CLASSIFICATION OF INPUT-OUTPUT FACTORS AND CRITICAL PATH SCHEDULING IN PLANNING BEEF PRODUCTION SYSTEMS

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CONTENTS

FOREWORD

The purpose of this presentation is to examine the possibilities for using systems analysis concepts in planning and analyzing various sizes and types of beef production units. There are a number of aspects to be considered in applying systems concepts to beef production systems, and this presentation will discuss some of them.

The basic reason for using this approach is to provide farm management with a method for improving a beef production operation where uncertain conditions exist that create problems for the farm manager. By using systems analysis planning models in a beef production operation, the farm manager may be able to pinpoint problem areas and eliminate or minimize their effects and decrease the level of uncertainty within certain areas of his operation.

As mentioned previously, this presentation will discuss the possibilities for applying systems analysis concepts to a beef production operation with the realization that further research and empirical work remain to be done in this area.

INTRODUCTION

Beef production in the United States is an important segment of agriculture and forms the basis for a substantial portion of income to farmers, en total. It also affects farmers who do not raise beef themselves, but who grow feed grains for sale to beef producers, and in addition, it affects numerous individuals in the processing and marketing of beef products.

In the following presentation emphasis is given to a systems analysis of the individual beef production unit, taking into account the various forms of beef production units, with emphasis on two general types, the finishing program where cattle are "fattened" for market and a cow-calf program where the calf is the primary product. Individual beef production systems will fall under the former or latter of these two types and in some instances, both of these operations may be found in an individual operation.

One of the important considerations in systems analysis is to classify the inputs and outputs in the system under study, in this case a beef production unit. The classification system that follows later will apply to the various forms and sizes of beef production operations that currently exist.

Within systems analysis there are various planning models. One of these planning models is critical path scheduling. The classification of inputs and outputs of beef production systems lends itself to the use of critical path scheduling for further analysis including cost considerations. Systems and critical path scheduling concepts can be useful for initially planning a beef production operation or for analyzing an existing operation.

SYSTEMS ANALYSIS CONCEPTS

Systems analysis is a relatively new approach in the business and management world. The systems approach has been used, perhaps inadvertently, by the physical sciences for a number of years in defining the actions and functions of various physical phenomena.

To start, perhaps it would be useful to define the terminology and general methodology associated with systems analysis. A system has been defined in a number of ways, but one of the simplest and more clearly defined is that a system is "a set of objects together with relationships between the objects and between their attributes."[1] Some definitions of a system include the added idea that the interaction of the objects and their attributes is intended to achieve a desired goal or objective. However, this additional part of the definition approaches that of a goal model, whereby the goal model begins with an objective or goal and all efforts are directed toward the attainment of that goal, whereas a systems model considers all elements in relation to the attainment of the goals or objectives of the system in total, rather than a particular objective of a sub-system as the goal model may become orientated.

The objects referred to are merely the parts or various components of the system and the attributes are their respective properties. The relationships are responsible for forming the objects and their attributes into a cohesive whole. Associated with each system is its external environment relating to and affecting the system. A change in the objects of the environment of the system affects the system, and conversely.

[1] "Definition of System" by A.D. Hall and R.E. Fagen; Modern Systems Research for the Behavioral Scientist by Walter Buckley (Ed.); Aldine Publishing Co., Chicago; 1968.

A system may be further subdivided into various components called subsystems. Also, there are various descriptions that may be given to systems depending on their particular characteristics. One of these is the centralized system in which one particular subsystem or component management world. The systems approach has been used, perhaps inadvertently, and is known as the leading part. A system may be characterized by decay or growth, both under the heading of progressive segregation and contrasts progressive systematization where there is a tendency toward wholeness or coherence of the system. Progressive centralization may occur with either progressive segregation or progressive systematization.

Systems may also be classified as natural or man-made and are self-definitive. Natural or man-made systems may further be classified as open or closed. An open system exchanges various levels of information, energy, or material with its environment, whereas a closed system does not. There are considerably more open systems than closed systems. A system that is able to favorably continue its operation in relation to its environment is known as an adaptive system, and, if certain variables within the system remain within defined limits, the system is also termed stable. When a system possesses the property that a part of the output is returned as an input into the system, such as information for example, this property is known as feedback.

The foregoing descriptive terms serve to provide reference points in systems analysis, but relationships and environment should be expanded further. As mentioned before, relationships are the cohesive entities and if these relationships were not included, the concept of a system would be without meaning. While a number of relationships may exist, the primary concern is with those relationships that affect the system as they change.

Through systems analysis the relationships may be more explicitly defined, and the analysis may identify relationships that were hitherto undefined. The environment may be more formally defined as "the set of all objects, a change in whose attributes affects the system, and also of those objects whose attributes are changed by the behavior of the system."[2] A problem arises on certain occasions when trying to decide which objects and relationships to include in the environment or in the system. First of all, only those objects that are relevant to the study of the system should be included in environment for the sake of reducing the problem to a manageable level. After the relevant information is assembled, one test or measure for determining whether an object belongs to the system proper or to the environment is to determine whether management has control over the object and its relationships with other objects or not. If management can exercise control over the object and its relationships with other objects, then it belongs to the system under study. If, however, management cannot exercise control, then the object belongs to the environment.

Signals are another important area to be considered in systems analysis. The signal is used to aid in directing the system. In systems analysis there are both inputs and outputs to be considered and signals are the basis for directing these inputs and outputs. The concept of the use of signals lends itself to a mathematical analysis of the system. "The output signal is the response of the system to the input signal."[3] The signal serves to direct the system and the system reacts in order to achieve the desired goal or objective, whether it is the system itself or a subsystem, and the signal almost invariably relates to time.

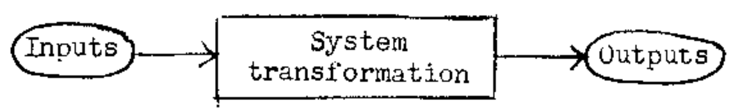
[2] Ibid; A. D. Hall and R. E. Fagen.

[3] Methods of Signal and System Analysis by George R. Cooper and Clare D. McGillem; Holt, Rinehart, and Winston, Inc., New York; 1967.

SYSTEM REPRESENTATION

A specific system may be shown diagrammatically and there are certain prescribed methods of representation. These methods may vary from one situation to another according to the author's particular viewpoint, but the following conventions will serve as an example.

The objects in a system may be represented by small circles and their respective relationships are represented by arrows. Both must be chosen so as to achieve a specific purpose. In this regard there is the quality of isomorphism that maintains the relationships between the objects in a one-to-one ratio or that denotes two systems having essentially the same structure. A flow diagram such as pictured below shows the inputs and outputs and their relationships:



In a more complex flow graph, two arrows in a series, multiply, and two arrows in parallel, add. The rectangle above represents changes within the system.

The transformation properties of the objects or elements must be described sufficiently in order to determine the relationship of the inputs to the outputs. There are various forms of these transformation operations which may be described as:

Conversion operation - a single transformation

Logical operation - application of a decision rule

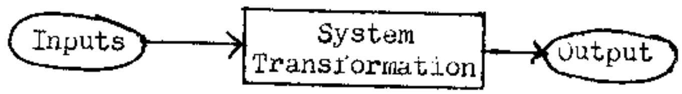
Correction operation - an observation phase

When a system is described in terms of a particular or discrete condition, this condition becomes known as the state of the system. The state of the system reflects a point in time, rather than a movement of the system over time and the objects or elements can be represented by discrete levels.

As a system becomes more complex, the number of objects or elements and their interactions can become ponderous and difficult to manage for analysis. Establishing a hierarchy within the system then becomes extremely important. The hierarchy refers to levels of classification within the system. By using the hierarchy of the objects and relationships within the system, the system may be broken down or built up for further analysis.

GENERAL BEEF PRODUCTION SYSTEMS MODEL

Recalling the general systems model presented earlier:



This may also represent a general systems model for an individual beef-producing unit where the inputs and output are aggregated for convenience of representation. System transformation refers to the conversion of these inputs through time into the output of finished beef or a calf crop depending on the type of operation. Also, in some cases, the waste material from these animals is an output of the operation and has value, whether recycled through a crop production program or dried and sold commercially.

This model can be expanded further when the environment external to the individual beef production operation is taken into account. Influencing the individual beef operation is the environment of the beef industry in the aggregate including industry demand and supply and the competitive conditions of the available markets. There is a flow of product from the individual operation to the industry and a reverse flow of information and financial returns. The environment of the industry is in turn influenced by the ultimate market or the consumers of beef products or the external environment[1]. The external environment forces that affect the ultimate market for finished beef products are scientific and technological forces, life style and life space forces, economic and political forces both domestic and international, and ethical, legal, and

[1] Managerial Marketing: Perspectives and Viewpoints by Eugene J. Kelley and William Lazer; Richard D. Irwin, Inc., Homewood, Illinois; 1967.

social forces. These forces are general, self-explanatory, and will not be specifically defined here other than to say that they affect the ultimate market for beef products and are constantly in a state of flux or change. They create problems of market determination and affect the environment within the industry extending to the individual beef operation itself. As the external environment and market change, so does the environment within the industry. The forces within the external environment are interdependent, also, and affect the industry supply and demand conditions as well as market conditions such as the price of products available to the individual beef producing operation as well as the level of competition of individual firms in the aggregate.

MANAGEMENT'S ROLE

There are a number of inputs, physical and non-physical, that enter into the beef production process. The over-all controlling factor that guides the acquisition of inputs and their transformation into output is management, and the general measure of the success or failure of management rests with the manager's ability to make "correct" decisions. The manager's ability to make decisions may be influenced by a number of factors including his educational background, past experience, the rules and regulations, and mores of the society in which he lives, his goals and objectives, and his personal reputation and financial standing in regard to his business, and also, by the nature of his business, in this case, beef production.

Among the authors on the topic of farm management there is agreement that management hinges on the decision-making process. This process has been broken down to a number of steps for solving a problem and they are:[1]

(1) make observations and form ideas concerning a problem,

(2) analyze the information from the observations,

(3) make a decision on the basis of the known information,

(4) take action on the decision, and

(5) bear financial responsibility for the decision and the action taken.

The need for decision-making by management is due to the dynamic nature of conditions in the world, especially those that affect the manager's business. These changing conditions lead to imperfect knowledge concerning future conditions creating risk and uncertainty as to the

[1] Farm Management Analysis by Lawrence A. Bradford and Glenn L. Johnson; John Wiley and Sons, Inc., New York; 1953.

