1974

Evaluation of alternative beef feeding systems for Iowa

Robert Boyd Boysen
Iowa State University

Evaluation of alternative beef feeding systems for Iowa

by

Robert Boyd Boysen

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
MASTER OF SCIENCE

Department: Economics
Major: Agricultural Economics

Iowa State University
Ames, Iowa
1974

TABLE OF CONTENTS

CHAPTER I. INTRODUCTION

Status of General Sector of Study

> The U.S., long preoccupied with rapid urbanization, is rediscovering its economic heritage and still its biggest industry--Agriculture. News of food prices, grain exports and supply and demand is in the headlines, underscoring for citizens and national leaders the tremendous influence that agriculture has on the economic, social, and political well-being of America and the world. (29, p.1)

This statement in the Wall Street Journal in late 1973 indicates a reawakening of the United States to its "economic heritage" and recognizes agriculture's influence in social and political spheres.

The "economic heritage" of American Agriculture is one of steadily increasing productive efficiency. In the United States from the mid-nineteenth century to World War I, food costs absorbed one-half to one-third of total consumption efforts (5, p.9). In 1973, however, the percentage of disposable income spent for food was only 15.8% (48b, p.9). The farmer's share of retail food costs in 1973 was only 45% (46a, p.6) or only about 7% of disposable income.

Because of these great productive efficiencies attained, however, society's concern for the agricultural industry is being turned from compelling economic factors to social and political considerations (5, p.9). This concern has been voiced by both agricultural economists (5; 17, p.5), and the popular press (3, p.1; 22). The force causing this concern is the trend in resource allocation toward a more highly capitalized agricultural industry resulting in "a state of economic and social decay throughout the towns in rural areas" (5, p. 935).

This trend toward capitalization primarily results from what is termed "economic development". With economic development the real price of capital resources declines relative to that of labor (5, p. 374). In the United States, highly capitalized technologies developed by public and private institutions and further induced by governmental farm policies have been adapted in the agricultural sector thus decreasing the relative demand for labor. This excess labor has been drawn to urban areas specializing in the production of consumer services. The resultant high concentration of people in urban areas has led to many of the sociological and ecological problems now confronting our cities (5, p. 375).

Simultaneously, other sociological and ecological problems have begun to occur in the agricultural sector. Substitution of capital for labor has resulted in the demise of smaller, more diversified farming enterprises (5, p. 382). Those enterprises such as livestock feeding which need not be land based have tended to become specialized autonomous units capable of spreading the high fixed costs associated with a capital intensive technology over a large concentrated volume of animal units.

The land area with which many of these highly capitalized livestock feedlots are associated is no longer capable of utilizing the large concentration of wastes produced and an ecologically unstable environment has been created (31b, p.5). These large scale capital intensive technologies have also served to reduce the need for labor once employed in rural areas resulting in the sociological problems previously referred (17, p. 935).

Thus, though the productive efficiency of United States agriculture has provided a plentiful supply of food nutrients at a relatively low cost, sociological and ecological problems in both rural and urban sectors of the United States economy have been created. The results to be found by this study pertain to the Iowa beef production industry. However, as shown in the following section, the trends evidenced in this specific industry are consistent with the general trends existing in the agricultural sector. As such, the specific industry analyzed is an integral part of the general sociological and ecological problem identified.

Status of Specific Sector of Study

The sector of agriculture to which this study specifically addresses itself is the Iowa beef production industry.

The general trend in agriculture toward large units capable of utilizing highly capitalized technologies becomes apparent when viewing this industry.

Historically, Iowa has been the number one fed cattle producing state in the nation. However, in recent years in the face of an expanding supply of corn-belt feeder calves (Table I-2) and a large supply of feed grains (24, p.12), Iowa's rating has dropped to number three (Table I-1).

Table I-1. Number of fed cattle produced in Iowa (43a)

Year	No. (mill.)	% of 1955	% of U.S.	Iowa Rank
1968	4.4	220	18.9	1
1970	4.6	232	17.8	1
1972	3.9	198	15.7	3

Table I-2. Percentage increase in beef cow population by regions and selected states 1958-1973 (42b)

Region:	Northeast	Southeast	Western	Central Plains	Cornbelt
% Increase 1958-1973	88	72	38	73	95

State (Cornbelt Region)	Missouri	Minnesota	Iowa	Illinois	Indiana	Ohio
% Increase 1958-1973	129	110	101	37	47	72

In the past, Iowa achieved its number one rank primarily by means of the small farmer-feeder who integrated cattle feeding into his production system. The importance of the small feeder in the Iowa beef production industry can be noted by data in Table I-3. The importance of the small cattle feeder is gradually diminishing. The trend in Iowa and the rest of the nation is to larger scaled, more highly concentrated feeding operations (Tables I-4 and I-5).

Table I-3. Average head per Iowa feedlot (43a)

Year:	1965	1970
No. Head:	70	108

Table I-4. Cattle feedlots and fed cattle, 23 major cattle feeding states (49a, 43a)

Year:	1962		1972	
Feedlot Scale (23 states)	No. Feedlots	% Mktings	No. Feedlots	% Mktings
Under 1000 hd.	229,365	63.7	152,429	38.3
1000 - 1999	751	5.0	912	4.8
2000 - 3999	362	5.3	484	5.1
4000 - 7999	189	7.5	311	8.1
8000 - 15999	106	10.4	216	12.1
16000 - over	31	8.1	184	31.6
Total	230,804	100.0	154,536	100.0

Table I-5. Cattle feedlots and fed cattle, Iowa (49a, 43a)

Year:	1962		1972	
Feedlot Scale (Iowa)	No. Feedlots	% Mktings	No. Feedlots	% Mktings
Under 1000 hd.	49,964	96.9	35,830	89.2
1000 - 1999	33	2.5	140	3.5
2000 - 3999	3	0.6	135	3.4
4000 - 7999	0	0	90	2.3
8000 - 15999	0	0	65	1.6
16000 - over	0	0	0	0
Total	50,000	100.0	36,000	100.0

Along with this trend toward larger scaled, more highly concentrated production of fed cattle, there has been an increase in the number of cattle fed under contractual agreement. In 1970, 22% of cattle fed in the United States were produced under some kind of contractual, vertically integrated system. In Texas and Colorado this amounted to 90% and 30%, respectively. In 1967 in the western corn belt, 4% of the cattle marketed were fed under some such system and it is expected that a trend will continue in this direction.[1]

Delimitation of Study's Objectives

As previously noted, pollution has become an attending problem with the advent of large scale, highly concentrated

[1]Gene Futrell, Interdepartmental Seminar on Future of Beef Cattle Feeding in Iowa, Iowa State University, November, 1973.

cattle feeding operations. In response to this problem the United States legislature passed a law in 1972 limiting feedlot pollution. Final regulations by the Environmental Protection Agency (E.P.A.) which came out in late 1973 have exempted those under the 1,000 head scale from applying for discharge permits. Recently, a New York-based environmental group called the National Resources Defense Council filed suit against the E.P.A. for "unlawfully exempting" most farms under the 1,000 head scale (2, p.1). Because of the relatively high capital investment costs involved in complying with the pollution regulations for feedlots under the 1,000 head scale it may not be economical for these feedlots to operate if forced to meet effluent guidelines. Thus, the trend toward larger scaled, more highly concentrated feedlots may be fostered by such action. This is a possibility which this study will consider.

Primarily, however, the broad objective of this study is to examine the optimal resource allocation and product combination on Iowa farms with respect to cattle feeding. Especially, its purpose will be to evaluate the profitability of various alternative beef production technologies available to the Iowa farmer-feeder with respect to competing alternative products under specified resource, organizational, and price situations. This study will be focused on technologies adaptable at the 0-1,000 head scale, and capable of being integrated into an Iowa farm firm. The comparative technical and economic efficiencies of confinement, open-lot, dry-lot, custom finishing, and backgrounding feeding technologies will be analyzed with respect to competing, complementary, and supplementary activities found on Iowa farms. Although activities entailed in swine, dairy, or sheep production are viable alternatives to the Iowa farmer, this study focuses on activities associated with the production of one type of livestock, beef cattle, and production of cash grain. Thus, emphasis will be placed on the analysis of alternative beef production technologies as they fit into the total production plan of an Iowa farmer.

CHAPTER II. METHODOLOGY

The general problem analyzed in this study deals with alternative beef feeding technologies capable of being integrated into an Iowa farm firm. Thus, analysis of the alternative technologies can not be divorced from that concerning the firm's other activities. Although focusing on evaluation of alternative beef feeding technologies, this study does not abstract their evaluation from the context of the total farm setting. Rather, it evaluates each technology in light of its interaction with the farm's alternative production opportunities.

In order to focus the analysis on alternative beef feeding technologies, a resource base and organizational structure were specified as indicated in the following chapter. Also specified were three alternative price structures under which the analysis was conducted. Within these three price structures two specific situations were viewed. The first concerned the use of existing facilities given certain start-up costs. These start-up costs could be viewed in two contexts, costs necessary to eliminate feedlot runoff pollution or costs necessary for general feedlot renovation. The second situation analyzed under the three alternative price structures was that of investment in new feedlot systems of various scale size.

In each situation the analysis was conducted in the context of other activities taking place simultaneously in the specified farm firm. Thus, the problem was one of optimal product combination.

The research tool selected to analyze the many alternatives available to a farmer-feeder was linear programming. This mathematical technique provides a method for solving the problem of optimal product combination.

In a static environment under pure competition, when resources are not significantly limiting, the product-combination problem may be mathematically defined as $\pi = \sum_{i=1}^{n} P_i Y_i - \sum_{i=1}^{n} \sum_{j=1}^{m} P_j X_{ij}$ where π = profit, P_i = price of i^{th} product, P_j = price of the j^{th} factor, and X_{ij} = j^{th} factor for the i^{th} product. Assuming conditions of certainty, when the marginal physical product of variable input on a defined producing unit is not decreasing and thus decreasing returns to scale are not implied, profit will be maximized by either specializing in one product at its maximum level or producing nothing at all. Under such conditions the farmer-feeder with fed beef and cash grain production alternatives would either specialize in one enterprise or produce nothing.

A farmer with unlimited resources as indicated by the specified unconstrained objective function, with no interaction between inputs present in the production function equation and with decreasing returns to scale, could view each enterprise as a specialized unit and solve each factor-product decision separately. Under the previously specified condition the farmer-feeder would not have to view cattle feeding in light of his production alternatives. The production decisions for his various enterprises would be made separately.

In actuality, however, resources are ultimately limiting and interaction often exists between the resources in the production function. It is for this reason that we must analyze beef production systems available to the Iowa farmer-feeder in light of his production alternatives. The farmer is unable to view each enterprise as a specialized unit. To optimize profit he must consider competitive, complementary, and supplementary relations between products caused by the constant flow of services from his fixed resources so that their marginal productivity is the same for each type of resource for each enterprise.

In the situation where some resource is limited to a level C_j and we wish to equalize the marginal return per unit of limited resource invested in each factor for each product, the farmer's profit function must be modified. Its mathematical form would be $\pi = \sum_{i=1}^{n} P_i Y_i - \sum_{i=1}^{n} \sum_{j=1}^{m} P_j X_{ij} + \sum_{j=1}^{m} \lambda_j (C_j - \sum_{i=1}^{n} X_{ij})$ where the terms are as previously defined and λ is a Lagrange multiplier representing the shadow price of the limiting resource.

The partial derivatives of profit with respect to each X_{ij} and λ_j specify the optimal solution to the new, constrained profit function. In this study, the λ's, or the shadow price of various limiting resources will be compared in the analysis of alternative investment opportunities. For example, the shadow price from one more unit of feedlot capacity can be compared with that from an additional unit of land.

Given the resource and interaction terms in each of the differential equations obtained from the farmer's profit function, inversion of the matrix of known coefficients would allow a means for determining the value of each X_{ij} and λ_j. Unfortunately, though, such detailed data as would be needed to obtain the coefficients required for solution of the differential equations are not readily available. The data used, therefore, was obtained from various secondary sources. Instead of considering the myriad of possibilities a continuous production function provides, unit budgets were used to determine costs associated with a discrete number of production alternatives. Thus, a discrete number of points on various isoquants and input-output curves have been specified as production alternatives.

Because the analysis of this study is not focused on input relations within a specified technology, but on products produced with alternative technologies, such specification of production alternatives is especially relevant. Under the conditions of great price and weather uncertainty existing in agriculture it is generally held that comparison of these production alternatives through analysis of linear relations existing between their specified input-output coefficients provides sufficient precision for adequate decision making.

Thus, the previously mentioned mathematical technique for analyzing linear relations, termed linear programming, has been employed in this analysis. A rigorous proof of this technique will not be attempted; however, a discussion of the assumptions underlying the use of the linear programming technique and their relevance to this study will be noted herein.

There are seven basic assumptions of a linear programming model. One, additivity of resources and activities is assumed. This implies the absence of any interaction among the resources. In the actual model, through proper formulation of the activities, interaction such as that between waste disposal on a fixed land area in different time periods is represented even though technical specification of variables in the model must adhere to additivity. Two, linearity of the objective function must exist for use of the linear programming technique. Thus, if as in monopolistic situations, price is a function of quantity sold the technique would not be applicable. Since agriculture exists in a competitive environment, conventional linear programming techniques can be utilized. Three, the decision variables can not be negative as is obviously the case for agriculture where the production of a negative ten steers is nonsense. Four, the linear programming technique assumes divisability of activities and resources. Thus, it assumes that we can raise 90.4 cows. Although four-tenths of a cow seems ridiculous, in most cases in the problem at hand the solutions may be rounded off without causing serious problems. Five, the situation is programmed as having a finite number of alternative activities and resource restraints. Other livestock enterprises such as swine and dairy were not programmed for analysis. Six, proportionality between activity levels and resources is assumed implying linear relationships between activities and resources. In the situation being considered this assumption is especially serious because of the cost economies accruing to larger-scale feedlot operations. In the specific case being examined, cropping activities are assumed to have reached the scale where most of the decline in unit costs has occurred. Declining costs in the cattle feeding activities are either approximated by linear regressions, as in the case of silo capacity, or the unit costs are estimated for defined scale ranges as in the case of feedlot capacity and feed and waste handling systems. Seven, resource supplies, input-output coefficients, prices of resources and activities, etc. are assumed to be known with certainty. By optimizing the programmed resources and activities under several price structures, however, the effect of a change in price expectations will be noted.

CHAPTER III. FARM SITUATION

Description of Land Base, Machinery and Labor Component

The land base assumed for the farm in this study is of sufficient size for most economies of scale involved in the production of cash grain crops to be attained (5, p. 379). This abstracts from the problem of declining marginal and average costs in grain production due to economies of size. Expansion of grain production by further investment in farmland would entail per acre fixed and variable tillage costs similar to those specified for the existing land base.

The amount of class A, B, and C soil in the 765 acre land base assumed for this study is set forth in Section I of the Appendix. Yield expectations for the various land classes under specified crops, pastures, and management practices are set forth in Sections II-VI of the Appendix.

Variable costs and field time requirements for management of various grains and forages are given in Sections II-VI of the Appendix. These costs were based on information given in an Iowa State University Master's Thesis authored by Craig Dobbins (10a). In conjunction with Dobbins' work, production costs estimated by a professional farm manager operating a land base of the scale specified in this study with the machinery component described below were incorporated into the model. These production costs were based on information reported by the farm manager for use in Iowa State University's "Crop Opt. Program" in early 1974.

Annual fixed costs for the machinery component are given in Appendix (Section XI). The machinery component was selected so as to be capable of tilling the specified crop acres in a timely manner. Thus, field time constraints imposed by the weather were not assumed to be restrictive. A six-bottom, mold-board, semi-mounted plow pulled by a 125 h.p. tractor was specified to plow cornstalk and sorghum ground. Where the crop was harvested as silage or stover, tillage with an 11-foot chisel plow was assumed to be sufficient. Chisel plowing also was assumed sufficient primary tillage for soybean ground. Only spring tillage was allowed on class B land to prevent soil erosion. On land plowed in the spring, secondary tillage with a twelve-foot roller attached behind a twelve-foot tandem disk was required to break clods. Commercial fertilizers and herbicides were custom applied and incorporated by the farmer when necessary with a thirty-foot spring tooth harrow. Farmyard manure was allowed to substitute for commercial fertilizer as discussed in Chapter VI.

Planting of row crops was done behind a mounted field cultivator to prepare the seedbed and kill the first weed growth. The planter specified was a six-row, thirty-inch unit. No herbicide or insecticide attachments were used on the planter since these only slow down the planting operation whose timeliness is critical.

Thirty-inch rows were chosen over wider rows because of their productive efficiency; and over narrower rows because they do not require such accurate planting to facilitate cultivation. Six-row equipment was specified because it is the largest size that can be easily transported (without trailering) across narrow county road bridges.

As herbicides were broadcast, only one rotary hoeing and cultivation were specified. Again six-row, thirty-inch equipment was assumed since it can be easily transported by one man if necessary.

To insure timely harvest and thus adequate time for fall plowing, a six-row, thirty-inch combine was specified. With the current shortage of storage space such timely harvest also provides a degree of insurance for adequate storage space at local grain elevators.

A twenty-ton truck and two, two hundred bushel wagons were specified to provide for hauling of harvested grain to storage. An 85 P.T.O. horsepower tractor was assumed to run the six-inch, forty-foot auger and do other jobs not requiring the use of a larger tractor. An endgate seeder was specified for the seeding of small grains and grasses.

Custom harvesting of corn stover was assumed so as not to delay the grain harvest and fall plowing. Silage and hay making were assumed to be more than a one man job. Thus, hay baling or silage chopping was specified on a custom basis, with the hauling and storage done by the operator.

Available operator labor was assumed to range from eight to nine hours per day with a six day work week during the year. Forty-eight hours of seasonal labor per week was assumed available for hire as indicated in Section XII of the Appendix. Additional labor was hired on a full time basis with the linear programming model choosing the optimal amount.

Costs for operating a beef cow herd are given in Section XI of the Appendix (10a). These unit costs are assumed to be applicable for an average sized Iowa beef cow herd.[1] The land base specified provides sufficient class B and C land to support such a herd. This land also provides forage land available for disposal of animal wastes. The comparative advantage of forages over row crops as disposal devices are discussed in Chapter VI.

Farm Business Structure

The business structure through which the firm is controlled has a large effect on the allocation of the firm's

[1]According to Paul Brackelsburg in Animal Science 444 in the fall of 1973, 98.7% of Iowa farms with beef herds have fewer than 100 head. Also 69.9% of all Iowa beef cows are in herds of 20-99 head.

resources and thus on the optimal product mix chosen. Today's agriculture is organized under many business structures. Traditionally absentee landlords and owner-operators have each controlled about 50% of Iowa's agricultural land (18, p. 587). As noted earlier, there is a trend toward contractual operating agreements in cattle feeding. Also, much to the concern of the state's legislators, relatively new business organizations, such as corporations, partnerships, and trusts, have begun to gain increasing control of portions of Iowa's agricultural resources (3, p.1). This section delineates the general nature of the business structure controlling the operations of the firm under study and briefly examines the effects expected to be caused by variation in specific factors. The analysis in this section was conducted so as to be generalizable to any business structure organized under the following specified conditions.

