CCOLLT(SUM2,9,RNCWT)  
RETURN  
9138 WRITE(ND,9136) NCWT  
9136 FORMAT(5X\*BREEDING SEASDN CN DAY=\*I5\*, NO BCARS EXIST,\*  
2\* SOW RETURNED OPEN\*)  
C INCREASE FAILS TO BREED COUNT.  
9300 IATRIB(12)=IATRIB(12)+1  
IF(IATRIB(12)-MXSRV) 9309, 9309, 9302  
C  
C  
C CHECK FAILS TO CONCEIVE IN BREEDING SEASON COUNT.  
C SET AGE UP TO AUTOMATICALLY CULL IN LDP DAYS.  
9302 IATRIB(1)=MXAGS-LDP  
IATRIB(10)=99  
C  
C NON CONCEPTION COUNT FOR NONB(3).  
9309 NCNB(3)=NCNB(3)+1  
NCNBK(3)=NONBK(3)+1  
RETURN  
END

```

SELECT
  SUBROUTINE SELECT(IN, VEN, JSLT, MAGE)
  CCMMCN /INIT/NR,NW,NC,NT7,NT8,ACAT,NS1,NS2
  4 /GEN/ ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
  5 /HOUSE/ NH(6),N1,N2,N3,N4,N5,N6,NXTFAR,MX1,MX2,MX3,MX4
  3/GAIN/GW1,GW23,GSRT,GFIN1,GFIN2,GSOWM,GSCWL,SCP,SSCWM,SSCWL
  8/BREC2/ABNCRG,GESM,GESE,GMIN,GMAX,ESTM,ESTS,EMIN,EMAX
  4/BREC4/KBRD,KSWGT(4),NCNB(4)
  4/CULL/NGLTS,MXSRV,MXAGS,PCULG,PCULS,PSSR,PRGT,MXBCR,LCP
  3/RPT3/MJEV,ISALS,IFARS,IBRDS

C
  DIMENSION IN(3,1),VEN(2,1)

C AGE .GT. 208 DAYS IS NEVER SELECTED, CLOSEST SELECTED FIRST .
C -JSLT- =NO. DESIRED, -MAGE- = MINUM AGE CRITERIA.

C
C
  KSLT=JSLT
  NAGE=MAGE
  NH4=NH(4)
  TWT=C
  KAGE=0
  NUM=0

C
C CHECK FEASIBILITY.
  IF(NH4.LT.1) GO TO 1308
  IF(KSLT.LT.1) GO TO 1308

C
C LOOP TO SELECT GILTS.
  DC 1010 KI=1,NH4
  CALL REMOV(IN, VEN, N3+1)
  IAT1=IATTRIB(1)
  J=IATTRIB(2)
  IF(J.NE.2) GO TO 1008
  IF(IAT1.LT.NAGE) GC TO 1008
  IF(IAT1.LT.209) GC TO 1018
  1008 CALL FILEM(IN, VEN, 7)
  GC TO 1010
  1018 IATTRIB(8)=0
C ESTRUS=99 MEANS ABNCRMAL, OTHERWISE SOURCE IS RNCRM.
  RN=RANUM(D)
  IF(ABNCRG-RN) 1103, 1103, 1101
  1101 IATTRIB(10) = 99
C SET AGE FOR AUTOMATIC CULL IN LDY DAYS.
  IATTRIB(1)=MXAGS-LCP
  GC TO 1109
  1103 IATTRIB(10)=RNCRM(ESTM,ESTS,EMIN,EMAX)
  RIA10=IATTRIB(10)
  IATTRIB(4)=RANUM(D)*RIA10
  1109 IATTRIB(11)=0
  ATRIB(2)=RNORM(GSCWM,SSCWM,-5.,10.)
  KAGE=KAGE+IAT1
  TWT=TWT+ATRIB(1)
  NUM=NLM+1
  CALL FILEM(IN, VEN, 6)
  IF(NUM.GE.KSLT) GC TO 1012
  1010 CCNTINUE
  1012 RNUM=NUM
  AGE=KAGE
  AGE=AGE/RNUM
  TWT=TWT/RNUM

```

IF(IBRDS) 1308, 1308, 1049 205  
1049 WRITE(ND,1050) KSLT,NLM,NCWT,AGE,TWT  
1050 FCRMAT(//5X\*SELECTION OF GILT REPLACEMENTS WITH A TARGET CF\*  
2I4\* RESULTED IN\*I4\* MOVED TO THE MAINTENANCE BUILDING\*  
3\* ON DAY\*I6/20X\* AVERAGE AGE=\*F6.0\*, AVERAGE WT.=\*  
4F8.1\* POUNDS\*)

C  
C  
C

C BREEDING SEASONAL REPCRT PART 1 FCR NC. ANIMALS AVAIL.  
C THIS CALL TO SELECT IS BEGINNING OF SEASDN.

1308 KBRD=0  
DC 1319 I=1,3  
NCNB(I)=0

1319 KSWGT(I)=0  
NCNB(4)=-999

C  
C COUNT KSWGT(1)= CPEN GILTS, KSWGT(2)=OPEN SCWS, KSWGT(3)=  
C ALL CTHERS IN MAINT. BLD., &SWGT(4)=NCWT  
KSWGT(4)=NCWT  
NH3=NH(3)  
IF(NH3) 1378, 1378, 1321

1321 DC 1341 I=1,NH3  
CALL REMCV(IN,VEN,N2+1)  
IF(IATRIB(3)-2) 1325, 1323, 1329

1323 IF(IATRIB(1)-365) 1325, 1337, 1337

1325 KSWGT(1)=KSWGT(1)+1  
GC TO 1327

1337 KSWGT(2)=KSWGT(2)+1  
GO TO 1327

1329 KSWGT(3)=KSWGT(3)+1

1327 CALL FILEM(IN,VEN,6)

1341 CCNTINUE  
RETURN

1378 WRITE(ND,1309) NH(4),NCWT,KSLT,NAGE

1309 FCRMAT(//\* SELECT INFEASIBLE, HCUSE 7 HAS\*I5\* HCGS AT NCWT=\*I6  
2 \* REQUESTED KSLT=\*I3\* MIN AGE=\*I3)

C  
C

RETURN  
END

## CLEAN4

```

SUBROUTINE CLEAN4(IN, VEN)
CCMON /INIT/NR,NW,NC,NT7,NT8,NDAT,NS1,NS2
4 /GEN/ .ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5 /HOUSE/ NH(6),N1,N2,N3,N4,N5,N6,NXTFAR,MX1,MX2,MX3,MX4
5 /CLEAN/ NDPREV,NH4CLN,LCSSL,SWTLP,SSLP,KL4
3/SCH/ DUMY(1000),IPT,IEVT,KCDE,IWE,IWN(45),NKT
4/CULL/NGLTS,MXSRV,MXAGS,PCULG,PCULS,PSSR,PRGT,MXBCR
6/SALES/MDSELL,WTS,NXTSAL
3/GAIN/GW1,GW23,GSRT,GFIN1,GFIN2,GSOWM,GSOWL,SDP,SSCWM,SSCWL
6/WRT1/KW
3/RPT3/MJEV,ISALS,IFARS,IBRDS

C
      TLTAL=0.
      KS=0
      KP=0

C NS1 DIAGNOSTICS SWITCH.
      IF(NS1.NE.11) GO TO 1349
      WRITE(NT7,130C) NCWT,NH(1)
1300 FCRMAT(* ENTER CLEAN4 AT NCWT=*I5* ,HCUSE4 HAS *I5
      2 * ANIMALS*)
      CALL CUT(IN,VEN,1,N1,11.2)

C
C
C CLEAN4 REMOVES ALL SOWS AND PIGS FROM HCUSE 4.
C
1349 MH=NH(1)
      IF(MH) 1399, 99, 50
50    DC 444 IM=1,MH
      CALL REMCV(IN,VEN,1)
C SCRT FOR SCWS .GT. 199 DAYS, AND PIGS GO TO 5000.
      IAGE=IATTRIB(1)
      IF(IAGE.LT.200) GC TO 5000

C
C SOWS
      KS=KS+1

C
C SET TC OVULATE IN 4-6 DAYS AFTER WEANING.
      IATTRIB(3)=2
      IATTRIB(4)=IATTRIB(10)/3*2+2
      IATTRIB(8)=0
      IATTRIB(11)=0
      ATRIB(2)=RNORM(GSCWM,SSCWM,-5.,10.)
C
C
C FILE IN 6 OR IN 9 FOR SALE.
C PROB. CULL HERE AND SEE WEANING IN SUB. MGT3
C FCRM SOW AND GILT CULLING PATTERN.
      RN=RANUM(D)
      IF(IATTRIB(1)-450) 4905, 4901, 4901
4901 PROB=PCULS
4903 IF(PRCB-RN) 4909, 4909, 4908
4905 PROB=PCULG
      GC TO 4903
4908 ISKIP=NXTSAL-NOWT
      SKIP=ISKIP
      IATTRIB(9)=IATTRIB(9)+ISKIP
      IATTRIB(1)=IATTRIB(1)+ISKIP
      ATRIB(1)=ATRIB(1)+SKIP*RNCRM(GSCWM,SSCWM,-5.,10.)
      CALL FILEM(IN,VEN,9)