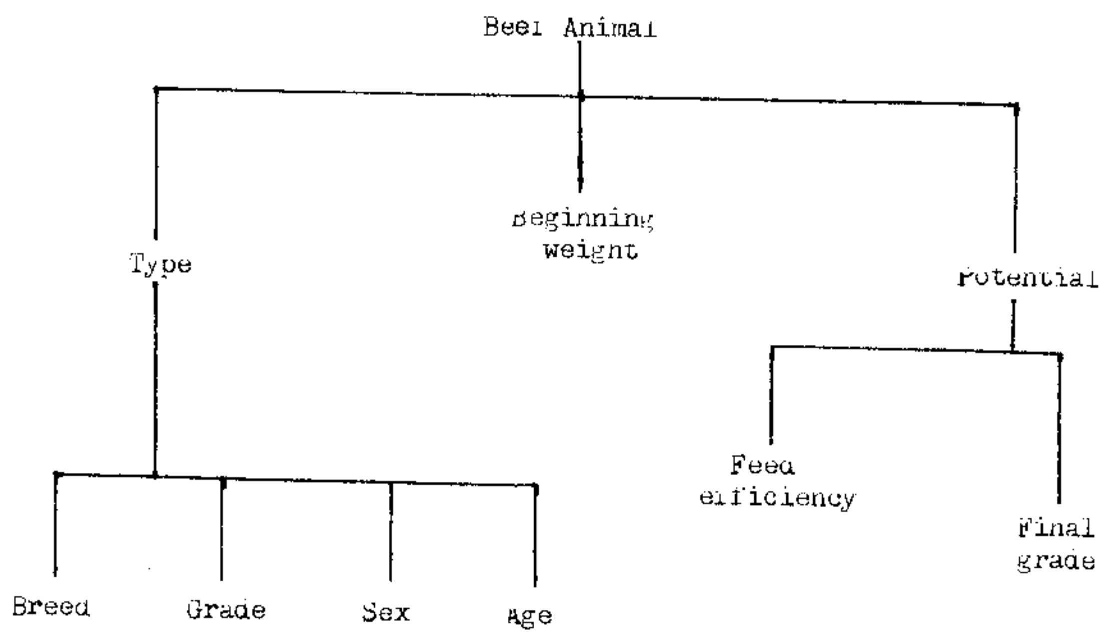
attainment of the goals and objectives desired by the manager.

When uncertainty exists as it does in beef production systems at present, management is the focal point in the operation and directs the transformation of inputs in the system into output. Uncertainty is incurred primarily from the disadvantages involved with various beef cattle enterprises such as the speculative risk involved in finishing programs and cow-calf programs due to changing market conditions. Also, there is a large capital investment for facilities, equipment, and feeders in finishing programs and a high initial investment for establishing a cow-calf program. Both programs need a good quality of labor in order to be efficientand this labor is generally required throughout the production period, which in many cases may be year-round. However, the labor requirements will vary from one type of operation to another. Management's problem is to provide for a continuous flow of labor when needed in his operation. Management will be the controlling element as long as uncertainty and risk are associated with beef production systems, and it affects the inputs and their transformation into output within the system.

Systems analysis can provide a means of planning and analyzing a beef production system through the use of planning models such as critical path scheduling and provide management with a means of determining feasible alternatives of action when a problem is encountered due to conditions of uncertainty. It can also provide a means of isolating and eliminating problems before they occur or at least to minimize the effects of the problem. One of the first steps is to classify the inputs into the beef production system and to map an existing beef production system into the classification scheme, or to initially plan a beef production system.

CLASSIFICATION OF INPUTS

One of the primary inputs into the beef production system is the beef animal itself. The beef animal is a natural sub-system within the man-made beef production system. The following diagram presents a general classification of factors to be considered within the beef animal.



General Classification
of Factors
of Beef Animal

This, and the following components are of a general nature of classification. As the situation exists, there are many types and sizes of beef production systems according to the methodology and technology that the farm manager employs and his skill and ability in making his decisions. Each manager may use his available resources in a different manner than another manager with the same level of resources, also. There are a number of different types of operations of beef production. One of these is the type of operation where the beef animal is purchased as a feeder or stocker. The farm manager then employs various resources, such as feed, labor, and capital, in order to "finish" the animal. To "finish" the animal refers to getting the animal to a higher, final weight and grade. The final grade level may be the same as, or hopefully higher, than the grade for the stocker or feeder. The profit from this type of operation is associated with the gain in the weight of the animal. There is the periodic purchase and sale of feeders and finished cattle involved in this type of operation, also. The turnover in this operation depends primarily on the initial weights of the feeders, whether it is a four hundred pound feeder or a nine hundred pound feeder on a comparatively shorter feeding period. Less capital is required to purchase the smaller feeder, but more time is required to produce the finished animal which places the date of achieving the final weight and grade further into the future and future marketing conditions become more uncertain. Conversely, more capital is required for the larger animal, but over a shorter feeding period. Even though the feeding period is shorter, the possibility of adverse marketing conditions presents the probability of greater capital loss on the invested capital. However, as time progresses with the smaller feeder, the situation approaches that of the heavier animal in that more capital has been invested in feed and labor.

There are a large number of variations in the size of finishing operations, either on a full time or on a part time basis. Full time basis refers to an operation that derives its primary source of income from a beef production enterprise and part time refers to an operation that derives income from various sources in addition to the beef production enterprise, even though the beef production operation is an important segment of the over-all enterprise, such as a cash crop-beef production enterprise. Examples of large beef finishing operations may be found in the Mid-west where several thousand head are finished annually. In this type of operation, the feed is purchased, usually in its entirety, and a minimum of shelter is provided. Usually the feed storage system is quite elaborate and the feeding network and facilities are extensive. However, the land requirements for this type of operation are not large.

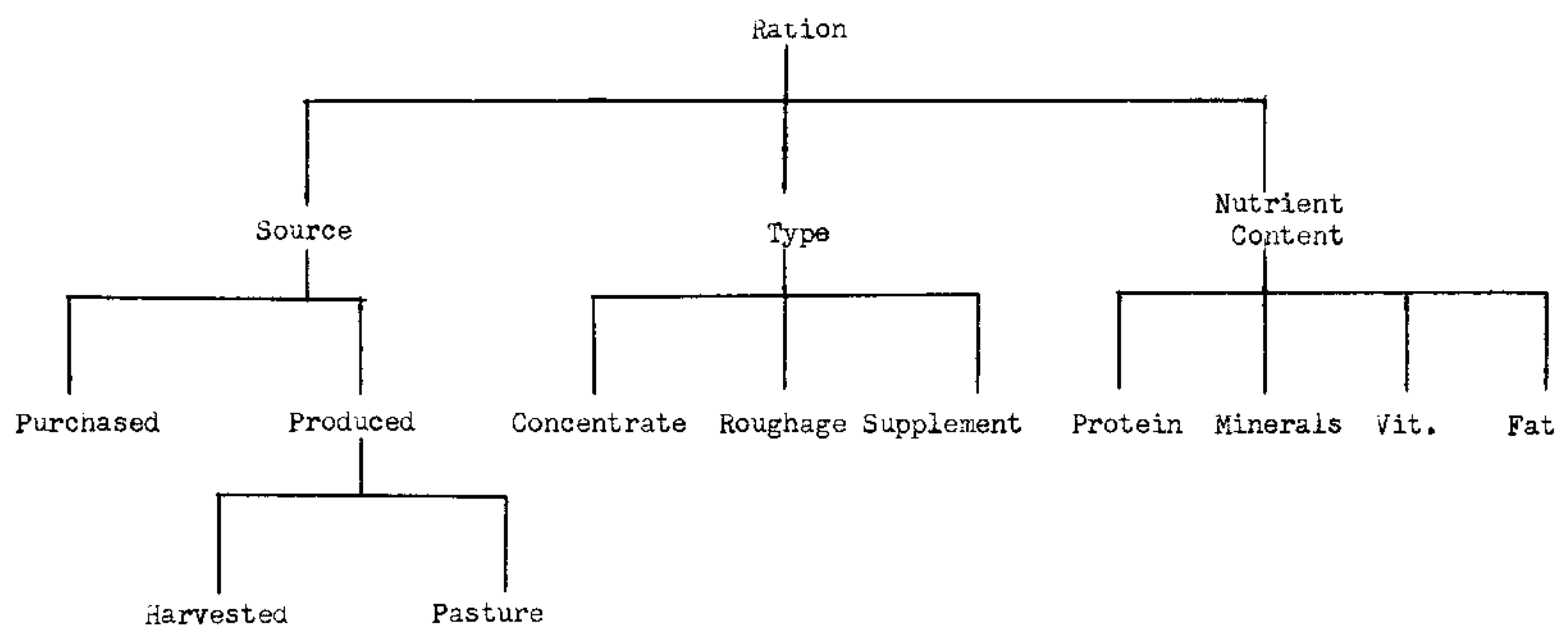
There is also the livestock operation that is joint with other farm operations such as cash cropping or hog raising. There are substantial variations in the size of and degree of importance of the beef production operation in the overall enterprise. In some cases, essentially all of the income is derived from the beef operation where crops such as corn or sorghum are raised and harvested to be used as feed for the cattle and in other cases a portion of the crop is sold after the needs for the cattle have been determined. The types of shelter, storage facilities, and the methods of feeding also are subject to large variation. The number of cattle fed in this type of operation may vary from less than one hundred to several hundred or several thousand head.

Another type of operation is that of the cow-calf segment of the beef cattle industry. In this operation, a herd is established for breeding in order to obtain the calf crop. Again, the farm manager employs resources and invests time and skill in order to obtain this crop. However, the farm manager has an alternative to consider, that is, whether to sell the calves as feeders or as veal or to retain them as inputs into a finishing program. In regard to the finishing program, the farm manager also has alternatives available. He may retain them in his own finishing program or he may contract the feeding operation to a commercial farm manager who finishes feeders and markets them for a fee that is specified in advance and who then forwards the proceeds to the cow-calf manager. The profit in the cow-calf operation depends in this instance on the value received for the calf crop. Unlike the finishing operation where the bulk of the investment is on a periodic basis and in the animals themselves, the initial investment in the breeding herd is a primary cost. Replacements over a period of time are necessary, but the establishment of the herd represents a rather large investment.

Again, there are a number of variations involved with the cow-calf operation as to its size and type, whether on a full time basis or part time basis just as in the finishing operation. However, the cow-calf operation lends itself to the use of pasture land where the animals may use pasture as an only source of feed or the pasture may be supplemented by other forms of feed such as hay or corn silage along with necessary vitamin and protein supplements. In many cases, salt is an essential supplementary item. The turnover in the cow-calf operation is on a deterministic basis and the number of calves available depends on the number of cows involved and on the percentage rate of the cows that actually drop a calf. The cow-calf operation may form the primary source of income for the farm manager or it may be in conjunction with the finishing operation, another livestock operation, and/or a cash crop program.

The diagram on the General Classification of Factors of the Beef Animal demonstrates the factors to be considered for a beef animal, primarily for a finishing operation. However, with modification the diagram can also apply to a cow used for breeding. The animal can be classified according to its breed, grade, sex, and age, whether Hereford or Angus for example, good, choice, or prime grade, heifer, bull, or steer feeder, and yearling or two year old for a finishing operation and breed, grade, and age for a cow in the cow-calf operation. Beginning weight refers to the initial weight of the feeder, or can refer to the purchase weight of a cow to serve as a guide along with the age of the animal for initiating breeding. Potential refers to the anticipated final grade of the animal in a finishing operation such as good to low choice, choice, and prime grades or to the anticipated quality of the calf when the cows and bull are selected in a cow-calf operation. The level of feed efficiency develops as time passes in terms of rate of gain and conversion of feed to pounds of gain or in terms of the amount of feed required to produce a calf. Initially, potential is a subjective evaluation, but through observation over a period of time, it develops into an objective, measurable quantity, which may be used as a basis for analysis in subsequent periods. As mentioned before, the beef animal forms a natural sub-system within the beef production system as a whole and is subject to an external environment separate from the manager's artificially created environment.