As previously noted in Chapter II, under static conditions with resources constrained, the product combination decision model can be mathematically defined as $\pi = \sum_{i=1}^{n} P_i Y_i - \sum_{i=1}^{n} \sum_{j=1}^{m} P_j X_{ij} + \lambda(C = \sum_{i=1}^{n} \sum_{j=1}^{m} P_j X_{ij})$ for the objective of profit maximization. Under a farm firm operated with one resource owner receiving r_i proportion of the i^{th} product and supplying S_{ij} proportion of the cost of the j^{th} input for the i^{th} product, and another resource owner receiving $(1 - r_i)$

proportion of the i^{th} product and supplying $(1 - S_{ij})$ proportion of the j^{th} input for the i^{th} product, the model can be defined as below for resource owner one and two respectively.

$$\Pi_1 = \sum_{i=1}^{n} r_i P_i Y_i - \sum_{i=1}^{n} \sum_{j=1}^{m} S_{ij} P_j X_{ij} + \lambda_1 (C_1 - \sum_{i=1}^{n} \sum_{j=1}^{m} S_{ij} P_j X_{ij})$$

$$\Pi_2 = \sum_{i=1}^{n} (1-r_i) P_i Y_i - \sum_{i=1}^{n} \sum_{j=1}^{m} (1-S_{ij}) P_j X_{ij} + \lambda_2 (C_1 - \sum_{i=1}^{n} \sum_{j=1}^{m} (1-S_{ij}) P_i X_{ij})$$

The corresponding marginal condition for the i^{th} product and the j^{th} input under profit maximization for owner one and two respectively are[1]:

$$dyi/dX_{ij} = S_{ij} r_i^{-1} P_j (1 + \lambda_1)$$

$$dyi/dX_{ij} = (1 - S_{ij})(1 - r_i)^{-1} P_i^{-1} P_j (1 + \lambda_2)$$

As can be seen by inspection of the designated marginal equations, assuming static conditions, pure competition, and decreasing marginal productivity, if the business structure specifies that $r_i < S_{ij}$, ceteris paribus, owner one will choose to use less of input j in producing product i than if $r_i = S_{ij}$. If for resource owner one, $r_i > r_{i+1}$, ceteris paribus, he will wish to include a greater proportion of product i in his product mix. In each case under the stated

---

[1] $\sum_{i=1}^{n} r_i P_i y_i = \sum_{i=1}^{n} \sum_{j=1}^{m} S_{ij} P_j X_{ij} + \lambda_1 (C_1 - \sum_{i=1}^{n} \sum_{j=1}^{m} S_{ij} P_j X_{ij})$

conditions resource owner two would choose to do the opposite. If $r_i = S_{ij}$ and $r_1 = r_{i+1}$, $i=1,\ldots,(n-1)$, under the stated conditions simultaneous agreement on input level and product mix will be reached by resource owner one and two if capital supplied by the two resource owners is proportional to the shares of input quantities supplied, i.e. ${S_{ij}}^{-1}(C_1) = (1 - S_{ij})^{-1}(C_2)$.

In this study the business structure under which the product combination decision is made was assumed to have the following characteristics.

(1) $r_i = S_{ij}$. Each resource owner's share of the factor of variable input must be the same as the share of output obtained therefrom.

(2) $r_1 = r_{i+1}$ where $i=1,\ldots,(n-1)$. The shares of all products are the same for each resource owner.

(3) Each resource owner receives the full share of the product earned by each unit of fixed and variable resource contributed.

(4) $\lambda_1 = \lambda_2$. The opportunity cost of capital employed in the firm is equal for resource owner one and two. This situation will prevail only if capital supplied by the two owners is proportional to the shares of input quantities supplied.

(5) The discounted value of future income flows is equal for each resource owner.

(6) The organizational form of business structure does not increase the risk facing the resource owners.

These conditions may be generalized to any number of resource owners and thus the results found in this study can be generalized to any business structure organized under the previously specified conditions.

Market Status

Market prices for commodities vary according to time and location. Thus, to ensure a precise statement of expected market prices both time and location must be specified.

The location to which the prices in this study apply is the state of Iowa. The markets chosen as a basis for price determination were those located at the par delivery points for futures contracts in Iowa.

The problem addressed in this study involves investment of capital. Thus, the period of time over which the stated market prices are expected to hold must be sufficient for evaluation of the magnitude and timing of expected future cash flows. Assuming returns are constant over time (as done in this study), a ten year planning horizon was specified.

The time period for which costs and prices were specified was January of 1974. Adjustments were made to the commodity prices existing in January of 1974 so as to more accurately reflect relations between product prices and production costs over the ten year planning period. Costs and prices existing in January of 1974 are shown in Table III-1. Cost-price relations in prior crop years are indicated in Table III-2. Number three yellow-corn delivered F.O.B. track in Chicago was used as the product price numeraire. As such, its relationship to the index of prices paid by farmers for commodities, services, interest, taxes, and wage rates is given for the last twenty-one crop seasons. Based on a product price-input cost relation expected to hold over the planning horizon, the index of prices paid by farmers existing in January of 1974 was used to adjust product prices to the current production period.

As can be seen, the ratio of corn price to the index of prices paid was very favorable toward grain farmers during January of 1974. Two of the many factors causing this situation deserve particular note.

(1) Increasing foreign demand for United States grains was created by devaluation of the United States dollar, improved relations with the communist world, and high levels of economic activity.

(2) A speculative demand for commodities during late 1973 was created through political uncertainty, inflation, weakness of the dollar in international trade, and a declining stock market (4a, p.13).

An increasing foreign demand is assumed to be a continuing factor in the market for United States grains. However, the speculative demand for commodities existing in late 1973 is assumed to decline in importance.

Table III-1. Selected commodity prices, price ratios, and other market rates, as of January 1974[a]

	Jan. 1974 Price Level
Selected Price Ratios	
Slaughter steer/corn	16.80
Feeder steer/slaughter steer (700-800 lb. feeder steer)	1.04
Corn/index of prices paid	.532
Selected Commodity Prices and Other Market Rates	
Feeder steers (choice, 400-500 lb., $/cwt., Omaha)	55.70
Feeder heifers (choice, 400-500 lb., $/cwt., Omaha)	50.70
Feeder steers (choice, 700-800 lb., $/cwt., Omaha)	50.00
Feeder heifers (choice, 600-700 lb., $/cwt., Omaha)	46.10
Slaughter steers (choice, 900-1100 lb., $/cwt., Omaha)	48.05
Slaughter heifers (choice, 900-1100 lb., $/cwt., Omaha)	47.42
Cull cows (utility cows, 900-1100 lb., $/cwt., Omaha)	31.45
Replacement heifers ($/cwt.)	50.90
Corn (number 3 yellow, $/bu., Chicago	2.86
Corn (average price received by farmers, $/bu.)	2.59
Soybeans (adjusted average price to farmers, $/bu.)	5.92
Grain Sorghum (average price received by farmers, $/100 lb.)	4.03
Oats (average price received by farmers, $/bu.)	1.32
Straw ($/ton, net at farm)	27.00
Hay (average price received by farmers, $/ton)	32.00
Corn silage (equivalent price of 5 bu. corn and 330 lb. hay, $/ton)	18.28
60% protein supplement (average price paid by farmers, $/cwt.)	8.90
Soybean meal (30% protein supplement, average price paid by farmers, $/cwt.)	9.20
Wage rate (owner-operator receiving twice farm labor rate)	4.52
Interest rate (annual rate, cattle feeding)	0.1025
Transportation rate ($/cwt./100 mi.)	0.20
Storage rate (for first 3 mo., 1¢ bu./mo. after)	0.05
Marketing cost (yardage + commission fees at midwest terminal mkt.)	3.30

[a] Sources: (48a, p.133; 45, p.3; 43. p.24).

In light of the above, the effect of three different cost-price relations was evaluated in this study. The three price relations tested are as follows:

(1) that existing in the 1972 crop year

(2) that existing from 1952 - 1972

(3) that existing from 1963 - 1972

Since devaluation occurred during the 1972 crop year, it could be assumed that the cost-price relationship existing then would be appropriate for the specified planning period. However, with rapid increases in production costs relative to product prices the lower cost-price relationships existing from 1952 - 1972 may be more appropriate. Large increases in production without corresponding increases in domestic and foreign demand may serve to push cost-price relationships even lower to those existing over the 1963 - 1972 production period. As indicated each of these three general price level possibilities is examined in Table III-7.

It should be noted that the main effect of price level variability will be on general investment profitability. The relative profitability of specific alternative investments hinges primarily on relationships existing in specific commodity markets. Before evaluating the relative profitability of specific alternative investments several adjustments were made to price expectations in the commodity markets of major importance.

Table III-2. Corn prices as compared to the index of prices paid by farmers

Year	Season Average Price, #3 Yellow Corn, Chicago, 1¢/bu.[a]	Annual Average Index of Prices Paid by Farmers[b]	Ratio of Corn Price/Index of Prices Paid
1952	159	278	.554
1953	153	277	.552
1954	148	278	.532
1955	124	276	.449
1956	131	278	,471
1957	121	287	.422
1958	121	294	.412
1959	117	298	.393
1960	110	300	.393
1961	111	302	.368
1962	119	307	.388
1963	120	312	.385
1964	126	313	.403
1965	127	321	.396
1966	136	334	.327
1967	112	342	.327
1968	117	355	.330
1969	125	373	.335
1970	144	390	.369
1971	121	410	.295
1972	188	432	.435
Jan. 1974 (1973 crop year)	286	538	.532
Average 1952 - 1962			.449
Average 1963 - 1972			.360
Average 1952 - 1972			.405

[a] Source: (44).

[b] Source: (41, p.8).

Price expectations in the fed beef market were adjusted in light of trend, cyclic, and seasonal price variation. The remaining variation from the expected price is assumed to be random, and unable to be predicted with any degree of certainty.

Trend relates to the general movement of prices over a relatively long period of time. Price and production trends for beef can be viewed in Table III-3. Apart from annual price fluctuations a gradual trend of increasing beef prices relative to those for corn can be observed from 1950 - 1973.

Present data indicates people are increasingly substituting other high-protein foods for meat (30a, p.24). Meanwhile, demand for United States feed grains continues to be strong as developing nations seek to have higher quality protein by importing and feeding United States grains (7, p.5).

This study does not assume a continuing upward trend in beef-corn price relationships. Rather, it tests effects of alternative price structures with beef-corn ratios both higher and lower than the average beef-corn ratio over the last cattle cycle.

Cyclic variations refer to price and number patterns which repeat themselves over periods longer than one year. Because of a lag in production response to price changes, cyclic patterns have developed in cattle markets.

Table III-3. Prices and price relationships between feeder steers, slaughter steers, and no. 3 yellow corn corresponding to cattle inventories per year

Year	Feeder Steer Price (47, p.212)	Slaughter Steer Price (47, p.212)	Corn Price per Season (44)	Cattle Inventory 1000 Hd. (47, p.28)	Slaughter Steer to Corn Ratio	Feeder Steer-Slaughter Steer Ratio
1950	$28.55	$28.88	$1.73	77,963		
1951	34.32	34.92	1.83	82,083	20.19	.983
1952	26.37	32.37	1.59	94,241	17.69	.815
1953	17.10	22.77	1.53	95,679	14.32	.751
1954	19.11	23.45	1.48	96,592	15.33	.815
1955	18.66	22.16	1.24	95,900	14.97	.842
1956	17.80	20.99	1.31	92,860	16.93	.848
1957	21.60	22.61	1.21	91,176	17.26	.955
1958	28.48	26.39	1.21	93,322	21.81	1.079
1959	28.61	26.93	1.17	96,236	22.26	1.062
1960	24.88	25.18	1.10	97,700	21.52	.988
1961	25.44	23.78	1.11	100,369	21.61	1.07
1962	26.84	26.45	1.19	104,488	23.83	1.015
1963	25.06	23.21	1.20	107,903	19.50	1.08
1964	21.53	22.21	1.26	109,000	18.51	.969
1965	24.50	25.12	1.27	108,862	19.94	.975
1966	27.33	25.69	1.36	108,783	20.23	1.064
1967	26.80	25.27	1.12	109,371	18.58	1.061
1968	27.86	26.83	1.17	110,015	23.96	1.038
1969	31.91	29.66	1.25	112,369	25.35	1.076
1970	33.05	29.33	1.44	114,578	23.46	1.127
1971	34.92	32.42	1.21	117,862	22.51	1.077
1972	42.91	35.83	1.88	121,534 (46b, p.6)	29.61	1.198
1973	53.67	43.89		127,540 (46b, p.6)	23.35	1.222
Av. (1963 - 1973)					22.27	1.08

Repetitions of the cattle cycle are often not of equal length. Likewise, upswing and downswing periods are frequently unequal even within a cycle. Because of these discrepancies, two cyclic divisions, A and B are illustrated in Table III-4. It should be noted that the cycles are of approximately ten years in length with the most recent ending in 1962. Thus, the most recent cattle cycle started in 1963. Experts are forecasting "a slide into the downside of the cattle cycle" during 1974 or early 1975 (15, p.1).

Assuming a leveling of the general trend, average price relationships between beef and corn over the preceding. cattle cycle (1963 - 1973)were used as a basis for

Table III-4. Upswing and downswing phases of past cattle cycles divided into two arbitrary divisions A and B [a]

Periods of Downswing		Periods of Upswing
	Division A for cycles	
1925 - 1927	....	1928 - 1934
1935 - 1937	....	1938 - 1944
1945 - 1948	....	1949 - 1954
1955 - 1957	....	1958 - 1962
	Division B for cycles	
1925 - 1927	....	1928 - 1933
1934 - 1937	....	1938 - 1943
1944 - 1948	....	1949 - 1953
1954 - 1957	....	1958 - 1962

[a]Source: (16, p. 262).

predicting future beef-corn price relationships. Deviations from the expected annual average beef-corn price ratio will directly affect feeding profits since feed typically accounts for nearly 90% of variable feeding costs (26, p.8). Thus, beef-corn price relationships serve as a relevant basis from which to define comparisons between alternative price structures. Three alternative beef-corn price structures are viewed in Table III-6, each corresponding to different specified beef-corn price ratios.

Prices for non-storable commodities such as beef have been shown to demonstrate a systematic seasonal variation from the annual average price within a year. Theoretically, seasonal price levels in non-storable commodities should be determined independently by potential market supplies and consumer demand during a specific period. Although, in reality, some dependence may exist between seasonal price levels (21, p.166), thus offering the opportunity of neutralizing seasonal effects through the futures market, price level speculation would be involved. Such speculation is not considered in this study and independence of fed beef price levels between seasons is assumed. Due to independent seasonal fluctuations, adjustments were made to the annual average fed beef price during different marketing periods. Adjustments to annual price were made on the basis of data presented in Table III-5, the significant effect being a seasonal rise in prices during

Table III-5. Seasonal price fluctuations in fed beef cattle

Month	1960 - 1972, Choice Cattle[a]				1960-1967, Beef Cattle[b]
	No. Yrs. Price Increased During Specified Mo.	Average Increase	No. Yrs. Price Declined During Specified Mo.	Average Decline	Index
January	7	+1.02	6	-0.79	99.97
February	9	+0.77	4	-0.86	97.80
March	6	+0.66	7	-0.49	99.75
April	5	+1.35	8	-0.94	99.38
May	8	+0.82	5	-1.83	99.20
June	9	+0.79	4	-0.51	98.94
July	8	+0.84	5	-1.14	100.36
August	3	+0.67	10	-0.52	103.07
September	3	+0.38	10	-0.64	102.63
October	5	+0.71	8	-0.70	101.49
November	8	+0.89	4	-0.84	99.60
December	11	+0.79	1	-1.63	98.12

[a] Source: J.M. Skadberg, Extention Economist, Iowa State University, unpublished paper, 1973.

[b] Source: (37a, p.4).

the summer months.

In this study May and June prices were assumed to be 99.4% of the annual average, with July, August, and September prices as indicated by the 1960-1967 index.

Feeder cattle prices were based on the 1963-1973 period for reasons similar to those posited for slaughter cattle. Feeder cattle price expectations were determined on the basis of their relationship to slaughter cattle prices. For a given beef-corn ratio the breakeven purchase price of a feeder calf will be in a relatively fixed proportion to slaughter price regardless of the absolute price level of corn.[1] Thus,

[1]Assume beef-corn ratio 22:1. Assume feed costs of $150.00. Corn price: $ 1.20/bu.

x 22
$26.42/cwt. slaughter cattle

$26.42/cwt.
x 10.50 cwt.
$277.41 gross return
- 150.00 feed costs
$127.41 amount which can be paid for feeder calf and break even over feed costs

4.5 cwt./ 127.41 = $28.27/cwt.

26.42 /28.27 = 1.06 relation of feeder calf price to slaughter steer price when corn at $1.20/bu.

Corn price doubles to $2.40/bu. With beef-corn ratio of 22:1, price of slaughter cattle is $52.84/cwt.

$ 52.84/cwt.
x 10.50 cwt.
$554.82 gross return
-300.00 feed costs
$254.82 total can pay for feeder calf

4.5 /254.82 = $56.40/cwt. for feeder calf

52.84/56.40 = 1.06 same relation as when corn is at lower price level.

Table III-6. Selected adjusted commodity prices, price ratios, and other rates[a]

Selected Price Ratios	Price Structure A	Price Structure B	Price Structure C
Slaughter steer/corn	19.53	22.27	25.01
Feeder steer/slaughter steer	1.06	1.08	1.08
Corn/index of prices paid	0.435	0.405	0.360
Selected Adjusted Commodity Prices and other Market Rates			
Feeder steers (400-500 lb./cwt.)	$53.96	$58.15	$58.37
Feeder heifers (400-500 lb./cwt.)	49.12	52.93	53.13
Feeder steers (700-800 lb./cwt.)	48.44	52.20	52.40
Feeder heifers (600-700 lb./cwt.)	44.66	46.35	48.31
Slaughter steers/cwt.	45.70	48.33	48.52
Slaughter heifers/cwt.	45.11	47.70	47.89
Cull cows/cwt.	29.93	31.56	31.45
Replacement heifers/cwt.	69.32	73.13	73.33
Corn/bu. (no.3 yellow)	2.34	2.17	1.94
Corn/bu. (average price received)	2.12	1.97	1.76
Soybeans/bu.	5.24	4.89	4.42
Grain sorghum/cwt.	3.30	3.06	2.73
Oats/bu.	1.08	1.00	0.90
Straw/t.	22.09	20.49	18.32
Hay/t.	26.18	24.28	21.71
Corn silage/t.	14.96	13.87	12.40
60% protein supplement/cwt.	8.90	8.90	8.90
Soybean meal/cwt.	9.20	9.20	9.20
Wage rate/hr.	4.52	4.52	4.52
Interest rate/yr.	0.1025	0.1025	0.1025
Transportation rate/cwt./100 mi.	0.20	0.20	0.20
Storage rate/first 3 mo.	0.05	0.05	0.05
Marketing cost/hd.	3.30	3.30	3.30

[a]Price ratios, commodities, and market rates are as indicated in Table III-1.

feeder prices were determined as a function of slaughter prices at a specified beef-corn ratio. This determination facilitates definition of the producer's problem of whether to feed or sell a feeder calf at a given beef-corn ratio.

Again assuming independence of feeder calf price levels between seasons, feeder calf prices were adjusted for seasonal price variation. The seasonal price index for feeder calves has two distinct levels. Spring feeders generally sell at a 3% higher price than do those in the fall (37a, p.7). This is caused by the seasonal pattern in feeder calf production.

Although price fluctuations occur in grain markets they do not appear to follow any cyclic pattern. Aside from an upward trend in production due to technological progress, fluctuation in the production of most crops is influenced primarily by weather, which for the most part, is not cyclic in its changes.

There is also "substantial evidence indicating lack of consistent seasonal variation in the price level of such storable commodities for which there are developed futures markets; the cost of storage taken into account" (21, p.291). Due to short-run disequilibrium in the storage market, however, a consistent seasonal basis gain in local grain markets often does exist. A farmer can profit by storing his grain while the cost of storage is less than the prospective basis gain. In a specific Iowa grain elevator this profit was consistently achieved by storage until the third week in May. Thus, the basis on Friday, May 24, 1974, at the specified elevator was used in computing the grain price to the farmer. The costs of storage to that time were subtracted. The adjusted commodity prices, price ratios, and other market rates are given in Table III-6. For delineation of specific commodities, price ratios, and other market rates set forth in Table III-6 reference should be made to Table III-1.

CHAPTER IV. CATTLE FEEDING TECHNOLOGIES

Feedlot Design

Situation A. Existing feedlot facilities

The resource base was assumed to have existing dry-lot facilities available for feeding 200 head of cattle. To begin operations, however, a start up cost of $8,000.00 (average annual cost of $5.60/ head) was necessary. Hand feeding methods, i.e. scoopshovel and bushel basket, were assumed for this technology.

Situation B. New beef feedlot facilities

In designing new beef feedlot facilities the choice of location may be nearly as important as the choice of structural design. Basically, one should select a feedlot site that provides a desirable micro-climate for the cattle, minimizes potential air and water pollution possibilities, and allows the feedlot operations to be carried on as efficiently as possible. In this study it was assumed that such a feedlot site had been chosen.