```

```
GC TC 444
4909 CALL FILEM(IN,VEN,6)
GC TC 444
C
C PIGS MOVED TC HOUSE NC 5 I.E. FILE 5
5000 KP=KP+1
    CALL FILEM(IN,VEN,5)
444 CCNTINUE
C
C SET CLEAN HOUSE FLAG -NH4CLN- =1
99 NH4CLN=1
C
C KL4 I.E. LITTERS IN FARRCING HCUSE SET=0
KL4=0
C
C IWE SET TC CFF, I.E.=2
IWE=2
C
C
C ISTOP4 SET UP TO ESTIMATED WEANING DATE.
ISTOP4=NCWT+NDPREV+KAGEW
WRITE(ND,1380)KS,KP,NCWT
1380 FCRRMAT(40X*NCTE(1) CLEANING MCVED*I4* SOWS, AND*I5
2* PIGS ON DAY=*I6)
C
C
C
C
C FARROWING SEASON REPORTING CALL TC SUB. REPT1
C STATS COLLECTED IN SUB. FARRCW, REPORT VIA KW=2.
IF(IFARS) 999, 999, 200
200 KW=2
CALL REPT1(IN,VEN)
KW=0.
999 RETURN
1399 WRITE(ND,1398)NCWT, NH(1)
1398 FCRRMAT(3X*ERRCR CLEAN4 AT NCWT=*I5* NH(1)=*I4)
END
```

## FILEM

```

SUBROUTINE FILEM(IN, VEN, JJ)
COMMON/INIT/NR,NW,ND,NT7,NT8,NCAT,NS1,NS2
4 /GEN/ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5 /HOUSE/ NH(6),N1,N2,N3,N4,N5,N6
7/KRS/KRS1,KRS2,KRS3
DIMENSION IN(3,1),VEN(2,1)
JH=JJ

C
C ITOT= TOTAL NUMBER, AND NH()= NUMBER IN EACH HOUSE FILE, INCREMENTED.
C JH IMPLIES THE J HCLSE=J FILE OF COLUMNS IN ARRAYS IN, VEN.
C PLACES ATTRIBUTES IATTRIB(4) AND ATTRIB(2) INTO JH FILES OF IN AND VEN
C IATTRIB(I)-1=IAGE,2=JSEX,3=KLAS,4=LTAL,5=MNUM,6=LCC,7=PEN NO.,
C 8=SCW NO. (OR NC. OF PIGS)
C ATTRIB(I) -1=WT
C IATTRIB AND ATTRIB ARE ZEROED BEFORE RETURN.
    NTCT=0
    DC 13 IK=1,6
13   NTOT=NTOT+NH(IK)
    IF(NTCT.NE.ITOT) WRITE(ND,1301) JH,(NH(KI),KI=1,6),ITOT
1301 FFORMAT(* ERROR FILE, ITCT .NE. TOTAL IN FILES, JH=*
    2 I2* NH()=*6I6* ITCT=*I7)
    JH=JH-3
    IF(JH.LT.1.OR.JH.GT.6) GO TO 99
    NH(JH)=NH(JH)+1
    JNH=NH(JH)
C INCREMENT TOTAL FILE SIZE ITOT AND LOAD AT END OF JH FILE.
C JNH NOW HOLDS THE TOTAL NUMBER IN FILE=NH(JH), AFTER INSERTION.
C
    ITOT=ITOT+1
C
C OVERLCAD PROTECTION FOR IN(), VEN() FILE STORAGE.
    IF(ITCT-KRS3) 400, 400, 1387
C
400  IATTRIB(6)=JH+3
C     PROVIDE FILE SPACE AT JNH OF FILE JH BY PUSHING ONE COLUMN
    IF(JH-2) 1,2,303
1     NP=ITCT-NH(1)
    GO TO 704
2     NP=ITCT-NH(1)-NH(2)
    GO TO 704
303   IF(JH-4) 3, 4, 505
3     NP=ITCT-NH(1)-NH(2)-NH(3)
    GO TO 704
4     NP=ITCT-NH(1)-NH(2)-NH(3)-NH(4)
    GO TO 704
505   IF(JH-6) 5, 6, 99
5     NP=ITCT-NH(1)-NH(2)-NH(3)-NH(4)-NH(5)
    GO TO 704
6     NP=0
    GO TO 504
704   DC 410 K=1,NP
    DC 402 I=1,3
402   IN(I,ITOT-K+1)=IN(I,ITOT-K)
    DC 403 II=1,2
403   VEN(II,ITCT-K+1)=VEN(II,ITCT-K)
    410  CCNTINUE
C PLACE ATTRIBUTES IN FILE SPACE PROVIDED BY PUSHING, CCOLUMN=ITCT-NP
C
504   IN(1,ITOT-NP)=IATTRIB(1)*1CCCCCCCCCCCC+IATTRIB(2)*1000000000+
    2 IATTRIB(3)*100000000+IATTRIB(4)*100000+IATTRIB(5)

```

```
IN(2,ITOT-NP)=IATRIB(6)*1CCCCC00000000+IATRIB(7)*
2 100C000G0CCC+IATRIB(8)*1CCCCCCC+IATRIB(9)
IN(3,ITOT-NP)=IATRIB(10)*10000000C0000+IATRIB(11)*
2 100C000+IATRIB(12)
VEN(1,ITCT-NP)=ATRIB(1)
VEN(2,ITCT-NP)=ATRIB(2)
888 DC 88 IK=1,12
88 IATRIB(IK)=0
DC 89 IKK=1,4
89 ATRIB(IKK)=0.
N1=NH(1)
N2=N1+NH(2)
N3=N2+NH(3)
N4=N3+NH(4)
N5=N4+NH(5)
N6=N5+NH(6)
RETURN
99 JH=JH+3
WRITE(ND,98) JH,NCWT
98 FCRMAT(* ERRCR FILEM, JH REQUESTED HOUSE=*I4*, NCWT=*I8)
WRITE(ND,1399) (IATRIB(I),I=1,12)
1399 FORMAT(4X*IATRIB(1-12)=*12I7)
      CALL CUT(IN,VEN,1,ITCT,161399.9)
RETURN
1387 WRITE(NW,1389) KRS3, NCWT, ITCT
1389 FORMAT(1H2///* ANIMALS TOTAL IS GREATER THAN THE*
2* DIMENSIONED SIZE CF IN(3,I),VEN(2,I) WHERE I=*I8/
3*      PRCGRAM STCP AT DAY=*I5*, TCTAL ANIMALS=*I10)
STOP
END
```

```

REMOV
      SUBROUTINE REMCV(IN, VEN, KC)
C
      COMMON /INIT/NR,NW,NC,NT7,NT8,NCAT,NS1,NS2
      4 /GEN/ITOT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
      5 /HOUSE/ NH(6),N1,N2,N3,N4,N5,N6
      DIMENSION IN(3,1), VEN(2,1)
C
      KCL=KC
C REMOVES FILE COLUMN KCL, DECREMENT NH(KCL) BY ONE.
C ATTRIBUTES PUT INTO IATTRIB(), AND ATTRIB().
C ITCT (TOTAL ENTRIES IN FILE) DECREMENTED.
C
      IF(KCL)88,88,200
 200 IF(KCL-ITCT)333,333,88
 333 IF(KCL-N1)1,1,20
      1 KF=1
      GC TC 555
 20 IF(KCL-N2)2,2,30
      2 KF=2
      GC TC 555
 30 IF(KCL-N3)3,3,40
      3 KF=3
      GC TC 555
 40 IF(KCL-N4)4,4,50
      4 KF=4
      GC TC 555
 50 IF(KCL-N5)5,5,60
      5 KF=5
      GC TC 555
 60 IF(KCL-N6)6,6,88
      6 KF=6
 555 IATTRIB(1)=IN(1,KCL)/100000000000
      IATTRIB(2)=MOD(IN(1,KCL)/10000000000,10)
      IATTRIB(3)=MOD(IN(1,KCL)/100000000,10)
      IATTRIB(4)=MOD(IN(1,KCL)/100000,1000)
      IATTRIB(5)=MOD(IN(1,KCL),10000)
C WORD NO. 2
      IATTRIB(6)=IN(2,KCL)/10000000000000
      IATTRIB(7)=MOD(IN(2,KCL)/100000000000,100)
      IATTRIB(8)=MOD(IN(2,KCL)/10000000,100000)
      IATTRIB(9)=MOD(IN(2,KCL),100000)
C WORD NO. 3
      IATTRIB(10)=IN(3,KCL)/1000000000000
      IATTRIB(11)=MOD(IN(3,KCL)/1000000,1000000)
      IATTRIB(12)=MOD(IN(3,KCL),100000)
C ATRIB()
      ATRIB(1)=VEN(1,KCL)
      ATRIB(2)=VEN(2,KCL)
C
C PUSH DOWN FILES, BRING /HOUSE/ COMMON UP TO DATE.
      DC 300 K=KCL,ITOT
      DC 302 I=1,4
 302  IN(I,K)=IN(I,K+1)
      DC 304 II= 1,2
 304  VEN(II,K)=VEN(II,K+1)
 300  CCNTINUE
      NH(KF)=NH(KF)-1
      ITOT=ITOT-1
      N1=NH(1)
      N2=N1+NH(2)

