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To the Graduate Council:

I am submitting herewith a dissertation written by James Marshal Anderson entitled "The Effects of Alternative Beef Cattle Finishing Systems on Farm Income Potential and Resource Utilization in Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

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THE EFFECTS OF ALTERNATIVE BEEF CATTLE FINISHING
SYSTEMS ON FARM INCOME POTENTIAL AND
RESOURCE UTILIZATION IN TENNESSEE

A Dissertation
Presented to
the Graduate Council of
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In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
James Marshal Anderson

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ABSTRACT

The purpose of this study was to determine the effects that alternative beef cattle finishing systems have on farm income potential and resource utilization in three distinct agricultural areas of Tennessee. Study areas included the Southern Plateau Slope, the Central Basin, and the Cumberland Plateau. In each area, alternative situations considered were: 1-, 2-, and 3-man year labor supplies; Small (100 acres of openland), Medium (250 acres of openland), and Large (600 acres of openland) size farms; and charges of 6, 9, and 12 percent for annual capital.

Results from 304 groups of cattle fed in trials conducted by several agricultural experiment stations were used to derive empirical estimates for corn grain and corn silage relationships as inputs for beef steer and heifer rations. These relationships were used to structure the steer and heifer budgets for the main analysis.

Linear programming techniques were utilized to maximize farm income to land, labor, and management in each given resource situation with and without the inclusion of alternative beef finishing systems. Predominant ration components included various combinations of corn silage, corn grain, and pasture forage. Income differentials obtained were used as indicators of the potential contribution by beef feeding to farm income in each of the resource situations considered.

When all capital was charged at a rate of 6 percent, the inclusion of beef feeding resulted in an increase in maximum potential income (ranging from \$6 to \$3,338, \$461 to \$2,091, and \$242 to \$3,026, respectively) on Small and Medium size farms of the Southern Plateau Slope and the Central Basin, and on all farm sizes in the Cumberland Plateau. The percentage and absolute improvements in farm income potential increased as the farm size increased in the Cumberland Plateau Area. In all resource situations of the primary analyses, increases in income potential were a result of feeding beef heifers. A special analysis which considered only beef steers indicated that feeding beef steers would increase farm income potential, but to a lesser degree than would feeding beef heifers.

Increasing the charge for annual capital above 6 percent had a significant effect on the income potential of beef heifer feeding. Increasing the size of the labor supply on a given size farm generally resulted in a larger absolute, but a smaller proportionate increases in income when beef heifers were fed.

Beef heifer feeding had a varied effect on the utilization of available land, but consistently reduced the proportion of labor which was unused. With one exception, excess labor was available between October 1 and February 28 in the optimal farming systems developed for the various resource situations considered.

Finishing of beef heifers using corn silage as the primary ration component was the primary beef system included in the optimal analysis on the smaller farms. Beef heifer feeding utilizing a system which

included a phase of pasture plus supplemental grain was most effective in increasing the potential incomes of Large size farms with rather limited labor supplies. Beef heifer feeding with corn grain as the predominant ration component was advantageous in only a few of the farm resource situations studied. A beef feeding system with a pasture only phase did not appear in any of the optimum solutions obtained in this study.



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CHAPTER I

INTRODUCTION

A. THE PROBLEM

Considerable attention has been given in recent years to poverty and to the low income segments of the U. S. population. Much of the emphasis to date has been directed toward the urban sector of our economy. More recently, however, concern has increased for the low income conditions which exist in the rural areas of the United States. [34, 35]. The Southeastern area has the lowest per farm income of any area in the U. S. Tennessee currently has the lowest income per farm in the Southeast and surpasses only New Hampshire and West Virginia nationally [42, pp. 10-11; 43, p. 18]. Somewhat more disturbing is the fact that net income per farm in Tennessee has increased at a much slower rate than most adjacent states during the period from 1954 to 1967 (Figure 1). These factors justify an economic evaluation of various farm production alternatives which may offer means of increasing farm income in Tennessee and similar areas by more efficient utilization of scarce resources.

Several economic studies have suggested that the contribution of the beef cattle industry to farm income in Tennessee is at best slightly positive and may even be negative [5, 8, 10, 31]. More specifically, Mitchell found that a negative relationship existed between changes in average net income per farm and the number of beef

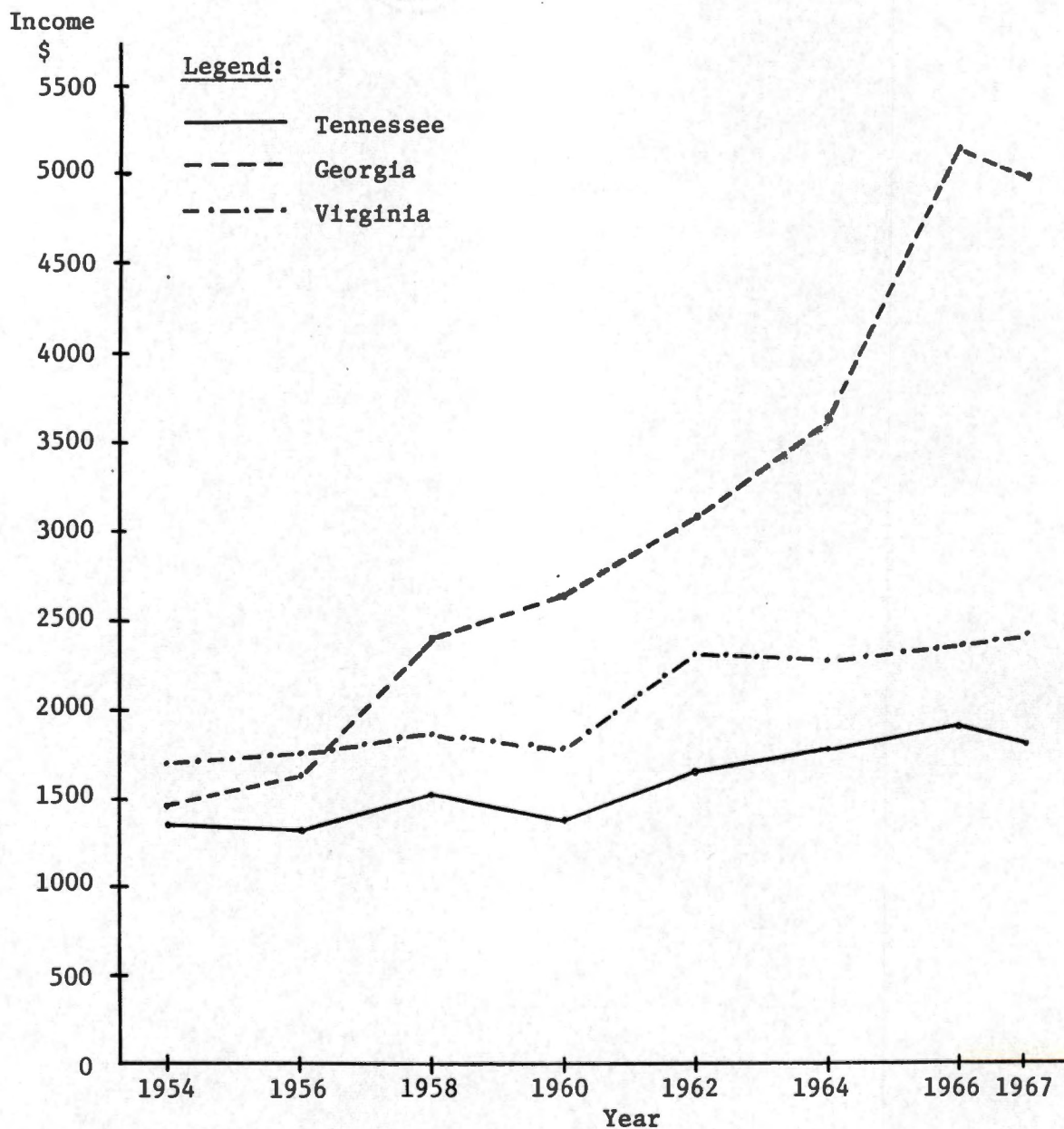


Figure 1. Realized net income per farm during selected years from 1954-1967 for Tennessee, Georgia, and Virginia.