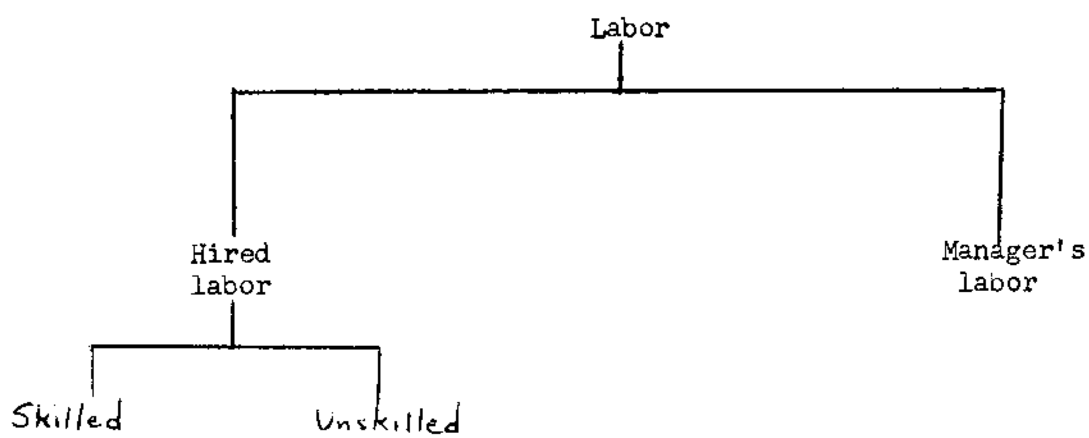
Another important input into the system is the ration as outlined on the following page. The ration, of course, is essential to both systems of beef production, but with the number of different types of feeds available the possible combinations for a ration are numerous. However, in the Mid-west and North Central States, corn as grain and silage is a primary ingredient in a ration as is sorghum in the Southwest due to it palatibility and relatively low cost. As the source for a ration, it may be either purchased or produced on the farm in its entirety. Large, commercial finishing operations in the mid-west may purchase all of their ingredients in the ration as influenced by their proximity to the production of the ingredients. In a cash-crop and beef production operation, the primary feeds may be grown, harvested, and stored for future use. Cows and calves and feeders may also be grazed on pasture as a source of feed. Certain items may be produced and some items purchased in a number of combinations. Feed production involves a cropping system and this cropping system will be considered external to the beef production system, but still under the control of the manager. A ration may be classified according to type, referring to the level of concentrate, roughage, and supplement it contains. Concentrate refers to an item such as corn in grain form for weight gain in a finishing operation and roughage refers to an item such as corn silage for use in both systems. Supplement refers to the use of other feedstuffs to make up for deficiencies in a ration of concentrate and roughage, if needed. Examples of a supplement are items such as soybean meal, minerals, and vitamins. The composition of the ration is based on the relative nutrient contents of the individual ingredients according to the



General Classification
of Factors
of the Ration

protein, mineral, vitamin, and fat or carbohydrate levels. Protein is an essential growth element while the carbohydrate level is to be considered in a finishing ration or for maintainance of the animal. Vitamins and minerals are also essential growth elements and are necessary for maintainance.

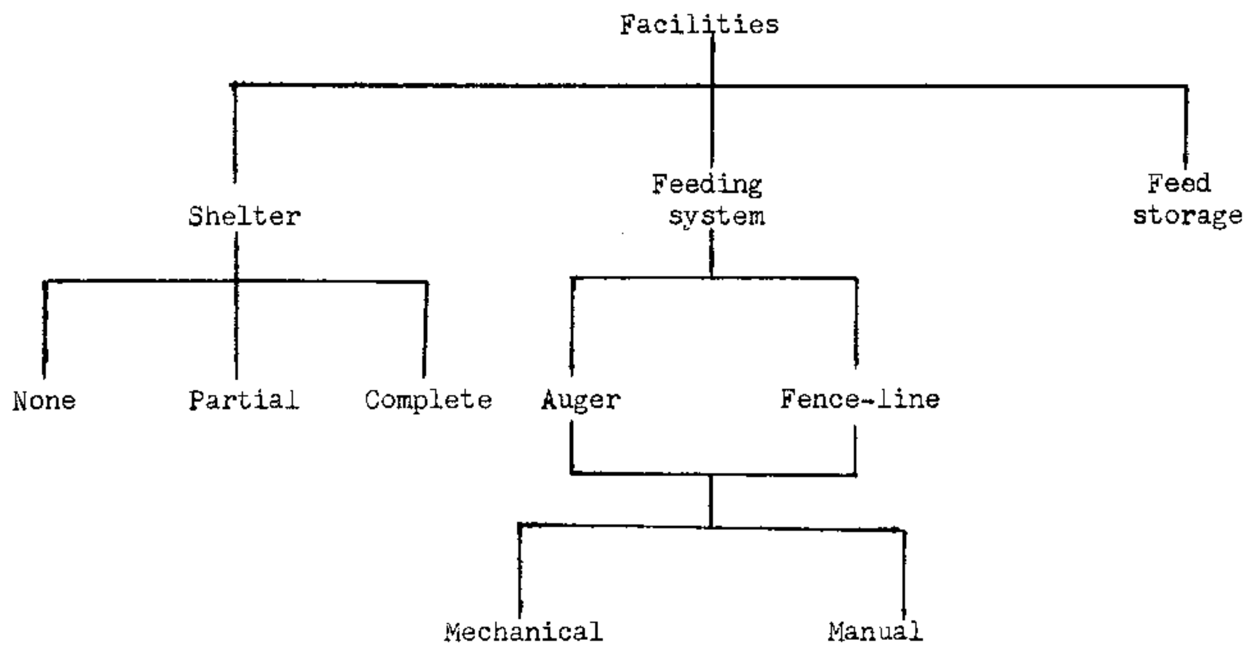
The labor input is essential to a beef production system, whether it is the manager's labor or additional hired labor according to the manager's discretion. The additional hired labor may be further classified as skilled or unskilled as in the illustration on the following page. The skilled labor component refers to professional services rendered, whether it is in establishing the system or maintaining the system. In establishing the system, this component may refer to the skilled labor required in construction or for consultant services that may be used for construction or financial affairs. When the system is in operation, the skilled labor may apply to services performed by a veterinarian or to services rendered in regard to consultation of financial and marketing affairs. For example, some of the large, commercial finishing operations in the Mid-west employ the services of a veterinarian on a year-round basis where the condition and health of several thousand animals is concerned and a high death rate means financial loss and possibly termination of the operation is losses continue over too long a period of time. The unskilled portion of labor refers to labor that is used primarily to facilitate the operation of the system in such tasks as inspection, feeding, and carrying on routine health measures of the animals. Also, labor may be required for the maintainance and care of equipment used in the system and in some cases this may call for the services of a skilled mechanic. It is to the discretion and judgment of the manager to decide whether he is able to or capable of performing the tasks that confront him, and further whether the task



General Classification
of Factors
of the Labor Component

requires the services of skilled or unskilled labor. However, there are many occasions when the farm manager must act as his own consultant in regard to decisions involving purchases and sales and their conditions and matters pertaining to the health and condition of the animals.

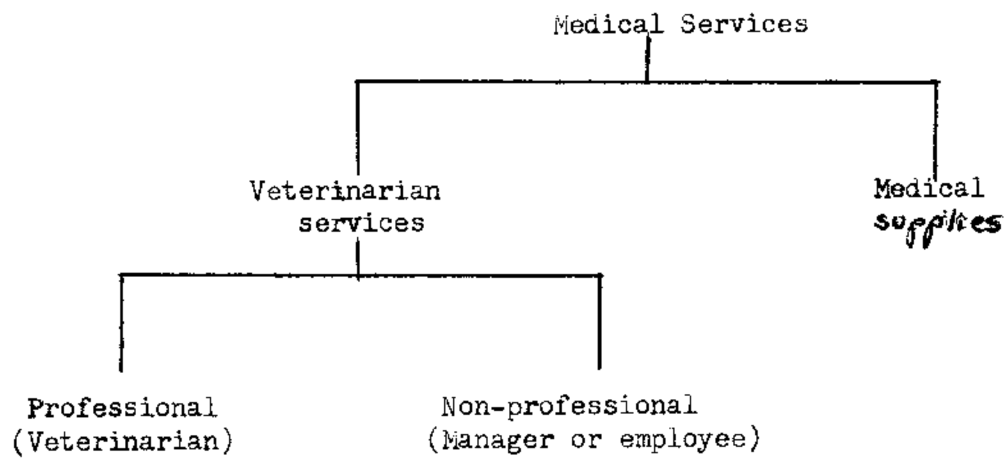
On the following page is a classification of factors involved with the physical facilities of a beef production system. One of the components is the provision for shelter for the beef animals. In some cases no shelter is provided for the animals of both systems and examples of this may be found typically on western ranges where the animals must cover a large area in order to find their feed and a single shelter or a number of shelter areas may not be feasible. There are also some examples of the opposite extreme where the animals are totally confined and all environmental factors relating to climate are controlled such as temperature within a certain range, humidity, and the flow of air. However, many operations provide a range of shelters that lie between the examples presented above, especially in humid, cold regions, to protect the animals against chilling winds and snowfall. Feed storage is another component of the facilities and refers to the structures required to store the feed over all or a part of the production period. The large finishing operations have storage facilities for ration ingredients in order to have feed on hand between deliveries or to allow for an unknown contingency when delivery cannot be made on schedule. This also applies to other operations except those that rely on the grazing range for winter feed supplies. Yet, even in this case hay may be stored in the event that adverse weather conditions prevent the animals from obtaining adequate feed. The structures may vary according to purpose, but they may take the form of an upright silo for storing grain and roughage, a trench silo for storing roughage, a corn crib, or a barn or shelter for storing dry hay and bedding although even these may be stored outside, but the risk of spoilage is greater. In this case bedding will be