```

```
N3=N2+NH(3)
N4=N3+NH(4)
N5=N4+NH(5)
N6=N5+NH(6)
RETURN
88  WRITE(ND,87)KCL,NCWT
87  FCRMAT(* ERROR REMCV, KCL REQUESTED=*I4*, NCWT=*I8)
RETURN
END
```

```

FIND      SUBROUTINE FIND(NXVA,MXCCD,J,JAT,KCO,IN,VEN)
C LOCATES THE CCOLUMN CALLED KCCL IN FILE JH.
C DESIGNATE AN MXCCDE RELATIONSHIP TO VALUE XVAL FRCM-
C FOULLCING OPTIONS, .LT. 10= FCR IATTRIB(), .GT. 10 FCR ATRIB().
C MXCODE=1,11 MAX GREATER THAN XVAL
C           2,12 MIN GREATER THAN XVAL
C           3,13 MAX LESS THAN XVAL
C           4,14 MIN LESS THAN XVAL
C           5,15 VALUE EQUAL TO XVAL
C           6,16 FIRST FIND GREATER THAN XVAL
C           7,17 FIRST FIND LESS THAN XVAL
C JATT IS THE ATTRIBUTE NUMBER I IN IATTRIB(I) OR ATRIB(I).
C KCCL IS THE CCOLUMN NUMBER OF THE LOCATED ENTRY, SEE P. 7C GASPII.
C
C           DIMENSION IN (3,1), VEN(2,1),IA(18)
C           CCMON /INIT/NR,NH,NC,NT7,NT8,NCAT,NS1,NS2
4 /GEN/ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATRIB(4)
5 /HOUSE/ NH(6),N1,N2,N3,N4,N5,N6
EQUIVALENCE(NVAL,XVA)
NVAL=NXVA
MXCCDE=MXCCD
JH=J-3
JATT=JAT
KCCL=KCO
C
C           HANDLE INTEGERS OF IATTRIB HERE, REAL IN SECTION GC TO NC. 1000.
C           BEST CANDIDATE CCOLUMN IS KBEST.
KBEST=0
C           NEXT TC CONSIDER IS NEXTK
NHH=C
DC 500 KK=1,JH
500 NHH=NHH+NH(KK)
NH1=NHH-NH(JH)+1
NEXTK=NH1
IF(NH(JH).LE.0) GO TC 160
IF(MXCODE.GT.10) GO TC 1000
IF(NEXTK)160,10,2
10 KCO=KBEST
RETURN
2   GO TC(1,1C2,3,104,5,106,7,8,1C9,110,111,112)JATT
1   IA(1)=IN(1,NEXTK)/1000000000
GO TC 21
102 IA(2)=MOD(IN(1,NEXTK)/1000000000,10)
GO TC 21
3   IA(3)=MOD(IN(1,NEXTK)/100000000,10)
GO TC 21
104 IA(4)=MOD(IN(1,NEXTK)/100000,1000)
GO TC 21
5   IA(5)=MOD(IN(1,NEXTK),100000)
GO TC 21
106 IA(6)=IN(2,NEXTK)/10000000000000
GO TC 21
7   IA(7)=MOD(IN(2,NEXTK)/1000000000000,100)
GO TC 21
8   IA(8)=MOD(IN(2,NEXTK)/1000000,100000)
GO TC 21
109 IA(9)=MOD(IN(2,NEXTK),1000000)
GO TC 21
110 IA(10)=IN(3,NEXTK)/1000000000000

```

GC TO 21  
111 IA(11)=MOD(IN(3,NEXTK)/1000C00,1000000) 213  
GC TC 21  
112 IA(12)=MOD(IN(3,NEXTK),1000000)  
GC TC 21  
21 GO TO (11,12,13,14,11,16,17) MXCCDE  
11 MGRNV=1  
NMAMN=1  
GC TC 20  
12 MGRNV=1  
NMAMN=-1  
GC TC 20  
13 MGRNV=-1  
NMAMN=1  
GC TC 20  
14 MGRNV=-1  
NMAMN=-1  
GC TC 20  
16 IF(IA(JATT).GT.NVAL) GC TO 15  
166 NEXTK=NEXTK+1  
IF(NEXTK-NHH)2,2,666  
666 KCO=0  
GC TC 160  
17 IF(IA(JATT).LT.NVAL) GC TC 15  
GC TC 166  
20 IF(MGRNV\*(IA(JATT)-NVAL))4,201,66  
C WHEN EQUALITY OBTAINED, TEST FCR MXCODE=5  
201 IF(MXCCDE-5)4,15,4  
66 IF(MXCCDE-5)6,4,6  
6 IF(KBEST) 160,80,70  
70 IF(NMAMN\*(IA(JATT)-KBHLC))4,4,80  
80 KBEST=NEXTK  
KBHLD=IA(JATT)  
4 NEXTK=NEXTK+1  
IF(NEXTK-NHH)2,10,10  
15 KCO=NEXTK  
RETURN  
160 WRITE(ND,1305)KBEST,NEXTK,MXCCDE,JH,JATT,KCOL,NHH  
1305 FCRMAT(\* ERROR FIND, KBEST=\*I8\* NEXTK=\*I8\* PARMs=\*5I8)  
C REAL COMPARISONS FOR THE ARRAY VEN()  
RETURN  
1000 XVAL=XVA  
MXCCDE=MXCCDE-10  
GC TC (1100,1200,1300,1400,1100,1600,1700)MXCCDE  
1100 RNV=1.  
AMN=1.  
GO TC 2000  
1200 RNV=1.  
AMN=-1.  
GC TC 2000  
1300 RNV=-1.  
AMN=1.  
GC TC 2000  
1400 RNV=-1.  
AMN=-1.  
2000 IF(RNV\*(VEN(JATT,NEXTK)-XVAL))400,2100,6600  
2100 IF(MXCODE-5)400,15,400  
6600 IF(MXCODE-5)600,400,600  
600 IF(KBEST) 1600,800,700  
700 IF(AMN\*(VEN(JATT,NEXTK)-VEN(JATT,KBEST)))400,400,800  
800 KBEST=NEXTK  
400 NEXTK=NEXTK+1  
IF(NEXTK-NHH)2000,10,10

1600 IF(VEN(JATT,NEXTK).GT.XVAL) GC TO 15  
1660 NEXTK=NEXTK+1  
IF(NEXTK-NHH)1600,16C0,666  
1700 IF(VEN(JATT,NEXTK).LT.XVAL) GC TO 15  
GC TC 1660  
END

```
SUBROUTINE ZRCSUM(SUM,JVARBL)
C*****STATPK
C           ZROSLM(SUM,JVARBL)          -INITIATION
C           COLLT(SUM,JVARBL,X)        -COLLECTION
C           STATS(SUM,JVARBL,AVE,VAR,STD) -CALCULATION
C EACH COLUMN -JVARBL- WILL HANDLE STATISTICS FOR ONE VARIABLE.
C DECLARE AN ACTUAL ARRAY LIKE -SUM()- IN THE CALL PROGRAM TC (5,J)
C      WHERE      5 IS ABSOLUTE
C              J= MAXIMUM NUMBER OF VARIABLES FOR COLLECTION.
C INITIATE BY CALLING ZRCSUM(SUM,JVARBL) WITH JVARBL= 1,2,... FOR THE
C FIRST, SECCND, ETC. VARIABLE TO BE INITIATED.
C CALL COLLT(SUM,JVARBL,X) TO COLLECT THE OBSERVATION -X-.
C CALL STATS(SUM,JVARBL,AVE,VAR,STD) FOR CALCULATION OF AVE,VAR,STD.
C      MIN,MAX,SUM X'S,SUM SQS, AND NC. CBS ARE IN -SUM()- ANYTIME.
C*****
DIMENSION SUM(5,1)
SUM(1,JVARBL)=0.
SUM(2,JVARBL)=0.
SUM(3,JVARBL)=0.
SUM(4,JVARBL)=1.E25
SUM(5,JVARBL)=-1.E25
RETURN
END
```

COLLT

```
SUBROUTINE COLLT(SUM,JVARBL,X)
DIMENSION SUM(5,1)
SUM(1,JVARBL)=SUM(1,JVARBL)+X
SUM(2,JVARBL)=SUM(2,JVARBL)+X*X
SUM(3,JVARBL)=SUM(3,JVARBL)+1.
SUM(4,JVARBL)=AMIN1(SUM(4,JVARBL),X)
SUM(5,JVARBL)=AMAX1(SUM(5,JVARBL),X)
RETURN
END
```

```
SUBROUTINE STATS(SUM,JVARBL,AVE,VAR,STD)
CCMMCN /INIT/NR,NW,NC,NT7,NT8,NDAT,NS1,NS2
DIMENSION SUM(5,1)
XS=SUM(1,JVARBL)
XSS=SUM(2,JVARBL)
XN=SUM(3,JVARBL)
AVE=XS/XN
IF(XN.LE.1.) GC TC 1
VAR=((XN*XSS)-(XS*XS))/(XN*(XN-1.0))
IF(VAR)1,1,7
7 STD=VAR**.5
RETURN
1 VAR=0.
STD=0.
RETURN
END
C*****END CF STATPK**
```

```
RANUM
      FUNCTION RANUM(DUMMY)
C
C RANDOM NUMBER RETURNED AS VALUE OF RANUM = .0-1. FROM SOURCE-
C   -RANF(0), SYSTEM FUNCTION, IF NRNOPT=1
C   -TAPE OF RANDOM NUMBERS IF NRNCPT=2, REQUIRES REQUEST I.E.
C     -REQUEST(TAPE50,987,MT,HI,READ) IN CONTROL CARDS.
C
COMMON /RAN/RRN(54),KANUM,RLIMIT,NRNCPT,ITAPE
IF(NRNOPT-1)2,2,20
2  RANUM=RANF(0)
  RETURN
20 KANUM=KANUM+1
  IF(KANUM-55)28,26,28
26 KANUM=1
28 IF(KANUM-1)50,40,50
40 READ(ITAPE)RRN
  IF(ECF,ITAPE) 41, 50
41 REWIND ITAPE
  GO TO 40
50 RANUM=RRN(KANUM)
  RANUM=RANUM/RLIMIT
  RETURN
END
```

```
FUNCTION RNORM(RMEAN,STD,RMIN,RMAX)
C ASSIGNS TRUNCATED RANDM NORMAL DEVIATE TO FUNCTION NAME RNCRM,
C      ASSIGNS THE VALUE RMIN OR RMAX, NOT RECALLED WHEN
C      OUTSIDE THE RANGE RMIN, RMAX.
C WHEN STD=0., RNCRM IS SET=RMEAN LEAVING MIN AND MAX INEFFECTIVE.
      IF(STD)99, 99, 1
1      RA=RANUM(D)
      RB=RANUM(D)
      V=(-2.0*ALOG(RA))**0.5*COS(6.283*RB)
      RNCRM=V*STD+RMEAN
      IF(RNCRM-RMIN) 6, 7, 8
6      RNORM=RMIN
7      RETURN
8      IF(RNCRM-RMAX) 7, 7, 9
9      RNCRM= RMAX
      RETURN
99     RNCRM=RMEAN
      RETURN
      END
```