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cows on farms in the eight Southeastern states studied. Eagan reported results of an analysis of optimum farm organizations in the Eastern Highland Rim Area of Tennessee [10]. No beef cow-calf production systems appeared in any of the solutions, but some optimum solutions did include beef steers finished on a predominantly corn grain ration. In a Virginia study steer feeding was included in the optimum enterprise organization of a 60-acre farm only when the original income estimates were increased by 10 percent [47]. In studies of separate areas of Tennessee, both Cowan and Bounds found optimum solutions including beef cow-calf production, but the frequency and size of the beef system were both relatively small [5, 8]. Beef cattle finishing systems were not considered as production alternatives by either Cowan or Bounds. Walker and Tramel found beef cattle finishing (steers from 715 to 1,040 pounds) to be more profitable than beef cattle conditioning (steers from 450 to 715 pounds) and that beef finishing made good use of seasonally excess labor from November to April [48].

Despite the apparently low level of profitability from beef cow-calf production, and for reasons not yet completely understood [26, 37], the number of adult beef cows in Tennessee has increased from an estimated 492,000 head on January 1, 1960, to an estimated 874,000 head on January 1, 1968 [39, p. 30]. In sharp contrast, a companion sector of the beef cattle industry, beef cattle finishing, has expanded little, if any, during the same 8-year period. On January 1, 1960, an estimated 42,000 head of cattle and calves were on feed [39, p. 31]. Quarterly

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estimates of cattle and calves on feed are available since 1964 and these indicate a slight decline in the number of cattle and calves on feed.

Herein, then, lies a paradox. Beef cow-calf production apparently makes a comparatively small contribution to farm income when allowed to compete with other enterprises. Yet, their numbers in Tennessee have grown some 77 percent during the period 1960 to 1968. On the other hand, some research and budget estimates suggest that beef cattle finishing may offer a definite potential for increasing farm income in Tennessee. Yet, statistics regarding beef cattle on feed indicate that the number of beef cattle finished annually has been fairly stable since 1960.

This recent statement from an article concerning opportunities for the small family farmers in Virginia to increase their income makes no mention of beef cattle finishing as a potential for increasing farm income:

Some of the best bets for income from livestock are the production of feeder pigs, dairying, production of veal calves, beef cow herds, and table eggs . . . [30]

A more exhaustive analysis of several different beef cattle finishing systems is needed to determine the possible effects of beef feeding on farm income under various basic resource situations.

B. OBJECTIVES OF THE STUDY

The general objective of this study is to determine the effects that alternative beef cattle finishing systems have on farm income potential and resource utilization in three major farming areas of Tennessee. . Within each major area, evaluation is to include a study of the effects on income and resource use when all possible combinations of the following basic resource situations are considered: three farm sizes (100, 250, 600 acres of openland); three sizes of permanent labor supply (one, two, and three men); and three charges for annual capital (6, 9, and 12 percent).

A secondary objective is to evaluate the various finishing systems within each of the above mentioned resource situations.

CHAPTER II

AREAS FOR STUDY

Agricultural resources and climatic environment are quite varied across Tennessee. The two most distant tips of the state are separated by agriculturally productive areas ranging from elevations of 250 feet to 2,000 feet above sea level. The length of the growing season ranges from 180 to 220 days, and average annual rainfall ranges from 44 inches to 56 inches. The distribution of rainfall is more favorable as one moves from west to east. Average temperature readings differ by some 6 degrees among the various areas of the state.

In addition to basic climatic variations, wide area differences exist in soil capability, topographical variations, crop production alternatives, input and output markets, availability and attitude of farm labor, and capital availability. Martin and Luebke have characterized 12 major farming areas in Tennessee [27]. From these major areas the Southern Plateau Slope, the Central Basin, and the Cumberland Plateau, as outlined in Figure 2, were selected as study areas. Selected areas provide a wide range in most of the important variables under consideration.

A. SOUTHERN PLATEAU SLOPE (AREA I)

The Grenada-Loring-Memphis and Memphis-Loring Soil Associations are predominant in this area. These soils range from moderately deep to deep loessial over a coastal plain layer of sands and clays.

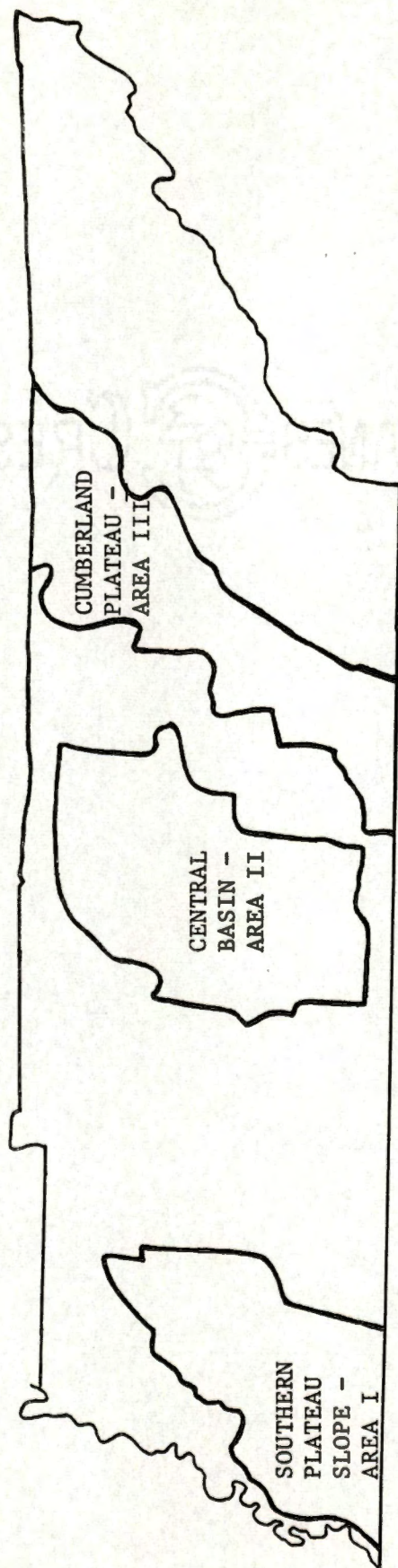


Figure 2. The generalized location of the three study areas.

Underlying fragipans often restrict drainage and land use potentials. Fertility ranged from low to moderate with generally good response to appropriate management techniques. Serious and extensive erosion limits the intensity with which row cropping practices may be adopted.

This area slopes south and west from about 600 feet elevation in the east to 250 feet near Memphis. Topography ranges from almost level to rolling with very little extremely rough land. Primary stream drainage is poor in many cases due to small changes in elevation and low, marshy river bottoms are quite common.

Annual precipitation averages about 48 inches with a growing season of 200 to 225 days. Average temperature is about 40 degrees in January and 80 degrees in July.

Until recently, the primary cash crop has been cotton. Various factors have contributed to a recent decline in the relative importance of this crop and an increase in the importance of soybeans. Corn, hay, small grains, and fruits and vegetables have been other important contributors to area income from crop production. Although traditionally low in the past, livestock production has received more attention in recent years due to the significant changes in the area labor supply.

B. CENTRAL BASIN (AREA II)

The soils of this area are among the most fertile in the state. Soil associations include Maury-Mimosa-Stony Land, Baxter-Dellrose-Mimosa and Talbott-Hagerstown-Stony Land. Several industries in the area are in the process of mining phosphorus from the soil. Since

many of the soils in this area are inherently high in phosphorus content, no phosphate fertilizers were included in the crop budgets.