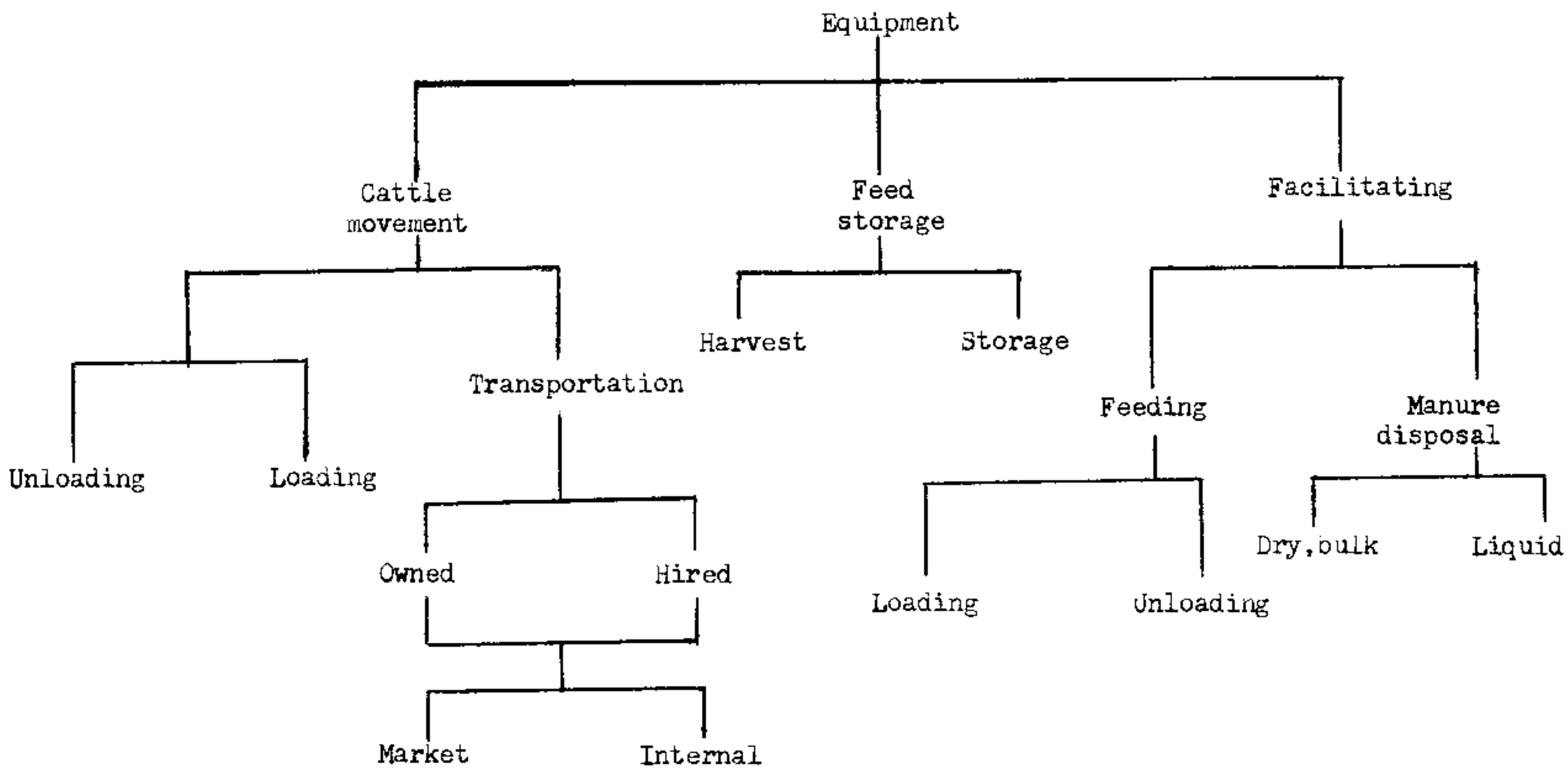
General Classification
of Factors
of the Facilities

discussed in the same manner as the procurement and storage of the feed component, especially that of dry hay where the storage facilities are similar whether purchased or produced and if it is produced on the farm, then the labor and equipment requirements may be identical to that of dry hay. However, the land use requirement will differ and allowances must be made for bedding in the cropping program if it is produced on the farm. If dry hay is not used in the ration, then bedding must be considered separately with regard to storage facilities, labor, equipment, and land use requirements. There is, at present, a trend toward the use of facilities that employ a liquid manure disposal sytem in which a minimum amount of, or no, bedding is used. Also, the problem of bedding is not encountered when cattle are grazed on open range or fed in large, commercial outdoor feed lots where paving is not used. Included in the facilities are the feeding system and the equipment and methods employed and generally they are of two distinct types, auger and fence-line, employing varying amounts of labor in relation to the degree of mechanization. The auger system can be constructed to operate on a virtually automatic basis where ingredients of the ration can be taken out of storage mechanically according to an established time-clock determined schedule, automatically weighed, and distributed for consumption by the animals. Due to the cost, the auger system becomes more costly on a per head basis than the fence-line system for large numbers of cattle. A small operation may employ a version of the fence-line system whereby most of the operations of feed distribution are completed manually. However, this method is unable to accomodate large numbers of cattle. Many fence-line systems employ the use of self-unloading vehicles to distribute the feed in a pre-mixed ration along a feeding line and requires an operator. Large numbers of cattle can be fed efficiently by employing the fence-line system, but labor requirements may generally be higher.

On the following page is a classification of the medical services and the components including medical supplies and veterinarian services associated with the administering of medical supplies or services. These services may be administered at the beginning of the production period and throughout its duration as the need arises. In a finishing operation the manager may choose to protect the animals against disease in a program of prevention by vaccinating or incorporating antibiotics into the feed or drinking water. In some cases this function may have been performed by the manager of the cow-calf operation by vaccination of the feeders in anticipation of stress conditions which may precipitate disease during transportation of the feeders to the finishing operation. Also, disease conditions may arise during the course of the production period and the afflicted animals would be in need of treatment. This condition may also occur in the cow-calf operation. Other activities need to be performed that are of a medical nature, primarily in a cow-calf operation although they occur at the beginning of a finishing operation. These activities may include the docking and castration of bull calves. However, there is increasing interest in using bull feeders in a finishing operation and this activity may be curtailed greatly in the future. Again, it is to the discretion of the manager whether to employ a veterinarian to perform the various services required or to assume the responsibility for the performance of these activities himself or to delegate a portion of this responsibility to his employees if present. However, in some occasions the farm manager may have no choice but to employ the services of a veterinarian due to the critical nature of the problem or due to the fact that certain medical supplies may be available only to a veterinarian.



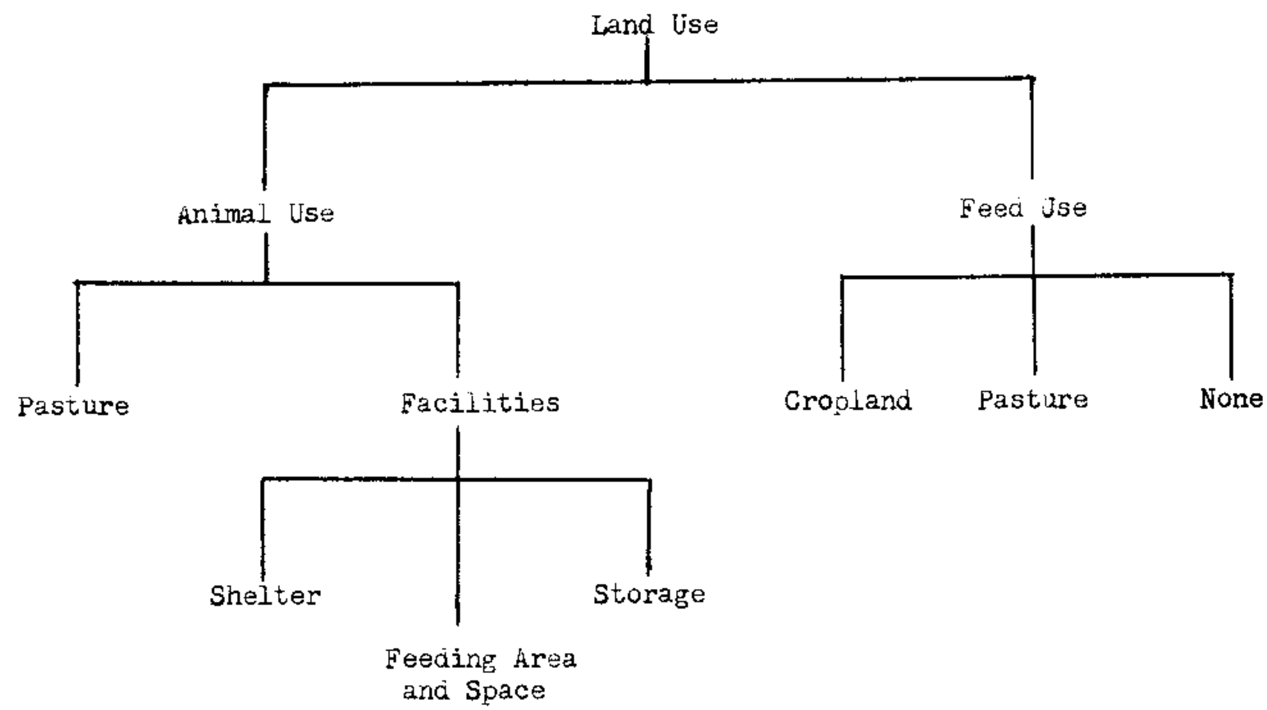
General Classification
of Factors
of the Medical Services



General Classification
of Factors
of the Equipment Input

feeding and manure disposal activities. The feeding equipment is used to remove the feed from storage and load it into unloading wagons and includes items such as silo-unloaders for use in a fence line feeding system. Silo-unloaders and auger equipment are used in the auger system. The size of and number of units of equipment depend in turn on the number of head of cattle within the system, as do the storage and other facilities. If there is an accumulation of manure, then manure disposal equipment is required. The manure may be in the form that it is relatively solid and contains remnants of bedding such that it can be removed by the use of a loader such as those mounted on a tractor. The manure may be sold, but if a cropping program is involved it is usually applied to the soil for its nutritive value in crop production. The manure may be in a liquid form as a result of cleaning the area with water and washing the animal manure through slats into a holding tank. From the holding tank it may be pumped into a liquid manure spreader and applied to the soil. In some large operations where manure disposal is a problem in itself and relates to the pollution problem, there is the consideration of reducing the manure by drying it and selling it commercially.