OUT

```

SUBROUTINE OUT (IN, VEN, ISTART, ISTCP, ICENT)
C PRINT INVENTCRY LOCATIOnS FRM ISTART TO ISTCP, DEBUGGING TCOL
  CCMMCN/INIT/NR,NW,CUMY,NT7,NT8,NDAT,NS1,NS2,NCWD
  4/GEN/ ITCT,ISIZE,NCWT,NCWY,NCAYS,NRUNS,IATTRIB(18),ATTRIB(4)
  5/CLEAN/ DUM(5),KL4
  5 /HOUSE/ NH(6),N1,N2,N3,N4,N5,N6
  5/RPT5/ IAAS,IAAE,IAAN,IAAFN,IAAM,IAAB,IAAFR
    DIMENSION IN(3,1),VEN(2,1)

```

C

C

```
C CHECK ISTART=7777 IMPLIES ANIMAL ATTRIBUTE PRINTING BY BLC.
```

```
  INTEGER SHFTR
```

```
  IF(ISTART=7777) 70, 500, 70
```

70

```
  ND=NT7
```

```
  INN=SHFTR(IDENT,48)
```

```
  IF(INN.EQ.0) GO TO 900
```

```
  WRITE(ND,80) NCWT,(NH(I),I=1,6),N6,IDENT
```

```
  80  FFORMAT(* CUT,NCWT=*I5* NH(I)=*6I3* N6=*I5* IDENT=*F15.3)
      GC TO 12
```

```
  900 WRITE(ND,90) NCWT,(NH(I),I=1,6),N6,IDENT
```

```
  90  FFORMAT(* CUT,NCWT=*I5* NH(I)=*6I3* N6=*I5* IDENT=*I15)
```

```
  12  WRITE(ND,299)
```

```
  299 FFORMAT(2X*1---234--5---- 67-8----9---- 1011----12---- 1314*
      2 *----15---- 1-----.---- 2-----,---*)
```

```
  DC 30 K=ISTART,ISTCP
```

```
  30  WRITE(ND,300)(IN(I,K),I=1,3),(VEN(II,K),II=1,2),K
```

```
  300 FFORMAT(1X,3I15,15X,2F15.3,I8)
```

```
  RETURN
```

C

C

```
C ANIMAL ATTRIBUTE PRINTING HOUSE BY HOUSE REQUEST.
```

C

```
500  IF(IAAS-NOWT) 502, 502, 899
```

```
502  IF(IAAE-NCWT) 899,504, 504
```

```
C      HEADING FOR NCWT DAILY ANIMAL ATTRIBUTES
```

```
504  NH2=NH(2)
```

```
  NH4=NH(4)
```

```
  NH3=NH(3)
```

```
  NH5=NH(5)
```

```
  NH1=NH(1)
```

```
  WRITE(NT7,5004) NCWT,NH2,NH4,NH3,NH5,NH1
```

```
  5004 FFORMAT(1H1,///,5X*DIAGNOSTIC REPORT OF ANIMAL ATTRIBUTES*
```

```
  2* AT END CF DAY*I5/1CX*INVENTCRY IS- NURSERY=*I4
```

```
  3*, FINISHING=*I5*, SCW MAINTENANCE=*I4*, *I3* BOARS, AND*
```

```
  4* FARROWING=*I4)
```

```
C NURSERY WRITE ATTRIBUTES
```

```
  N777=0
```

```
  IF(IAAN) 700, 700, 550
```

```
  550  IF(NH2) 700, 700, 552
```

```
  552  WRITE(NT7,5552)
```

```
  5552 FFORMAT(/5X*NURSERY BLD., SEX CLASS J=2 IS FEMALE, J=3 IS MALE,*
```

```
  2* SUBCLASS K=1 IS NEVER CVULATED.*)
```

```
  WRITE(NT7,5005)
```

```
  5005 FFORMAT(15X*HERD NC.=          AGE=      SEX J=      SUB.K=  DAY SIM.*
```

```
  2*     BRTWT=      WT.=      GAIN=  *)
```

```
  NI=N1+1
```

```
  NF=5
```

```
  N77=NH2
```

```
  706  DC 559 I=1,N77
```

```
  CALL REMCV(IN, VEN, NI)
```

R11=IATRIB(11)

221

BRTWT=R11/100.

WRITE(NT7,5559) IATRIB(5), IATRIB(1), IATRIB(2), IATRIB(3),  
2 IATRIB(9), BRTWT, ATRIB(1), ATRIB(2)

5559 FCRMAT(12X,5I10,3F10.2)

CALL FILEM(IN, VEN, NF)

559 CCNTINUE

IF(N777) 700, 700, 600

C FINISHING HOUSE WRITE ATTRIBUTES

700 IF(IAAFN) 600, 600, 702

702 IF(NH4) 600, 600, 704

704 WRITE(NT7, 5704)

5704 FCRMAT(/5X\*FINISHING BLD., SEX CLASS J=2 IS FEMALE, J=3 IS\*  
2\* MALE, SUBCLASS K=1 IS NEVER OVULATED.\*)

WRITE(NT7, 5005)

C USE NURSERY LCCP ABOVE, GC TO MAINTENANCE AFTER

NI=N3+1

NF=7

N77=NH4

N777=1

GC TC 706

600 IF(IAAM) 800, 800, 602

602 IF(NH3) 6900, 6900, 604

604 WRITE(NT7, 5604)

5604 FCRMAT(/5X\*MAINTENANCE BLD., SEX CLASS J=2 IS FEMALE, SUBCLASS\*  
2\* K=1 IS NEVER OVULATED, K=2 IS\*/8X\*OVULATING OPEN, K=3 IS\*  
3\* GESTATION, K=4 IS LACTATION, LTAL= NC. DAYS IN ABOVE SUB\*  
4\*CLASS, \*/8X\*PIGS= NC. OF PIGS AT BIRTH, LEST= NC. DAYS IN\*  
5\* ESTRUS CYCLE, LGST= NC. DAYS FOR THIS GESTATION\*)

WRITE(NT7, 5606)

5606 FORMAT(7X\*HERD NO.= AGE= SEX J= SUB.K= LTAL=\*  
2\* PIGS= LEST= LGST= DAY SIM. WT.= GAIN=\*)

DC 659 I=1, NH3

CALL REMOV(IN, VEN, N2+1).

WRITE(NT7, 5669) IATRIB(5), IATRIB(1), IATRIB(2), IATRIB(3),

2 IATRIB(4), IATRIB(8), IATRIB(10), IATRIB(11), IATRIB(9),

3 IATRIB(1), IATRIB(2)

5669 FORMAT(5X, 9I9, 2F9.2)

CALL FILEM(IN, VEN, 6)

659 CCNTINUE

6900 NH6=NH(6)

WRITE(NT7, 6905) NH6

6905 FCRMAT(5X\*CULL PEN HAS\*I5\* SCWS FOR SALE IN ADDITION\*

2\* TO THOSE IN MAINT. BLD.\*)

IF(NH6) 800, 800, 6958

6958 DC 6959 I=1, NH6

CALL REMOV(IN, VEN, N5+1)

WRITE(NT7, 5669) IATRIB(5), IATRIB(1), IATRIB(2), IATRIB(3),

2 IATRIB(4), IATRIB(8), IATRIB(10), IATRIB(11),

3 IATRIB(9), IATRIB(1), IATRIB(2)

CALL FILEM(IN, VEN, 9)

6959 CCNTINUE

800 IF(IAAB) 400, 400, 802

802 IF(NH5) 400, 400, 804

804 WRITE(NT7, 5804)

5804 FCRMAT(/5X\*BCARS, SEX CLASS J=1 WITH SUBCLASS K=1 FCR NEW\*  
2\* K=2 FOR YOUNG, K=2 FCR MATURE, LTAL=CAYS IN\*/8X\*SUBCLASS\*  
3\* K WEEK=6 DIGIT USE WITH RIGHTMOST RECENT DAY, ETC., \*  
4\* SERVS= TOTAL SERVICES TC DATE\*)

WRITE(NT7, 5806)