Average elevation is 500 feet above sea level with hills as high as 800 feet resulting from the resistant nature of the overlying siliceous Limestone of the Highland Rim. The topography is generally rolling to rolling and hilly and is sometimes rough and stony.

Annual precipitation averages about 50 inches with a growing season of 195 to 200 days. Average temperatures are about the same as in Area I.

Corn and hay are the two predominant crops with burley tobacco production an important cash crop on many farms. The proportion of cropland acreage devoted to small grains is much greater than in the state as a whole. Cotton is grown in scattered areas, but has generally diminished in importance in the Central Basin.

Livestock production has held an important place in the economy of this area. Types of livestock produced include beef, dairy, hogs, and sheep. Both the excellent marketing facilities available for all classes of livestock and the inherent forage producing capabilities of the phosphatic soils have been important in stimulating extensive livestock production in this area.

C. CUMBERLAND PLATEAU (AREA III)

Drastically different in almost every respect from the other two areas, the Cumberland Plateau is an elevated tableland of about 4,500 square miles extending in a northeast-southeast direction across

the state at an elevation of about 2,000 feet above sea level. The soils in this area are easily tilled, low in natural fertility, and somewhat shallow. Only one-fourth to one-half of the area is considered to have sufficient soil depth to support production of cultivated crops. The principal soil associations are Muskingum-Hartsells and Hartsells-Muskingum.

The growing season ranges from 170 to 180 days and rainfall averages 55 inches annually with up to 60 inches in some parts of the area. Average temperatures are around 38 degrees in January and 74 degrees in July.

The primary crops of the area are corn and hay. At one time Irish potatoes were an important cash crop, but have declined in importance during the last 15 years. A large percentage of the land area is devoted to production of forest products. Livestock production in the form of beef cattle and hogs has increased in more recent years and are important contributors to farm income in an area characterized by small, non-commercial, residential, and part-time farms.

Until the very recent development of the Interstate Highway System with accompanying feeder road improvements, the farm market facilities for this area were inadequate locally and very difficult to reach by using pre-Interstate roads and highways. Current market facilities accessible to this area are essentially as adequate as any area in the state.

CHAPTER III

FRAMEWORK FOR ANALYSIS

A. INTRODUCTION

Techniques of linear programming have been used in numerous research studies to determine the optimum use of some set of limiting resources. Linear programming is used routinely by feed manufacturers to minimize ration costs while remaining within certain nutritional constraints.

In a similar manner, linear programming can be used to maximize some objective, say income, subject to certain resource limitations, [23]. In this study, the objective was to determine a set of product outputs in each study area which would yield the maximum return to land, labor, and management during an annual production period. This maximization was subject to the constraints imposed by the availability of resources required to make these products and the constraints that there can be no negative production for any product. Algebraically, the maximization model, sometimes called the maximization primal, can be represented as:

$$Z_{\max} = \sum_{j=1}^n C_j X_j$$

subject to:

$$(1) \sum_{j=1}^n a_{ij} X_j \leq b_i \text{ (for all } i = 1, 2, \dots, m)$$

$$(2) X_j \geq 0 \text{ (for all } j = 1, 2, \dots, n)$$

where $Z_{\max}$ = net income;

C_j = the known amount of net income per unit of X_j produced;

X_j = the unknown amount of output for 1, 2, ...n possible outputs;

a_{ij} = known amount of the i^{th} resource required to produce one unit of the j^{th} product; and

b_i = the known availability of the i^{th} resource for $i = 1, 2, \dots, m$ resources.

The number of activities in any given solution can be no greater than the number of resource restrictions in the problem.

Since each linear programming problem has a dual which is solved simultaneously with the primal, we routinely obtain marginal values for each limiting resource at the point where resources are utilized in an optimum manner. Although traditional marginal analysis is implicitly indicated, there is one major difference. Changes in marginal values are not continuous as in marginal analysis, but rather, occur in discontinuous and irregular intervals.

In this study income was maximized first under the several resource situations with beef feeding activities excluded from consideration. Then, similar objective functions with the same basic resource

restrictions were maximized with beef cattle finishing systems included as alternatives. Differences obtained were additions to net farm income made possible by including beef feeding alternatives.

The major underlying assumptions of the linear programming technique are as follows:

- (1) Additivity and linearity - When two or more activities are used, their total product must be the sum of their individual products.
- (2) Divisibility - Resources can be used and products produced in fractional units.
- (3) Finiteness - There is some limit to the number of alternatives and to the resource restrictions which are to be considered.
- (4) Single-value expectations - Resource supplies, input-output coefficients, and prices are known with certainty. [19, pp. 17-18].

Intermediate activities were included in the analysis to allow use of farm products as inputs for further production of other items.

B. RESOURCE ASSUMPTIONS

Land Availability

The average size farm in Tennessee in 1967 contained an estimated 116 acres of land [39, p. 6]. Although this value has persistently increased for many years, the average farm in Tennessee is still much smaller than the average U. S. farm which had 360 acres in 1967 [44, p. 594]. In anticipation of a continuation of this trend and recognizing the great need of small farm operators to locate ways and means of increasing their income, farms with 100, 250, and 600 acres of openland

and referred to as Small, Medium, and Large farms, respectively, have been included in the analysis to provide a wide range of basic land resource availabilities. Cowan's study indicated that the land-labor ratio was an important factor in determining farm income and optimum use of resources [8, p. 64].

Soil variations were taken into account since soil capabilities are heterogeneous between areas, within areas, within farms, and even within fields. An inventory of soils by capability and by county in Tennessee was used to estimate the percent of each soil capability unit found in each of the study areas [38, pp. 27-60]. Since the study areas do not follow county lines and the soil inventory was available only on a county basis, three contiguous counties within each of the given areas were selected as representative of the soil capability distribution in the entire area. The three counties representative of Area I were Fayette, Haywood, and Madison; soil patterns in Area II were estimated from data for Maury, Williamson, and Rutherford counties; and Area III was characterized by summarizing soils data for Cumberland, Fentress, and Morgan counties. The percent of soil capability by class and area is shown in Table I. Woodland acreage was not considered in the analysis.

Soil Group 1 included deep, well drained, fertile soils in the Soil Conservation Service (SCS) capability unit I-e-1. These soils are well suited to intensive cropping practices with few limitations and were permitted to be row-cropped every year.

TABLE I
PERCENTAGE OF OPENLAND WITHIN SELECTED
SOIL CAPABILITY GROUPS BY AREA

Soil Group	Area I	Area II	Area III
	-----Percent-----		
1	0.96	6.06	0.46
2	55.79	52.91	32.72
3	22.62	19.12	36.05
4	9.87	15.92	22.56
5	5.20	2.23	4.82
6	5.56	3.76	3.32

Source: Calculated from Tennessee Conservation Needs Committee, Tennessee Soil and Water Conservation Needs Inventory, Nashville, Tennessee State Soil Conservation Committee (1961) pp. 27-60.

Soil Group 2 included soils classified in the SCS system as capability units II-e-1, II-e-2, II-w-1, and II-w-2. These soils are subject to some erosion, have gentle slopes, less than ideal soil structure and depth, and subject to an occasional overflow in some cases. Not more than one-half of the total acreage available in this soil group was permitted to be row-cropped in a given year.

Soil Group 3 contained soils with SCS capability units III-e-1, III-e-2, and III-s-1. These soils can be used for row crops, but require extensive soil management practices due to moderately steep slopes, shallow depths, low moisture retention capacity and generally low inherent fertility. Row cropping was restricted to one-third of the acreage of these soils each year.

Soil Group 4 was defined to contain soils with SCS capability units IV-e-1, IV-e-2, and IV-s-1. These soils have steep slopes, are susceptible to severe erosion, and are shallow with low moisture holding capacity. Row cropping was not permitted on these soils due to the severe erosion hazard and the inherent low yields.