Construction of four alternative beef feedlot facilities was compared: open lot, drylot, solid floor confinement, and cold slat (slatted floor) confinement. To facilitate consistent design and evaluation procedures each feedlot was designed as a function of several general parameters whose specifications were defined for each individual case. The general parameters chosen were: (1) shelter area, (2) windbreak and mounds (for open lots), (3) lot area (unsheltered area), (4) feedbunk, (5) waterers, (6) fencing, (7) gates, (8) gravel along feed alleyway, (9) concrete aprons, and (10) feeding floors. Based primarily on these parameters an algorithm created by H.A. Hughes at Michigan State University was used to design four basic types of feedlots, each representing a different feeding technology (31a). Each of the designed feedlots included a 30' x 50' turn-around area, holding pen, and loading area in addition to the feeding system itself. Gravel was spread on the feed alleyway in front of the feedbunks. A cost of $1,500. was assessed to provide a watering system. Unit costs were based on a uniform set of construction costs as indicated in Table IV-1. Design specifications and derived budgets are given for each feeding system in Tables IV-2, 3, 4, and 5. A brief description of each technology follows.

Open lot   The open lot facility consists of a partially paved lot with no shelter other than an eight foot high windbreak fence provided along one side of the feedlot. A dirt mound 75' wide at the base, 6' high, and 15' wide at the top provides a minimum of 30 square feet of mound space per animal. The lot is dirt except for a ten foot wide, four inch deep concrete apron next to the windbreak fence and along the fence-line feedbunk. Twenty square-feet of lot area is provided per 100 pounds of animal bodyweight. Fencing is provided around the perimeter of each pen, and eighteen linear inches of feedbunk space is provided per animal. Two gates are needed in excess of one per pen to allow for access to the loading pen and for manure removal. One waterer is provided for each 75 head and 150 animals are allowed per pen.

Drylot   This system is similar to the open lot except that it requires no dirt mound, only fifteen square-feet of lot and two square-feet of shelter per 100 pounds of animal bodyweight. The building is all steel construction with a fourteen foot eve height. Twenty-six guage roofing and siding material screw fastened to the building main frame is assumed to be used throughout. Continuous vent louvers on the north side of the building are to be provided to allow for additional summer ventilation. A ten inch continuous ridge opening is assumed to be provided to prevent a buildup of moisture during the winter.

Solid floor confinement   This facility consists of an open front shed of the same construction previously

Table IV-1. Unit cost assumption for feedlot facilities[a, b]

Shelter	$ 1.60 per sq. foot
Windbreak	3.00 per linear foot
Land for lot	0.02 per sq. foot ($870/acre)
Dirt work (mound)	0.75 per cu. yd.
Waterers	300.00 each
Fence	2.00 per linear foot
Gates	65.00 each
Feedbunk	7.50 per linear foot
Concrete	0.65 per sq. foot
Slatted floor w/pit	0.57 per cubic foot
Gravel	1.05 per linear foot

[a]Sources: (11; 31).

[b]Ken Steiner, Confinement Builders, Inc., Eldora, Iowa, personal interview, September 1973.

described with a solid concrete feeding floor. Two and five-tenths square feet of shelter per 100 pounds of bodyweight are provided. No lot area is necessary as the cattle are totally enclosed under the shelter. Nine linear inches of a fenceline, concrete, high-capacity feedbunk is provided per animal. And, one waterer is assumed for each 75 animals.

Cold slat confinement This facility is similar to the solid floor confinement structure; however, instead of solid concrete, a slatted concrete feeding floor is provided. A manure storage pit underneath the slats is specified to

Table IV-2. Capital investment in open lot facilities for feeding beef cattle at three different scale levels

Scale (midpoint):	300		500		800	
Feeding Facilities	Specifications		Specifications		Specifications	
Wind break	225' x 8'	$ 225.00	375' x 8'	$ 375.00	600' x 8'	$600.00
Dirt mound	1500 cu. yd.	1,125.00	2500 cu.yd.	1,875.00	4000 cu.yd.	3,000.00
Lot	225' x 280'	1,260.00	375' x 280'	2,100.00	600' x 280'	3,360.00
Feedbunk	450'	3,750.00	750'	5,625.00	1050'	7,875.00
Waterers	5	1,500.00	7	2,100.00	10	3,000.00
Fence	1475'	2,950.00	1905'	3,810.00	2550'	5,100.00
Gates	5	325.00	6	390.00	7	455.00
Concrete	6750'	4,387.50	1050'	6,825.00	15,750'	10,237.50
Well	120'	1,500.00	120'	1,500.00	120'	1,500.00
Gravel	450'	473.00	750'	787.50	1050'	1,102.50
Total		$17,495.50		$25,387.50		$36,230.00
Equipment[a]						
Loader	1	$2,000.00	1	$2,000.00	1	$2,500.00
Spreader	5 ton	1,800.00	5 ton	1,800.00	8 ton	3,000.00
Feed wagon	144 bu.	4,225.00	144 bu.	4,225.00	144 bu.	4,225.00
Total		$8,025.00		$8,025.00		$9,725.00

[a]Sources: (1, p.25; 11).

Table IV-3. Capital investment in drylot facilities for feeding beef cattle at three different scale levels

Scale (midpoint):	300		500		800	
Feeding Facilities	Specifications		Specifications		Specifications	
Shelter	225' x 28'	$10,080.00	375' x 28'	$16,800.00	600' x 28'	$26,880.
Lot	225' x 210'	945.00	375' x 210'	1,575.00	600 x 210'	2,520.
Feedbunk	450'	3,750.00	750'	5,625.00	1200'	9,000.
Waterers	5	1,500.00	7	2,100.00	11	3,300.
Fence	1026'	2,052.00	1264'	2,528.00	1621'	3,242.
Gates	5	325.00	6	390.00	7	455.
Concrete	6750'	4,387.50	10,500'	6,825.00	19,500'	12,675.
Well	120'	1,500.00	120'	1,500.00	120'	1,500.
Gravel	450'	473.00	750'	787.50	1200'	1,260.
Total		$25,012.50		$38,130.50		$60,832.
Equipment[a]						
Loader	1	$2,000.00	1	$2,000.00	1	$2,000.
Spreader	5 ton	1,800.00	5 ton	1,800.00	8 ton	3,000.
Feed wagon	144 bu.	4,225.00	144 bu.	4,225.00	144 bu.	4,225.
Total		$8,025.00		$8,025.00		$9,725.

[a] Sources: (1, p.25; 11).

Table IV-4. Capital investment in solid floor confinement facilities for feeding beef cattle at three different scale levels

Scale (midpoint):	300		500		800	
Feeding Facilities	Specifications		Specifications		Specifications	
Shelter	225' x 35'	$12,600.00	375' x 35'	$21,000.00	600'x35'	$33,600.00
Lot		0.00		0.00		0.00
Feedbunk	225'	1,687.50	375'	2,812.50	600'	4,500.00
Waterers	5	1,500.00	7	2,100.00	11	3,300.00
Fence	425'	850.00	610'	1,220.00	887.5'	1,775.00
Gates	5	325.00	6	390.00	7	455.00
Concrete	7875'	5,118.75	13,125'	8,531.25	21,000'	13,650.00
Well	120'	1,500.00	120'	1,500.00	120'	1,500.00
Gravel	225'	236.25	375'	393.75	600'	630.00
Total		$23,817.50		$37,947.50		$59,410.00
Equipment[a]						
Loader	1	$2,000.00	1	$2,000.00	1	$2,500.00
Spreader	5 ton	1,800.00	5 ton	1,800.00	8 ton	3,000.00
Feed wagon	144 bu.	4,225.00	144 bu.	4,225.00	144 bu.	4,225.00
Total		$8,025.00		$8,025.00		$9,725.00

[a]Sources: (1, p.25; 11).

Table IV-5. Capital investment in cold slat confinement facilities for feeding beef cattle at three different scale levels

Scale (midpoint):	300		500		800	
Feeding Facilities	Specifications		Specifications		Specifications	
Shelter	225' x 28'	$10,080.00	375'x 28'	$16,800.00	600'x 28'	$26,880.00
Lot		0.00		0.00		0.00
Feedbunk	225'	1,687.00	375'	2,812.50	600'	4,500.00
Waterers	5	1,500.00	7	2,100.00	11	3,300.00
Fence	411'	812.00	589'	1,178.00	856'	1,712.00
Gates	5	325.00	6	390.00	7	455.00
Concrete		0.00		0.00		0.00
Slatted pit:						
Depth	10.16'		10.16'		10.16'	
Width	20'		20'		20'	
Length	225'		375'		600'	
Cost		26,455.64		43,550.80		69,494.48
Well	120'	1,500.00	120'	1,500.00		1,500.00
Gravel	225'	236.25	375'	393.75	600'	630.00
Total		$42,606.39		$68,725.05		$108,471.40
Equipment (1, p.25; 11)						
Loader	1	$2,000.00	1	$2,000.00	1	$2,500.00
Spreader	3000 gal.	4,200.00	3000 gal.	4,200.00	2-3000 gal.	8,400.00
Pump	1	2,000.00	1	2,000.00	1	2,000.00
Feed wagon	144 bu.	4,225.00	144 bu.	4,225.00	144 bu.	4,225.00
Total		$12,425.00		$12,425.00		$17,125.00

provide six months storage capacity on a high silage ration for the system's effluent.

Annual fixed cost of the feedlot facilities and feedlot equipment was assumed to be 14% and 16%, respectively, of the initial investment cost (11, p.33). Investment cost in feedlot facilities is not only a function of technology, but of scale size as can be seen in Tables IV-2, 3, 4, and 5. Most of the scale cost economies are incurred by the 500-700 head level. There may be further pecuniary economies of scale, but these were not estimated in this model.

Animal Performance

Animal performance was assumed to be affected by energy level in the ration as indicated in Tables V-1, 2, 3, and 4. Animal performance has also been shown to be significantly affected by the surrounding environment (34, pp.272-275). Different feedlot designs may serve to modify the feedlot environment and thus, affect animal performance. Before examining actual comparisons between feedlot designs, several environmental variables affecting animal performance and their interaction with other variables will be noted.

Based on data collected at Iowa State University's Allee Experimental Farm at Newell, Iowa, and analyzed at the University of Illinois (34), during the summer feeding periods performance of cattle submitted to a "temperature-humidity index" (T.H.I.) above 69 showed decreased rate of gain and feed efficiency. Results from summer feeding period tests also indicated that cattle in the middle weight class performed better than the relatively lighter weight or heavier weight cattle. This would indicate that the heavier cattle may have suffered more from heat stress and thus had lower daily gains.

During the winter feeding periods, animal performance at the Allee Experimental Farm seemed to be affected by the following: 1) average daily temperature which was less than a daily still air, wind-chill temperature of 19 degrees Fahrenheit, 2) average daily temperature which was greater than a critical stress value of 69 T.H.I., and 3) average weight of cattle during the feeding period. The data indicated that heavier cattle could better withstand the cold than lighter weight cattle.

Net energy for maintenance and gain also was affected by average hours of precipitation per day (34, p.180). But, the effect of precipitation on feed efficiency was not as great as the effect caused by differences in composition of the ration fed. During the winter cattle fed a corn silage ration gained relatively better compared to their expected gain than did cattle fed a corn cob roughage source (34, p.183).

Research conducted at Michigan State University concludes that energy level in the ration becomes a critical factor when feeding under adverse environmental conditions, and that an all silage ration is best adapted to a housed system of feedlot management (23, p.46). Thus, in this study only housed feeding facilities were considered with the all silage ration.

Depending on whether cloudy or clear skies exist, either confinement or drylot feeding facilities may have a relative advantage. Research at Canada has shown that cattle can lose a considerable amount of radiant energy to a clear night sky (34, p.184). Under heat stress this could prove to be a relative advantage to animals fed in a drylot as opposed to confinement. On the other hand, if conditions are overcast with attendant precipitation, drylots often turn to mud lots resulting in decreased animal performance (34, p.186).

On the basis of these studies it may be seen that heat, cold, and precipitation variables all affect an animal's performance. Thus, feedlot facilities providing a degree of protection from these factors would be expected to increase animal performance. However, it also should be noted that weight of cattle fed, protein level, energy level, and fiber content of the ration interact with these environmental variables. Different climatic conditions, e.g. clear night skies, may change the relative advantage of different feedlot designs with respect to an animal's performance. Thus, if the actual relative advantage of one feedlot design is not sufficiently great it may be masked by interaction with such variables as ration, weight, and climatic factors noted above.

In a summary of twenty-one actual experiments conducted at seven different experiment stations comparing sheltered vs. non-sheltered feedlots, rate of gain and feed efficiency was consistently lowered in both summer and winter feeding periods in non-sheltered lots. The mean percentage decrease in average daily gain during the winter was 12% (20, p.8). The mean percentage increase in feed cost during winter feeding periods was 14% (20, p.8). The mean percentage decrease in average daily gain during summer periods was 5%, while feed costs increased an average of 4% (20, p.12).

In comparisons between confinement and other sheltered feedlot designs the results are not as consistent and seem to be influenced by season and possibly by weight of cattle fed. In some early work at the Ohio Experiment Station, the performance of sheltered steer calves was inferior to that of confined calves during cold periods, but superior to the performance of confined calves during summer feeding periods (20, p.15).

Research conducted in Michigan compared steer calves fed with 40% and 100% of their respective lot area under a roof. Very little difference in animal performance was noted in either summer or winter tests (20, pp. 13-14).

Winter trials conducted at Iowa State University indicated that without exception, rate and efficiency of gain for yearling steers fed in open lots was inferior to that of similar cattle fed in drylot or confinement facilities. In the first test both rate of gain and cost of gain favored the cattle fed in confinement. In subsequent tests performance of confinement cattle has been inferior to that of cattle fed in drylot. In summer tests yearling steers fed in confinement did not perform as well as similar cattle fed in open or drylot facilities (9b).

In extensive tests at the University of Minnesota, relative performance of confinement fed cattle has been somewhat better than that indicated at Iowa State. Minnesota tests were conducted with steer calves that as previously indicated because of their lighter weight may have been more subject to cold stress. Also, the feeding tests did not run clear through the warm summer months where heavy cattle may be especially subject to heat stress. Comparison of the Iowa and Minnesota tests suggests that the relative advantage of confinement fed cattle may be influenced by season and weight of cattle fed (see Table IV-6).

On the basis of the preceding data I have assumed cattle fed in drylot facilities will have an approximately 10% increase in rate of gain and a 5% decrease in dry matter consumed daily as a percentage of body weight as compared to similar cattle fed in open lots. However, in the data set forth no consistent relative advantage or disadvantage in performance of animals fed in drylot versus confinement facilities can be observed. Hence, no relative advantage or disadvantage in animal performance between drylot and confinement facilities was assumed. This assumption is supported by similar assumptions made in a recent evaluation of feeding systems at Iowa State University (11).

Pollution Control Investment

Section 101 (a), (1) of the Federal Water Pollution Control Act, as amended by the Water Pollution Control Act Amendments of 1972 sets forth a national objective of elimination of the discharge of pollutants into navigable waters by 1985. Section 306 (a) defines "standard of performance" as a "Standard for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the administrator determines to be achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives,

TableIV-6. Effect of feedlot type on animal performance at two locations during similar time periods (1969-1973)

Iowa State University[a]

	Winter Tests			Summer Tests		
Animal Type:	yearling steers			yearling steers		
Feeding Period:	Nov.-April			June-Oct.		
Feedlot Type:	Open lot	Drylot	Cold slat Confinement	Open lot	Drylot	Cold slat Confinement
Animal Performance						
Average daily gain	2.26	2.58	2.50	2.80	3.01	2.38
D.M./lb. gain	7.80	6.66	6.94	6.42	6.01	6.58

University of Minnesota[b]

Feeding Period: November - July
Animal Type: Steer calves

Feedlot Type:	Open lot	Drylot			Solid floor confinement			Cold slat confinement		
Density, sq.ft./hd.	250	30	20	17	30	20	17	30	20	17
Animal Performance										
Average daily gain	2.21	2.36	2.26	2.30	2.36	2.44	2.49	2.43	2.36	2.30
D.M./lb. gain	6.35	5.93	6.19	6.04	5.92	5.69	5.81	5.87	6.09	6.14

[a]Source: (9b).

[b]Source: (32b, p.9).

including where practicable, a standard permitting no discharge of pollutants." (37b, p.1). The performance standards specified by the Environmental Protection Agency (E.P.A.) call for retention facilities to control the runoff that can be expected from a rain once in ten years, to be built by 1977; that which can be expected once in 25 years, by 1983.

Currently, the E.P.A. is focusing on feedlots over the 1,000 head scale. A New York based environmental group is attempting through legal action to force the E.P.A. to make closer scrutiny of smaller feedlots. To the extent that performance standards are enforced on feedlots under the 1,000 head scale, the cost of pollution abatement is of concern to this study.

The costs of pollution abatement are highly situation specific. A regression analysis of investment cost for pollution abatement in beef feedlots in Southwestern Minnesota found that only 39% of the variation could be associated with variation in feedlot capacity (36, p.37). In Iowa with a large proportion of class A land, minimal runoff control may be necessary. Specific situations, however, may require additional investment in pollution abatement facilities.

Engineering estimates of annual costs necessary for control of runoff on open and drylot feeding facilities are given in Tables V-7 and 8. Annual investment cost is assessed at

Table IV-7. Estimated annual runoff control costs for an open lot feeding facility at different scale sizes (30b)

Scale (midpoint)	100	300	600	1,000
Investment				
Diversion	$100	$200	$350	$550
Settling basin	100	200	350	550
Retention	346	1485	1968	3214
Fencing	210	360	390	453
Irrigation system	520	1430	1870	2050
Total investment	$1276	$3675	$4928	$6817
Labor and operating assumptions				
Acres irrigated	2	6	12	20
Number of sets	15	24	18	15
Motor type	Electric	Electric	Tractor	Tractor
Motor h.p.	1.5	10	30	40
Pumping time (hrs.)	150	110	140	218
Hours - set @ 1.5 hr.	22.5	36.0	27.0	22.5
Maintenance (+10%)	2.2	3.6	2.7	2.2
Total hours of labor	24.7	39.6	29.7	24.7
Annual cost				
Investment	$229.68	$661.50	$887.04	$1227.06
Irrigation power	4.50	22.00	504.00	959.20
Labor ($2.26/hr.)	55.82	89.50	67.12	55.82
Manure credit	107.00	321.00	535.00	1070.00
Total	$183.00	$452.00	$923.16	$1172.08
Per head capacity	$1.83	$1.51	$1.54	$1.17

Table IV-8. Estimated annual runoff control costs for a drylot feeding facility at different scale sizes (30b)

Scale (midpoint)	100	300	600	1,000
Investment				
Diversion	$100	$200	$350	$550
Settling basin	100	200	350	550
Retention	227	642	1253	2063
Fencing	206	272	336	398
Irrigation system	520	1430	1870	2050
Total investment	$1153	$2744	$4159	$5611
Labor and operating assumptions				
Acres irrigated	1.2	3.8	7.6	12.6
Number of sets	12	12	12	10
Motor type	electric	electric	tractor	tractor
Motor h.p.	1.5	10	30	40
Pumping time (hrs.)	95	68	82	136
Hours - set @ 1.5 hr.	18.0	18.0	18.0	15.0
Maintenance (+10%)	1.8	1.8	1.8	1.5
Total hours labor	19.8	19.8	19.8	16.5
Annual Cost				
Investment	$207.54	$493.92	$748.62	$1009.98
Irrigation power	2.85	13.60	295.20	598.40
Labor	44.75	44.75	44.75	37.29
Manure credit	-70.62	-221.86	-353.10	-706.20
Total	$184.52	$330.41	$735.47	$939.47
Per head capacity	$1.84	$1.10	$1.23	$ .94

18% of the initial investment cost. Irrigation power costs were assessed on the basis of two cents per horsepower-hour for electric motors. Costs for operating 30 and 40 horsepower tractors are $3.60/hr. and $4.40/hr. respectively. Fertilizer value of the manure was credited as indicated. Implications of these costs to the feeder will be reviewed in Chapter VII.

Feed Storage and Handling

The primary considerations in the choice between different feed storage alternatives are the basic ration components. In the feeding systems under the 200 head scale, dry shelled corn was the concentrate specified. Storage was provided in an elevator grain bank from which the corn was removed as needed. Trucking to the farm was costed at $.07 per bushel. Feeding losses were assumed to be 1.5% for dry corn (see Table III-6). The roughages fed at the 0-200 head scale are allowed to be chosen by the computer program because of their interaction with the forages fed in the beef cow activities. Costs and labor requirements for feeding roughages are indicated in Appendix A.