5806 FCRMAT(7X\*HERD NO.= AGE= SEX J= SUB.K= LTAL= \*  
2\*WEEK= SERVS= DAY SIM.= WT.= GAIN=\*)

DC 859 I=1, NH5

```
CALL REMCV(IN, VEN,N4+1)
WRITE(NT7,5889)IATRIB(5),IATRIB(1),IATRIB(2),IATRIB(3),
2IATRIB(4),IATRIB(11),IATRIB(12),IATRIB(9),ATRIB(1),ATRIB(2)
5889 FCRMAT(5X,8I9,2F9.2)
CALL FILEM(IN, VEN,8)
859 CCNTINUE
400 IF(IAAFR) 788, 788, 402
402 IF(NH1) 788, 788, 404
404 WRITE(NT7,5404)
5404 FCRMAT(/5X*FARROWING BLC., SEX CLASS J=2 FOR FEMALE, J=3 *
2*IS MALE, SUBCLASS K=4 FCR SCWS IN LCATATION,*/8X*K=1 CR C FCR*
3* BABY PIGS, LTAL= NC. DAYS IN SUBCLASS K FCR SCW BUT=0*
4* FCRM PIGS, PIGS/DAM=*//8X*NC. PIGS AT BIRTH FCR SCW,*
5* BUT HERD NO. OF DAM IF A PIG. BRTHWT= WT. AT BIRTH,*
6*=0 FCR SCWS*)
WRITE(NT7,5406)
5406 FORMAT(7X*HERD NC.=      AGE=      SEX J=      SUB.K=      LTAL=*
2* PIGS/DAM DAY SIM.= BRTHWT=      WT.=      GAIN=*)
DC 459 I=1,NH1
CALL REMOV(IN, VEN,1)
R11=IATRIB(11)
BRW=R11/100.
WRITE(NT7,5449)IATRIB(5),IATRIB(1),IATRIB(2),IATRIB(3),
2IATRIB(4),IATRIB(8),IATRIB(9),BRW,ATRIB(1),ATRIB(2)
5449 FCRMAT(5X,7I9,3F9.2)
CALL FILEM(IN, VEN,4)
459 CCNTINUE
788 WRITE(NT7,6788)
6788 FCRMAT(5X*END ANIMAL ATTRIBUTES DIAGNOSTIC REPORT*
2* FCRM SUBROUTINE OUT*//)
899 RETURN
END
```

REPT1

SUBROUTINE REPT1 (IN, VEN)

C REPORT SUMMARY FOR HERD BASIS

```

COMMON/INIT/NR,NW,NC,NT7,NT8,NCAT,NS1,NS2,NCWD
2 /RAN/ IRN(54),KTRANU,RLIMIT,ARNCP,ITAPE
3 /STAT/ SUM(5,20),SUM2(5,10),SUM3(5,10),SUM4(5,10)
4 /GEN/ ITOT,ISIZE,NCWT,NOWY,NDAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5/HOUSE/NH(6),N1,N2,N3,N4,N5,N6,NXTFAR,MX1,MX2,MX3,MX4
6/WRT1/KW
1/RPT1/ISMYP,ISMGB,ISMGBG,ISMF,ISMW,ISMW,ISMW
4/BRED4/KBRD,KSWGT(4),NCNB(4),NCNBK(4)
4/GAIN2/SCP(6),HOP(6),SSLD(6),HSLD(6),SEND(6),HEND(6)
6/SALES/MSELL,WTS,NXTSAL,NSLD(4),WTSVD(4),VSLD(4),PRIH,PRIS
CCMNC/CLEAN/D(5),KL4
DIMENSION IN(3,1),VEN(2,1)

```

C

C SEND TO KW TYPE OF REPRT.

C =2 IS FARROWING SEASCN REPORT.

IF(KW=3) 2000, 3000, 40

40 IF(KW=5) 4000, 5000, 60

60 IF(KW=7) 6000, 7000, 4

4 RETURN

C

C

C

C SEASONAL FARROWING REPRT CD. 55 CELL 4 IS ON.

2000 WRITE(ND,501) NCWT,NOWY,NCWD

501 FORMAT(//5X\*SEASCNAL FARRCWING REPRT ON DAY=\*I4/
25X,95(1H=)/10X\*YEAR=\*I2\*, DAY OF YEAR=\*I3\*, THE FARRCWING\*
3\* HOUSE WAS CLEANED TDAY, SEE (1)\*)
WRITE(ND,503)

503 FORMAT(/10X\*-----ITEM----- MEAN----- ST. DEV.---\*
2\* ---MINIMUM--- ---MAXIMUM---\*)

C

C KW=2 IMPLIES SEASCNAL FARRCWING REPRT IN SUM2()

C SUM2( ,1)=LITTER SIZE SEASCN, NO. OBS.=NO. LITTERS.

C SUM2( ,2)=DATE CF BIRTH.

C SUM2( ,3)=PERCENTAGE BLD. IS FILLED.

C SUM2( ,4)=BIRTH WEIGHTS PIGS.

C SUM2( ,5)=NO. PIGS LCST FCR BLD. NOT CLEAN.

C SUM2( ,6)=NO. PIGS LCST FCR EXCEEDING CAPACITY.

NL=SUM2(3,1)

WRITE(ND,505) NL

505 FORMAT(/6X\*FARROWED\*I3\* LITTERS IN FARRCW BLD.\*)

C

C

IF(NL)504, 504, 506

504 IF(NCWT-10) 1505, 1505, 530

1505 WRITE(ND,508)

508 FORMAT(/20X\*ZERO OBSERVATIONS, LITTERS WERE BORN\*
2\* BEFOR DAY ZERO CF SIMULATION, REPRT TERMINATED\*)

GO TO 530

506 CONTINUE

CALL STATS(SUM2,1,ASIZ,VAR,SSIZ)

MNSIZ=SUM2(4,1)

MXSIZ=SUM2(5,1)

WRITE(ND,507) ASIZ,SSIZ,MNSIZ, MXSIZ

507 FORMAT(10X\*LITTER SIZE ALIVE= \*F13.3,F16.3,2I16)

CALL STATS(SUM2,2,ADAT,VAR,SDAT)

MNDAT=SUM2(4,2)

MXDAT=SUM2(5,2)

WRITE(ND,509) ADAT,SDAT,MNDAT, MXDAT

```

509  FCRMAT(10X*DATE OF BIRTH=      *F13.3,F16.3,2I16)
     CALL STATS(SUM2,3,ACAP,VAR,SCAP)
     RNCAP=SUM2(4,3)
     RXCAP=SUM2(5,3)
     WRITE(ND,511) ACAP, SCAP, RNCAP, RXCAP
511  FORMAT(10X*CAPACITY BLD., PCT.=*F13.3,F16.3,2F16.3)
     CALL STATS(SUM2,4,AWT,VAR,SWT)
     RNWT=SUM2(4,4)
     RXWT=SUM2(5,4)
     WRITE(ND,513) AWT,SWT,RNWT,RXWT
513  FCRMAT(10X*BIRTH WEIGHT CF PIGS=*F12.3,3F16.3)
     NL=SUM2(3,5)
     WRITE(ND,515) NL
515  FCRMAT(/6X*LCST*I3* LITTERS, BLD. NOT CLEANED*)
     IF(NL) 520, 520, 516
516  CALL STATS(SUM2,5,ALCS,VAR,SLCS)
     MNL=SLM2(4,5)
     MXL=SLM2(5,5)
     WRITE(ND,517) ALCS,SLCS,MNL,MXL
517  FCRMAT(10X*LITTER SIZE LOST=    *F13.3,F16.3,2I16)
     NL=SLM2(3,6)
     WRITE(ND,521) NL
521  FORMAT(/6X*LOST*I3* LITTERS, CUE TO BLD. OVERFLOW*)
     IF(NL) 530, 530, 523
523  CALL STATS(SUM2,6,ALCS,VAR,SLCS)
     MNL=SLM2(4,6)
     MXL=SUM2(5,6)
     WRITE(ND,527) ALCS,SLCS,MNL,MXL
527  FCRMAT(10X*LITTER SIZE LCST=   *F13.3,F16.3,2I16)
530  WRITE(ND,531)
531  FCRMAT(/6X*END SEASCNL FARRCING REPCRT*65(1H=))
C
C ZERO COLLECTING ARRAYS FCR NEXT SEASCN.
C   DO 561 I=1,6
561  CALL ZROSLM(SLM2,I)
     RETURN
C
C
C
C SEASONAL BREEDING REPCRT
C   START SEASON IN SUB. SELECT FCR INVENTORY OF SCWS AVAIL.
C   KBRC IS AVAILABLE= TCTAL NC. EXPCSED (TARGET NO. TC BREED)
C   DURING THE SEASON.
C   KSWGT() 1=OPEN GILTS, 2=CPEN SOWS, 3= CTHERS., 4= DAY
C   SUB. BREED COLLECTS STATS FCR CCNCEIVING SCWS AND GILTS
C   SUM2( ,7)=AGE OF SCW AT FARRCING.
C   SUM2( ,8)=ASSIGNED LITTER SIZE.
C   SUM2( ,9)= DAY CF CONCEPTION.
C   COUNT NCN CCNCEIVING IN ARRAY NCNB().
C   NONB() 1= NC. REFUSED BECAUSE MAX PREVIOUSLY REACHED.
C           2= NC. FCR LACK CF BCARS, 3= NO. FAILING PRCB. TEST.
C           4= DAY TARGET REACHED, -999 IF NCT REACHED.
3000  WRITE(ND,3501) NCWT, NCWY, NCWD
3501  FCRMAT(////5X*SEASCNL BREEDING REPORT ON DAY=*I4/5X,
     295(1H=)/10X*YEAR=*I2*, DAY CF YEAR=*I3*, BREECING*
     3* SWITCH TURNED CFF TCCDAY.*)
     ITO=0
     DO 3505 I=1,3
3505  ITO=ITO+KSWGT(I)
     WRITE(ND,3507) ITO,KSWGT(4),KSWGT(1),KSWGT(2),KSWGT(3)
3507  FCRMAT(/6X*AFTER GILT SELECTION MAINTENANCE BLD. HAD*I3
     2* FEMALES ON DAY=*I5/10X*CPEN GILTS*9X*=*I4/1CX*OPEN SCWS*