Soil Group 5 contained soil SCS capability units III-w-1, III-w-2, IV-w-1, and IV-w-2. These soils are subject to overflow, poor drainage and poor aeration. They are best suited for crops growing in the relatively dry portion of the year. Row cropping was permitted each year, but yields are very low compared to other soil groups.

Soil Group 6 included SCS soil capability units VI-e-1 and VI-e-2. These soils are generally used only for pasture or woodland.

The forage yields are very low due to steep slopes, severe erosion, stoniness, shallow root zones, and low moisture capacity.

Size of Labor Force

From 1961 to 1967 wage rates paid by farmers have increased about 50 percent [39, p. 11] with the greatest rate of increase during the period between 1965 and 1967 as shown in Figure 3. More than ever before farmers are having to compete with industrial users of labor for their labor force. Industry is able to offer such advantages as a 40-hour week, relatively high rates of pay, fringe benefits, and generally comfortable working conditions.

As would be expected when the price of one input increases relative to the price of another input, the use of the relatively higher priced item decreases. In this case the price of labor has increased relative to the price of capital goods such as machinery. Despite the increase in wage rates, the percent of the total cost of production going to labor has declined 3.4 percent during the period 1961 to 1967 [38, pp. 8-9].

Seasonal labor is becoming less readily available. Fewer and fewer are the occasions when a farmer can secure the quality of labor able to operate highly technical components of production just as the pressures of seasonal needs dictate. The data shown in Figure 4, comparing the amount of hired labor in 1960 and 1967, clearly illustrate the trend toward a lessening of variation in the number of workers regardless of the season of the year. More and more farmers are

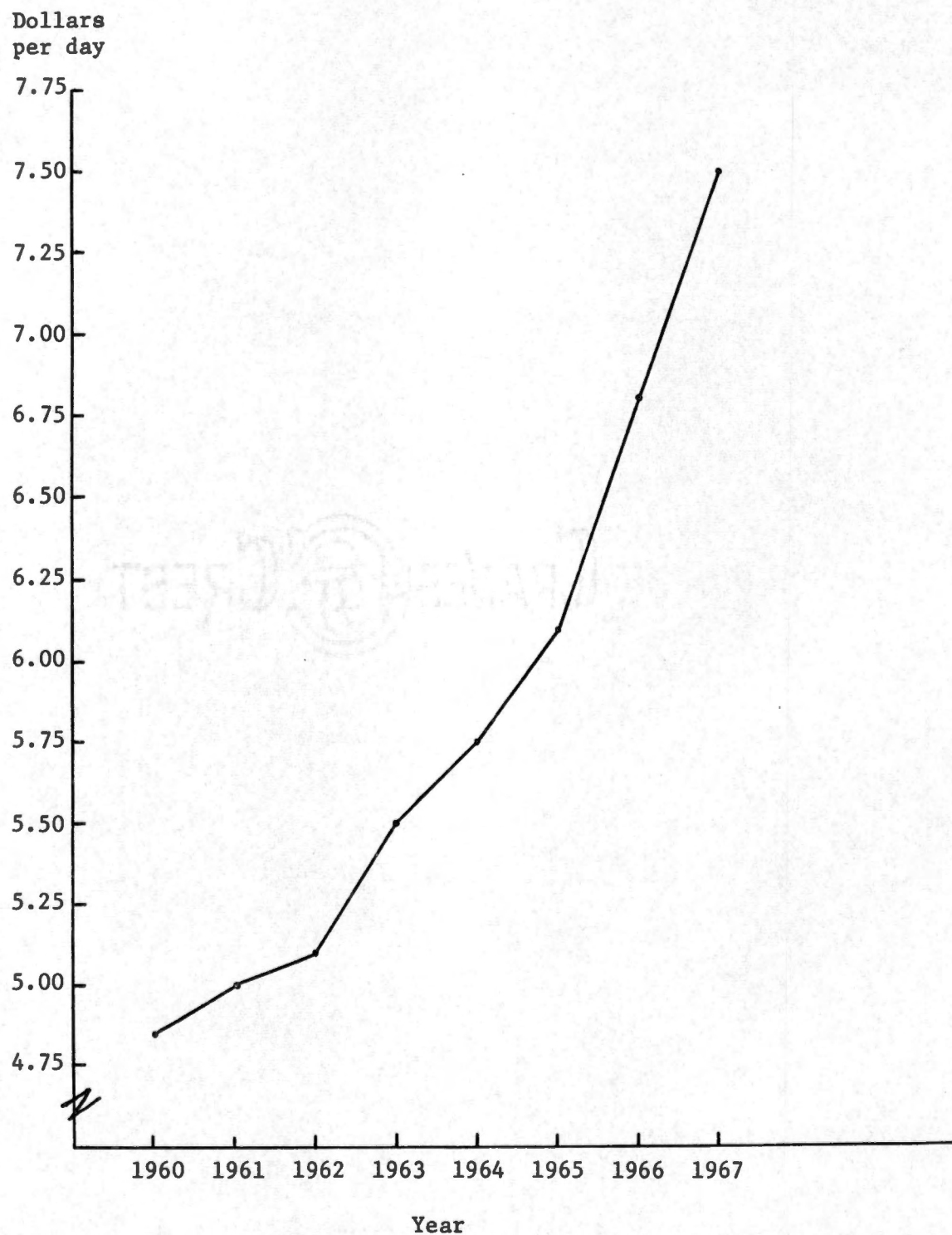


Figure 3. Farm wage rates per day in Tennessee as of October 1 each year without room or board, 1960-67.