In feeding activities ranging from 200 to 1,000 head in scale high moisture shelled corn and corn silage are the specified ration ingredients, and concrete stave silos are the storage structures. The feeding losses assumed are 10% for corn silage, and 3% for high moisture shelled corn. In computing silo capacity requirements, 38 bushels of high moisture shelled corn was equated to one ton of corn silage.

A linear regression of annual cost to silo capacity was used for cost estimation purposes to adjust for economies of scale in feed storage. Table V-5 indicates investment and annual cost for various silo capacities in Iowa. An adjustment figure of 122% is used to adjust investment costs given on a 1971 basis to that of January 1974. This adjustment factor was derived by means of the Department of Commerce Construction cost index. The annual fixed cost of the feed handling and storage facilities is assumed to be 14% of the initial capital investment (11, p.33). This annual cost is broken down into a fixed and incremental portion by the regression performed. As the correlation coefficient was high (.991), the estimated fixed and incremental values are expected to hold over the specified range.

Table IV-9. Investment and annual silo ownership costs[a]

Silo Type and Size (feet)	Silo Capacity (tons silage)	1971 Investment Cost Silo	Unloader	Total	Adjusted Jan. of 1974 Total Cost	Annual Cost
18 x 50	302	$4,500	$1,775	$6,275	$7,656	$1071.84
18 x 60	387	5,400	1,775	7,175	8.754	1225.56
20 x 50	373	5,000	1,900	6,900	8,418	1178.52
20 x 60	478	6,200	1,900	8,100	9,882	1383.48
20 x 70	597	7,400	1,900	9,300	11,346	1588.44
22 x 50	452	5,800	2,000	7,800	9,516	1332.24
22 x 60	579	7,200	2,000	9,200	11,224	1571.36
22 x 70	714	8,700	2,000	10,700	13,054	1827.56
24 x 50	538	6,900	2,100	9,000	10,980	1537.20
24 x 60	689	8,400	2,100	10,500	12,810	1793.40
24 x 70	852	10,300	2,100	12,400	15,128	2117.92
24 x 80	1,034	11,900	2,100	14,000	17,080	2391.20
26 x 60	807	9,700	2,250	11,950	14,579	2041.06
26 x 70	1,000	11,400	2,250	13,650	16,653	2331.42
26 x 80	1,250	13,000	2,250	15,250	18,605	2604.70
28 x 60	940	10,800	2,400	13,200	16,104	2254.56
28 x 70	1,159	12,500	2,400	14,900	18,189	2544.92
28 x 80	1,383	14,200	2,400	16,600	20,252	2835.28
30 x 60	1,076	12,100	2,550	14,650	17,873	2502.22
30 x 70	1,332	13,900	2,550	16,450	20,069	2809.66
30 x 80	1,588	16,000	2,550	18,550	22,631	3168.34

Regression: y = $623.73 + $1.65X R^2=.9913754, where y= annual ownership cost,
X = tons of silo capacity

[a]Source: (39b).

CHAPTER V. CATTLE FEEDING ACTIVITIES

Rations

Within each separate cattle feeding technology several different cattle feeding activities can be compared. These comparisons arise from differences between cattle type and ration fed. In this study, age, sex, ration, and feeder origin were varied within specified feeding technologies. Where the majority of the feeder calves originated on the farm, age, sex, and ration were varied with housing type held constant. Where the feeder calves originated off the farm, age, ration, and housing type were varied.

In this study the rations were referred to according to percent concentrate (shelled corn) in the ration. A 1% concentrate ration is interpreted to mean the daily feeding of shelled corn equal in weight to 1% of the body weight of the animal, plus a full feed of corn silage. Rations with similar energy levels, but with different roughage sources were also referred to on this basis. Although various roughage sources were considered under the 200 head feedlot capacity scale, only a specified amount of the ration was allowed to be roughage so as to insure adequate palatability.

A 1% concentrate shelled corn—corn silage ration is equivalent to approximately 40% corn and 60% corn silage on on a dry matter basis. On a fresh as fed basis this ration would approximate 38% corn and 62% corn silage. A 1.5% concentrate ration is approximately equivalent to a 60% corn and 40% corn silage ration on a dry matter basis.

A 1% concentrate ration was assumed to reduce the average daily gain (A.D.G.) by 0.15 below the 1.5% concentrate ration. The expected rate of gain for steer calves fed a 1.5% concentrate ration was assumed to average 2.40 pounds per day on a gained weight basis. Thus, the expected A.D.G. for steer calves fed a 1% concentrate ration would be 2.25 pounds on a gained weight basis.

The feed requirements for calves are given in Tables V-1 and 2 on a gained weight basis, i.e. they are not adjusted for "in" and "out" shrink. This adjustment occurs later in the marketing activities. It should be noted, however, that in Tables V-1 and 2, the "in weight" of yearling cattle custom finished on the 1.5% concentrate ration is shrunk approximately 6% from the "out weight" of cattle backgrounded on the .5% concentrate ration. This shrink occurs in the transfer of calves from the backgrounding to custom finishing facility.

"In shrink" for feeder calves in Tables V-3 and 4 was assumed to be 6%. This would apply to calves in transit for 7-9 hours. "Out shrink" for fat cattle was assumed to be 3%, applying to cattle in transit for 1-2 hours (25, p.90). For feedlots of under 200 head capacity, it was assumed feeder calves would be raised on the farm or purchased locally with negligible "in shrink". "Out shrink" and marketing cost adjustments were made for all cattle bought and sold.

With an "in shrink" of 6%, a 450 pound calf would shrink approximately 27 pounds. At 2.25 pounds A.D.G. it would take 12 days of feedlot time to regain this 27 pounds. With a 3% "out shrink" a 1050 pound calf would shrink about 32 pounds. At 2.25 pounds A.D.G. this would equal 14 days of feedlot time. Instead of 267 days, e.g. 600 pounds of gain at 2.25 pounds a day, it will take this calf 267 + 12 + 14 = 293 days to make a 600 pound gain. Thus, average daily gain on a payweight to payweight basis would be 600/293 = 2.05.lb. Likewise, for the 1.5% concentrate ration with an expected A.D.G. of 2.40 pounds the payweight to payweight A.D.G. would be 2.18 pounds.

Yearlings were expected to gain approximately 15% faster than calves (38, p.3). Thus, with sheltered feedlot facilities yearling steers fed the 1.5% and 1% concentrate rations were expected to gain 2.75 and 2.55 pounds per day, respectively, on a gained weight basis. Gain for steers fed in facilities without shelter was assumed to be .2

of a pound a day less than steers fed in sheltered feedlot facilities (see Chapter IV). On a payweight to payweight basis with the shrink previously stated yearling steers fed the 1.5% concentrate ration were expected to gain 2.27 and 2.10 pounds per day with and without shelter, respectively. Yearlings were expected to consume 10% - 15% more dry matter as a percent of body weight daily than calves resulting in 0.2% to 0.3% higher daily dry matter intake for yearlings. Feed efficiency is in favor of calves over yearlings. The latter require about 16% more feed per pound of gain (38, p.4).

Although in some cases unjustified discrimination between sexes may be claimed, when comparing steers and heifers, it is commonly held that steers and bull calves make more rapid and efficient gains than heifers (33, p.4). However, although heifers gain more slowly in pounds per day, they are gaining more rapidly in proportion to their end weight, i.e. they are finishing more rapidly. Thus, in this study it is assumed that when fed equal lengths of time heifers gain about 7% slower and consume 10% more feed per cwt. of gain (38, p.4). When fed to a similar market grade, e.g. choice for each sex, average daily gain for heifers was assumed to be 4% less. Feed efficiency for heifers is also less, with the greatest difference lying in the net energy required for gain (12, p.11-13). Because of slower gains, however, net energy required for maintenance is also increased.

In this study it was assumed that cattle are in medium rather than fat or thin condition when started. It was further assumed that the cattle fed are of medium scale. University of Wisonsin data has demonstrated that when fed to the same grade, extremely large-type cattle gain approximately 10%-15% faster than extremely small-type cattle. However, there is essentially no difference in feed efficiency of the various body types when fed to equal grade end-points such as low-choice (38, p.4). This means slaughtering small-type cattle at lighter weights than large-type cattle.

The consideration of larger breeds with more genetic growth potential would not have a great effect on the makeup of the feeding activities considered. For example, on a payweight to payweight basis, if medium-type calves were fed from 450-1050 pounds gaining 2.15 pounds a day the feeding period would be 279 days. If large-type calves were fed from 500-1150 pounds, gaining 2.40 pounds per day, the feeding period would be 271 days.

The difference between genetic growth potential of feeder types that should be noted is their relative profitability. As previously indicated, faster gaining, larger-type cattle may not necessarily be more efficient in the feedlot. However, due to fixed costs and the potentially increased gain, the larger-type cattle are expected to be more profitable.

In feeding activities computed on a payweight to payweight basis the rations were based on a paper done by J. Roy Black and Harlan D. Ritchie (6). High moisture corn and corn silage were specified as the ration ingredients. For feeding activities on a gained weight basis the rations were derived from "Basic Feedlot Nutrition" by Dr. Mitchell Geasler (12). With on-farm feeding the concentrate was specified as either corn or sorghum grain and the roughage allowed to be chosen by the program. This procedure was followed since the roughage utilized in the cattle feeding activities may have interaction with that utilized in the beef cow activities.

The required amounts of roughage were determined for the most part on a net energy basis. For this reason net energy expressed in megacalories was used to determine roughage requirements in Tables V-1, 2, 3, and 4. Net energy contents of feedstuffs were taken from "Basic Feedlot Nutrition" (12). Total digestible nutrients (T.D.N.) and and digestible protein (D.P.) were used to specify the feed requirements during the first month of the backgrounding program where the calves were grown on cornstalks.

The protein requirements in Tables V-1 and 2 were derived from a new system proposed by Burroughs and co-workers (12, p.15). Their measurements employ a "metabolizable protein" criterion. With the heavy use of urea this system more accurately designates the protein requirements of a specific ration. The metabolizable protein requirements in Tables V-1 and 2 refer to that needed to supplement the concentrate in the specified ration. Part or all of this requirement may be met by the metabolizable protein in the roughage source. Urea was allowed to replace natural protein when the animal reached 600 pounds. However, protein from natural sources can substitute for urea at any weight level. The metabolizable protein content of various feedstuffs was based on information in Table 27 of "Basic Feedlot Nutrition" (12). A free choice mineral mixture supplement was provided to the cattle as indicated in Tables V-13 and 14.

Labor Requirements

In lots under 200 head scale capacity, labor requirements were computed from data obtained from 59 farmers in southern Minnesota. All feeding was assumed to be done twice a day by hand feeding methods. Labor for feeding

Table V-1. Feed requirements on a gained weight basis for steers fed various rations in a sheltered lot

Feeding Program:	Farm Finish	Custom Finish	Background
Age of feeder	yearling	yearling	calf
% concentrate, ration[a]	1%	1.5%	0.5%
Weight range	765-1100	720-1100	450-765
A.D.G. lb./da.	2.55	2.75	2.10
Total gain lb.	335	380	315
Days on feed	132	138	150
Concentrates: lb. corn 85% D.M.	2132	1847	1257
Roughages:[b] lb. corn silage 35% D.M.		2989	
Hay, corn stover, or straw[c] N.E.g.(megcal)	260		232
Supplement: Metabolizable Protein Natural (grams)			7749
non-natural (g)	12450		
Lb. urea 60% C.P.		105	
T.D.N. (lb.) November			206
D.P. (lb.) November			23

[a]In rations where corn silage is not specified as the roughage source rations may have a higher level of shelled corn than comparable corn-corn silage rations. The energy level, however, is equivalent to a ration composed of the specified percent of animal bodyweight daily in the form of shelled corn plus a full feed of corn silage.

[b]As cornstalk or hay roughage was fed, no additional bedding was assumed necessary over that which was wasted and trampled by cattle.

[c]N.E.g. = Net energy for gain.

Table V-2. Feed requirements on a gained weight basis for heifers fed various rations in a sheltered lot

Feeding program	Farm Finish	Custom Finish	Background
Age of feeder	yearling	yearling	calf
% concentrate, ration[a]	1%	1.5%	0.5%
Weight range	687-950	626-950	425-687
A.D.G. lb./da.	2.50	2.70	1.97
Total gain lb.	263	324	292
Days of feed	105	118	150
Concentrates			
lb. corn 85% D.M.	1773	1596	1282
Roughages[b]			
lb. corn silage 35% D.M.		2645	
Hay, corn stover, or straw[c]			
N.E.g. (megcal)	182		255
Supplement			
Metabolizable protein			
Natural (grams)			8524
Non-natural (g)	8395		13907
Lb. urea 60% C.P.		85	
T.D.N. (lb.) November			225
D.P. (lb.) November			25

[a] In rations where corn silage is not specified as the roughage source, rations may have a higher level of shelled corn than comparable corn-corn silage rations. The energy level, however, is equivalent to a ration composed of the specified percent of animal bodyweight daily in the form of shelled corn plus a full feed of corn silage.

[b] As corn stalk or hay roughage was fed, no additional bedding was assumed necessary over that which was wasted and trampeled by cattle.

[c] N.E.g. = Net energy for gain.

Table V-3. Feed requirements on a payweight to payweight basis for yearling steers fed 1.5% concentrate rations in sheltered and unsheltered lots

Lot	No Shelter	Shelter
% concentrate, ration	1.5%	1.5%
Weight range	750-1107	750-1107
A.D.G. lb./da.	2.10	2.27
Total gain	357	357
Days on feed	170	157
Concentrates		
lb. corn 75% D.M.	2502	2311
Roughages		
lb. silage 35% D.M.	6766	6013
Supplement		
lb. S.B.M. 90% D.M.		
lb. urea 60% C.P.	135	119
Bedding (tons/hd.)		
open, drylot, solid floor confinement	.25	.20

Table V-4. Feed requirements on a payweight basis for steer calves fed all silage and 1% concentrate rations in sheltered and unsheltered lots

Lot	No shelter	Shelter	Shelter
% concentrate, ration	1%	all silage	1%
Weight range	450-1050	450-1050	450-1050
A.D.G. lb./da.	1.80	1.80	2.05
Total gain	600	600	600
Days on feed	333	333	293
Concentrates			
lb. corn 75% D.M.	2451		2156
Roughages			
lb. silage 35% D.M.	10922	14,672	9259
Supplement			
lb. S.B.M. 90% D.M.	86	86	71
lb. urea 60% C.P.	159	159	134
Bedding, (tons/hd.)			
open, drylot, solid floor confinement	.4	.35	.275

roughage and for waste disposal was considered separately. Since average labor per head decreases as the number fed increases, labor requirements were estimated at the mid-point of the 0-200 head scale, i.e. the 100 head scale. A detailed breakdown of labor requirements is given in Table V-5 for hand feeding technologies at the 0-200 head scale. In Table V-6 labor requirements per period for steers and heifers backgrounded on a .5% concentrate ration and finished on a 1% concentrate ration are set forth.

For lots greater than 200 head scale, labor requirements are given for each of four housing systems, two rations, and two types of cattle in Tables V-7, 8, 9, 10, 11, and 12. These labor requirements include time spent for such tasks as feeding, bedding, watering, observation, care and treatment of sick animals, and miscellaneous jobs. The manure loading, hauling, and spreading operation is handled in a separate activity. However, time is allocated for periodic scraping (once every ten days) of the solid waste handling units as may be necessary (36, pp.75-76).

The housing systems considered were open-lot, drylot, solid floor confinement, and cold slat confinement. The values given by Carl Pherson based on a comparison of the stated housing systems at the University of Minnesota's West Central Experiment Station at Morris, Minnesota, served

Table V-5. Labor requirements specified by task[a] for backgrounding calves on a 0.5% concentrate ration and for yearlings fed a 1% concentrate ration in a drylot at 100 head scale[b]

	Average hours per week per head for specified Task		Average hours per week per head for specified Task
Backgrounding labor tasks:		Finishing labor tasks:	
Filling granary[c]	.0021	Filling granary[d]	.0021
Limited fed grain, twice/da.	.0240	Full fed grain, twice/da.	.0521
Watering and observation	.0072	Watering and observation	.0054
Care of sick animals	.0012	Care of sick animals	.0012
Misc. jobs	.0094	Misc. jobs	.0094
Total hours per week per head	.0439	Total hours per week per head	.0723
Care on cornstalk pasture	.0114		

[a]Labor for manure disposal and roughage feeding not included here.

[b]Source: (27, p.5).

[c]Six inch auger moves 1,600 bu./hr.; 75 min. set up time, 8.4 min. filling time, 2 min. misc., 7.5 min. unhitch; thus, takes 25.4 min. every 2 weeks to fill 225 bu. granary.

[d] Load granary once every week taking 25.4 min./wk. and thus .423 hr./wk./100 hd.

Table V-6. Labor requirements[a] per period for steers and heifers fed 0.5% and 1% concentrate rations in drylots at 100 head scale

Ration: Feeding Program: Cattle Type:	0.5% Background Steer or heifer	1% Finish Steer	1% Finish Heifer
Time Period			
January 1-31	.2008		
February 1-28	.1814		
March 1-15	.1035		
March 16-31	.1083		
April 1-15		.1567	.1567
April 16-30		.1567	.1567
May 1-15		.1545	.1545
May 16-31		.1648	.1648
June 1-15		.1437	.1437
June 16-31		.1533	.1533
July 1-31		.2907	.1219
August 1-31		.1030	
September 1-15			
September 16-30			
October 1-15			
October 16-31			
November 1-15	.1004		
November 16-30	.1004		
December 1-31	.2008		

[a]Labor for manure disposal and roughage feeding not included.