```

C  
C GEST STATS ON BREEDINGS AND PRINT THEM OUT.  
NB=SUM2(3,7)  
WRITE(ND,3509) NB  
3509 FCRMAT(/6X\*BREEDINGS RESULTED IN\*I4\* CONCEPTIONS\*)  
IF(INB) 3516, 3516, 3510  
3510 IF(NCNB(4)+999) 3598, 3592, 3598  
3592 WRITE(ND,3593)  
3593 FCRMAT(1H+,48X\* TARGET NC. NCT REACHED\*)  
GC TC 3599  
3598 WRITE(ND,3597) KBRD, NCNB(4)  
3597 FCRMAT(1H+,44X\*, TARGET NC. EXPCSED=\*I4\* REACHED DAY=\*I6)  
3599 WRITE(ND,503)  
CALL STATS(SUM2,7,AAG,VAR,SAG)  
AMN=SLM2(4,7)  
AMX=SUM2(5,7)  
WRITE(ND,3511) AAG,SAG,AMN,AMX  
3511 FCRMAT(/10X\*AGE CF SCW AT FARROWING=\*F9.3,3F16.3)  
CALL STATS(SUM2,8,ALS,VAR,SLS)  
MN=SUM2(4,8)  
MX=SUM2(5,8)  
WRITE(ND,3513) ALS,SLS,MN,MX  
3513 FCRMAT(10X\*ASSIGNED LITTER SIZE=\*F12.3,F16.3,2I16)  
CALL STATS(SLM2,9,ADY,VAR,SDY)  
MN=SUM2(4,9)  
MX=SUM2(5,9)  
WRITE(ND,3515) ADY,SDY,MN,MX  
3515 FCRMAT(1CX\*DAY CF BREEDING=\*F17.3,F16.3,2I16)  
C      NON CONCEIVING SECTION, NCNB(4)=DAY MAX REACHED.  
3516 ITO=0  
DC 3517 I=1,3  
3517 ITO=ITO+NCNB(I)  
WRITE(ND,1319) ITC, NCNB(1),NCNB(2),NCNB(3)  
1319 FCRMAT(/6X\*SCWS IN HEAT BUT NCT BRED\*24X\*\*=I8/6X  
2\*DUE TO- TARGET PREVIOUSLY REACHED\*14X\*\*=I8/16X  
3\*LACK OF BOARS\*26X\*\*=I8/16X\*FAILING PROBABILITY CF\*  
4\* CONCEPTION TEST =\*I8)  
WRITE(ND,1321)  
1321 FCRMAT(/5X\*END SEASCNAL BREEDING REPORT\*67(1H=))  
DC 1329 I=1,3  
NCNB(I)=0  
1329 CALL ZRCSUM(SLM2,I+6)  
NCNB(4)=-999  
RETURN  
C  
C  
C  
C BUILDING USE PERIODIC REPRT.  
C KW=4 CALL, CALCULATION IS IN SLB. MGT3 WITH OVERFLW CHECKS.  
C SUM4( ,1)= NURSERY STATS CN PERCENT CAPACITY  
C SUM4( ,2)= FINISHING BUILDING STATS  
C SUM4( ,3)= MAINTENANCE STATS  
C SUM4( ,4)= FARROW CRATES STATS  
C  
4000 LDAY=NOWT-ISMYP  
WRITE(NW,4003) NCWT,LDAY,NCWD,NCWY  
4003 FCRMAT(////5X\*BUILDING USE PERIODIC REPORT CN DAY=\*I4/  
25X,95(1H=)/10X\*PREVIOUS REPRT WOULD HAVE BEEN CUE CN DAY\*  
3I4\*, TODAY IS DAY\*I4\* CF YEAR\*I2)  
WRITE(NW,4005) ISMYP  
4005 FCRMAT(/20X\*(NO.TCDAY)\*10X\*PERCENT OF MAXIMUM CAPACITY OVER\*  
2I4\* DAYS\*)

```

        WRITE(NW,4007)
4007  FCRMAT(21X*----- *68(1H-))
        WRITE(NW,503)
C          NURSERY
        CALL STATS(SUM4,1,AVE,VAR,STD)
        RMIN=SUM4(4,1)
        RMAX=SUM4(5,1)
        WRITE(NW,4011) NH(2),AVE,STD,RMIN,RMAX,MX2
4011  FCRMAT(/10X*NURSERY      (*I3*)=*F10.2,3F16.2
2 /12X*CAPACITY=*I4)
C          FINISHING
        CALL STATS(SUM4,2,AVE,VAR,STD)
        RMIN=SUM4(4,2)
        RMAX=SUM4(5,2)
        WRITE(NW,4015) NH(4),AVE,STD,RMIN,RMAX,MX4
4015  FCRMAT(10X*FINISHING    (*I3*)=*F10.2,3F16.2/12X*CAPACITY=*I4)
C          MAINTENANCE
        CALL STATS(SUM4,3,AVE,VAR,STD)
        RMIN=SUM4(4,3)
        RMAX=SUM4(5,3)
        WRITE(NW,4021) NH(3),AVE,STD,RMIN,RMAX,MX3
4021  FCRMAT(10X*MAINTENANCE (*I3*)=*F10.2,3F16.2/12X*CAPACITY=*I4)
C          FARROWING CRATES
        CALL STATS(SUM4,4,AVE,VAR,STD)
        RMIN=SUM4(4,4)
        RMAX=SUM4(5,4)
        WRITE(NW,4027) KL4,AVE,STD,RMIN,RMAX,MX1
4027  FCRMAT(10X*FARROW CRATES(*I3*)=*
2F10.2,3F16.2/12X*CAPACITY=*I4)
        WRITE(NW,4029)
4029  FCRMAT(5X====END BUILDING USE REPORT*69(1H=))
C SET SUM4, 1-4 =ZERO
C 4031 I=1,4
4031  CALL ZROSUM(SUM4,I)
        RETURN
C
C
C
C KW=5 PERICDIC BREEDING REPORT
C SUM3() 7,8 USED FOR AGE AND LITTER SIZE.
C NCNBK() 1-3 ARE MAX REACHED, LACK BCARS, FAILS PROB.,
C BUT 4 IS COUNTER FOR NO IN SEASCN.
C
5000  CCNTINUE
        WRITE(NW,5501) NCWT,NCWD,NCWY
5501  FORMAT(//5X*PERICDIC BREEDING REPORT ON DAY=*I4/5X,
2 95(1H=)/10X*TODAY IS DAY*I4* OF YEAR* I2)
        NB=SUM3(3,7)
        WRITE(NW,5509) NB
5509  FCRMAT(/6X*BREEDINGS RESULTED IN*I8* CONCEPTIONS.*)
        IF(NB) 5516, 5516, 5510
5510  WRITE(NW,503)
C          AGE OF SOW
        CALL STATS(SUM3,7,AAG,VAR,SAG)
        AMN=SUM3(4,7)
        AMX=SUM3(5,7)
        WRITE(NW,3511) AAG,SAG,AMN,AMX
C          SIZE OF LITTERS
        CALL STATS(SUM3,8,ALS,VAR,SLS)
        MN=SUM3(4,8)
        MX=SUM3(5,8)
        WRITE(NW,3513) ALS,SLS,MN,MX

```

5516 ITO=0  
CC 5517 I=1,4  
5517 ITC=ITC+NCNBK(I)  
WRITE(NW,1319) ITC,NCNBK(1),NCNBK(2),NCNBK(3)  
WRITE(NW,5519) NONBK(4)  
5519 FCRMAT(16X\*SEASCN CLCSED\*26X\*=?I8)  
WRITE(NW,5321)  
5321 FCRMAT(/5X\*END PERICCIC BREEDING REPCRT\*67(1H=))  
CC 5329 I=1,4  
5329 NCNBK(I)=0  
CALL ZROSUM(SUM3,7)  
CALL ZROSUM(SUM3,8)  
RETURN