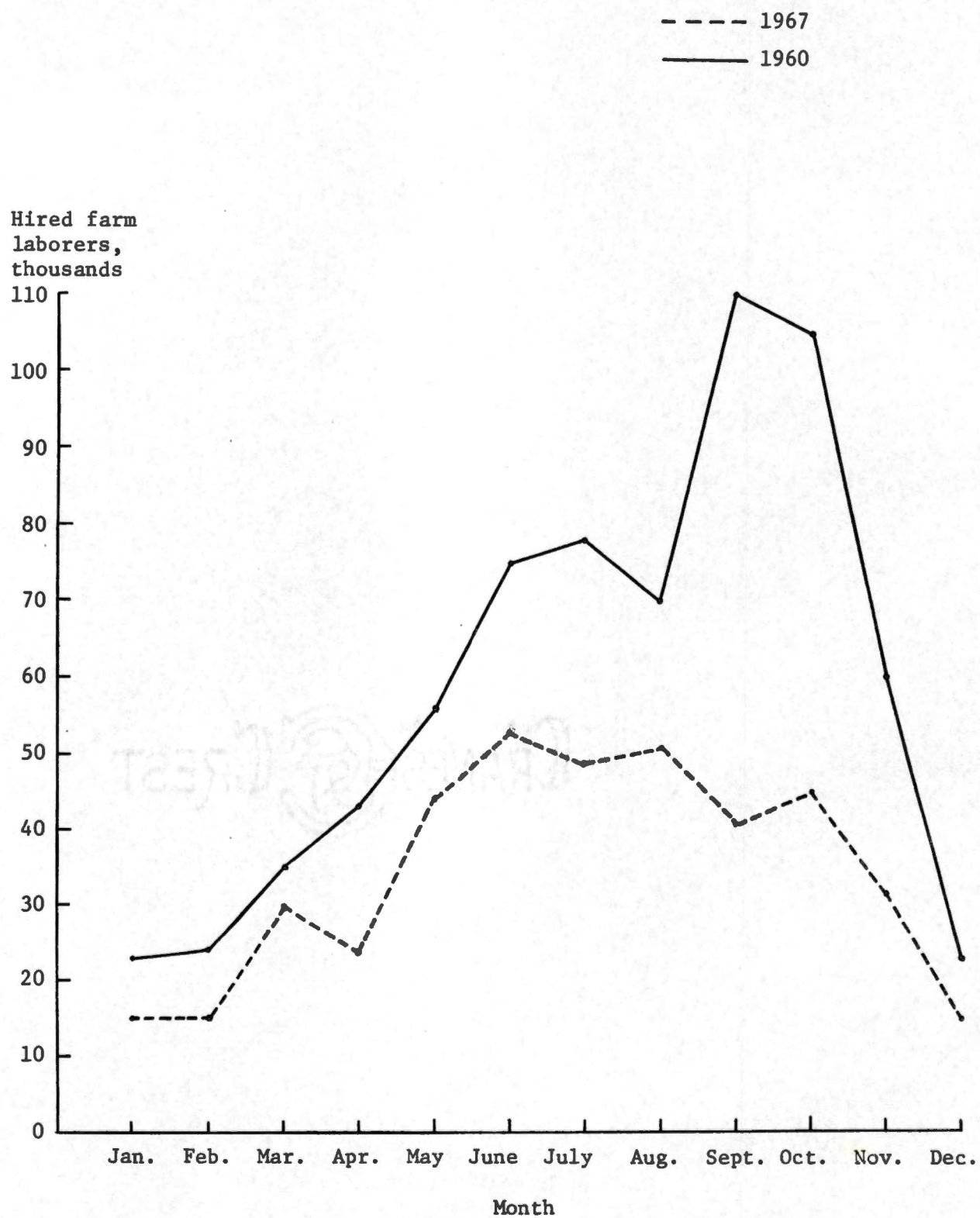


Figure 4. Total number of hired farm laborers in Tennessee by months for 1960 and 1967.

orienting their farm operations to their annual labor supply rather than depending on hiring seasonal labor during peak seasons. In this study the labor supply was assumed to be limited to a fixed amount of annual or resident labor. Hiring of seasonal laborers was not permitted. Each man-unit of labor was assumed to be available for work an average of 44 hours per week less an allowance for vacation time. The available labor was divided into six time periods and the total amount available by period and annually is shown in Table II. No charge was made for the labor required in the enterprise budgets.

Capital Availability

Both investment capital and annual operating capital were charged at an annual rate of 6 percent in the crop and livestock budgets. Since net income was computed as the returns to land, labor, and management, no charge was made for land capital. Annual capital was charged for the time it was tied up in farm production activities. Since beef feeding may involve rather large quantities of annual capital and involves greater relative risk than crop alternatives, solutions were also obtained when annual capital was charged at 9 and 12 percent.

TABLE II
LABOR AVAILABILITY BY PERIOD AND SIZE
OF LABOR FORCE

Labor Period	Hours		
	1-man	2-man	3-man
1. Dec. 1-Feb. 28	541	1,082	1,623
2. Mar. 1-Apr. 14	271	542	813
3. Apr. 15-May 31	284	568	852
4. June 1-Aug. 15	458	916	1,374
5. Aug. 16-Sept. 30	277	554	831
6. Oct. 1-Nov. 30	379	758	1,137
Total for Year	2,210	4,420	6,630

CHAPTER IV

DERIVATION OF THE PRODUCTION COEFFICIENTS

One crucial part of any linear programming analysis is the development of the appropriate technical coefficients for use in the model under consideration. Coefficients used in these analyses for beef cattle finishing systems, for livestock enterprises other than beef cattle finishing, and for crop enterprises are discussed in that order.

A. FEED RELATIONSHIPS FOR BEEF PRODUCTION

Traditionally, the ration for finishing beef cattle for the slaughter market has been built around extensive use of corn grain as the primary ration component. However, the use of corn silage as the primary energy source in slaughter cattle rations has increased during the past few years. Total production of corn silage in Tennessee climbed from 483,000 tons in 1960 to 1,094,000 tons in both 1965 and 1967 [39, p. 16]. This represents an increase of 126 percent in the production of corn silage. Beef cows are large users of corn silage, but their rate of increase (77 percent) was considerably less than the increase in corn silage production. Since dairy cow numbers have decreased slightly and the number of cattle finished each year is about the same, it is likely that the proportion of the total energy

derived from corn silage for finishing beef cattle was greater in 1967 than in 1960.

Large yields of nutrients per acre, few digestive disturbances in the feedlot, ease of adaptation to mechanized feeding, and the increasing acceptance of supplementing corn silage with a non-protein-nitrogen compound at the time of ensilaging are all factors contributing to the increased use of corn silage in beef finishing rations. Despite the increased use of corn silage in finishing rations, current information regarding substitution relationships between corn grain and corn silage is inadequate. Neither is there any information which relates, functionally, the rate of corn silage feeding with gains made by beef cattle.

The performance of 304 different groups of experimental beef cattle [4, 6, 7, 11, 12, 18, 21, 25, 29, 32, 33, 36, 46, 49] fed various combinations of corn grain and corn silage during the time period between 1958 and 1968 was analyzed to develop a functional relationship between these two independent variables (corn grain and corn silage) for feeding trials and the dependent variable (gain by beef cattle). Data from states other than Tennessee were included to widen the range of observations and increase the applicability of the results. Experimental procedures, especially within the Tennessee system, were generally uniform and consistent. All groups were assumed to have been fed at a protein level at least as great as the accepted minimum requirement for that particular group of cattle.

Stepwise regression techniques [9, pp. 233-54] were utilized to derive the following estimating equation for gain by beef steers and heifers fed various combinations of corn grain and corn silage:

$$\hat{Y} = 0.9159 + 0.1479X_1 - 0.002754X_1^2 + 0.1160X_2 + 0.001629X_2^2 \\
\begin{matrix} (0.0109) & (0.000692) & (0.0195) & (0.000861) \end{matrix} \\
- 0.0001102X_2X_4 - 0.0007262X_3 - 0.1010X_5 \\
\begin{matrix} (0.0000239) & (0.000380) & (0.0570) \end{matrix}$$

where $\hat{Y}$ = estimated daily gain, pounds (1.94 ± 0.39);

X_1 = daily ration of corn grain, pounds (5.25 ± 4.3);

X_2 = daily ration of corn silage, pounds of air dry matter
(7.03 ± 3.4);

X_3 = length of feeding period, days (137 ± 38);

X_4 = initial weight, pounds (531 ± 103); and

X_5 = dummy variable for heifers.

Means and standard deviations are included in parentheses immediately following the definition of each variable. Standard errors are included in parentheses just below the appropriate coefficients. The standard error of the estimate was 0.226 and the R^2 value was 66.75 percent. The above form was selected for expressing the relationship because this form provided the best fit of the several functional forms tried, was easy to fit, and has been found by other workers to best represent feed:animal gain relationships [20].

Utilizing the production function equation above, the amount of X_1 required for a given level of $\hat{Y}$, X_2 , X_3 , and X_4 is determined for

steers by the following expression:

$$X_1 = 26.8519 \pm [(0.03197 + 0.00128X_2 + 0.000018X_2^2 - 0.00000121X_2X_4 - 0.0000080X_3 - 0.01102Y)^{1/2} (-0.005508)^{-1}].$$

Although there are two possible solutions to the equation, negative values for corn grain (X_1) are irrational and are disregarded. An estimate of the rate of gain was obtained for use in the feeding systems of this study by substitution of these calculated values back into the original equation and solving for Y.

There are several conclusions which can be made from this analysis:

(1) Additional increments of corn grain result in smaller and smaller incremental increases in daily gain. This is substantiated by the negative sign on the squared term for corn grain and indicates that these data were collected from experiments operating in Stage II of the classical production function. The coefficients obtained in this study for corn grain are generally in agreement with those developed by Heady et al. in an experiment designed to establish corn grain-pasture clipping-beef animal gain relationships [20, p. 883].