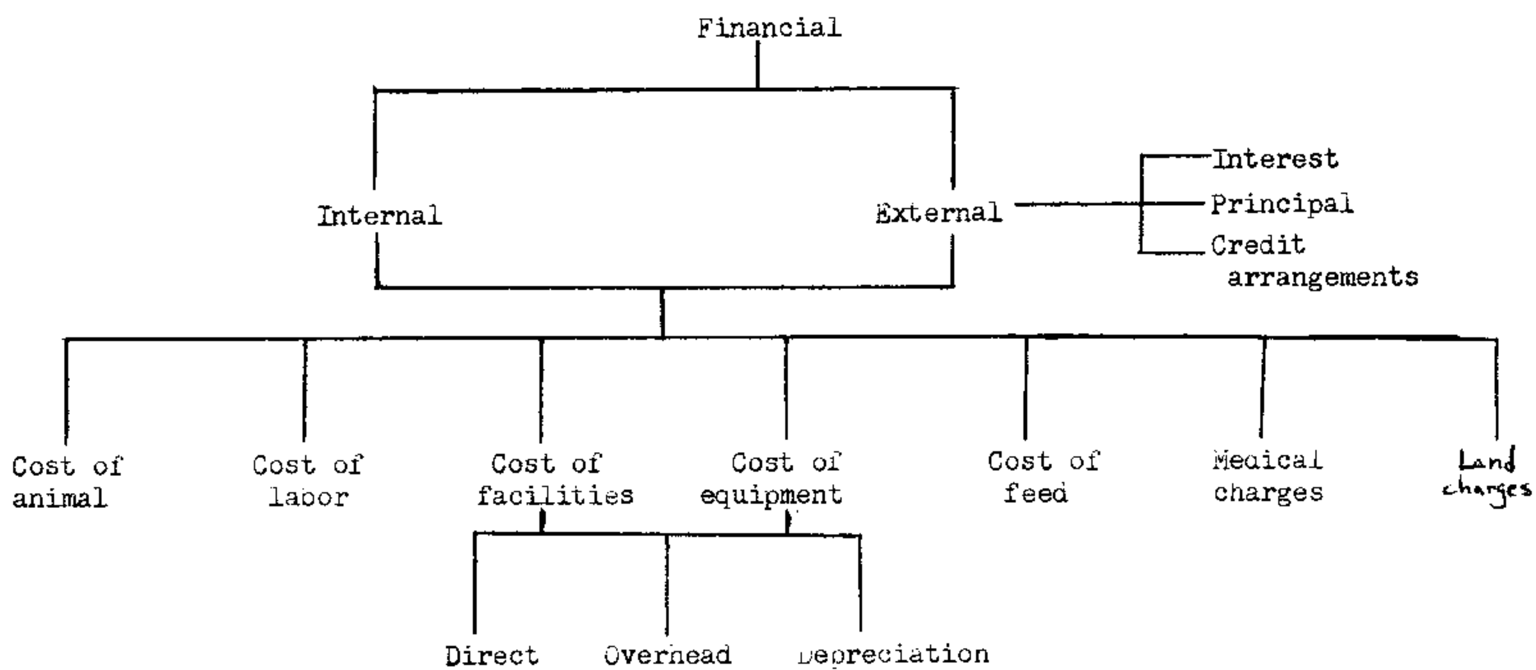
Another important input is the land involved with the beef production system. This involves the amount of land actually committed to the feedlot and storage areas. If the animals are grazed on rangeland or pasture the land requirements may be quite extensive. If the land is used intensively for grazing animals, such as the addition of irrigation, then the same area will support a greater number of animals on a per unit basis. Where there are shelter, storage, and feeding areas there is also a land requirement. While this requirement may be relatively small, the value



General Classification
of the Factors
of the Land Component

it represents may be very high due to the fixed nature of the associated facilities. Where the feed is produced on the farm, the amount of land used to produce the feed is associated with the beef production system and entails an analysis of the cropping system, at least to the point where the feed inputs are priced internally at a determined level such as competitive market prices. In the case of animals on pasture the feed use and animal use amounts of land may be the same. However, if supplemental feed is used for the animals on pasture, then the amounts will differ. Where an operation purchases all of its feed, then only the land used for the feedlot and other facilities will be considered. By the nature of the land input, once the site for the operation is selected, it may not be changed without the possibility of incurring a financial loss depending on the size and nature of the production system. Also, the proximity of the markets for purchase and sale are generally determined. In establishing an operation a number of factors should be taken into consideration; namely, the presence or absence of suitable markets, the availability of feed, the problem of manure disposal in regard to the operation, and the manure problem as related to the proximity of surrounding neighbors in regard to the problem of undesirable odors and pollution restrictions.

The financial input provides the source of capital for investment in a beef production system and a classification is shown on the following page. The source of funds is either internal or external. Internal refers to those funds available from within the system or generated by the system from a previous production period and is the surplus from that period after payment of expenses. However, if funds are not forthcoming from this source or are not adequate, then the farm manager must seek funds externally, that is, to make arrangements with a lending



General Classification
of the Factors
of the Financial Component

institution such as a bank or credit association. If funds are not forthcoming from either source, then the farm manager will have to terminate his operation. However, if credit arrangements are made, the rate and amount of interest has to be considered as does the principal. The credit arrangements refer to the length of time established for repayment of the loan and the method and place of payment of interest and principal on the loan. Once the source and amount of funds is established, various expenses associated with the operation are paid over the course of the production period, or in some cases, at the end of the production period as funds become available. One of the primary costs is the cost of the beef animal itself. In a finishing operation, the cost of the feeder is a cost to be met for each production period, whereas, in the cow-calf operation the cost of an initial, and each subsequent replacement, animal used for breeding is spread over the useful life of the animal with a portion of the cost assigned to a production period in the form of depreciation and repayment of an external loan can be made over more than one production period. If additional labor is hired, this then becomes a direct cost in the production period. The manager can also place a value on his own labor as a measure for further analysis of the operation. Feed costs and medical costs are charges that have to be met over each production period. Feed that is produced on the farm may be priced internally to the over-all enterprise in order to establish a measure for analyzing the efficiency of the beef production system and also the crop production system. One measure of the value of crops produced on the farm is the competitive market price for a crop in a given region. Medical services rendered by employees other than the services of a veterinarian will in all likelihood be incorporated in the labor costs. The manager's efforts in this area may be incorporated in his own labor charge, because of the difficulties associated with assigning this particular cost unless complete labor records are kept. There are also costs associated with the equipment and facilities of the production system that in turn cover more than one production period and any loan used to establish these facilities and to purchase equipment may be repaid over a period of time longer than a single production period. However, the cost of these assets should be appropriated over the useful life of the asset in the form of depreciation. There are also direct and overhead charges incurred in the operation and maintainance of these assets such as the cost of fuel, electricity, routine repairs, and interest on the loan for their acquistition and construction. Also, return on investment is an internal measure of efficiency in the financial analysis of these assets as is the case with land charges. One direct cost of land ownership is in the form of real property taxes.

In the classification scheme, the financial component associates costs with the other inputs. By doing so, the financial component provides a common basis with which to analyze the efficiency of the physical components. It also provides a common basis for analyzing relationships between the inputs and whether or not it will be advisable to alter a particular component with respect to another.

RELATIONSHIPS OF INPUTS

Thus far, a general classification of the inputs involved in beef production systems has been presented. It is of a general nature because of the number of variations of type and size of beef production systems included in the two general types, namely, the finishing operation and the cow-calf operation.

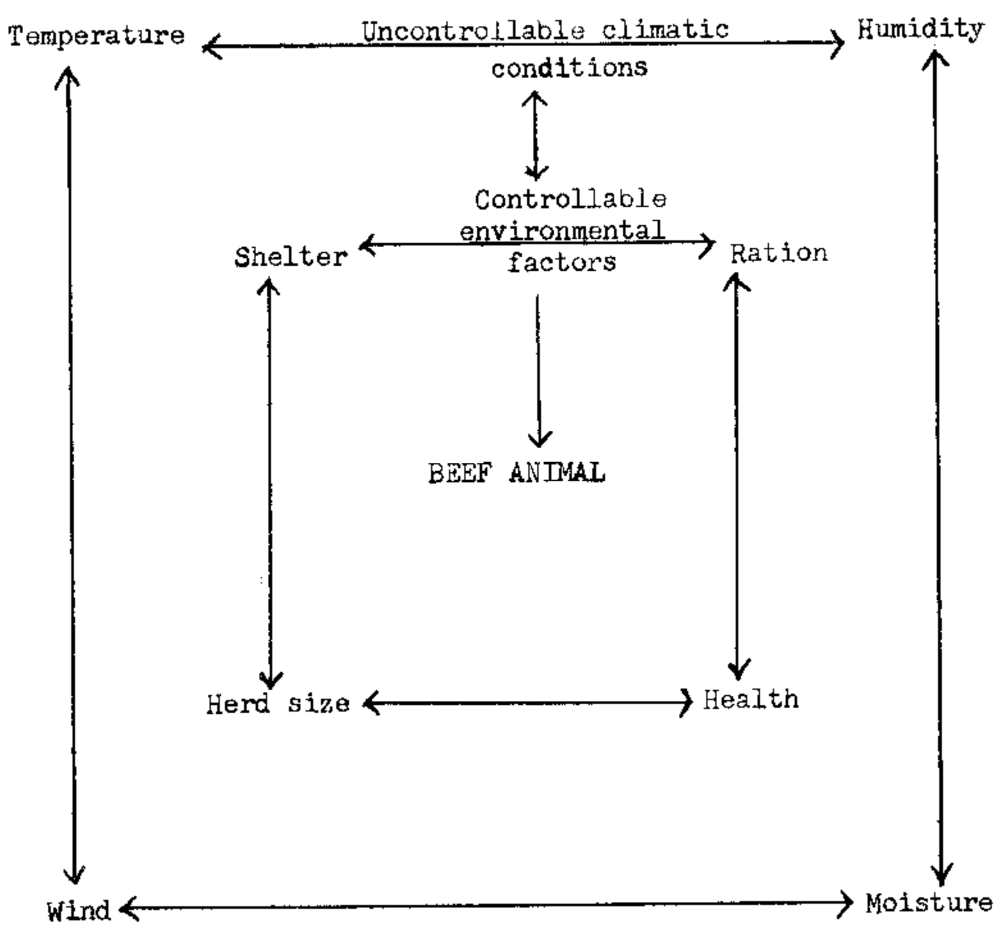
The inputs as they have been classified are:

Beef animal Ration Labor Facilities Medical services Equipment Land use	} Financial

The financial input shows the charges or costs associated with each of the physical components. Management is concerned with the transformation of these components into output and is the essential, controlling factor. Management controls the disposition of these inputs.

Each of the inputs listed above is a sub-system of the overall beef production system, but each by itself serves no purpose. Each input, when classified as a separate sub-system, is dependent upon at least one other sub-system. Each must be incorporated into a cohesive whole in order to operate as an efficient beef production system. Management, through the use of signals, directs this total system.

The beef animal forms a natural sub-system and the other inputs are supportive to this sub-system and, in addition, form part of the environment. The beef animal is also subject to other conditions that form part of its environment such as climatic conditions. The basic input into the beef animal sub-system is the ration which is converted by the natural body processes of the animal into pounds of gain in the finishing operation and into a calf in the cow-calf operation. The factors that comprise the environment may be further classified into the uncontrollable climatic conditions and the controllable environmental factors and they may be represented as follows:



Environmental Conditions Affecting the Beef Animal

The manager has control over factors concerning shelter, ration, herd size, and general health of the animal and they are inter-related. The uncontrollable factors relate primarily to weather conditions such as temperature, humidity, wind, and moisture levels. Extremes of these conditions which are inter-related can adversely affect the beef animal. These adverse effects can result in a lower rate of gain and lower feed efficiency or conversion and possibly result in higher death losses due to an increased incidence of disease from the animal's lowered resistance. It is to the discretion of the individual manager according to the location of his operation and climatic conditions associated with the region as to the degree of control he finds economically feasible in employing the controllable factors such as shelter to protect the animal against the uncontrollable climatic conditions.