Table V-7. Labor requirements per period for steer calves fed 1 percent concentrate rations in open lot and drylot systems for different scale sizes

	Open lot system			Dry lot system		
Scale (midpoint)	300	500	700	300	500	700
Time Period						
January 1-31	.2676	.2371	.2202	.2508	.2193	.2032
February 1-28	.2407	.2142	.1989	.2272	.1982	.1836
March 1-15	.1333	.1170	.1086	.1238	.1087	.1010
March 16-31	.1408	.1248	.1159	.1319	.1158	.1069
April 1-15	.1214	.1065	.0989	.1128	.0989	.0920
April 16-30	.1214	.1065	.0989	.1128	.0989	.0920
May 1-15	.1197	.1050	.0975	.1111	.0975	.0907
May 16-31	.1276	.1120	.1040	.1184	.1040	.0960
June 1-15	.1113	.0977	.0907	.1033	.0907	.0843
June 16-31	.1176	.1042	.0967	.1101	.0968	.0892
July 1-31	.2230	.1984	.1834	.2096	.1693	.1559
August 1-31	.2230	.1984	.1834	.1360	.1100	.1000
September 1-15	.1197	.1050	.0975			
September 16-30	.1116	.0980	.0910			
October 1-15						
October 16-31						
November 1-15	.1308	.1147	.1065	.1214	.1066	.0990
November 16-30	.1197	.1050	.0975	.1111	.0975	.0907
December 1-31	.2676	.2371	.2202	.2508	.2193	.2032

Table V-8. Labor requirements per period for steer calves fed 1 percent concentrate rations in solid floor and cold slat confinement systems for different scale sizes

	Open lot system			Dry lot system		
Scale (midpoint)	300	500	700	300	500	700
January 1-31	.2759	.2412	.2235	.2122	.1855	.1719
February 1-28	.2499	.2180	.2020	.1922	.1677	.1553
March 1-15	.1362	.1196	.1111	.1047	.0920	.0854
March 16-31	.1451	.1274	.1176	.1116	.0980	.0904
April 1-15	.1241	.1088	.1012	.0954	.0837	.0778
April 16-31	.1241	.1088	.1012	.0954	.0837	.0778
May 1-15	.1222	.1072	.1998	.0940	.0825	.0767
May 16-31	.1302	.1144	.1056	.1002	.0880	.0812
June 1-15	.1136	.0998	.0927	.0874	.0767	.0713
June 16-31	.1211	.1065	.0981	.0931	.0819	.0755
July 1-31	.2306	.1862	.1715	.1773	.1432	.1319
August 1-31	.1496	.1210	.1100	.1151	.0931	.0846
September 1-15						
September 16-31						
November 1-15	.1335	.1173	.1089	.1027	.0902	.0838
November 16-31	.1222	.1073	.0997	.0940	.0825	.0767
December 1-31	.2759	.2412	.2235	.2122	.1855	.1719

Table V-9. Labor requirements per period for steer calves fed all silage rations in cold slat confinement systems at different scale sizes

	Cold slat confinement system		
Scale (midpoint)	300	500	700
January 1-31	.2228	.1948	.1805
February 1-28	.2019	.1761	.1631
March 1-15	.1100	.0965	.0898
March 16-31	.1172	.1029	.0950
April 1-15	.1002	.0879	.0817
April 16-31	.1002	.0879	.0817
May 1-15	.0987	.0866	.0805
May 16-31	.1210	.0924	.0853
June 1-15	.0918	.0805	.0749
June 16-31	.0978	.0860	.0793
July 1-31	.1862	.1504	.1385
August 1-31	.1862	.1504	.1385
September 1-15	.0987	.0866	.0805
September 16-30	.0921	.0817	.0752
October 1-15			
October 16-31			
November 1-15	.1275	.0947	.0880
November 16-30	.0987	.0866	.0805
December 1031	.2220	.1948	.1805

Table V-10. Labor requirements per period for steer calves fed all silage rations in dry lot and solid floor confinement systems at different scale sizes

	Dry lot system			Solid floor confinement system		
Scale (midpoint):	300	500	700	300	500	700
January 1-31	.2633	.2303	.2134	.2898	.2533	.2347
February 1-28	.2386	.2081	.1928	.2625	.2289	.2121
March 1-15	.1300	.1141	.1061	.1430	.1255	.1167
March 16-31	.1385	.1216	.1123	.1524	.1338	.1235
April 1-15	.1184	.1039	.0966	.1302	.1143	.1063
April 16-30	.1184	.1039	.0966	.1302	.1143	.1063
May 1-15	.1167	.1024	.0952	.1284	.1126	.1047
May 16-31	.1243	.1092	.1008	.1367	.1201	.1109
June 1-15	.1085	.0952	.0885	.1194	.1047	.0974
June 16-31	.1156	.1016	.0937	.1272	.1118	.1031
July 1-31	.2201	.1778	.1637	.2421	.1956	.1801
August 1-31	.2201	.1778	.1637	.2421	.1956	.1801
September 1-15	.1167	.1024	.0952	.1284	.1126	.1047
September 16-30	.1089	.0966	.0889	.1198	.1063	.0978
October 1-15						
October 16-31						
November 1-15	.1275	.1119	.1040	.1403	.1231	.1144
November 16-30	.1167	.1024	.0952	.1284	.1126	.1047
December 1-31	.2633	.2303	.2134	.2896	.2533	.2347

Table V-11. Labor requirements per period for yearling steers fed 1.5 percent concentrate rations in open lot and dry lot systems of different scale sizes, two lots per year

	Open lot system			Dry lot system		
Scale (midpoint)	300	500	700	300	500	700
January 1-31	.2588	.2293	.2129	.2425	.2121	.1965
February 1-28	.2336	.2070	.1922	.2196	.1916	.1774
March 1-15	.1347	.1182	.1097	.1251	.1098	.1020
March 16-31	.1422	.1261	.1171	.1332	.1169	.1080
April 1-15	.1249	.1096	.1018	.0464	.0407	.0379
April 16-30	.0333	.0294	.0272			
May 1-15	.1325	.1162	.1079	.1230	.1079	.1004
May 16-31	.1413	.1240	.1151	.1311	.1151	.1063
June 1-15	.1231	.1081	.1003	.1143	.1003	.0933
June 16-31	.1301	.1153	.1070	.1218	.1071	.0987
July 1-31	.2018	.1795	.1659	.1897	.1532	.1411
August 1-31	.2469	.2197	.2030	.2321	.1874	.1726
September 1-15	.1282	.1140	.1054	.1205	.0973	.0896
September 16-30	.1282	.1140	.1054	.1205	.0973	.0896
October 1-15	.1094	.0973	.0899	.0241	.0195	.0179
October 16-31	.0085	.0076	.0070			
November 1-15	.1395	.1224	.1136	.1295	.1137	.1056
November 16-30	.1277	.1120	.1040	.1185	.1040	.0968
December 1-31	.2588	.2293	.2129	.2425	.2121	.1965

Table V-12. Labor requirements per period for yearling steers fed 1.5 percent concentrate rations in solid floor and cold slat confinement systems of different scale sizes, two lots per year

	Solid floor confinement			Cold slat confinement		
Scale (midpoint):	300	500	700	300	500	700
January 1-31	.2668	.2332	.2161	.2052	.1794	.1662
February 1-28	.2415	.2107	.1952	.1850	.1621	.1501
March 1-15	.1376	.1208	.1122	.1058	.0929	.0863
March 16-31	.1466	.1287	.1188	.1127	.0990	.0913
April 1-15	.0511	.0482	.0417	.0393	.0344	.0320
April 16-30						
May 1-15	.1353	.1187	.1105	.1041	.0913	.0849
May 16-31	.1442	.1266	.1169	.1109	.0974	.0899
June 1-15	.1257	.1104	.1026	.0967	.0849	.0788
June 16-31	.1339	.1178	.1085	.1030	.0906	.0835
July 1-31	.2086	.1684	.1552	.1604	.1296	.1193
August 1-31	.2553	.2061	.1899	.1963	.1585	.1460
September 1-15	.1325	.1069	.0986	.1019	.0823	.0758
September 16-30	.1325	.1069	.0986	.1019	.0823	.0758
October 1-15	.0265	.0214	.0197	.0203	.0165	.0151
October 16-31						
November 1-15	.1424	.1251	.1161	.1096	.0962	.0894
November 16-30	.1304	.1145	.1064	.1003	.0880	.0818
December 1-31	.2668	.2332	.2161	.2052	.1794	.1662

as the basis for derivation of the labor requirements specified (36). Pherson's study assumed a fenceline feeding system at a scale of 350-700 head for computation purposes. However, whereas Pherson used equal labor requirements for drylot and solid floor confinement systems, this study assumed a 10% greater labor requirement for the solid floor confinement system. This assumption is based on the calculations in R.E. Smith, et al. (40, p.12), and on replies from Experiment Station personnel at the Morris, Minnesota, Experiment Station who "note a 'tendency' for higher labor requirements in the scrape (solid floor confinement) barn" (36, p.77).

A study done at Iowa State University by James Gibbons was used to explicitly adjust the basic labor relations given by Carl Pherson for economies of scale (13). The scale relations represented in Gibbon's fenceline feeding system were chosen for adjustment purposes so as to be congruent with the feeding system used in Pherson's study. The labor requirements given in Gibbon's study did not include time spent for waste disposal and so were congruent with the Pherson study in that respect as well. Because of the greater bulk handled, an additional five percent daily labor was assumed when high silage rations were fed (36, p.77).

The labor requirements were also adjusted for seasonality and feeder type (25, p.114). Ordinarily, regular chore labor during the spring, summer, and fall seasons is not as time consuming as in the winter periods where inclimate weather and snow removal interfere with daily chores. Also, labor requirements for comparable amounts of gain on steer calves is less time consuming than that for yearling steers (10b, p. 16).

Other Variable Expenses

"Other variable expenses" were derived so as to represent those existing in the January 1974 production period. As such, they are expected to be congruent with product prices expressed as a specified multiple of the index of prices paid by farmers for commodities, services, interest, taxes, and wage rates during the January 1974 production period. The rates charged for the various selected expenses are explicitly set forth in Table III-6. In Chapter III a more detailed explanation is given for the procedure relating product prices to production costs. In Tables V-13 and 14 selected variable expenses are set forth.

Transportation from the farm to a custom feedlot was assumed to be 200 miles. Interest for the total feeding period was computed on the basis of rates existing in January of 1974. In those activities where feeding was separated into backgrounding and finishing programs each feeding program was allocated a portion of the total interest cost in relation to the amount of time spent in each activity. Yardage costs for calves finished in custom feedlots was 12¢ per day. In custom feedlots feed prices were marked up 10% although this is not indicated in Table V-13. Vet costs assumed for calves was twice that assumed for yearlings. Vet costs were adjusted to January of 1974 by the index of prices paid by farmers for commodities, services, interest, taxes, and wage rates. Death loss was assumed to be 1% for calves and .5% for yearlings. Costs were based on the January 1974 purchase price. Salt and mineral was costed at $3/cwt. used. Transportation to market was assumed to be 100 miles at the specified January 1974 transportation rate. The transportation rate is based on a liveweight haul of 44,000 pounds. Marketing cost was composed of yardage plus commission fees at a midwest terminal market.

Transportation for feeder calves in Table V-14 was assumed to be 400 miles. All other expenses were computed in a manner similar to those in Table V-13. It should be noted, however, that expenses for yearlings are based on feeding two lots per year.

Table V-13. Selected variable expenses for specified cattle feeding activities at 0-200 head scale of operations (46b, p.22)

Feeding Program	Background		Farm Finish		Custom Finish	
Feeder Type	Steer calf	Heifer calf	Yrling. steer	Yrling. heifer	Yrling. steer	Yrling. heifer
% conc., ration	0.5%	0.5%	1%	1%	1%	1%
Shelter or no:	Shelter	Shelter	Shelter	Shelter	Shelter	Shelter
Selected Expenses						
Interest on purchase price	$10.56	$9.08	$9.29	$6.35	$9.71	$7.13
Transportation to feedlot					3.06	2.75
Yardage					45.60	38.88
Vet medicine	1.70	1.70	.85	.85	.85	.85
Death loss	1.68	1.44	.83	.71	.83	.71
Salt and mineral	.60	.60	.50	.50	.50	.50
Materials handling	1.00	1.00	1.00	1.00	2.10	
Transportation to market			2.10	1.90	3.30	1.90
Marketing expenses			3.30	3.30		3.30
Misc. and indirect costs	2.55	2.55	2.55	2.55	—	—
Total	$18.09	$16.37	$20.42	$17.16	$65.95	$56.02

Table V-14. Selected variable expenses for specified cattle activities at 200-1000 head scale of operations[a]

Feeding program			Finish		
Feeder steer type % conc., ration Shelter or no	calf 1% No shelt.	calf 0% Shelt.	calf 1% Shelt.	yearling 1.5% No shelt.	yearling 1.5% Shelt.
Selected Expenses					
Transportation to feedlot[b]	$4.80	$4.80	$4.80	$4.80	$4.80
Interest on purchase price[c]	23.44	20.62	23.44	35.80	33.70
Vet medicine	2.55	2.55	2.55	2.55	2.55
Death loss	2.50	2.50	2.50	7.50	7.50
Salt and mineral	1.35	1.20	1.35	2.00	1.80
Materials handling	2.00	2.00	2.00	3.00	3.00
Transportation to market	2.10	2.10	2.10	4.60	4.60
Marketing expenses	3.30	3.30	3.30	6.60	6.60
Misc. and indirect costs	5.10	5.10	5.10	5.10	5.10
Total	$47.14	$44.17	$47.14	$76.75	$74.45

[a]Source: (46b, p.22).

[b]Transport 400 mi. allocated to steer and yearling purchasing activities.

[c]$1.15 and $1.71 allocated to steer and yearling purchasing activities to compensate for interest on time spent recovering in shrink.

CHAPTER VI. WASTE DISPOSAL ACTIVITIES

Land disposal of wastes was assumed in this study. Though the oldest method, it is still the most common and could become increasingly important if nitrogen supplies become scarce.

Two methods for disposing of the animal's waste onto the land were analyzed in this study. One utilized liquid waste and the other solid. In the cold slat confinement system, waste was handled in a liquid form. In the open-lot, drylot, and solid floor confinement systems, waste was assumed to be handled primarily in a solid form. Table VI-1 indicates the operating costs and labor requirements for both the solid and liquid waste handling systems. Annual costs for collecting and handling run-off from open-lot and drylot feeding facilities is indicated in Tables V-7 and 8.

Regardless of the method of handling, a soil-plant filter was assumed to provide the means for reducing the potentially harmful nitrates and pathogenic bacteria existing in beef excreta. Different plants may be used as the soil-plant filter. Of the plants considered in this study, corn, soybeans, and sorghum were assumed capable of safely removing 160 pounds of nitrogen per season, alfalfa and tall grasses, 240 pounds, and bluegrass, 60 pounds. With 240 pounds of nitrogen applied to alfalfa and tall grasses, the applications were not allowed to be concentrated at one time because of the nitrate problem which may develop. If application to grasses was concentrated at one time, only one half the nitrogen removal capability was assumed.

Because of their individual characteristics, the relative advantage of specific plants as disposal devices may change. Row crops generally do not adapt as well to this use as do forages. Crops such as corn, soybeans, and grain sorghum require relatively dry conditions for planting. Dry conditions at this time of the year are often scarce and the time necessary to spread manure in the spring often imposes a large opportunity cost to the farmers.

In this model, costing of two resources, labor and land available for disposal, was used to delineate the comparative disposal advantage of forages versus row crops. Separate resource rows were created for row crop and forage waste disposal. The row crop acres available for disposal were increased by the class B land placed in row crops. Forage acres available for disposal included permanent pasture and class B land not placed in row crops.

The time required for each disposal activity was allowed to compete with alternative activities occurring simultaneously. No disposing of wastes was allowed in the winter months (December - March), and all waste accumulated during the winter, spring, and summer periods was required to be hauled by October 30. Disposal of waste accumulated in the fall was allowed which would result in a smaller carry-over into spring periods. Since the pits in the cold slat confinement facilities were designed to hold a 6 month supply of waste produced on a low concentrate ration, this was the maximum allowed to accumulate.

The cost of disposing wastes varies between and within technologies as the scale of operations increases. Depending on the scale of operations, the solid waste handling system was assumed to use either a 2.5 ton, a 5 ton, or an 8 ton spreader. The liquid waste handling system used 1,500 gallon or 3,000 gallon spreaders. Thus, the largest liquid spreader had 8,900 pounds more capacity than the solid spreader. However, because more waste accumulates in the liquid system, the liquid spreaders were assumed to be used more intensively than the solid spreaders.

Investment cost for waste disposal equipment was based on information from extension engineer Vernon Meyers (11, pp.27-29), as indicated in Tables IV-1,2,3, and 4. Labor requirements and operating costs for disposal activities are given in Table VI-1.

Table VI-1. Operating costs and labor requirements for solid and liquid waste disposal activities at three different scale levels[a]

Feedlot Scale	Liquid disposal system		Solid disposal system[b]	
	Hours per load	Operating cost/hour	Hours per load	Operating cost/hour
0-200 head	.333	$3.60	.551	$2.60
200-600 head[c]	.448	$4.75	.596	$4.30
600-1,000 head[d]	.560	$4.75	.666	$4.30

[a] Source: (11, pp.27-29; 31).

[b] Loading time = 2/3 of spreading time, personal communication, Vernon Meyers, Iowa State University Department of Agricultural Engineering, Dec. 1973.

[c] .09 hr./load extra travel time over that required at the 0-200 head scale.

[d] .21 hr./load extra travel time over that required at the 0-200 head scale.

The total amount of removable waste excreted was varied as a function of feeding period, ration, feedlot type, and body weight of the animal. In this study it was assumed that low concentrate rations produced 1.75 times as much manure as high concentrate rations (19, pp. 70-72; 49, p.392; 32, p.49; 39a, pp.615-617. Excrement on low concentrate rations was assumed to be 60 pounds per day at 90% moisture for a 1,000 pound beef animal. For 1,000 pound animals in cold slat confinement facilities on low concentrate rations it was assumed that the pits fill at the rate of one cubic foot per day (8, p.47). In lots exposed to snowmelt and rainfall it was assumed that 25% of the manure is carried off of the lots (8, p.35; 14, p.14).

Quantities of waste produced are given in Tables VI-2 and 3 for various time periods, rations, housing, and feeder types (36, p.81). The removable waste is given on a wet basis, as hauled, including wasted feed and water. The liquid waste handling systems include one half ton of water per head placed in the pit at the beginning of the feeding period to insure proper distribution of wastes. All solid waste was assumed to average 33% dry matter for all systems throughout the year (36, p.82). All liquid waste averages 10% dry matter (36, p.82). Since no consistent pattern of manure buildup has been shown to occur (36, p.

Table VI-2. Estimated pounds of removable wastes per period for calves raised off farm, fed high and low concentrate rations in various housing facilities

Feeding program	Purchased steer calves fed 1 lot per year						
Manure system Housing system Cattle type Concentrate level	solid open lot calves high	solid drylot calves low	solid drylot calves high	solid confine. calves low	solid[a] confine. calves high	liquid[b] confine. calves low	liquid confine. calves high
Dec. 1 - Apr. 15	680	2652	1700	3876	2584	5236	3536
Apr. 16 - 30	75	293	188	428	285	578	390
May 1 - June 15	230	897	575	1311	874	1711	1196
June 16 - 30	75	293	188	428	285	578	390
July 1 - 31	155	605	338	884	589	1194	806
Aug. 1 - 31	155	605	338	884	513	1194	702
Sept. 1 - 15	75	293		428		578	
Sept. 16 - 30	70	273		399		539	
Oct. 1 - Nov. 15	75	293	188	428	285	578	390
Nov. 16 - 30	75	293	188	428	285	578	390
Maximum accumulation	1665	3876	3703	3876	2584	8163	8163
Times spread/yr.	1/yr.	2/yr.	1/yr.	3/yr.	2/yr.	2/yr.	1/yr.

[a]Solid = 33% D.M.

[b]Liquid = 10% D.M.

Table VI-3. Estimated pounds of removable wastes per period for steer calves, heifer calves, and purchased yearling steers fed high and low concentrate rations in various housing facilities

Feeding program	Background	On-farm finish		Purchased yrling. steers 2 lots/yr.			
Manure system Housing system	solid drylot	solid drylot	solid drylot	solid open lot	solid drylot	solid[a] confine.	liquid[b] confine.
Cattle type	calves	steer calves	heifer calves	yrling.	yrling.	yrling.	yrling.
Concentrate level	low	high	high	high	high	high	high
Dec. 1-Apr. 15	1872			816	2032	2794	4318
Apr. 16-30		188	175	24			
May 1-June 15		575	526	276	736	1012	1564
June 16-30		188	175	90	240	330	510
July 1-31		387	152	186	496	682	1054
August 1-31		125		186	496	682	1054
Sept. 1-15				90	240	330	510
Sept. 16-30				90	240	330	510
Oct. 1-Nov. 15	234			192	304	418	646
Nov. 16-30	234			90	240	330	510
Maximum accumulation	2340	1463	1028	2040	2507	2794	9163
Times cleaned/yr.	1/yr.	1/yr.	1/yr.	1/yr.	3/yr.	3/yr.	2/yr.

[a]Solid - 33% D.M.

[b]Liquid - 10% D.M.

82), waste was estimated as an average over the feeding period. Waste production in backgrounding and heifer feeding activities was adjusted lower to compensate for lighter body weights.

Nutrients per ton of waste vary according to time of storage, storage conditions, dry matter content, ration, and amount of bedding used. Tables VI-4 and 5 give estimated equivalent commercial fertilizer nutrient contents of solid and liquid beef wastes for the feeding programs specified. These values are based on studies done in Minnesota and Michigan (36, p.85). Tests conducted at Iowa State University correspond to the estimates for low concentrate rations with 6.6 pounds of nitrogen in a ton of liquid manure and ten pounds of nitrogen in a ton of solid manure on a wet basis (28, p.2). H.R. Peverly, in a thesis done at the University of Illinois, calculated comparable values for calves and yearlings on low concentrate rations, but he did not include the nutrient value of bedding (35, pp.48-55).

Besides the nitrogen, phosphorus, and potassium nutrients valued in the model, it should be noted that farmyard manure can also increase the water holding capacity of spots which tend to dry up faster than the rest of the field (9a, p.1). These considerations, however, were not explicitly valued in the model.