(2) Additional increments of corn silage result in larger and larger incremental increases in gain as indicated by the positive sign associated with the squared term for corn silage. This suggests that cattle being fed in these experiments were either in Stage I of the production function or that the data used were composed of several different production functions which could result in a spurious estimate of the production function. However, this observation probably resulted

from the inability of young animals with relatively small stomach capacities to ingest sufficient dry matter to reach Stage II. If these results represent an accurate estimate of the production relationships, then we can conclude that if any corn silage is to be fed, it should be limited only by the animal's appetite.

(3) The interaction term between corn silage and initial weight suggests that at a given level of corn silage feeding, increases in initial weight result in decreases in daily gain.

(4) As the length of the feeding period increases, the daily gain decreases. This suggests that the maintenance requirements increase as the length of the feeding period increases.

(5) Given the same values for the other variables in the equation, steers gain an average of 0.101 pound per day more than heifers.

All of these comments concern a single production process and these relationships were used to estimate corn grain and corn silage requirements for appropriate portions of five finishing systems.

B. BEEF CATTLE FINISHING SYSTEMS

For the purpose of this study, a beef cattle finishing system is defined as a feeding method or combination of feeding methods which will result in a 500-pound steer weaned in the Fall attaining a slaughter weight of 1,000 pounds and grading USDA high Good-low Choice or a 450-pound heifer weaned in the Fall attaining a slaughter weight of 850 pounds and grading USDA high Good-low Choice. There are many possible combinations of feeding methods available for accomplishing this

transition. The systems considered in this study included: (1) feeding corn grain and/or corn silage as the primary ration ingredient(s), varying the proportion of each in order to obtain the desired finishing product, or (2) limited corn grain or corn silage during the winter months followed by either (a) limited grain plus pasture and a short feedlot, or (b) no grain on pasture, plus a longer feedlot period than necessary in (a) above.

One set of requirements has been determined for steers and one set for heifers utilizing the relationships developed in the preceding section to determine the amount of corn, grain, and silage required for each given feeding system. A total of ten beef feeding systems were included as potential activities in the linear programming matrix to maximize net farm income for an entire farming operation.

Cattle for all systems were assumed to be purchased on October 15, spend 2 weeks on an adjustment ration, and then be placed on the given finishing system on November 1. The systems included in the analyses are described in Table III. Feeding rations for all systems except the pasture phase of Systems 4 and 5 included 2 pounds per head per day of alfalfa hay or its equivalent. Urea was added in sufficient quantities to balance the protein needs in all systems, except in the limited feeding phase of Systems 4 and 5. Cottonseed meal was used to balance the rations in these two instances because the relatively low energy level of the rations prevents efficient conversion of urea to a usable form. Detailed total feed requirements for each system are included in Table IV.

TABLE III

LENGTH OF FEEDING PERIODS AND DAILY GAINS ASSUMED FOR BEEF CATTLE FINISHING SYSTEMS

System	Ration Description by Feeding Period	Steers		Heifers	
		Length of Feeding Period, days	Daily Gain, pounds	Length of Feeding Period, days	Daily Gain, pounds
1	Full feeding corn silage	234	1.75	177	1.75
	Full feeding corn grain	36	2.50	40	2.25
2	Full feeding corn silage, plus 5 lb. corn grain per head per day	228	2.20	190	2.10
3	Full feeding corn grain	208	2.40	182	2.20
4	Limited feeding corn silage	150	1.00	150	1.00
	Pasture only	105	1.50	112	1.40
	Full feeding corn grain	70	2.75	41	2.25
5	Limited feeding corn grain	150	1.00	150	1.00
	Pasture with supplemental grain	146	1.85	120	1.75
	Full feeding corn grain	32	2.50	18	2.25

TABLE IV
ESTIMATED TOTAL FEED REQUIREMENTS PER HEAD FOR
450-HEAD BEEF CATTLE FINISHING SYSTEMS

Item	<u>Systems</u>				
	1	2	3	4	5
<u>Steers</u>					
Corn grain, bushels	9.75	20.36	57.82	26.00	29.20
Corn silage, tons (air dry matter)	1.45	1.02	--	0.22	--
Alfalfa hay, tons	0.31	0.27	0.25	0.49	0.45
Cottonseed meal, tons	--	--	--	0.08	0.08
Urea, tons (281% feed grade)	0.03	0.02	0.02	0.01	0.01
Pasture, cow acre days					
Forage period II	--	--	--	60.4	30.7
Forage Period III	--	--	--	43.6	30.7
Forage period IV	--	--	--	--	16.6
Salt, tons	0.03	0.02	0.02	0.04	0.03
Dicalcium phosphate, tons	0.01	0.01	0.01	0.02	0.02
<u>Heifers</u>					
Corn grain, bushels	9.36	16.96	44.88	9.59	21.88
Corn silage, tons (air dry matter)	1.09	0.88	--	0.32	--
Alfalfa hay, tons	0.26	0.23	0.23	0.46	0.44
Cottonseed meal, tons	--	--	--	0.08	0.08
Urea, tons (281% feed grade)	0.02	0.02	0.02	0.01	0.01
Pasture, cow acre days					
Forage period II	--	--	--	60.4	30.2
Forage period III	--	--	--	50.6	29.8
Salt, tons	0.02	0.02	0.02	0.03	0.03
Dicalcium phosphate, tons	0.01	0.01	0.01	0.01	0.01

Purchase prices for steers and heifers were assumed to be \$27.26 and \$23.35 per hundred pounds, respectively. These prices were the average price paid for Good grade cattle in organized feeder calf sales in Tennessee during the Fall of 1965 and 1966 [45]. Slaughter prices were \$25.03 and \$23.98 per hundred pounds for steers and heifers, respectively. These prices were averages of prices paid for USDA Choice grade cattle on seven markets (Chicago, Omaha, Sioux City, Kansas City, National Stock Yards, South St. Joseph, and Denver) during the calendar years of 1966 and 1967 [41, p. 54]. Since the average slaughter price for heifers was much closer to the average slaughter price for steers (a difference of \$1.05 per hundred pounds) than the feeder price (a difference of \$3.91 per hundred pounds), then heifers had a more favorable buying and selling margin than steers.

Labor requirements for each system are listed in Table V. Two publications were used in arriving at estimates for labor by period for each of the beef cattle finishing systems [22, 28]. The 450-head size farm feedlot was used to calculate requirements in this study. A Kansas study found only a small reduction in costs per unit of gain for non-feed costs beyond a 280-head size farm feedlot; hence, results utilizing the 450-head size farm feedlot have a broad spectrum of applicability. The labor requirements were prorated into periods based on data in the Tennessee publication [22].

Non-feed production expenses were based on the Kansas study with appropriate adjustments for price and area differences [28]. A summary of receipts and expenses for each system is contained in Table VI.

TABLE V
LABOR REQUIRED PER ANIMAL BY LABOR PERIOD FOR 450-HEAD
BEEF CATTLE FINISHING SYSTEMS

	Systems				
	1	2	3	4	5
	----- Hours -----				
<u>Steers</u>					
Period 1	1.50	1.50	1.50	1.50	1.50
Period 2	1.01	1.01	1.01	0.45	0.45
Period 3	0.78	0.78	0.76	0.35	0.51
Period 4	1.00	0.30	--	0.97	0.75
Period 5	--	--	--	1.00	0.96
Period 6	0.75	0.75	0.75	0.75	0.75
<u>Heifers</u>					
Period 1	1.50	1.50	1.50	1.50	1.50
Period 2	1.01	1.01	1.01	0.45	0.45
Period 3	0.78	0.48	0.32	0.35	0.51
Period 4	0.15	--	--	0.98	0.85
Period 5	--	--	--	0.40	0.04
Period 6	0.75	0.75	0.75	0.75	0.75

TABLE VI

SUMMARY OF RECEIPTS, PRODUCTION EXPENSES, FIXED EXPENSES, RETURNS, AND CAPITAL REQUIREMENTS PER HEAD FOR 450-HEAD BEEF CATTLE FINISHING SYSTEMS