C  
C  
C  
C PERICCIC FARRCWING REPCRT.  
C KW=6, SUM3() WITH AS IN SEASCNAL REPCRT  
C  
6000 WRITE(NW,6501) NCWT,NCWD,NCWY  
6501 FORMAT(1H1,5X\*FARRCWING PERICCIC REPCRT ON DAY=?I5/5X,  
295(1H=)/10X\*TODAY IS DAY\* I4\* OF YEAR\*I2)  
NL=SUM3(3,1)  
WRITE(NW,503)  
WRITE(NW,505) NL  
C LITTER SIZE  
IF(NL) 6533, 6533, 6505  
6505 CALL STATS(SUM3,1,ASIZ,VAR,SSIZ)  
MNSIZ=SUM3(4,1)  
MXSIZ=SUM3(5,1)  
WRITE(NW,507) ASIZ,SSIZ,MNSIZ, MXSIZ  
C CAPACITY  
CALL STATS(SUM3,3,ACAP,VAR,SCAP)  
RNCAP=SUM3(4,3)  
RXCAP=SUM3(5,3)  
WRITE(NW,511) ACAP,SCAP, RNCAP, RXCAP  
C BIRTH WTS.  
CALL STATS(SUM3,4,AWT,VAR,SWT)  
RNWT=SUM3(4,4)  
RXWT=SUM3(5,4)  
WRITE(NW,513) AWT,SWT,RNWT,RXWT  
C LOST LITTERS  
6533 NL=SUM3(3,5)  
WRITE(NW,515) NL  
IF(NL) 620, 620, 616  
616 CALL STATS(SUM3,5,ALCS,VAR,SLCS)  
MNL=SUM3(4,5)  
MXL=SUM3(5,5)  
WRITE(NW,517) ALCS,SLCS,MNL,MXL  
620 NL=SUM3(3,6)  
WRITE(NW,521) NL  
IF(NL) 630, 630, 623  
623 CALL STATS(SUM3, 6,ALCS,VAR,SLCS)  
MNL=SUM3(4,6)  
MXL=SUM3(5,6)  
WRITE(NW,527) ALCS, SLCS, MNL, MXL  
630 WRITE(NW,631)  
631 FORMAT(/6X\*END PERICCIC FARRCWING REPCRT\*65(1H=))  
CC 635 I=1,6  
CALL ZROSLM(SUM3,I)  
635 CCNTINUE  
RETURN

```

C
C
C WEIGHT GAINS PERIODIC REPORT, END INVENTORY TAKEN HERE.
C
C      COMMON USED IS 4/GAIN2/...
7000 IF(ISMW.GT.0) WRITE(NW,75C1)NCWT,NOWD,NOWY
7501 FCRMAT(////5X*WEIGHT GAINS PERIODIC REPRT CN DAY=*I4/5X,
2 95(1H=)/10X*TODAY IS DAY*I4* CF YEAR* I2)
C
C CALCULATE AN ENDING INVENTORY WT., USE IT, THEN
C COPY IT TO OPENING AND ZERO THE COUNTERS OF
C ARRAY (1)=NO., (2)= WT., (3)= VALUE
C
C SALES ARE ADDED IN SUB. SELL
C ORIGINAL OPENING INVENTORY FOUND IN SUB. CPEN.
C
DC 7009 I=1,ITOT
ICHK=IN(1,I)/1000000000
IF(ICHK-240) 7001, 7005
C HCGS AND PIGS LT. 240 DAYS OF AGE
7001 HEND(1)=HEND(1)+1.
HEND(2)=HEND(2)+VEN(1,I)
HEND(3)=HEND(3)+VEN(1,I)*PRIH/100.
GC TC 7009
C SCWS AND BOARS OVER 240 DAYS OF AGE
7005 SEND(1)=SEND(1)+1.
SEND(2)=SEND(2)+VEN(1,I)
SEND(3)=SEND(3)+VEN(1,I)*PRIS/100.
7009 CCNTINUE
C WT.= END INV. + SALES - OPENING INV.
C HOGS LESS THAN 240 DAYS.
IF(ISMW)7077, 7077, 7010
7010 NW1=HEND(1)+HSLD(1)-HCP(1)
W2=HEND(2)+HSLD(2)-HCP(2)
W3=HEND(3)+HSLD(3)-HCP(3)
WRITE(NW,7011)
WRITE(NW,7013)
7011 FCRMAT(/6X*PRODUCTION NET OF INVENTORY CHANGE-*)
7013 FCRMAT(/30X*-----NUMBER----- ---WEIGHT LBS.----*
2* ----VALUE DOL.----*)
WRITE(NW,7015)NW1,W2,W3
7015 FCRMAT(/10X*HOGS UNDER 240 DAYS =*I11,2F20.1)
C SCWS I.E. OLDER THAN 239 DAYS OF AGE.
NW1=SEND(1)+SSLD(1)-SCP(1)
W2=SEND(2)+SSLD(2)-SCP(2)
W3=SEND(3)+SSLD(3)-SCP(3)
WRITE(NW,7017) NW1, W2, W3
7017 FCRMAT(10X*SCWS(ALL 240 AND UP)=*I11,2F20.1)
WRITE(NW,7019)
7019 FCRMAT(/6X*ENDING INVENTORY-*)
NHEND=HEND(1)
WRITE(NW,7015) NHEND, HEND(2), HEND(3)
NSEND=SEND(1)
WRITE(NW,7017) NSEND,SEND(2),SEND(3)
WRITE(NW,7021)
7021 FCRMAT(/5X*END WEIGHT GAINS PERIODIC REPRT*63(1H=) )
C
C
C CALL REPT2 FOR COSTS AND RETURNS SUMMARY.
C      COUNTERS ARE ZERED THERE.
7077 CALL REPT2(IN,VEN)

```

RETURN  
END

229

```
SUBROUTINE REPT2(IN, VEN)
COMMON/INIT/NR,NW,ND,NT7,NT8,NDAT,NS1,NS2,NOWD
3/STAT/SUM(5,20),SUM2(5,10),SUM3(5,10),SUM4(5,10),SUM5(5,10)
4/GEN/ITOT,ISIZE,NOWT,NOWY,NDAYS,NRUNS,IATTRIB(18),ATTRIB(4)
5/HOUSE/NH(6),N1,N2,N3,N4,N5,N6,NXFAR,MX2,MX3,MX4
6/SALES/D(15),PRIH,PRIS
5/COST/FCS,FCB,CLAB,TFAR,TNUR,TSOW,TFIN,VAR(3),COST(30)
1/RPT1/ISMYP
2/RPT2/ISMYC,ISMCS,ISMCH,ISML,ISMSS,ISMSH,ISMGR
4/GAIN2/SOP(6),HOP(6),SSLD(6),HSLD(6),SEND(6),HEND(6)
DIMENSION IN(3,1),VEN(2,1)
```

C

C

```
C COST AND RETURNS SUMMARY REPORT
C COLLECTED IN SUB. MGT3, CALLED FROM REPT1 PERIODICALLY.
C GAINS ARRAYS ZEROED HERE.
```

```
C COST() 1=T. SOW DAYS, 2=FARROW BLD. MINUTES, 3=NURSERY BLD. MIN.,
C 4=MAINT. BLD + CULL MIN., 5= FINISHING BLD. MIN.
```

C

```
IF(ISMYC) 898, 898, 801
801 WRITE(NW,803) NOWT, NOWD, NOWY, ISMYP
803 FORMAT(1H1,5X*COSTS AND RETURNS PERIODIC REPORT ON DAY=*I4/
2 5X,95(1H=)/10X*TODAY IS DAY*I4* OF YEAR*I2* PERIOD*
3* COVERED=*I5* DAYS*)
```

```
C FEED COST SOWS C1
```

```
C1=COST(1)*FCS
IF(ISMCS)8200, 8200, 8100
8100 WRITE(NW,8105) C1, FCS
8105 FORMAT(/10X*FEED COSTS SOWS=*F8.2* DOL. AT*F4.2* PER DAY PER SOW
C FEED COST PER 100 LBS. HOGS PRODUCED.
8200 G=(HEND(2)+HSLD(2)-HOP(2))/100.
CH=G*FCB
IF(ISMCH)8300, 8300, 8201
8201 WRITE(NW,8205) CH, FCB
8205 FORMAT(/10X*FEED COSTS HOGS=*F8.2* DOL. AT*F6.2* PER*
2* 100 LBS. PRODUCED*)
```

```
C LABOR COSTS BY BLD.
```

```
8300 C2=COST(2)/60.*CLAB
IF(ISML) 8400, 8400, 8301
8301 WRITE(NW,8305) CLAB, C2
8305 FORMAT(/6X*LABOR COSTS BY BUILDING INCLUDING CULL PEN AT*
2F5.2* DOL. PER HOUR*/10X*FARROWING=*F20.2)
8400 C3=COST(3)/60.*CLAB
C4=COST(4)/60.*CLAB
C5=COST(5)/60.*CLAB
WRITE(NW,8309) C3, C4, C5
8309 FORMAT(10X*NURSERY=*F22.2/10X*SOWS MAINT. +CULLS=*F11.2/
210X*FINISHING=*F20.2)
```

C

```
C VALUE PRODUCED
```

```
S2=(SEND(2)+SSLD(2)-SOP(2)) / 100.
VS2= S2* PRIS
IF(ISMSS) 8500, 8500, 8401
8401 WRITE(NW,8405) S2, VS2
8405 FORMAT(/6X*SOWS PRODUCED=*F12.1* CWT. AT VALUE OF*
2F14.2* DOL.*)
8500 H2=(HEND(2)+HSLD(2)-HOP(2)) /100.
VH2= H2* PRIH
IF(ISMSH) 8600, 8600, 8501
8501 WRITE(NW,8505) H2, VH2
8505 FORMAT(/6X*HOGS PRODUCED=*F12.1* CWT. AT VALUE OF*
```

2F14.2\* DOL.\*)

231

C COSTS AND RETURNS NUTSHELL SUMMARY.  
C USE ABOVE CALCULATIONS FOR TABLE  
8600 IF(ISMGR) 8650, 8650, 8601  
8601 WRITE(NW,8603) ISMYP, NOWD,NOWY  
8603 FORMAT(//5X\*COSTS AND RETURNS SUMMARY OVER A\*  
2I5\* DAY PERIOD.\*/10X\*TODAY IS DAY\*I4\* OF YEAR\*I2)  
WRITE(NW,8605)  
8605 FORMAT(/41X\*-----SOWS----- HOGS----- \*  
2\*TOTAL HERD---\*/32X,3(17X,3H(\$)))  
TV2=VS2+VH2  
WRITE(NW,8611) VS2, VH2, TV2  
8611 FORMAT(44X\*(1)\*/10X\*PRODUCTION NET OF INVENTORY \*  
2\*CHANGE\*F9.2,2F20.2)  
TCF=C1+CH  
WRITE(NW,8617) C1,CH,TCF  
8617 FORMAT(19X\*(2)\*/10X\*FEED COST\*14X,3F20.2)  
C24=C2+C4  
C35=C3+C5  
TCL=C24+C35  
WRITE(NW,8621) C24, C35, TCL  
8621 FORMAT(20X\*(3)\*/10X\*LABOR COST\*13X,3F20.2)  
RS=VS2-C1-C2-C4  
RH=VH2-CH-C3-C5  
GR=TV2-TCF-TCL  
WRITE(NW,8631)RS,RH,GR  
8631 FORMAT(/10X\*RETURN OVER FEED AND LABOR\*F17.2,2F20.2)  
WRITE(NW,8641)  
8641 FORMAT(6X,93(1H-)/6X\*(1) SOWS INCLUDE ANIMALS 240 DAYS OF\*  
2\* AGE AND OVER, OTHERWISE THEY WHERE CLASSED AS HOGS AND PIGS.\*  
3/6X\*(2) FEED COST FOR SOWS BASED ON DAYS OF MAINTENANCE\*  
4 \* (INC. CULL PEN) AND LACTATION.\*/6X\*(3) LABOR COST BASED\*  
5\* ON BUILDING OCCUPANCY, ALL FARROWING HOUSE LABOR WAS\*  
6\* ASSIGNED TO SOWS.\*)  
8650 WRITE(NW,8651)  
8651 FORMAT(5X\*==END COSTS AND RETURNS SUMMARIES\*61(1H=))  
C ZERO COST ARRAY  
C  
898 DO 8801 I=1,5  
8801 COST(I)=0.  
C  
C ZERO GAIN ARRAYS.  
DO 899 I=1,3  
HOP(I)=0.  
SOP(I)=0.  
HSLD(I)=0.  
SSLD(I)=0.  
HOP(I)=HEND(I)  
SOP(I)=SEND(I)  
HEND(I)=0.  
899 SEND(I)=0.  
RETURN  
END