Table VI-4. Estimated equivalent fertilizer nutrient content of beef wastes for steer calves purchased off the farm and fed various rations in different housing facilities

Specification of cattle type, feeding program, ration, and housing facility	Total Pounds		
	N	P	K
Steer calves fed 1 percent concentrate ration in an open lot	12.5	6.7	9.2
Steer calves fed all silage ration in a drylot	35.8	26.0	35.8
Steer calves fed 1 percent concentrate ration in a drylot	27.8	14.8	20.4
Steer calves fed all silage ration in a solid floor confinement feeding facility	52.3	38.0	52.3
Steer calves fed a 1 percent concentrate ration in a solid floor confinement finishing facility	42.8	22.8	31.4
Steer calves fed an all silage ration in a cold slat confinement finishing facility	46.8	29.8	31.2
Steer calves fed a 1 percent concentrate ration in a cold slat confinement finishing facility	46.8	16.8	17.5

Table VI-5. Estimated equivalent fertilizer nutrient content of beef wastes for various rations, cattle types, feeding programs, and housing facilities (liquid waste @10% D.M. and solid waste @ 33% D.M.)

Specification of cattle type, feeding program, ration, and housing facility	Total Pounds		
	N	P	K
Steer and heifer calves raised and backgrounded on farm, fed a .5% concentrate ration in a drylot	12.9	9.4	12.9
Steer calves raised and finished on farm, fed a 1% concentrate ration in a drylot	12.4	6.6	10.8
Heifer calves raised and finished on farm, fed a 1% concentrate ration in a drylot	9.2	4.9	6.8
Yearling steers fed a 1.5% concentrate ration in an open lot with a turnover of two lots per year	15.3	8.2	11.2
Yearling steers fed a 1.5% concentrate ration in a drylot with a turnover of two lots per year	37.7	20.1	27.6
Yearling steers fed a 1.5% concentrate ration in a solid floor confinement finishing unit turning over two lots per year	51.8	27.6	38.0
Yearling steers fed a 1.5% concentrate ration in a cold slat confinement finishing unit turning over two lots per year	64.1	23.0	24.0

CHAPTER VII. PROGRAM RESULTS

The results provided by the programming technique employed in this study indicate the optimal level of production for each alternative activty, the income penalty incurred by employing an activity at a non-optimal level, the utilization of each specified resource, and the shadow price of the last unit of each limiting resource employed.

To focus the analysis on alternative beef production systems, only results directly relating to their evaluation will be explicitly set forth. However, since each alternative beef production system is indirectly related to alternative activities occurring on the farm, a discussion of the optimal total farm plan will be presented.

Situation A

In Situation A existing drylot capacity for two hundred head of steers was assumed available. To bring the facility into operation an investment cost averaging $5.60 per head per year was assumed necessary. No silage capacity was assumed on the farm and at this scale silage activities were not considered.

Under each price structure analyzed, the program results indicated corn to be the major crop produced. The corn crop was planted by the middle of May with a $19.00 per acre income penalty for corn planted after the fifteenth of May. Corn was harvested during the last part of October and during the first part of November. Corn stover was harvested during the last part of November with only a $.50 per acre income penalty for that harvested during the preceeding fifteen day period.

A maximum amount of seasonal labor available was hired from April 1-30 and from October 15-November 15 at $2.26 per hour. No full time hired labor was employed. Shadow prices on labor during April were $2.50 per hour. During late October and early November the timeliness of operations was critical with shadow prices on labor ranging up to $10.61 an hour.

It is within this context that the beef production systems set forth in Tables VII-1 and 2 are to be viewed. The beef cow forage systems were computed through use of a model developed by Craig Dobbins (10a). The backgrounding program described in Chapter V utilized cornstalks during the month of November so as not to conflict with scarce labor during that time period. This causes the extra requirement for cornstalks and supplemental protein during the month of November. As can be seen in Table VII-1, the basic forage system is very stable under the price structures analyzed.

Table VII-1. Optimal beef forage programs under Situation A for three alternative price structures

	Price Structure		
	1	2	3
Returns after all variable costs and fixed land and machinery costs	$66,767.33	$60,230.24	$46,580.10
Beef cows	60	61	64
Acres of forages grown			
Alfalfa hay, 2 cuttings, stockpiled and fall grazed	19	20	22
Alfalfa hay, 3 cuttings, regrowth grazed	17	16	14
Tall fescue hay, 2 cuttings graze aftermath	16	16	18
Birdsfoot Trefoil, grazed spring and fall	23	21	19
Crown Vetch, continuous graze	36	38	39
Oats-harvested as grain	21	21	21
Roughages fed-beef cows			
Fescue hay (T.)	66	66	78
Oat straw (T.)	15	15	15
Corn stover (T.)	23	23	23
Cornstalks (acres)			
Nov. only	179	164	166
Nov., Dec., Jan.	327	350	347
Supplemental protein			
Cwt. (S.B.M.)	29	13	10
Month	Nov.	Nov.	Nov.

Table VII-2. Optimal beef feeding activity levels and income penalties associeted with non-optimal activities under Situation A

	Price Structure					
	1		2		3	
Specific Activity:	Activity Level	Income Penalty	Activity Level	Income Penalty	Activity Level	Income Penalty
Sell steer calves	27			-$10.44		-$10.44
Sell heifer calves		-$10.45		- 3.00		- 1.84
Purchase steer calves		- 10.45	144		142	
Purchase heifer calves	173			-20.69		- 8.11
Background steer calves		- 8.48	172		171	
Background heifer calves	200		28		29	
Custom finish steers						
Custom finish heifers		- 40.47		- 34.22		- 33.88
Farm finish steers			172		171	
Farm finish heifers	200		28		29	
Ration Ingredient						
Dry shelled corn (bu.)	10985		12134		12134	
Alfalfa hay (T.)	102		99		99	
Soybean meal (cwt.)	264		267		267	
Waste Disposal						
April 1-30		- 1.25		- 1.25		- 1.25
June 15-30						- 1.20
November 1-15		- 8.09		- 8.09		- 2.68

The optimal beef production system, however, varies between the specified price structures as can be seen in Table VII-2. Under price structures 2 and 3 purchased steers are more profitable to feed than purchased heifers. Under the first price structure, however, heifers are more profitable to feed than steers. This occurs because of the relatively large price discount for heifer calves. In the case of the first price structure the difference between the gross margin (sales price - purchase price) for steers and the gross margin for heifers is only \$17.25 per head. Under price structure 2 and 3 the difference between the gross margin for steers and the gross margin for heifers is greater than \$17.59 per head. As can be seen from Table VII-2 the income penalty for selling heifer calves and purchasing steer calves for finishing is \$10.45 per head.

Under price structures 2 and 3 the advantage in gross margin for the steers is not enough to offset the cost economies of feeding out heifers raised on the farm. This is due to the additional transportation and marketing costs which would be incurred by selling heifer calves and purchasing steers. As can also be seen in Table VII-2, the income penalty for selling heifers and purchasing steers decreases as the difference in gross margin increases in favor of the steer calves under price structure 3.

Custom finishing steer calves bore little income penalty but was not optimal. It appears as though custom finishing of steers may be profitable. In the specified situation, however, it was more profitable to finish steers on the farm. Because of this, the custom finishing of steer calves did not come into the optimal solution

Custom finishing of yearling heifers did not seem profitable because of the short turnover and because of the relatively high transportation costs and shrink incurred. However, as the beef-corn ratio improves from the first to the third price structure the income penalty for custom finishing heifers becomes relatively less.

Alfalfa hay was chosen over corn stover or straw as the roughage source in the animals' diet. Shelled corn and soybean meal supplement were chosen in the indicated amounts.

Several alternative time periods serve equally well for disposal of wastes at the 0-200 head feedlot scale since the amounts of waste produced are relatively small. Such being the case, only the non-optimal spreading times were indicated with their associated income penalties in Table VII-2.

In Table VII-3, the shadow price of an additional unit of scarce resource is given for Situation A, where there is existing feedlot capacity and silage activities are not considered. Care must be taken in viewing these shadow prices as they apply only to one additional unit of the specified scarce resource. The range over which they hold is not indicated.

Situation B

The second situation studied considers silage activities and construction of new feedlot facilities. Three feedlot scale sizes are considered: 200-400 head, 400-600 head, and 600-1000 head of capacity.

Table VII-3. Shadow price of an additional unit of scarce resource in Situation A

	Price Structure		
Scarce Resource	1	2	3
Land-acre of class A	$199.36	$179.86	$158.93
Land-acre of class B	135.83	151.27	137.04
Land-acre of class C	86.00	94.00	102.51
Silage capacity-ton of dry matter	127.57	142.26	131.61
Feedlot capacity-head	2.14	22.51	43.29
Straw-ton	43.47	47.61	44.14
Fescue hay-ton	45.69	50.03	46.39
Alfalfa hay-ton	56.86	63.55	58.11

As indicated in Table VII-4 both seasonal and full time labor were hired under Situation B. Because of the increased number of livestock in price structure 3 more full time labor was hired than under the other two price structures. Seasonal labor was hired in the spring under all three price structures, with amounts decreasing as the amount of full time labor increased. The labor critical time period in Situation B was during the September corn silage harvesting period rather than later during the shelled corn harvesting period as in Situation A.

Acres of land fall plowed in Situation B were greater than in Situation A. This was primarily due to three factors, each influenced by the cattle feeding activities. First, harvesting of corn silage during September allowed labor requirements to be decreased during the later fall shelled corn harvesting periods. Second, additional full time help was hired and was available to plow the silage ground during October. Third, because larger amounts of silage and stover were harvested, greater use could be made of the labor saving chisel plow rather than the conventional mold-board plow.

Fall plowing is generally viewed as a good management practice by grain farmers. The silage harvesting, stover harvesting, and full time labor employment allowing this to be done stem primarily from the increased level of livestock operations. In this sense the livestock and grain farming activities may be viewed as supplementary.

However, in determining the optimal utilization of class B land, both livestock and cash grain activities are

Table VII-4. Optimal beef forage programs under Situation B for three alternative price structures at the 200-400 head feedlot scale

	Price Structure 1	Price Structure 2	Price Structure 3
Returns after all variable costs and fixed land and machinery costs	$84,773.75	$80,619.99	$68,387.33
Beef cows	104	130	147
Acres of forages grown			
Alfalfa hay, 2 cuttings stockpiled and fall grazed	43	50	50
Birdsfoot Trefoil, continuously grazed	66	59	50
Oats-harvested as grain	16		
Oats-harvested as silage	7	23	23
Sorghum sudan, alternate grazing		18	33
Forages fed-beef cows			
Alfalfa hay (T.)	106	124	124
Oat straw (T.)	12		
Oat silage (T.)	33	135	135
Corn stover (T.)	178	209	243
Corn stalks (acres)			
Nov. only	110	39	
Nov., Dec., Jan.	212	283	290
Corn silage (T.)		14	69
Supplemental protein			
Cwt.	27	34	39
Month	Jan.	Jan.	Jan.
Cwt.	47	60	68
Month	Feb.	Mar.	Mar.
Cwt.	24	30	34
Month	Mar.	Apr.	Apr.
Cwt.	38		
Month	Sept.		
Part time labor (hr./yr.)	381	433	435
Full time labor (hr./mo.)	110	118	128

directly competing. As in Situation A, under the first price structure in Situation B, all class A and B land is placed in corn. As can be seen in Table VII-4, as the beef-corn ratio becomes more favorable to beef in Situation B increasing amounts of sorghum sudan grass enter the rotation on class B land in place of corn.

In Situation B the oat straw is fed to the beef cow herd either as straw bales or as oat silage. It is more valuable in this use than it would be when used for straw bedding.

All the bedding for the cattle feeding activities comes from corn stover rather than straw. One hundred forty tons of stover were used for bedding in the optimal program at the 200-400 head feedlot scale under each price structure. The amount of stover available and the opportunity cost associated with its production were crucial parameters in determining the optimal beef feeding system.

Table VII-5, Part I indicates optimal and non-optimal feeding systems at the upper range of the 200-400 head feedlot scale. Part II of Table VII-5 indicates optimal and non-optimal feeding systems at the lower range of the 400-600 head feedlot scale. In each case, income penalties associated with non-optimal production are indicated.

Table VII-5. Optimal beef feeding systems and income penalties associated with non-optimal systems at the upper range of the 200-400 head feedlot scale and lower range of the 400-600 head feedlot scale under Situation B

Specific activity	Price Structure 1	2	3
Part I: (200-400 hd. scale - upper range)			
Calves fed 1% concentrates in open lot	$67.45	$75.44	$77.01
Calves fed 1% concentrates in drylot	9.27	16.38	19.02
Calves fed 1% concentrates in solid floor confinement	5.10	12.22	14.86
Calves fed 1% concentrates in cold slat confine.	14.49	21.56	23.73
Calves fed all silage in drylot	.56	.56	.56
Calves fed all silage in solid floor confine.	- optimal system -		
Calves fed all silage in cold slat confine.	9.60	9.55	8.95
Yearlings fed 1.5% concentrates in open lot	42.86	43.18	42.45
Yearlings fed 1.5% concentrates in drylot	4.49	4.49	4.49
Yearlings fed 1.5% concentrates in cold slat confine.	6.66	6.60	5.92
Yearlings fed 1.5% concentrates in solid floor confine.	1.05	1.05	1.05
Part II: (400-600 hd. scale - lower range)			
Calves fed 1% concentrates in open lot	67.67	75.67	77.24
Calves fed 1% concentrates in drylot	10.34	17.45	20.09
Calves fed 1% concentrates in solid floor confine.	6.45	13.56	16.20
Calves fed 1% concentrates in cold slat confine.	14.83	21.90	24.07
Calves fed all silage in drylot	.29	.29	.29
Calves fed all silage in solid floor confine.	- optimal system -		
Calves fed all silage in cold slat confine.	8.83	8.78	8.18
Yearlings fed 1.5% concentrates in open lot	43.04	43.36	42.63
Yearlings fed 1.5% concentrates in solid floor conf.	.37	.37	.37
Yearlings fed 1.5% concentrates in cold slat confine.	5.40	5.34	4.66

Because a range analysis was not undertaken, the range over which these income penalties will hold is not known. However, the income penalties in Part II of Table VII-5 would tend to suggest that in the specified situation, when fed all silage rations, less labor intensive systems such as drylot and cold slat confinement become more competitive as feedlot scale increases above 400 head. It also appears that as feedlot scale increases over 400 head and cattle feeding becomes a larger part of the farm business, the feeding of yearlings incurs a lower income penalty. Also, as the beef-corn ratio increases, making cattle feeding more profitable, the larger amount of beef marketed in a yearling system lowers its income penalty.

In the specified situation where corn stover was utilized for bedding, the drylot system was a close competitor of the solid floor confinement system. However, it should be recalled that added costs for control of pollution may be necessary in the drylot system. If annual costs per head capacity exceed $10.00, it would appear that cold slat confinement would be a better alternative than the drylot facility. An estimate of costs necessary for control of pollution has been presented in Chapter IV. It does not seem likely that annual costs for pollution control in drylot systems would reach $10.00 per head of feedlot capacity.

As was previously mentioned the cost of bedding is a crucial factor in determining the optimal feeding system. Table VII-6 indicates the value of this and other scarce resources. In Part I of Table VII-6 the amount of bedding obtained from harvested corn stover is limited only by, one, the opportunity cost of the corn stover to the farmer and, two, the cost of harvesting them. In Part II of Table VII-6 the amount of harvested corn stover available is effectively limited to that amount of land which cannot be fall plowed. Since in this case the only alternative source of bedding is straw, both cattle feeding and beef cow activities must compete for its use.

As can be seen in Part II of Table VII-6, when harvested corn stover is limited, the shadow price of bedding rises. This is turn affects the optimal feeding system chosen. Cold slat confinement now becomes the optimal housing system. Steer calves fed an all corn silage ration are still the optimal feeder type and ration. Returns to feedlot capacity drop however as indicated in Table VII-6.

Under all but the first price structure the oats grown was fed as silage to the beef cows. Under the first price structure in part II of Table VII-6, however, part of the oats was harvested as grain with the straw being baled and used as bedding in the solid floor confinement feeding facility.

Table VII-6. Return from the last unit of specified scarce resource under three alternative price structures when corn stover for bedding is limited and when it is not

Specified scarce resource	Price Structure 1	2	3
Part I: (corn stover for bedding not limited)			
Land - acre of class A	$205.78	$186.56	$163.00
Land - acre of class B	133.95	139.54	130.50
Land - acre of class C	119.48	130.73	122.76
Corn silage (T.)	18.97	18.05	16.95
Hay (T.)	41.52	40.87	38.37
Straw (T.)	33.42	32.89	30.86
Bedding (T.)	4.74	4.88	6.58
Feedlot Capacity (hd.): 200-400 hd. scale	10.66	25.95	34.27
Part II: (limited corn stover for bedding)			
Land - acre of class A	$205.81	$186.51	$159.21
Land - acre of class B	127.19	129.08	122.97
Land - acre of class C	100.76	113.01	115.40
Corn silage (T.)	19.10	18.29	17.01
Hay (T.)	42.17	41.67	38.78
Straw (T.)	34.40	34.17	34.17
Bedding (T.)	34.40	34.17	34.17
Feedlot capacity (hd.): 200-400 hd. scale	not limiting	14.67	24.83
Feedlot capacity (hd.): 400-600 hd. scale	6.29	19.94	30.11
Feedlot capacity (hd.): 600-1,000 hd. scale	7.30	21.23	31.40

The number of beef cows in the solutions where stover was limited decreases because of the lack of cheap roughage during the late winter months. Due to this the total amount of silage and hay fed also decreases. Thus, as would be expected the marginal value product for both increases. The shadow price of land is generally lower in Part II of Table VII-6 as would be expected since the added returns from harvesting corn stover are not included.

Table VII-7 indicates optimal beef feeding systems and income penalties associated with non-optimal systems at the upper range of the 400-600 head scale and the lower range of the 600-1,000 head feedlot scale under the second price structure.

Again, since adequate cornstalk bedding is available at a relatively low cost ($5.09/T.), the solid floor confinement system is optimal. At the upper range of the 400-600 head scale an all silage ration is optimal. However, as scale increases the income penalty associated with higher concentrate rations decreases. At the lower range of the 600-1,000 head scale the feeding of calves in the solid floor confinement system on a 1% concentrate ration becomes optimal.

At this scale labor costs during the September silage harvesting period have become restrictive. Thus, to reduce labor requirements calves are finished out earlier on the

Table VII-7. Optimal beef feeding systems and income penalties associated with non-optimal systems at the upper range of the 400-600 head feedlot scale and lower range of the 600-1,000 head feedlot scale under price structure #2

Specific Activity	Income Penalty
Part I (400-600 hd. scale-upper range)	
Calves fed 1% concentrates in open lot	$59.24
Calves fed 1% concentrates in drylot	4.95
Calves fed 1% concentrates in solid floor confinement	.94
Calves fed 1% concentrates in cold slat confinement	9.33
Calves fed all silage in drylot	1.35
Calves fed all silage in solid floor confinement	-optimal system-
Calves fed all silage in cold slat confinement	8.53
Yearlings fed 1.5% concentrates in open lot	40.79
Yearlings fed 1.5% concentrates in drylot	2.72
Yearlings fed 1.5% concentrates in solid floor confine.	-alternative-
Yearlings fed 1.5% concentrates in cold slat confine.	3.88
Part II (600-1,000 hd. scale-lower range)	
Calves fed 1% concentrates in open lot	$52.33
Calves fed 1% concentrates in drylot	3.45
Calves fed 1% concentrates in soli floor confinement	-optimal system-
Calves fed 1% concentrates in cold slat confinement	7.92
Calves fed all silage in drylot	7.93
Calves fed all silage in solid floor confinement	6.34
Calves fed all silage in cold slat confinement	15.04
Yearlings fed 1.5% concentrates in open lot	46.52
Yearlings fed 1.5% concentrates in drylot	9.34
Yearlings fed 1.5% concentrates in solid floor confine.	6.34
Yearlings fed 1.5% concentrates in cold slat confine.	10.33

higher concentrate ration, and the amount of corn silage necessary in the ration decreases. Because yearlings must be fed through the September period the income penalty associated with their feeding becomes more restrictive at the 600-1,000 head scale.

It should be recalled that it is difficult for the linear programming technique to deal with economies of scale. Economies of scale in silage handling not built into the model may occur, extending the scale to which all silage rations are optimal. It should also be noted that as feedlot capacity has increased from the 200-400 head to the 600-1,000 head scale, the relative income penalty for feeding similar feeder types in cold slat confinement rather than in solid floor confinement has generally decreased. At the upper range of the 400-600 head scale the the income penalty for feeding yearling steers in cold slat confinement is only $3.88 per head of capacity. Since each unit of feedlot capacity turns over two head per year, each unit requires .4 of a ton of bedding per year. A $10 increase in the cost of bedding to $15.09 per ton would offset the $3.88 income penalty incurred by the cold slat yearling system presented in Table VII-7, Part I. In Part II of Table VII-7, if bedding were to increase in price to $30.00 per ton, the feeding of calves on a 1% concentrate ration in cold slat finement could well become the optimal system. The actual outcome would depend on labor utilization and other factors.