	Steer Systems				
	1	2	3	4	5
Total Receipts ^a (less shrinkage)	\$242.79	\$242.79	\$242.79	\$242.79	\$242.79
Production Expenses (variable)					
Feeder animals ^b	136.30	136.30	136.30	136.30	136.30
Veterinary expense ^c	0.85	0.85	0.85	0.85	0.85
Electricity expense ^c	0.62	0.62	0.62	0.62	0.62
Fuel expense ^c	1.15	1.15	1.15	1.15	1.15
Insecticide expense ^c	0.50	0.50	0.50	0.50	0.50
Death loss ^c	1.65	1.65	1.65	1.65	1.65
Insurance on cattle ^c	4.12	4.12	4.12	4.12	4.12
Trucking ^d	2.81	2.81	2.81	2.81	2.81
Purchased feeds and related items ^e	4.90	3.94	3.63	10.89	10.26
Total variable expenses	152.90	151.94	151.63	158.89	158.26
Interest Items (variable)					
Cattle purchase ^f	6.68	5.78	5.33	8.18	7.78
Purchased feed and implants ^g	0.10	0.08	0.07	0.22	0.20
Raised feeds					
Hay ^h	0.31	0.27	0.25	0.48	0.45
Corn grain (56 lb./bu.) ⁱ	0.37	0.76	2.17	1.30	1.46
Corn silage ^j	1.15	0.81	--	1.16	--
Fixed expenses	6.31	6.31	6.31	6.31	6.31
Total expenses	167.82	165.95	165.76	176.54	174.46
Net returns ^k	74.97	76.84	77.03	66.25	68.33
Operating capital	145.61	128.42	130.38	171.61	164.82

TABLE VI (Continued)

	Heifer Steers Systems				
	1	2	3	4	5
<u>Total Receipts (less shrinkage)</u>	\$197.72	\$197.72	\$197.72	\$197.72	\$197.72
<u>Production Expenses (variable)</u>					
Feeder animals	105.08	105.08	105.08	105.08	105.08
Veterinary expense	0.85	0.85	0.85	0.85	0.85
Electricity expense	0.62	0.62	0.62	0.62	0.62
Fuel expense	1.15	1.15	1.15	1.15	1.15
Insecticide expense	0.50	0.50	0.50	0.50	0.50
Death loss	1.65	1.65	1.65	1.65	1.65
Insurance on cattle	4.12	4.12	4.12	4.12	4.12
Trucking	2.44	2.44	2.44	2.44	2.44
Purchased feeds and related items	3.81	3.28	3.20	10.21	9.86
Total variable expenses	120.22	119.69	119.61	126.62	126.27
<u>Interest items (variable)</u>					
Cattle purchase	4.27	3.80	3.66	5.63	5.23
Purchased feed and implants	0.08	0.07	0.05	0.20	0.20
<u>Raised feeds</u>					
Hay	0.26	0.23	0.22	0.46	0.43
Corn grain (56 lb./bu.)	0.35	0.64	1.68	0.48	0.11
Corn silage	0.86	0.70	--	0.14	--
Fixed expenses	6.31	6.31	6.31	6.31	6.31
Total expenses	132.35	131.44	131.53	139.98	138.55
Net returns	65.37	66.28	66.19	57.74	59.17
Operating capital	96.90	90.51	93.89	115.19	115.94

TABLE VI (Continued)

- ^aSteers @ \$25.03/cwt for 436,500 pounds; heifers @ \$23.98/cwt for 371,025 pounds.
- ^bSteers @ \$27.26/cwt for 225,000 pounds; heifers @ \$23.35/cwt for 202,500 pounds.
- ^cAdapted from McCoy, J. H., and Wakefield, H. D., Economies of Scale in Farm Cattle Feedlots of Kansas--An Analysis of Nonfeed Costs, Kansas Agricultural Experiment Station Technical Bulletin 145 (1966).
- ^d\$0.25/cwt/100 miles, average market distance = 75 miles.
- ^eUrea, \$88/ton; limestone, \$13/ton; cottonseed meal, \$100/ton; salt, \$30/ton; dicalcium phosphate, \$80/ton; and stilbestrol implants, \$0.10 each.
- ^fPurchase price at 6 percent for length of feeding period plus 30 days.
- ^gTotal purchased @ 6 percent for 4 months.
- ^hAt \$31.35/ton @ 6 percent for 6.3 months (alfalfa equivalent).
- ⁱAt \$1.19/bu. @ 6 percent for 6.3 months, except 8.4 months for Systems 4 and 5.
- ^jAt \$26.4/ton of air dry matter @ 6 percent for 6 months, except 4 months for System 4.
- ^kNet returns to land, labor, management, and intermediate ration components.

Investment requirements for the beef cattle finishing systems in this study were adopted from the Kansas study and are shown in Table VII. Cattle were assumed to be fed in the open, since beef feeding experiments have shown that no added economic benefits were gained by providing cattle on feed shelter from the weather [29].

C. OTHER LIVESTOCK ENTERPRISES

A set of unpublished budgets provided the majority of the data for the two swine systems, the beef cow-calf system, and the manufacturing milk production system which were included as potential activities in each of the three areas [24, pp. 40-41, 50-58]. Only minor adjustments were made to permit use of farm produced feeds and to reflect price changes since these budgets were assembled.

Swine Production

Production was assumed to be in 12-sow herd units. The Swine I alternative involved production of market hogs averaging 210 pounds in weight. The market hog and cull sow prices were assumed to be \$16.00 and \$12.00 per hundred pounds, respectively. Each 12-sow unit required 3 acres of pasture on Soil Group 3 and 3 acres of pasture on Soil Group 4.

The swine II alternative permitted the production of feeder pigs in 12-sow units to be sold at an average weight of 40 pounds and an average price of \$12.00 per head. Cull sows were sold at the same price as in swine I. Each 12-sow unit was allowed 1.5 acres of pasture on Soil Group 3 and 1.5 acres of pasture on Soil Group 4.

TABLE VII

INVESTMENT, DEPRECIATION, AND ANNUAL COST OF EQUIPMENT
REQUIRED FOR A 450-HEAD BEEF CATTLE FEEDLOT

Item	Average Value	Depreciation	Repairs and Maintenance	Interest
Grain bin	\$1,500.00	\$150.00	\$38.95	\$90.00
Hay shed	1,200.00	80.00	26.67	72.00
Upright silo	2,000.00	67.00	6.70	120.00
Trench silo	500.00	25.00	15.00	30.00
Storage-other feeds	153.00	15.30	1.53	9.18
Machine shed	360.00	24.00	8.00	21.60
Tractor	900.00	60.00	60.00	54.00
Manure spreader	300.00	30.00	10.00	18.00
Roller-crimper	360.00	36.00	12.00	21.60
Feed wagon (power box)	600.00	75.00	25.00	36.00
Truck (ordinary)	750.00	150.00	50.00	45.00
Pickup	450.00	90.00	30.00	27.00
Tractor loader	180.00	36.00	12.00	10.80
Portable elevator	180.00	36.00	12.00	10.80
Silage blower	300.00	30.00	10.00	18.00
Portable auger	240.00	24.00	8.00	14.40
Cattle spray equipment	120.00	12.00	4.00	7.20
Feed bunks (fence line)	990.00	49.50	4.95	59.40
Fence	600.00	60.00	30.00	36.00
Concrete aprons	1,100.00	36.67	3.67	66.00
Cattle chute	70.00	7.00	7.00	4.20
Oilers	270.00	90.00	45.00	16.20
Water facilities	450.00	45.00	22.50	27.00
Miscellaneous	250.00	25.00	5.00	15.00
Total ^a	\$13,823.00	\$1,253.47	\$447.97	\$829.38

^aInsurance and taxes were estimated to be \$308.69 per year.

Source: Adapted from McCoy, J. H., and Wakefield, H. D., Economies of Scale in Farm Cattle Feedlots of Kansas--An Analysis of Nonfeed Costs, Kansas Agricultural Experiment Station Technical Bulletin 145, 1966.