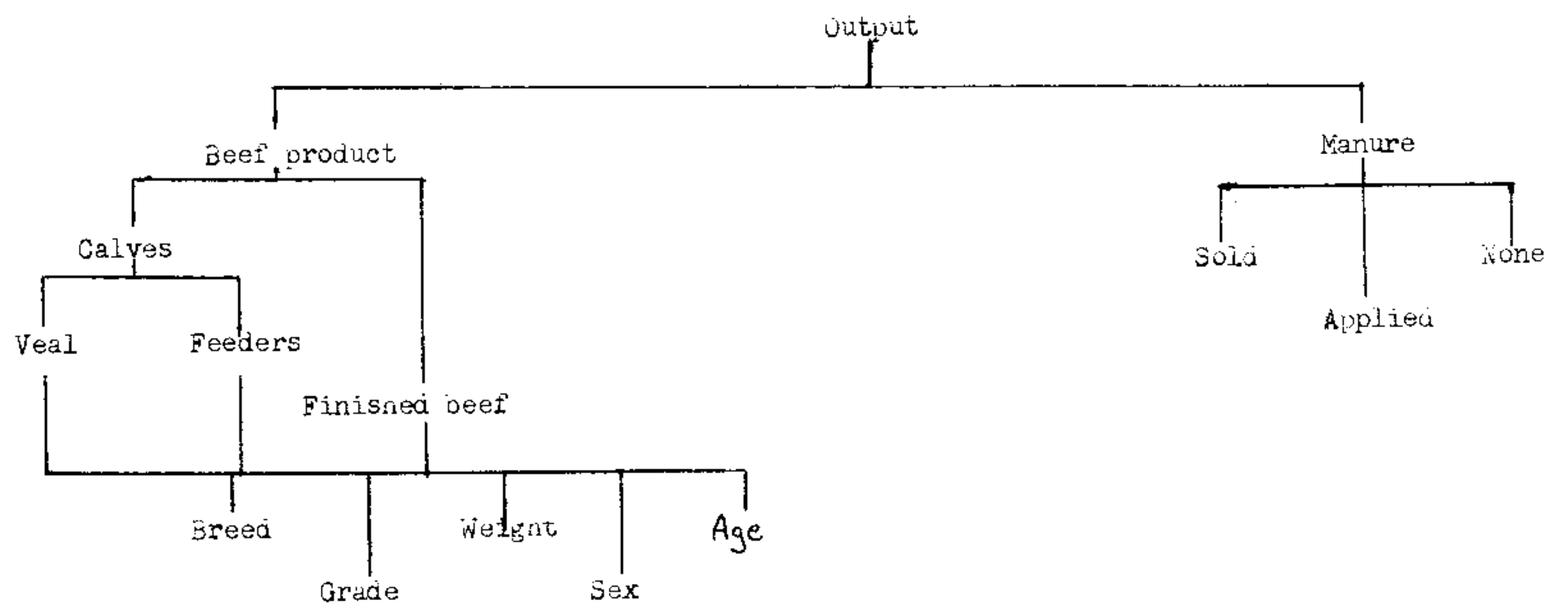
The beef production system is a dynamic operation by virtue of the changing nature of the inputs over the space of time. The beef animal changes over time in a finishing operation as a result of a gain in weight and in a cow-calf operation as a result of the growth of the calf during the gestation and nursing/feeding periods. During these same periods there is also a change in the quantities of the physical and non-physical inputs. For example, the physical component of labor increases as time passes as does the non-physical component of cost associated with labor.

CLASSIFICATION OF OUTPUT

The number and types of output from the beef production process are not as numerous as the inputs and are represented in physical terms on the following page. A measure of the manager's ability relates to his efficiency in converting the various inputs into marketable output. Once the output is obtained, the manager's ability in the area of marketing is important in determining the profitability of the enterprise.

One form of output that is a by-product of the beef production process is the waste material or manure. When animals are grazed on rangeland or pasture, then the manure returns to the soil and it cannot be sold or applied to other areas. This is the reason for the term None on the chart implying that the manager need not concern himself with its removal and disposal. In some occasions this by-product can be sold when removed from a feedlot area, thus providing a source of additional revenue. However, where a beef production operation is joint with a cropping program as a source of feed, a common practice is to return the manure to the soil as a source of plant nutrients.

The primary product of the beef production process is the beef animal itself. In a cow-calf operation the product is in the form of the calf crop which may be held for sale as veal or for sale as stockers or feeders in a finishing operation. The value of the veal depends on the grade and weight of the animal whereas the value of the feeder depends on breed, grade, weight, sex, and age in combination. The cow-calf operation manager may wish to hold the calves for a finishing program of his own where the end product is finished beef, the same as



General Classification
of the Factors
of Output

the manager who initially buys the feeders. The value of the finished beef animal depends on its final grade, final weight, and sex. At present, finished steers of similar grade as finished bulls or heifers command a higher price per unit of weight in the marketplace. However, this practice could change in time.

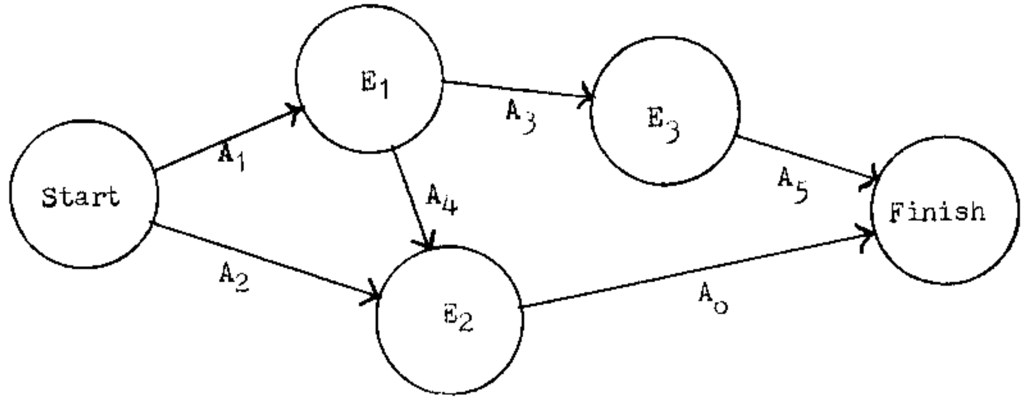
The financial output associated with the physical output depends largely on the quality and level of physical output and on the manager's marketing ability in assessing information on the market conditions. His profit level depends on the manager's ability to efficiently convert the inputs into output at minimum cost.

The profit level for one manager when compared to another may be quite different even though each manager has essentially the same number and level of use of inputs. The difference lies in the manner the managers use signals to direct the system to transform inputs into output. The manager who is not achieving a desired level of efficiency in the tranformation of inputs into output may find the use of systems planning models helpful in attaining a greater level of efficiency. Also, the manager who currently is reasonably efficient in his operation may find areas of improvement through the use of a systems planning model. One of these models is in the form of critical path scheduling.

CRITICAL PATH SCHEDULING

Critical path scheduling is a relatively new tool for management to use in the decision-making process and at present two variations of this method are known and used, CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique). They are useful tools for planning and analysis by scheduling the efficient use of time for a project in order to reduce costs and thereby increase the profit margin or at least to avoid or minimize losses. The project may be of a repetitive nature such as in the home construction industry or of a non-repetitive nature such as in the development of a new missile program where several unknowns may enter into the picture. PERT and CPM use the same methodology and the major difference lies in the manner in which the time for the completion of the project is treated. CPM treats the time element for the completion of the project in a deterministic manner, whereas, PERT assigns probabilities to the times required to complete activities within the project and the time for the project as a whole and deals with the variances associated with the time estimates. PERT deals with the element of uncertainty. Consequently, CPM may be thought of as a special form of PERT or sub-form and the following discussion deals with PERT, recognizing the same principles apply to CPM.

The heart of PERT is the arrow network diagram, which is shown below:



Each arrow in the diagram represents an individual activity within the project and may be designated by A_1, A_2, A_3,... . The length of the arrows do not necessarily represent the length of time required to complete the activity. The beginning and end of the activity corresponds to the head and tail of the arrow from left to right, respectively. The numbered circles represent events such as the completion of an activity or activities and may also mark the beginning of a succeeding activity or activities as well. A simple network such as the one shown can be solved easily, but larger, more complicated networks can be solved more easily and at less cost through the use of a computer, when all variables are taken into account.

Associated with each activity is an estimate of the time required for its completion, and due to uncertainty, a probability is assigned to the completion of the activity in the estimated time along with the respective variance. The time estimate for each activity may be derived from the formula:*

$$t_e = \frac{a + 4m + b}{6}$$

where t_e is the time estimate for an activity, a is the most optimistic estimate of time required to complete the activity, m is the most likely estimate of time, and b is the pessimistic estimate. a represents the optimum period of time in which the activity may be completed barring all disruptive factors and b considers these same factors. The variance of this mean is:

$$v = \left(\frac{b - a}{6}\right)^2$$

In the diagram presented, the activity A_1 must occur before event E_1 and activities A_3 and A_4 can occur and activity A_2 must occur before event

*Schedule, Cost, and Profit Control with PERT by Robert W. Miller; McGraw-Hill Book Co., Inc., New York; 1963; Chapter 2.

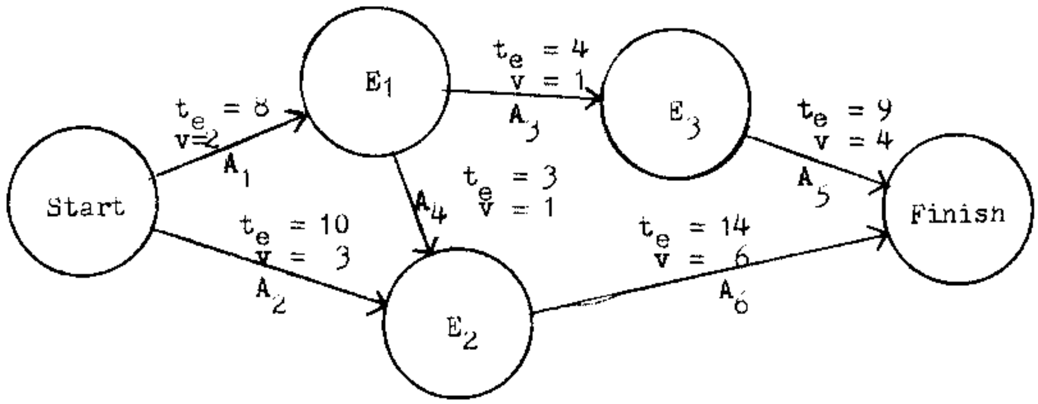
E_2 and activity A_6 can occur, and so on. All the activities must be performed before the total project can be finished, including activities A_1, A_2, A_3, A_4, A_5, and A_6. Consequently, all the events must take place before the final event, the finish of the project. By listing and defining the activities involved in a project, the first step in the actual planning process is initiated.

In the example presented, it is possible to demonstrate the process of selecting the critical path. In essence, the critical path involves that series of successive activities that takes the longest time to complete and other activities may be performed concurrently with the critical activities. Selecting the critical path involves the concept of float or slack time, which in turn is determined by the earliest start-time (T_E) and latest starting time (T_L) for each activity. The earliest starting time for an activity is the earliest time that an activity can begin and the latest starting time is the latest allowable time for an activity to begin without affecting the overall series of activities and the overall time allotted for the completion of the project.