Another factor influencing the choice between solid floor and cold slat confinement feeding systems is the relative advantage of liquid versus solid waste disposal. Table VII-8 indicates optimal disposal periods and the income penalty associated with disposal during non-optimal periods for the solid floor confinement system, under the second price structure, at the 400 and 600 head feedlot size. As can be seen large amounts of waste were disposed of on pasture during the summer periods. Income penalties for disposal during periods when labor was scarce are indicated. If the pasture acres were not available for disposal, the optimal feeding system could well change. In a recent doctoral dissertation done at the University of Minnesota (36) feeding systems similar to those analyzed here were compared when disposal during summer periods was limited to idle set-aside acreages. The Minnesota study considered only class A land, only one scale (500 hd.), and did not consider the use of corn stover for bedding. Under these conditions the cold slat confinement system was optimal.

Table VII-8. Optimal disposal times and income penalty associated with disposal during non-optimal periods at the 400 and 600 head feedlot scale under the second price structure

Disposal period and location	200-400 Hd. Scale		400-600 Hd. Scale	
	Loads Hauled	Income Penalty	Loads Hauled	Income Penalty
April 1-15, row crop	alternate		alternate	
April 16-30, row crop		$ .34	alternate	
April 1-15, pasture	150		177	
April 16-30, pasture		.34	16	
June 1-15, pasture	18		49	
June 16-30, pasture		.18	16	
July 1-31, pasture	108		33	
August 1-31, pasture	31		29	
September 1-15, pasture		19.29		$26.47
September 16-31, pasture		19.63		26.47
October 1-15, pasture	22		33	
October 16-31, pasture	16		24	
November 1-15, pasture	17			1.39
November 16-30, pasture	alternate		alternate	
November 1-15, row crop	alternate			1.39
November 16-30, row crop	17		alternate	

CHAPTER VIII. CONCLUSIONS

This study utilized a mathematical technique termed linear programming to analyze alternative beef feeding systems available to the Iowa farmer-feeder. The analysis was conducted under two farm situations (designated A and B) and under three alternative price structures. Both Situation A and B had a similar land base. A specified amount of seasonal labor was available. Full time labor was also available for hire with the computer program choosing the optimal amount. In each situation cash grain, beef cows, and cattle feeding were the predominant enterprises existing on the farm.

The first situation assumed existing drylot facilities available for feeding two hundred head of beef cattle. These facilities, however, required a start-up cost of $8,000 to bring them into operating condition. Backgrounding, custom finishing, and farm finishing of both steers and heifers were compared. No silage activities were considered in this specified farm situation.

Under Situation B silage activities and construction of four types of new beef feedlot facilities were considered. The alternative feedlot types were : 1) open lot, 2) drylot, 3) solid floor confinement, and 4) cold slat confinement. Within each feedlot type, feeding programs for both calves and yearlings were compared. The calves were fed either all silage or 1% concentrate rations with a specified turnover of one lot per year. The yearlings were fed 1.5% concentrate rations with a specified turnover rate of two lots per year.

Results from analysis of Situation A indicate a fairly stable forage system between the various price structures viewed. The optimal feeding program changed from feeding heifers to feeding steers under different price structures. This would indicate the need to closely evaluate the feeding program chosen each year. The linear programming technique utilized in this study provides a means by which this analysis could be conducted in the context of the total farm plan.

Program results set forth in Table VII-3 indicate that under two of the three price structures viewed, investment in renovation of existing facilities would provide relatively high returns. However, under the first price structure it seems that investment in farmland may be a better alternative.

Under the first price structure, returns to labor and management from an additional unit of feedlot capacity were slightly over 5%. Under the same price structure, with annual fixed machinery costs of $24.49 per acre subtracted, at a

5% return to labor and management, and paying 9% annual interest on the capital invested, class A land would be worth $1249 per acre. With land appreciating in value at over 5% a year and with the risks involved in cattle feeding, comparative returns from investment in the renovation of cattle feeding facilities do not appear good. If, however, as demonstrated under the second and third price structures, the beef-corn ratio should return to previous or higher levels, profits from cattle feeding compare very favorably to that of land priced at current levels.

The returns from construction of new facilities are viewed in Situation B. The rate of return to labor and management from investment in the optimal solid floor confinement feeding system under the first price structure at the 200-400 head scale was 11%. This rate increased to 37% under the third price structure.

When corn stover for bedding was limited, the cold slat confinement system became optimal. Because of higher investment costs however, its rate of return to labor and management was lower than for the solid floor confinement system. Under the first price structure, at the 200-400 head feedlot scale, with stover limited, feedlot capacity was not a limiting resource. Under the second and third price structures, rate of return to labor and management from investment in the cold slat system ranged from 7% to 13%. Considering the risks involved in cattle feeding, this seems relatively low.

In general, this study found the housing systems analyzed to rank in order of profitability when the use of corn stover for bedding was not limited as follows: 1) solid floor confinement, 2) drylot, 3) cold slat confinement, and 4) open lot. When corn stover bedding was limited, however, the cold slat confinement system became optimal. A recent doctoral dissertation at the University of Minnesota (36) found the systems compared in this study to rank in order of profitability: 1) cold slat confinement, 2) drylot, 3) solid floor confinement, and 4) open lot. The labor requirements and values for waste nutrients used in this study were based largely on data from the University of Minnesota and so are very similar between the two studies. By viewing several other differences between the two studies, however, the comparative advantage of the various systems under different situations may be better understood.

In both studies the open lot system compared rather poorly to the others. This was primarily due to the decrease in animal performance assumed.

The difference in rank between the drylot and solid floor confinement systems in the two studies may be attributed to several factors. In this study drylot feeding facilities were assumed to cost \$4 more per head of capacity than the solid floor confinement system. In the Minnesota study drylot facilities were assumed to cost \$13 less per head of capacity than the solid floor confinement system. This variance between the two studies can be largely attributed to the higher land, fencing, and feedbunk costs assumed in this study. For example, this study charged fencing at \$2 per foot, land at \$870 per acre, and required 18 inches of feedbunk space per animal in the drylot. The Minnesota study charged fencing at \$1.30 per foot, land at \$367 per acre, and required only one foot of feedbunk space per animal in the drylot. In a recent evaluation of Iowa cattle feeding systems done at Iowa State University a similar comparison showed the drylot to cost \$15.32 more per head of capacity than a solid floor confinement system (11).

In this study, labor requirements for the solid floor confinement facility were increased relative to those of the drylot. The Minnesota study used equal labor requirements between systems. In the Minnesota study, however, all labor for hauling of wastes was required either in spring or fall periods. No class B or C land was available for the summer spreading of wastes. This assumption is one of the basic differences in the two studies.

Although perhaps unrealistic, it should be stressed that in some cases little land may be available for disposal of wastes during the summer. Also, because the machinery component may not be of the type capable of completing the tillage and harvesting operations in a timely manner, high shadow prices on labor may occur during spring and fall periods. If the bulk of the waste from feeding systems must also be hauled during spring and fall periods then either systems with less waste to be hauled, e.g. drylot, or systems where waste may be handled more rapidly, e.g. cold slat confinement, may well be optimal.

Other differences worthy of note between this and the Minnesota study were that the Minnesota study was conducted only at the 500 head scale. Lower interest rates on capital were used, and nitrogen was valued at only $.06 per pound. In this study higher inflation expectations were assumed to cause higher interest rates and nitrogen fertilizer was valued at $.18 per pound.

In the Minnesota study the stated reasons that the cold slat confinement system was optimal were the following: 1) a greater number of cattle can be fed due to the fast turnover rate, 2) no bedding is purchased for the slatted floor facility, 3) earlier timing of crop planting and harvesting can be achieved due to rapid waste handling (36, p.117).

The first reason given applies only to comparisons with the open lot since drylot and solid floor confinement provide equally rapid turnover. As previously discussed, the advantage due to earlier timing of crop planting and harvesting depends to a relatively large degree on the availability of class B and C land for summer spreading of wastes.

Since full time labor is assumed to be available at a cost of $3.75 per hour, the extra labor requirements of the solid floor confinement facility do not present a problem in this study. The added labor costs are offset by increased savings and added returns in other areas.

The problem of obtaining low cost bedding seems to be the parameter of crucial importance. As indicated in this study the returns from the use of straw for bedding cannot compete with the returns available from straw in alternative uses. Thus, straw is a relatively high cost source of bedding. This study allowed the use of corn stover for bedding. This source of bedding was not considered in the Minnesota study. As indicated in Chapter VII, when the opportunity of using corn stover for bedding was considered, the program results changed dramatically, increasing returns to feedlot capacity by over $10.00 per head and changing the optimal system from cold slat to solid floor confinement.

The potential value of corn stover and the problems associated with its use have been realized for some time. The following quotation by Zintheo in 1907 (4b, p.8) could well apply today.

> Machinery for the care of the corn crop has been much more difficult to develop than any other line of farm implements. Although there has been considerable progress in methods of harvesting corn, the larger part of the crop is still husked by hand from the standing plant, only the ears being gathered, while the leaves and stalks are almost a total loss.

In recent years research has provided new, more efficient methods of handling corn stover. However, many problems with its use still persist.

Due to the large bulk which must be handled in stover systems, high costs per ton may be incurred. As feedlot scale increases, the tonnage of bedding needed increases. The distance which stover stacks must be hauled also increases. Because of the linearity assumptions inherent in the use of the linear programming technique, it should be recognized that increased stover costs due to longer hauls were not included in the model.

The program results show decreasing income penalties for cold slat confinement at larger feedlot scales. This coupled with the increased hauling costs for bedding previously noted, indicates an increasing relative profitability for cold slat confinement systems at larger scales.

In comparing the relative advantage of cold slat confinement systems, such aesthetic values as working environment must also be considered. Some cattle feeders may prefer the working conditions in cold slat confinement over that existing in other facilities.

In comparing cold slat confinement with other feeding systems it should be noted that an investment credit tax advantage may accrue to owners of cold slat confinement systems. In this study, however, it was assumed that the additional risk of a more inflexible investment would offset this advantage. Tax credit for pollution control facilities on open and drylot systems was not considered for similar reasons. To the taxpayer with a large risk capacity, however, this tax advantage may be an important consideration.

As pointed out in the first chapter, because of the relatively great productive efficiencies attained, concern for the agricultural industry is being turned from compelling economic factors to sociological and ecological considerations. In comparison with open and drylot systems, both cold slat and solid floor confinement systems minimize runoff pollution potential. In the same vein, both are relatively good in the conservation of nitrogen. The basic difference between the two production systems is that one is capital intensive while the other is labor intensive.

Sociological implications of capital and labor intensive production systems previously recognized, will not be reiterated here. Based on an economic evaluation of the specified beef feeding systems one can conclude given the assumptions in this study, that the relatively labor intensive feeding system, solid floor confinement, can be profitably integrated into an Iowa farm firm. This is especially so at the lower feedlot scales which are predominant in Iowa. Under these conditions the economical all silage ration seems to fit well into the cattle feeding program.

One of Iowa's most valuable beef production resources is its relatively large number of farmers who have some cattle feeding expertise. Another is the vast amount of corn stover presently plowed under the soil which could be used for feed or bedding. Yet another is a relatively economical feed source, corn silage.

In the recommendation of further research it is the belief of this author that such resources must not be overlooked. At the same time, conservation of available nitrogen resources must be emphasized.

With the trend toward decreasing costs of capital relative to labor, an open eye must be given to capital intensive beef production systems. However, their development and their use must not be overemphasized. In development of beef feeding technologies for use by the Iowa farmer it may be more appropriate in many situations to promote less capital intensive beef feeding systems capable of being integrated into a farm firm. Further research on the problems involved with the efficient harvesting and handling of corn stover would seem to be an appropriate step in the development of such systems.

BIBLIOGRAPHY

1. "Agronomic Feasibility of Finishing Cattle in the Four Corners Economic Development Region." New Mexico Agricultural Experiment Station Report 263, October 1973.

2. "All Farms May Have to Apply." Pro Farmer 2 (January 5, 1974): 1.

3. "Argue Reins on Corporate Iowa Farms." Des Moines Register, February 13, 1974.

4a. Atkinson, J.H. "Land Prices--How Much Higher." Journal of American Society of Farm Managers and Rural Appraisers, Inc. 38 (Denver, Colorado, April 1974): 1.

4b. Ayres, George E. "An Evaluation of Machinery Systems for Harvesting the Total Corn Plant." Ph.D. Thesis, Iowa State University, Ames, Iowa, 1973.

5. Ball, Gordon A.; and Heady, Earl O. Size, Structure and Future of Farms. Ames Iowa: Iowa State Press, 1972.

6. Black, J. Roy; and Ritchie, Harlan D. "Average Daily Gain and Daily Dry Matter Intake of Various Kinds of Cattle Fed Three Different Rations Under Several Environmental Situations." Michigan Agricultural Economics Department Staff Paper 1973-1, January 1973.

7. Brunthaven, Carroll G. As quoted in Top Farmer's Intelligence 8 (February 8, 1974): 2.

8. Butchbaker, A.F.; Garton, J.E.; Mahoney, W.A.; and Paine, M.D. "Evaluation of Beef Cattle Feedlot Waste Management Alternatives." Oklahoma Agricultural Experiment Station, November 1971.

9a. "Cattle Feeding Research." Iowa State University Cooperative Extension Service AS-388, July 1973.

9b. "Crop Clues." University of Nebraska Research Reports 5 (September 1973): 6.

10a. Dobbins, Craig Lee. "A Model for Programming Forage Supplies." M.S. Thesis, Iowa State University, Ames, Iowa, 1974.

10b. Erickson, Duane E. "Economic Comparison of Confinement, Conventional Drylot, and Open Lot Beef Feeding Systems." Illinois Cooperative Extension Service AE-4250, August 1970.

11. "Evaluation of Iowa Beef Cattle Systems." Iowa State University Extension Publication EC-900A, November 1973.

12. Geasler, Mitchell. "Basic Feedlot Nutrition." Iowa State University Cooperative Extension Service Pm-555, February 1973.

13. Gibbons, James R. "Cost Economies in Cattle Feeding and Combinations for Maximization of Profit and Stability." Ph.D. Thesis, Iowa State University, Ames, Iowa, 1967.

14. Gilberton, C.B.; McCalla, T.M.; Ellis, J.R.; Cross, O.E.; and Woods, W.R. "The Effect of Animal Density and Surface Slope on Characteristics of Runoff, Solid Wastes, and Nitrate Movement on Unpaved Beef Feedlots." University of Nebraska Technical Bulletin SB-508, June 1970.

15. Grimes, Glen. University of Missouri Livestock Marketing Specialist. As quoted in Pro Farmer 2 (February 1974): 6.

16. Gruber, Josef; and Heady, Earl O. "Econometric Analysis of the Cattle Cycle in the United States." Iowa State University Research Bulletin 564, July 1968.

17. Heady, Earl O. "Allocations of Colleges and Economists." American Journal of Agricultural Economics 54 (1972): 5.

18. Heady, Earl O. Economics of Agricultural Production. Englewood Cliffs, N.J.: Prentice-Hall, May 1965.

19. Hegg, R.O.; and Larson, R.E. "The Waste Pattern of Beef Cattle on Slatted Floors." Livestock Waste Management and Pollution Abatement, St. Joseph, Michigan, American Society of Agricultural Engineers, April 1971.

20. Henderson, Hugh E.; and Geasler, Mitchell. "Effect of Environment and Housing on the Performance of Feedlot

Cattle Under Midwest Conditions." Michigan State University Research Paper AH-BC-48, 1969.

21. Hieronymus, Thomas. Economics of Futures Trading. New York, N.Y.: Commodity Research Bureau, Inc., 1971.

22. Hightower, James. "Hard Tomatoes, Hard Times: The Failure of the Land Grant College Complex." Washington D.C.: Agribusiness Accountability Project, 1972.

23. "Housing Systems and Concentrate Levels for Feedlot Cattle Under Midwest Conditions." Michigan State University Research Report Number 108, 1970.

24. Iowa Development Commission. Statistical Profile of Iowa. Des Moines, Iowa: Iowa Development Commission, 1972.

25. James, Sydney C. "Midwest Farm Planning Manual." Ames, Iowa: Iowa State Press, 1972.

26. James, Sydney C. "Risk and Uncertainty Considerations in Cattle Feeding." Unpublished staff paper, Iowa State University, Ames, Iowa, May 1973.

27. Johnson, R.G.; and Nodlund, T.R. "Labor Used in Cattle Feeding." Minnesota Agricultural Experimental Station Bulletin 451, March 1960.

28. "Land Disposal of Beef and Swine Wastes." Iowa Cooperative Extension Service Pm-552 (REV.), August 1972.

29. "Land of Plenty." Wall Street Journal November 19, 1973.

30a. "Meat Market Turnaround." Wall Street Journal March 22, 1974.

30b. Melvin, Stuart E. Unpublished research. Iowa State University, Ames, Iowa, July 1974.

31a. Michigan State Beef Feedlot Program, Michigan State University, East Lansing Michigan, December 1973.

31b. Miner, Ronald J. "Farm Animal Waste Management." North Central Regional Publication 206, May 1971.

32a. Neuman, A.L.; and Snapp, R.R. Beef Cattle New York: John Wiley and Sons, Inc., 1960.

32b. "Minnesota Cattle Feeders Report." Saint Paul, Minnesota: University of Minnesota Agricultural Extension Service, 1972.

33. Newland, H.W. "Effect of Age, Sex, and Grade in Fattening Cattle." Michigan State University Cooperative Extension Service AH-BC-7, January 1965.

34. Petritz, David C. "Economic Implications of the Effects of Climatic Stress on Shelter Alternatives for Finishing Cattle." Ph.D. Thesis, University of Illinois, Champaign, Illinois, 1972.

35. Peverly, H.R. "An Economic Analysis of Alternative Cattle Feeding Systems." M.S. Thesis, University of Illinois, Champaign, Illinois, 1967.

36. Pherson, Carl L. "Economics of Alternative Waste Management Systems Complying With Pollution Control Regulations on Beef Feedlots in Southwestern Minnesota." Ph.D. Thesis, University of Minnesota, Saint Paul, Minnesota, 1974.

37a. Rahn, Allan P. "Seasonal Price Patterns." Iowa State University Special Report #59, 1968.

37b. "Review of Development Document for Effluent Limitations, Guidelines and Standards of Performance in Feedlot Industry." College of Agriculture, Iowa State University, Ames, Iowa, July 1973.

38. Ritchie, H.D. "Average Daily Gain and Dry Matter Intake of Various Kinds of Cattle Fed Three Different Rations Under Several Environmental Situations." Michigan State University Cooperative Extension Service AH-BC-81, July 1973 (Rev.).

39a. Schulz, A.H. "Basic Requirements for Beef Cattle Housing, Feeding, and Handling." Agricultural Engineering 41 (September 1960) 615-617.

39b. "Silage Production and Use." Iowa State University Cooperative Extension Service Pm-417 (Rev.), December 1972.

40. Smith, R.E.; Hanke, H.E.; Lindor, L.K.; Goodrich, R.D.; Meiske, J.C.; Thonney, M.; Crawford, D.; Hasbargen, P.R.; Bates, D.W.; and Ryan, D.M. "A Comparison of Five Housing Systems for Feedlot Cattle." 1972 Minnesota Cattle Feeders Report, Department of Animal Science, University of Minnesota, Saint Paul, Minnesota, 1972.

41. U.S. Department of Agriculture. Crop Reporting Board. Statistical Reporting Services. "Annual Price Summary." Washington D.C.: Government Printing Service, June 1973.

42a. U.S. Department of Agriculture. "A.S.C.S., Commodity Fact Sheet." Washington D.C.: Government Printing Service, 1973.

42b. U.S. Department of Agriculture. Statistical Research Service. "Cattle." Washington D.C.: Government Printing Service, Annual Reports, 1958-1973.

43a. U.S. Department of Agriculture. Statistical Research Service. "Cattle on Feed." Washington D.C.: Government Printing Service, Annual Issues, 1968-1973.