**APPENDIX D**

**INPUT DATA**

547231146	1	478.
362231096	2	370.
367231136	3	363.
110823 996	4	524.
744231146	5	498.
1106231046	6	486.
748231036	7	487.
92923 996	8	555.
928231116	9	485.
54623 996	10	425.
360231126	11	395.
922231136	12	499.
929231136	13	469.
749231016	14	471.
359231036	15	384.
1106231136	16	550.
74823 996	17	525.
358231096	18	388.
542231106	19	421.
359231146	20	408.
349231046	21	397.
751231096	22	507.
355231006	23	389.
1110231046	24	502.
65023 996	25	489.
650231096	26	479.
545231006	27	514.
545231006	28	498.
54523 996	29	457.
36523 996	30	389.
6666		
18230 07	31	188.
18021 07	32	174.
18330 07	33	204.
18321 07	34	210.
18330 07	35	224.
17921 07	36	208.
17921 07	37	196.
17830 07	38	260.
17821 07	39	196.
17830 07	40	226.
17621 07	41	230.
17621 07	42	204.
17621 07	43	216.
17530 07	44	228.
17521 07	45	216.
17530 07	46	212.
17330 07	47	206.
17321 07	48	200.
17321 07	49	182.
17221 07	50	224.
16721 07	51	196.
16630 07	52	236.
16630 07	53	182.
16621 07	54	196.
16321 07	55	198.
18221 07	56	206.
18321 07	57	160.
18321 07	58	198.
18321 07	59	198.
17830 07	60	232.

17630	07	61	208.
17521	07	62	206.
17530	07	63	198.
17321	07	64	200.
17321	07	65	174.
17330	07	66	210.
17321	07	67	194.
17330	07	68	238.
17330	07	69	248.
17321	07	70	208.
17230	07	71	244.
17230	07	72	210.
16721	07	73	202.
16730	07	74	226.
16721	07	75	190.
16621	07	76	192.
16621	07	77	172.
16621	07	78	196.
16621	07	79	158.
17130	07	80	218.
18030	07	81	202.
18330	07	82	228.
18321	07	83	202.
17930	07	84	216.
17830	07	85	231.
17830	07	86	264.
17821	07	87	234.
17621	07	88	228.
17630	07	89	225.
17530	07	90	224.
17521	07	91	220.
17521	07	92	186.
17321	07	93	208.
17330	07	94	174.
17121	07	95	184.
16721	07	96	200.
16730	07	97	210.
16621	07	98	204.
16621	07	99	206.
16630	07	100	222.
16621	07	101	182.
16630	07	102	240.
16621	07	103	176.
16330	07	104	196.
18221	07	105	192.
18231	07	106	184.
18231	07	107	206.
18021	07	108	206.
18321	07	109	202.
18330	07	110	228.
17921	07	111	228.
17930	07	112	232.
17830	07	113	222.
17830	07	114	200.
17621	07	115	224.
17630	07	116	202.
17621	07	117	225.
17621	07	118	212.
17621	07	119	206.
17630	07	120	228.
17521	07	121	192.
17330	07	122	190.
17130	07	123	222.

17121	07	124	220.
17121	07	125	186.
16730	07	126	232.
16621	07	127	174.
16321	07	128	204.
16330	07	129	214.
18221	07	130	208.
17921	07	131	216.
17621	07	132	212.
17330	07	133	206.
17230	07	134	234.
17121	07	135	202.
16730	07	136	236.
16721	07	137	158.
16730	07	138	234.
16730	07	139	224.
16630	07	140	214.
16621	07	141	200.
16621	07	142	202.
16630	07	143	210.
16621	07	144	164.
16621	07	145	200.
16630	07	146	198.
16621	07	147	198.
16621	07	148	202.
16621	07	149	202.
18230	07	150	188.
18021	07	151	174.
18330	07	152	204.
18321	07	153	210.
18330	07	154	224.
17921	07	155	208.
17921	07	156	196.
17830	07	157	260.
17821	07	158	196.
17830	07	159	226.
17621	07	160	230.
17621	07	161	204.
17621	07	162	216.
17530	07	163	228.
17521	07	164	216.
17530	07	165	212.
17330	07	166	206.
17321	07	167	200.
17321	07	168	182.
17221	07	169	224.
16721	07	170	196.
16630	07	171	236.
16630	07	172	182.
16621	07	173	196.
16321	07	174	198.
18221	07	175	206.
18321	07	176	160.
18321	07	177	198.
18321	07	178	198.
17830	07	179	232.
17630	07	180	208.
17521	07	181	206.
17530	07	182	198.
17321	07	183	200.
17321	07	184	174.
17330	07	185	210.

17321	07	186	194.
17330	07	187	238.
17330	07	188	248.
17321	07	189	208.
17230	07	190	244.
17230	07	191	210.
16721	07	192	202.
16730	07	193	226.
16721	07	194	190.
16621	07	195	192.
16621	07	196	172.
16621	07	197	196.
16621	07	198	158.
17130	07	199	218.
18030	07	200	202.
18330	07	201	228.
18321	07	202	202.
17930	07	203	216.
17830	07	204	231.
17830	07	205	264.
17821	07	206	234.
17621	07	207	228.
17630	07	208	225.
17530	07	209	224.
17521	07	210	220.
17521	07	211	186.
17321	07	212	208.
17330	07	213	174.
17121	07	214	184.
16721	07	215	200.
16730	07	216	210.
16621	07	217	204.
16621	07	218	206.
16630	07	219	222.
16621	07	220	182.
16630	07	221	240.
16621	07	222	176.
16330	07	223	196.
18221	07	224	192.
18231	07	225	184.
18231	07	226	206.
18021	07	227	206.
18321	07	228	202.
18330	07	229	228.
17921	07	230	228.
17930	07	231	232.
17830	07	232	222.
17830	07	233	200.
17621	07	234	224.
17630	07	235	202.
17621	07	236	225.
17621	07	237	212.
17621	07	238	206.
17630	07	239	228.
17521	07	240	192.
17330	07	241	190.
17130	07	242	222.
17121	07	243	220.
17121	07	244	186.
16730	07	245	232.
16621	07	246	174.
16321	07	247	204.
16330	07	248	214.

18221 07

249

208.

7777

236

## STANDARD CCNTRCL DATA AS OF 9-17-72

51. 365. 1. 14. 1. 1950.

1. 15.

10. 1. 180. 260. 1. 300. 350. 0. 730. 450.

14. 15. 2. 0.

15. 125. 1.

16. 80.

17. 240. 1.

8. 14. 215. 20.5 17. .50

13. .14 11.75 3. 6.5 .21 .8 .005

20. 3. 10. 3. 15. 2. 60. 180. 260.

12. -.10 -.05

11. 10. 2. 1600. 20. 20. 730. 60.

3. .10 .10 .035 .05 .015 .015 .015 .075 0.

4. .05 20.7 2.1 16.0 25.0 .75 .60 -.005 0.

2. 21. 17. 28. 18. 82.

5. 114.0 2.0 110.0 118.0 .040 .035 .020

6. 9.5 3.0 4.0 16.0 3. 0.47 1.25 5.0

7. 0.45 0.58 0.75 1.25 1.70 15.0

9. 1.0 .2 -0.5 1.0 5. .5

53. 365. 1. 1. 1. 1. 1. 1.

54. 1. 1. 1. 1. 1. 1. 1.

55. 0. 0. 0. 0.

56. -1. -1. 0. 0. 0. 0. 0. 0.

57. -1. -1. 0. 0. 0. 0. 0. 0.

58. 0. 0.

8888.

VITA

## VITA

Name: Jay Loren Strom

Birth: February 1, 1937 at Worthington, Minnesota

Citizenship: United States of America

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Children: Two sons, Channing, born August 18, 1969  
Eric, born November 18, 1972

Education:

- (1) Worthington High School, Worthington, Minnesota
- (2) McPherson College, McPherson Kansas 1955-56
- (3) University of Minnesota, B. S. in Animal Science 1956-59
- (4) Purdue University, M. A. in Agricultural Economics 1965-67
- (5) Purdue University, Ph.D. in Agricultural Economics,  
Candidate, May, 1973

Professional Experience: Farm Management Consulting - Purdue Fellows  
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Employment: Self Employed in Farming 1961-65  
Purdue University Fellows Program  
Purdue University Cooperative Extension  
CANFARM, Canadian Farm Management Data System, Guelph,  
Ontario 1972-