First, for the purpose of illustration, estimated times and associated variances are assigned to each of the activities for the project according to the following table that is measured in days:

	t_e	v
A_1	8	2
A_2	10	3
A_3	4	1
A_4	3	1
A_5	9	4
A_6	14	6

such that the diagram now becomes:



The earliest starting time for event E_1 to occur and activity A_3 to begin is 8 days and the earliest starting time for event E_3 to occur and activity A_5 to begin is 11 days. The T_E for the completion of the project is the longest path along the activity arrows, 25 days (8 + 3 + 14). The earliest starting times for the various events are cumulative as are the variances. The earliest starting times for the events starting at time 0 are:

Event	E_1	E_2	E_3	Finish
T_E	8	11	12	25

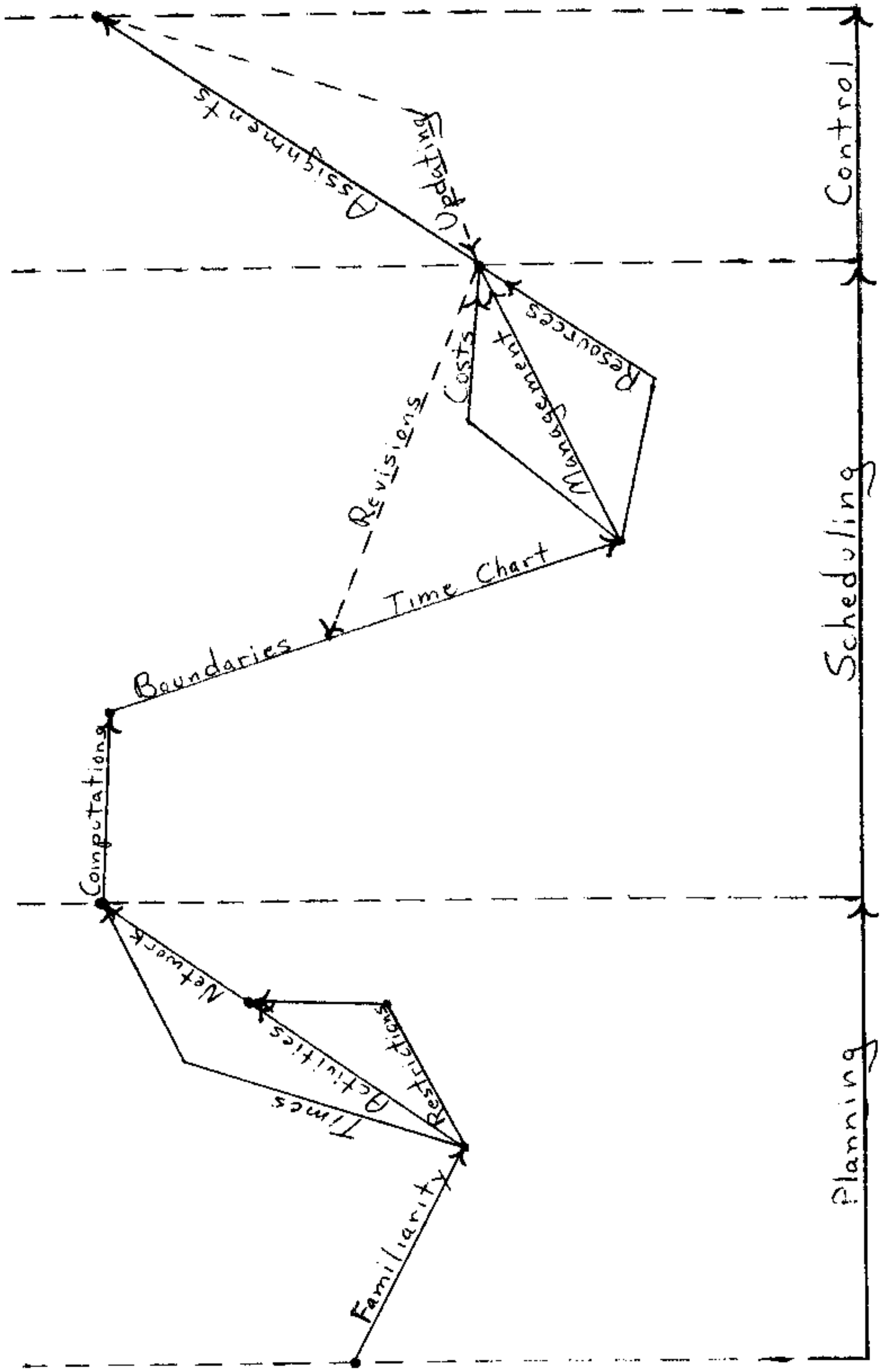
The latest starting time for an event to occur for the beginning of an activity without altering the time for completion of the project is found in a reverse manner starting at the event for the finish of the project such that:

Event	E_1	E_2	E_3	Finish
T_L	8	11	16	25

Slack or float time is the difference between T_E and T_L and may be demonstrated by;

Event	E_1	E_2	E_3	Finish
T_E	8	11	12	25
T_L	8	11	16	25
Float	0	0	4	0

Planning, Scheduling, and Control Components
of Critical Path Scheduling



From: Guide to Cost Reduction Through Critical Path Scheduling by James L. Riggs and Charles O. Heath; Prentice-Hall, Inc., Englewood Cliffs, N.J.; 1966; p. 18.

diagram, the heart of the planning process.

The time chart also forms an important analytic tool in scheduling. In the scheduling process an estimated earliest starting time and latest starting time is scheduled for each activity. The critical path consists of those activities that must be completed as scheduled in order to complete the total project within the allocated time. The time chart provides a basis for cost analysis as costs are assigned to the activities according to resource requirements. The time chart outlines the critical activities and provides a means of pointing out possible trouble areas.

By implementing the planning and scheduling processes, the element of control is exercised. Planning and scheduling are an attempt at control. Through action and evaluation the control function examines adherence to the planned schedule and at this point management is concerned with any significant deviations from the planned levels of time and resource use (management by exception). These deviations may then be corrected by revising the original plan and schedule to meet the new requirements.

The restriction list is a means of ordering the activities and events in the project. By necessity some activities must precede others; that is, the foundation must be laid before the house is built, for example, and the restriction list places events in proper sequence so that the network is easier to construct.

Also, some activities may be aggregated for convenience, for even the activity of raising one's hand to push a button can be included in the network. However, to do so would make the task of analyzing the network hopelessly monumental and confusing. By the same token, the process can lump too many activities together and the analysis could not locate a specific problem. If this problem occurs, then it would be advantageous to break the aggregated activity down into its component activities for further study.

While some activities must of necessity precede other activities, there are some activities that may also be performed concurrently. This was implied by the diagrams and mentioned in the preceding chapter. However, the number of activities that can be performed concurrently depends in essence on the amount of labor available and whether it is desirable from an economic viewpoint to perform more activities concurrently in order to compress the schedule or to follow a sequence of activities.

CRITICAL PATH SCHEDULING IN BEEF PRODUCTION

Critical path scheduling has been described in terms of business, construction, and research applications in the literature that explains and discusses its applications. This form of analysis can also be useful to the field of farm management. PERT would provide a means of planning and scheduling various activities in farming operations, such as cash crop production, livestock production, and combinations thereof. The following discussion is concerned primarily with applications to the field of beef production.

From the classification scheme presented earlier there are numerous activities implied by the breakdown of the component parts of a beef production system. Each of the classifications will be treated separately to identify the significant activities. Some of these classifications do not actually enter into the physical process of beef production, and the ration, land use, and financial components will be considered only as they affect the other components.

In the field of business management the time period used is the time required to complete or finish the project at hand. In the beef production process there are a number of production periods over the total productive period of fixed assets such as machinery, buildings and facilities, and land. However, the relevant period for analysis is a single production cycle, whether for a finishing or cow-calf program. This single cycle includes all the activities for beef production that need be considered. In turn, this period can be further broken down to periods that include thirty days, one week, or a period of a single day. The activities can be broken down into component parts for closer scrutiny, also.

In an analysis of the various activities over the period of one day, for example, the arrow network shows the order of events and activities and the time chart demonstrates the scale of time use. By analyzing the associated costs, management may find areas where the schedule can be compressed by acquiring additional outside labor and/or machinery, allowing more time for the completion of other essential activities, especially if the farm manager is engaged in a combination beef cattle and cropping operation where crops are grown both for feed and for sale, a common type of operation in the state of Michigan. Activities involved in the cropping program can be integrated into the beef operation. The operation then becomes considerably more complex and complicated since the cropping program is subject to the uncertainty of weather conditions and relies on seasonal activities.

Existing beef cattle production units can be mapped into the classification scheme presented earlier. The classification process is designed to provide a basis for selecting alternative activities in order to plan for a more profitable operation. The alternative activities require additional resources or a new combination of existing resources and a change to an alternative schedule would be made if the cost analysis so indicated.

The process would be useful too, in planning an operation from the very beginning, even before buildings and facilities were constructed and before equipment was purchased. Planning an operation in this manner would provide the means to make a cost analysis of the activities involved and select the equipment and feeding layout that is both efficient in terms of labor and that keeps cost/unit of production at a minimum.

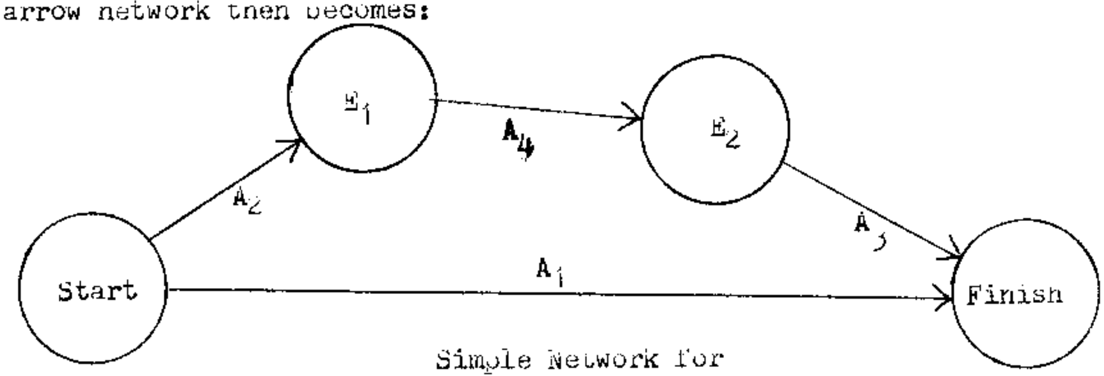
An example of the use of PERT in beef production covering a period of one day follows. The time scale is based on a full day of twenty-four hours in a finishing program. The use of this time scale is that the animal gains weight during the whole day, whereas, the labor requirements are based on an eight or ten hour work day. First, a list of activities is made concerning a beef production unit in operation:

A_1 - growth of animal
A_2 - first feeding
A_3 - second feeding
A_4 - waste removal and disposal

and in this simple example, it is assumed to be a one-man operation. The restriction list then becomes:

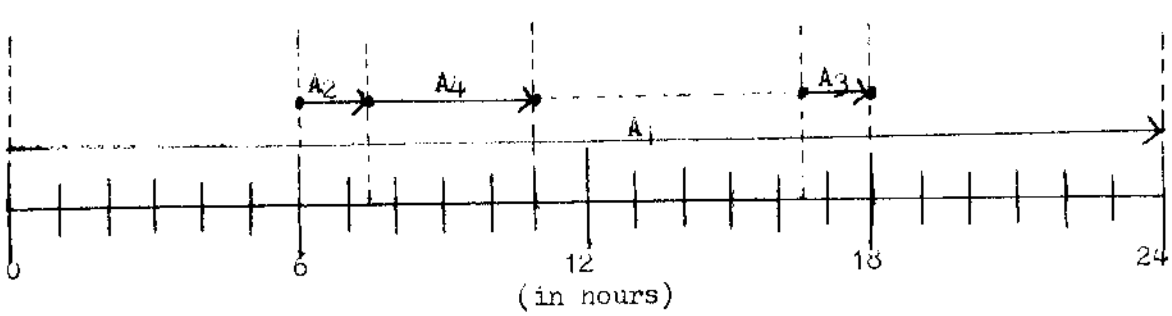
A_2 before A_4
A_4 before A_3

The activity A_1 takes place concurrently with the other activities. The arrow network then becomes:



Simple Network for
Daily Activities

The time chart imposes the network against a scale of time and gives a clearer perspective of the activities and events:

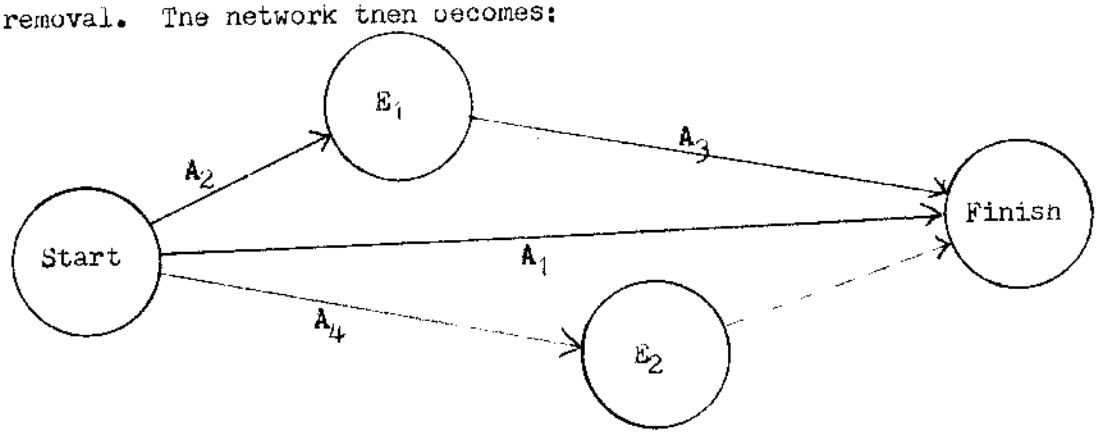


Time Chart for
Daily Activities

where the estimated times for completion are:

Activity	t_e (in hours)	v (in hours)
A_1	24.0	0.00
A_2	1.5	0.25
A_3	1.5	0.25
A_4	3.5	0.75

The activity designated as the growth of the animal will be discussed later. However, from this example, the activity of waste disposal takes a large portion of this farm manager's time. This could be a point for further analysis. By examining the operation, one might find for example that the equipment for waste disposal is not adequate and that it would be financially beneficial to buy larger, more efficient equipment to handle waste or to hire additional labor and expand the feeding activities by taking on additional animals and expanding the operation. If it is advantageous for this manager to hire additional labor, then the estimated time for the completion of each activity is reduced and/or some of the activities can then be performed concurrently such as feeding and waste removal. The network then becomes:

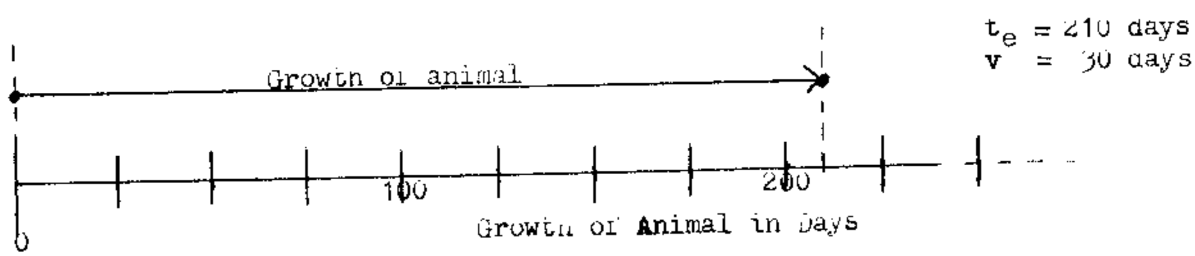


Revised Network for
Daily Activities

The time chart will then reflect these changes. If at any point there are significant deviations from the schedule, then the schedule should be re-examined.

The dotted arrow in the preceding illustration is known as a dummy arrow and does not indicate an activity, but rather, its purpose is to demonstrate the order of the activities and events and to show that an event must occur before a succeeding event.

The illustrations thus far presented show the application of PERT to the short period of time of one day. The time scale was determined by the length of a day and the activity of the growth of the animal was absolute. However, over the full period that the animal is on feed, the time for the completion of the activity or the finishing of an animal cannot be stated with certainty. The rate of growth of the animal depends on the characteristics of the beef animal as classified earlier. The growth of the animal is listed as an activity because it forms a focal point for the whole operation. Poor performance in this area will affect all other activities in terms of efficiency and cost, as will good performance. The length of time required to finish the animal determines one full cycle in the feeding operation. For example, a good to low choice feeder steer of the Hereford breed classified as a yearling and weighing 400 pounds initially, may take an estimated time of 210 days to reach a final weight of 1000 pounds and a final choice grade. This activity may be represented as:



The estimated time required to finish the animal depends on the animal's efficiency in converting feed to pounds of gain and the ration used as well as the animal's beginning weight, age, type, and condition or health.

The variance associated with the estimated time for finishing the animal is primarily due to the physical differences that exist between animals and their efficiency of rate of gain for a given ration. Associated with each animal is the uncertainty that the animal will reach the projected date of reaching final grade due to sickness, injury, or even death. This is reflected in a probability level, also.

Analysis of the activity listed as the growth of the animal gives an insight into the degree of efficiency of the ration used. By checking the schedule at various points, it would be possible to pinpoint problem areas relating to nutrient deficiencies, for example. These deficiencies could be corrected by adding and/or altering the various ingredients. It may be found that it is possible to achieve a more profitable rate of gain by moving to a higher concentrate ration. A higher concentrate ration would be more costly, but it is a means of compressing the schedule through a faster rate of gain. The time chart would be a critical and important tool for analysis in this case. By scheduling this activity, the level of concentrate in the ration may be changed periodically and if the animal is not at the desired level at specific times, the schedule should be checked for deficiencies and altered if necessary. Changes in the schedule are subject to cost considerations. The cost of a higher concentrate ration and compressing the schedule should be weighed against achieving a higher rate of turnover and greater use of existing facilities.

The activity of the growth of the animal, is directly influenced by the farm manager in terms of the environment provided for the animal. This is reflected in the shelter and ration provided and is an essential activity in the beef production process.

A low percentage of survival of beef animals at the scheduled date for finishing indicates a poor program for health and medical services.

If this is encountered in an existing program for a finishing operation, then the activities for an efficient medical program should be scheduled on a periodic basis. Through the process of scheduling, the manager can determine if he and/or his hired labor have sufficient time to carry out an adequate health program. If not, he can schedule for the services of a qualified veteranarian on a periodic basis.

The labor, facilities, and equipment components are closely interwoven. The equipment component and the feeding layout can determine in large part the labor requirement for a given number of head of cattle. By scheduling these components in an existing program of beef production, problem areas can be pinpointed and a new, more efficient schedule can be drawn up containing a new resource and labor mix. Determining the new schedule depends on the information available to the manager and the extent to which he makes use of it.

Using critical path scheduling in the form of PERT and CPM would be a tool for analyzing existing beef production systems and for planning a beef production system "from scratch". Certain of the activities involved in the operation can be determined on the time scale on a deterministic basis as in CPM such as the use of the manager's labor in daily feeding activities. The time for completing these activities can be forecast rather accurately if the existing operation runs smoothly. However, if a particular operation is subject to a series of disruptive breakdowns and labor problems, then the activities involved cannot be scheduled on a deterministic basis and probabilities need to be assigned to the completion of the activities within the estimated times. The point for analysis is to isolate the factors that are causing the problem and then attempt to eliminate it. However, at present, uncertainty and assigning probabilities to the completion of activities cannot be eliminated for certain activities. The activity listed as the growth as the animal is an example. Uncertainty arises with respect to disruptive factors that can affect the beef animal such as illness, death, and the efficiency of the animal in converting feed to pounds of gain.

First, however, further empirical work is needed in the area regarding the activities involved in a beef production system. For example, accurate figures are needed for the efficiency of various types of equipment and feeding layouts in order to form reasonable estimates for the times required by labor to perform the activities in a beef production system.

The nutrient requirements for a ration for beef animals have been outlined in various publications such as those presented by the National Research Council and these requirements can be compared with the ration in an individual beef operation to determine any deficiencies. This would be important in determining whether a schedule for feeding animals can be compressed by producing a faster rate of gain.

This form of scheduling provides management with a tool for planning and analysis that helps pinpoint areas of trouble at any one specific point in time. It is an aid to management in determining whether to employ additional resources (or decrease the level of some resources) and/or reschedule various activities, whichever a cost analysis warrants.

IMPLICATIONS OF SYSTEMS ANALYSIS FOR BEEF PRODUCTION

Systems analysis can be a useful method of planning and analysis in beef production operations. Through systems analysis the beef production operation is viewed as an integrated whole influenced by its external environment. There is an exchange of information and materials between the external environment and the beef operation, primarily through the actions of the farm manager. The farm manager controls the flow of resources into his beef production system and the flow of output from the system. He also directs the flow of inputs or resources through various stages of transformation into output within the system. The latter concept is of special interest.

By the use of the classification scheme, the sub-systems within the individual beef production system can be identified. In turn the individual operation can be mapped into the classification for further analysis. One method of planning and analyzing the individual operation is through the use of critical path scheduling in the forms of PERT or CPM. This method lists the various activities and their estimated times for completion in a beef production operation. By selecting alternative activities implied in the classification process, it may be possible to improve upon an existing operation. These activities may also suggest a re-arrangement of current inputs or the addition of new inputs. By selecting the most efficient activities it may also be possible to plan a new beef production operation that will in turn be the most profitable.

However, because of the large number of possible combinations of the various activities involved, the task of planning and analyzing by manual means becomes monumental in terms of time requirements and complexity. The computer is a tool that would enable farm managers and extension personnel to quickly sift through these possible combinations to arrive at the most profitable combination or re-combination of resources or inputs for the farm manager engaged in beef production using his own or additional labor. These plans would be subject to existing and projected markets for both the inputs and beef output. While the element of uncertainty would not be eliminated, its effects would be minimized to a degree through the application of systems analysis and critical path scheduling to the individual beef production system.

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