43b. U.S. Department of Agriculture. Economic Research Service. "Feed Situation." Washington D.C.: Government Printing Service, 1974.

44. U.S. Department of Agriculture. Economic Research Service. "Feed Statistics, Supplement for 1971." Washington D.C.: Government Printing Service, June 1972.

45. U.S. Department of Agriculture. Grain Division, Agricultural Marketing Service. "Grain Market News." Government Printing Office, February 5, 1974.

46a. U.S. Department of Agriculture. Economic Research Service. <u>Marketing and Transportation Situation</u>. Washington D.C.: Government Printing Office, November 1973.

46b. U.S. Department of Agriculture. Economic Research Service. "Livestock and Meat Situation." Washington D.C.: Government Printing Office, February 1974.

47. U.S. Department of Agriculture. Economic Research Service. "Livestock and Meat Statistics." Washington D.C.: Government Printing Office, 1972.

48a. U.S. Department of Agriculture. Livestock Division, Agricultural Marketing Service. "Livestock Meat Wool Market News." Washington D.C.: Government Printing Office, February 5, 1974.

48b. U.S. Department of Agriculture. Economic Research Service. National Food Situation. Washington D.C.: Government Printing Office, November 1973.

49a. U.S. Department of Agriculture. Statistical Reporting Service. "Number of Feedlots by Size Groups and Number of Fed Cattle Marketed." Washington D.C.: Government Printing Office, July 1968.

49b. Wells, D.M.; Meenaghan, G.F.; Albin, R.C.; Coleman, E.A.; and Grub, W. "Characteristics of Wastes from Southwest Beef Cattle Feedlots." Washington D.C.: Graphics Management Corporation, Waste Management Research, 1972.

APPENDIX

Section I. General information concerning land base of farm

A. Composition of land base

1. Class A	600/A
2. Class B	100/A
3. Class C	65/A

B. Estimated cash rent

1. Class A	$70/A
2. Class B	$50/A
3. Class C	$30/A

C. Cultural practices

1. Acres that can be continuously row cropped (Class A)	600/A
2. Maximum Class A acres that can be placed in soybeans each year	300/A
3. Acres that must be placed in a rotation (Class B)	100/A
4. Maximum acres of Class B that can be placed in row crops	33/A
5. Maximum acres of Class B that can be placed in soybeans each year	11/A
6. Acres that must be kept in improved permanent pasture (Class C)	65/A

Section II. Annual crop yield expectations--(expected yields for normal weather conditions)

Yields represent the average of owned and rented land for each land class. It is assumed that yields of oat grain, oat hay, oat silage, and straw will be the same in Class A and Class B land.

	Class A	Class B	Class C
Corn grain	130 bu/A	110 bu/A	
Corn silage	21.60 ton/A	17 ton/A	
Soybeans	40 bu/A	35 bu/A	
Grain sorghum	130 bu/A	110 bu/A	
Oats			55 bu/A
Oats silage			5.60 ton/A
Oat hay		1.03 ton/A	0.93 ton/A
Straw		0.80 ton/A	0.60 ton/A
Forage sorghum silage	15 ton/A	13.50 ton/A	

Section III. Crop residues and supplemental pasture yields

The crop residues and supplemental pastures in the model are listed below:

The yields given are in terms of total available dry matter. Those yields enclosed in parentheses, ( ), approximate field moisture yields.

Crop and Management	Class	Total Dry Matter Available Ton/Acre
1. Corn stover, continuous graze	A	2.60 (4.00)
2. Cornstalks, flail chop-ensile	A	2.60 (4.33)
3. Cornstalks, Stakhand harvest	A	3.60 (3.96)
4. Corn stover, continuous graze	B	2.40 (3.96)
5. Corn stover, flail chop-ensile	B	2.40 (4.00)
6. Corn stover, Stakhand harvest	B	2.40 (3.65)
7. Forage sorghum, stockpile fall	A	6.75 (17.22)
8. Forage sorghum, stockpile fall	B	6.07 (15.04)
9. Forage sorghum, silage-graze	A	.83 (2.81)
10. Forage sorghum, silage-graze	B	.75 (2.54)
11. Grain sorghum stubble, continuous graze	A	2.16 (2.70)

Crop and Management	Class	Total Dry Matter Available Ton/Acre
12. Grain sorghum stubble continuous graze	B	1.95 (2.70)
13. Sorghum sudan alternate graze	A	4.08 (13.60)
14. Sorghum sudan alternate graze	B	3.72 (14.88)
15. Sorghum sudan stockpile fall	A	4.01 (13.37)
16. Sorghum sudan stockpile fall	B	3.61 (14.44)

Section IV. Perennial forage yields

The perennial forages and their managements considered in the model and the total dry matter available, are listed below.

Part I. Varieties and managements available on Class B land

	Crop	Management	Yield Ton D.M./Acre	Hay Equiv.
1.	Alfalfa Grass	Rotational graze	3.08	3.50
2.	Alfalfa Grass	Harvest 1, graze	3.57	4.06
3.	Alfalfa Grass	Harvest 2, graze	3.57	4.06
4.	Alfalfa Grass	Harvest 2, stock-pile for fall grazing	3.57	4.06
5.	Alfalfa graze	Harvest 3, graze	3.35	3.81
6.	Birdsfoot Trefoil	Continuous graze	2.41	2.65
7.	Birdsfoot Trefoil	Stockpile early summer	2.30	2.53
8.	Birdsfoot Trefoil	Stockpile late summer	2.23	2.45
9.	Birdsfoot Trefoil	Harvest 1, stock-pile late summer	2.39	2.63
10.	Orchardgrass	Continuous graze, 120 lbs. N/A	2.77	3.14
11.	Orchardgrass	3-season graze, 120 lbs. N/A	2.39	2.71
12.	Orchardgrass	3-season graze, early, 120 lbs. N/A	2.19	2.48
13.	Orchardgrass	Harvest 2, 120 lbs. N/A	2.65	3.00
14.	Orchardgrass	3-season graze, 240 lbs. N/A	4.19	5.03
15.	Orchardgrass	Harvest 2, graze 250 lbs. N/A	4.67	5.29

	Crop	Management	Yield Ton D.M./Acre	Hay Equiv.
16.	Orchardgrass	Harvest 1, graze early 240 lbs. N/A	4.63	5.24
17.	Reed Canary Grass	Continuous graze 120 lbs. N/A	3.38	3.70
18.	Reed Canary Grass	Harvest 2, graze 120 lbs. N/A	3.49	3.82
19.	Reed Canary Grass	Harvest 1, round bale 2, 120 lbs. N/A	3.49	3.82
20.	Reed Canary Grass	3-season graze early 240 lbs. N/A	4.70	5.15
21.	Reed Canary Grass	3-season graze 240 lbs. N/A	4.54	4.97
22.	Reed Canary Grass	Harvest 2, graze 240 lbs. N/A	4.94	5.41
23.	Reed Canary Grass	Harvest 1, graze 240 lbs. N/A	5.11	5.60
24.	Smooth Brome	Continuous graze 120 lbs. N/A	2.73	3.04
25.	Smooth Brome	3-season graze 120 lbs. N/A	2.34	2.62
26.	Smooth Brome	3-season graze early 120 lbs. N/A	2.15	2.40
27.	Smooth Brome	Harvest 2, Graze 120 lbs. N/A	2.61	2.91
28.	Smooth Brome	3-season graze 240 lbs. N/A	3.82	4.26
29.	Smooth Brome	Harvest 2, graze 240 lbs. N/A	4.28	4.59
30.	Smooth Brome	Harvest 1, graze 240 lbs. N/A	4.13	4.60
31.	Switchgrass	Continuous graze 60 lbs. N/A	3.40	3.86
32.	Tall Fescue	3-season graze 240 lbs. N/A	5.95	6.72
33.	Tall Fescue	Harvest 2, graze 240 lbs. N/A	6.70	7.57

	Crop	Management	Yield Ton D.M./Acre	Hay Equiv.
34.	Tall fescue	Harvest 1, graze 240 lbs. N/A	6.73	7.60

Part II. Varieties and management available on Class C land

	Crop	Management	Yield Ton D.M./Acre	Hay Equiv.
1.	Birdsfoot Trefoil	Continuous graze	2.41	2.65
2.	Birdsfoot Trefoil	Stockpile early summer	2.30	2.53
3.	Birdsfoot Trefoil	Stockpile late summer	2.23	2.45
4.	Birdsfoot Trefoil	Harvest 1, stock-pile late summer	2.39	2.63
5.	Crown Vetch	Continuous graze	3.13	3.56
6.	Kentucky Bluegrass	Continuous graze	1.42	1.60
7.	Kentucky Bluegrass	Continuous graze 60 lbs. N/A	2.67	3.00
8.	Kentucky Bluegrass	3-season graze 60 lbs. N/A	2.72	3.06

Section V. Grazing during renovation year

Crop	Yield Ton D.M./Acre	Hay Equiv.
A. Class B land: oats harvested as grain		
1. Alfalfa Grass	.73	.83
2. Birdsfoot	.55	.60
3. Orchardgrass	.69	.78
4. Reed Canary Grass	.74	.81
5. Smooth Brome	.68	.76
6. Switch Grass	.48	.55
7. Tall Fescue	.87	.98
B. Class B land: oats harvested as silage		
8. Alfalfa Grass	.73	.83
9. Birdsfoot Trefoil	.55	.60
10. Orchardgrass	.69	.78
11. Reed Canary Grass	.74	.81
12. Smooth Brome	.68	.76
13. Switch Grass	.48	.55
14. Tall Fescue	.87	.98
C. Class B land: oats harvested as hay		
15. Alfalfa Grass	.98	1.11
16. Birdsfoot Trefoil	.95	.82
17. Orchardgrass	.93	1.05
18. Reed Canary Grass	1.01	1.11
19. Smooth Brome	.91	1.08
20. Switch Grass	.86	.98
21. Tall Fescue	1.17	1.32
D. Class C land: oats harvested as grain		
22. Birdsfoot Trefoil	.55	.60
23. Crown Vetch	.75	.85

Crop	Yield Ton D.M./Acre	Hay Equiv.
24. Kentucky Bluegrass	.92	.81
E. Class C land: oats harvested as silage		
25. Birdsfoot Trefoil	.55	.82
26. Crown Vetch	.75	.85
27. Kentucky Bluegrass	.72	.81
F. Class C land: oats harvested as hay		
28. Birdsfoot Trefoil	.75	.82
29. Crown Vetch	1.01	1.15
30. Kentucky Bluegrass	.98	1.10

Section VI. Harvesting last cutting as small round bales and grazing in fall

	Crop	Management	Yield: Ton D.M./Acre	Hay Equiv.
1.	Alfalfa Grass	Harvest 2, round bale 3	3.11	3.53
2.	Orchardgrass	Harvest 1, round bale 2 120 lbs. N/A	2.65	3.00
3.	Orchardgrass	Harvest 1, round bale 2 240 lbs. N/A	4.67	5.29
4.	Reed Canary Grass	Harvest 1, round bale 2 120 lbs. N/A	3.49	3.82
5.	Reed Canary Grass	Harvest 1, round bale 2 240 lbs. N/A	4.94	5.41
6.	Smooth Brome	Harvest 1, round bale 2 120 lbs. N/A	2.61	2.91
7.	Smooth Brome	Harvest 1, round bale 2 240 lbs. N/A	4.28	4.77
8.	Tall Fescue	Harvest 1, round bale 2 240 lbs. N/A	6.70	7.57
9.	Birdsfoot Trefoil[1]	Harvest 1, round bale 2	2.14	2.35

[1] Birdsfoot Trefoil is harvested as round bales on Class B and C land.

Section VII. Harvesting last cutting as large round bales and grazing in the fall

	Crop	Management	Ton D.M./Acre	Hay Equiv.
1.	Alfalfa Grass	Harvest 2, round bale 3	3.11	3.53
2.	Orchardgrass	Harvest 1, round bale 2 120 lbs. N/A	2.65	3.00
3.	Orchardgrass	Harvest 1, round bale 2 240 lbs. N/A	4.67	5.29
4.	Reed Canary Grass	Harvest 1, round bale 2 120 lbs. N/A	3.49	3.82
5.	Reed Canary Grass	Harvest 1, round bale 2 240 lbs. N/A	4.94	5.41
6.	Smooth Brome	Harvest 1, round bale 2 120 lbs. N/A	2.61	2.91
7.	Smooth Brome	Harvest 1, round bale 2 240 lbs. N/A	4.28	4.77
8.	Tall Fescue	Harvest 1, round bale 2 240 lbs. N/A	6.70	7.57
9.	Birdsfoot Trefoil[1]	Harvest 2, round bale 2	2.14	2.35

[1] Birdsfoot Trefoil is harvested as round bales on both Class B and C land.

Section VIII. Variable costs and field time requirements[1] for cash annual crops and supplemental pastures

	Cost per Acre	Hours per Acre
A. Corn: variable cost and field time requirements		
Primary field preparation	$1.54	.30
Secondary field preparation	.52	.20
Planting operations	1.01	.21
Weed control	.80	.26
Harvest-grain	5.95	.58
Drying cost per 10 points moisture removed	.10/bu.	
Harvest-silage		
Haul and store	4.08	1.61
Chop-custom	12.60	0.0
Other variable costs		
Seed	9.00	
Fertilizer and lime	30.00	
Herbicide	12.00	
Miscellaneous	.50	
B. Soybeans: variable cost and field time requirements		
Primary field preparation	1.03	.22
Secondary preparation	.52	.20
Planting operations	1.01	.21
Weed control	.80	.26
Harvest	3.90	.58
Other variable costs		
Seed	9.00	
Fertilizer and lime	5.00	
Herbicide	12.00	
Miscellaneous	.50	

[1]Item includes only the labor required from the fixed labor supply.

	Cost per Acre	Hours per Acre
C. Grain sorghum: variable cost and field time requirements		
Primary field preparation	$1.54	.30
Secondary field preparation	.42	.10
Planting operations	1.01	.19
Weed control	.80	.26
Harvest grain	5.95	.58
Drying cost per 10 points of moisture removed	.10/bu.	
Other variable costs		
Seed	5.00	
Fertilizer and lime	30.00	
Herbicide	12.00	
Miscellaneous	.50	
D. Forage sorghum: variable cost and field time requirements		
Primary field preparation	1.54	.30
Planting operations	1.43	.29
Weed control	.80	.26
Silage harvest		
Haul and store	3.60	1.29
Custom chop	10.60	
Other variable costs		
Seed	3.50	
Fertilizer and lime	6.00	
Herbicide	4.00	
Miscellaneous	.50	
E. Sorghum sudan: variable cost and field time requirements		
Field preparations	1.54	.30
Planting operations	1.01	.19
Weed control	.80	.26
Other variable costs		
Seed	5.50	
Fertilizer and lime	6.00	
Herbicide	4.00	
Miscellaneous	.25	

	Cost per Acre	Hours per Acre
F. Oats: variable costs and field time requirements		
Growing	$1.42	.53
Harvesting grain	3.88	.58
Haul and store straw	.42	1.16
Haul and store oat silage	1.46	1.65
Custom hire		
Baling straw	10.60	
Harvesting-oat silage	12.60	
Other variable costs		
Seed	3.50	
Fertilizer and lime	10.00	
Miscellaneous	.50	

Section IX. Forage production

A. Productive life of grass and legume species[1]

Alfalfa Grass	3
Birdsfoot Trefoil	10
Crownvetch	10
Kentucky Bluegrass	20
Orchardgrass with 120 lbs. of N applied each year	8
Orchardgrass with 240 lbs. of N applied each year	10
Reed Canary Grass with 120 lbs. of N applied each year	6
Reed Canary Grass with 240 lbs. of N applied each year	8
Smooth Brome	10
Switchgrass	20
Tall Fescue	6
Birdsfoot Trefoil	10

B. Fertilizer costs per pound

N	$ .18
P_2O_5	.14
K_2O	.06

C. Seed costs per pound

Alfalfa	$ .70
Birdsfoot Trefoil	.90
Crown Vetch	1.50

---

[1]The productive life of a forage is defined as being the number of years the forage will be available for use after the seeding year.

Kentucky Bluegrass	$ .30
Orchardgrass	.40
Reed Canary Grass	.70
Smooth Brome	.40
Switchgrass	.30
Tall Fescue	.27

D. Variable costs and field time requirements of production

	Costs per Acre	Hours per Acre
Planting	$ .51	.33
Maintenance		
Clipping	.44	.33
Fencing[1]	.58	.8
Fertilizer application	.23	.11

[1]This fencing cost is for the additional fencing required when rotational grazing or alternate grazing is used.

Section X. Harvest and utilization of hay, crop residues, and other forages, costs reflect the expense incurred to perform these operations once per year

	Variable Cost	Field Time Labor
A. Harvesting hay		
Haul and store	$.40/T	.8/T
Custom hire for hay baling, mowing, and raking		
Rectangular	15.00/A	
Small round	15.00/A	
Large round	15.00/A	
B. Harvesting corn stover		
Flail chopping, hauling, and storage	.36/T	.25/T
Stakhand hauling, and storage	.10/T	.05/T
Custom hire for harvesting corn stover		
Flail chopping	3.15/T	
Stakhand	5.40/T	
C. Utilization of harvested forage		
Feeding hay	1.02/T	1.10/T
Feeding corn and sorghum silage	.66/T	.38/T
Feeding oat silage	.74/T	.48/T
Corn stover in Stakhand	.10/T	.05/T

Section XI. Annual ownership costs associated with specified machinery component

	Annual Ownership Cost
125 P.T.O. tractor	$2537.70
6-16" plow	306.90
12' tandem disk	198.00
12' roller	107.00
11' chisel plow	171.60
6-30" planter	484.00
210" field cultivator	159.50
30' springtooth harrow	198.75
Endgate seeder	26.45
Rotary hoe	179.30
Row crop cultivator (6-30")	250.80
6-30" combine	4571.60
18' grain platform	594.00
6-30" corn head	1589.50
2-200 bu. wagons	255.20
6", 40' auger	124.20
85 h.p. tractor	1665.40
20 T. truck w/hoist	1890.00
Pickup truck	495.00
Total	$15504.90

Annual cost per tillable acre $24.49

Section XII. Beef cow herd

A. General information

1. Average weight of mature beef cows	1,000 lbs.
2. Average value of cow	$500/cow
3. Calving season will begin	March
4. Percent of cows that are bred that will wean a calf	90%
5. Average weaning weight of steer calves	450 lbs.
6. Average weaning weight of heifer calves	425 lbs.
7. Percent of the cows that will be culled each year	10%

B. Variable cost and labor requirements for a cow and calf

Salt and mineral	$1.60/hd.
Vet and medical	2.50
Supplies	2.00
Power and fuel	2.50
Miscellaneous	.50
Subtotal	$9.10/hd.
Total yearly non-feed labor for a cow and calf	2.73 hrs.

C. Variable cost and labor requirements for herd bulls

Salt and mineral	$2.00/hd.
Vet and medical	2.00
Supplies	1.50
Power and fuel	2.50
Insurance	2.00
Miscellaneous	.50
Subtotal	$10.50/hd.
Total yearly non-feed labor per bull	1.60 hrs.

D. Variable cost and labor requirements for replacement stock[1]

Salt and mineral	$1.40/hd.
Vet and medical	2.00
Supplies	1.50
Power and fuel	2.50
Insurance	1.00
Miscellaneous	.50
Subtotal	$8.90/hd.
Total yearly non-feed labor per replacement	4.00 hrs.

E. Marketing costs for feeder calves

Trucking	$1.20
Marketing	3.30
Subtotal	$4.50

[1]The costs involved in raising a replacement from seven months of age until she enters the cow herd at two years of age are specified.

Section XIII. Man hours of labor available, 6 day work week assumed

Seasonal labor hourly wage rate: $2.26; full time hired labor wage rate: $3.75

	Hours of Labor Available per Day	
Time period	Operator	Hourly hired labor
January	8	2
February	8	2
March 1-15	8	2
March 16-31	9	2
April 1-15	9	8
April 16-30	9	8
May 1-15	9	8
May 16-31	9	8
June 1-15	9	8
June 16-30	8	2
July	8	2
August	8	2
Sept. 1-15	8	2
Sept. 16-30	9	8
Oct. 1-15	9	8
Oct. 16-31	9	8
Nov. 1-15	9	8
Nov. 16-30	9	8
December	8	2