Beef Cow-Calf Production

Production of weanling feeder calves was the only beef cow-calf alternative considered in this study. Calves were assumed to have an average birth date of February 15, to have gained an average of 1.80 pounds per day to weaning, and to have been sold in October weighing an average of 462 pounds at a price of \$25.96 per hundred pounds. A 90 percent calf crop, less replacement heifers, resulted in 18 feeders being sold from a 25-cow unit. Cull cows were assumed to be sold for \$15.00 per hundred pounds.

Dairy Production

The production of manufacturing milk was considered as an alternative with calculations based on units of 10 cows each. Average production per cow was assumed to be 7,500 pounds of 4 percent milk sold at an average price of \$3.50 per hundred pounds.

D. CROP ENTERPRISES

Row Crops and Grains

Production expenses, capital requirements, and labor requirements for most enterprises were obtained from a set of unpublished crop enterprise budgets [24, pp. 1-9]. The three sizes of farms considered in this study are similar to sizes 2, 3, and 4 in the budgets prepared by Keller and Lard. The burley tobacco budget for Area II was adapted from the set of budgets published by Hudson and Ray. The same coefficients were used for the different size farms [22, p. 12]. Yield

estimates by area and soil capability are included in Tables VIII, IX, and X were obtained from published experiment station data [1, 2, 14, 15, 16]. The West Tennessee Experiment Station was used as the yield guide for Area I; the Middle Tennessee Experiment Station was used as the guide for Area II; and the Plateau Experiment Station was used as a guide for Area III.

An average of the appropriate variety trials, excluding experimental varieties, was used as the yield estimate for a given crop on the given soil under good management conditions for the respective area under consideration [17]. In some cases unpublished sources were utilized to obtain yield estimates [5, 8, 10].

A budget for corn silage production is included in Table XI. Yields per acre for corn silage by area and soil capability were obtained using the following conversion factor:

$$\begin{array}{l} \text{Tons of corn silage} \\ \text{(air dry matter)} \end{array} = 2.8 \times \text{tons of corn grain [3, 13].}$$

Seven percent of the calculated corn silage yield was deducted as an allowance for spoilage and waste. Labor requirements for production of an acre of corn silage by period and farm size are shown in Table XII.

Both buying corn and selling corn were permitted alternatives. It was assumed that corn could be purchased for \$1.25 per bushel or sold for \$1.19 per bushel. Other prices assumed in this study were: lint cotton, \$0.26 per pound; cottonseed, \$0.0225 per pound; soybeans, \$2.50 per bushel; oats, \$0.80 per bushel; and tobacco, \$0.60 per pound. In Area I the cotton allotment was assumed to be equal to 10 percent of

TABLE VIII
ESTIMATED YIELDS PER ACRE FOR CROP ENTERPRISES BY SOIL GROUP -- AREA I

Crop	Unit	Soil Group					
		1	2	3	4	5	6
Cotton	Pounds, lint	770	700	575	-- ^a	--	--
Corn	Bushels	89	80	65	--	44	--
Soybeans	Bushels	38	35	29	--	--	--
Oats	Bushels	--	60	50	38	--	--
Corn silage	Tons, air dry matter	6.513	5.833	4.739	--	3.208	--
Alfalfa hay	Tons	--	3.9	3.4	2.9	--	--
Orchardgrass-red clover hay	Tons	--	2.7	1.9	1.2	--	--
Lespedeza hay	Tons	--	1.7	1.6	1.2	1.6	--
Orchardgrass-ladino clover pasture	CAD ^b	--	138	129	111	--	--
Fescue-ladino clover pasture	CAD	--	145	131	126	134	70
Bermuda-ladino clover pasture	CAD	162	162	144	100	105	70
Lespedeza pasture	CAD	--	91	85	64	85	--

^aBecause of prevailing economic or physical relationships, certain crop-soil capability alternatives were not permitted to enter the matrix as potential solution alternatives.

^bCAD = cow acre days. This term attempts to quantify the production of forage in the form of pasture. Each CAD is assumed to be equivalent to 25 pounds of dry matter.

TABLE IX
ESTIMATED YIELDS PER ACRE FOR CROP ENTERPRISES BY SOIL GROUP -- AREA II

Crop	Unit	Soil Group					
		1	2	3	4	5	6
Tobacco	Pounds	2,276	-- ^a	--	--	--	--
Corn	Bushels	79	71	58	--	39	--
Soybeans	Bushels	40	36	29	--	--	--
Oats	Bushels	--	49	40	30	--	--
Corn silage	Tons, air dry matter	5.781	5.176	4.229	--	2.844	--
Alfalfa hay	Tons	--	3.9	3.4	2.9	--	--
Orchardgrass-red clover hay	Tons	--	2.0	1.4	1.0	--	--
Lespedeza hay	Tons	--	1.7	1.6	1.2	1.6	--
Orchardgrass-ladino clover pasture	CAD ^b	--	130	120	110	--	--
Fescue-ladino clover pasture	CAD	--	140	128	123	130	70
Lespedeza pasture	CAD	--	91	85	64	85	--

^aBecause of prevailing economic or physical relationships, certain crop-soil capability alternatives were not permitted to enter the matrix as potential solution alternatives.

^bCAD = cow acre days. This term attempts to quantify the production of forage in the form of pasture. Each CAD is assumed to be equivalent to 25 pounds of air dry matter.

TABLE X
ESTIMATED YIELDS PER ACRE FOR CROP ENTERPRISES BY SOIL GROUP -- AREA III

Crop	Unit	Soil Group					
		1	2	3	4	5	6
Corn	Bushels	86	77	63	-- ^a	43	--
Corn silage	Tons, air dry matter	6.293	5.614	4.593	--	3.135	--
Alfalfa hay	Tons	--	2.9	2.8	2.5	--	--
Orchardgrass-red clover hay	Tons	--	3.0	2.5	2.0	--	--
Orchardgrass-ladino clover pasture	CAD ^b	--	120	110	100	--	--
Fescue-ladino clover pasture	CAD	--	125	111	107	105	70

^a Because of prevailing economic or physical relationships, certain crop-soil capability alternatives were not permitted to enter the matrix as potential solution alternatives.

^b CAD = cow acre days. This term attempts to quantify the production of forage in the form of pasture. Each CAD is assumed to be equivalent to 25 pounds of dry matter.

TABLE XI

ESTIMATED COSTS BY SIZE OF FARM FOR PRODUCING ONE ACRE
OF CORN SILAGE ON SOIL 2 IN AREA I

Items	Size of Farm		
	Small	Medium	Large
<u>Variable Expenses</u>			
Seed-15 lb. @ \$0.18	\$ 2.70 ^a	\$ 2.70 ^a	\$ 2.70 ^a
Fertilizer			
Nitrogen - 120 lb. @ 0.12	14.40 ^a	14.40 ^a	14.40 ^a
Phosphorous - 70 lb. @ \$0.07	4.90 ^a	4.90 ^a	4.90 ^a
Potash - 130 lb. @ \$0.06	7.80 ^a	7.80 ^a	7.80 ^a
Lime - 0.25 ton @ \$5.00	1.25 ^a	1.25 ^a	1.25 ^a
Atrazine - 2.5 lb. @ \$3.00	--	7.50 ^b	7.50 ^b
Custom harvest @ \$7.766 per ton air dry matter	45.30	45.30	--
Tractor	9.04	7.10	6.69
Other equipment	3.63	2.12	11.33
Interest	0.93	1.08	1.08
Total variable expense	89.95	94.15	57.65
<u>Fixed Expenses</u>			
Tractor	1.45	1.28	1.14
Other equipment	1.08	0.63	2.94
Total fixed expense	2.53	1.91	4.08
Total production expenses	92.48	96.06	61.73
Annual capital	15.50	18.00	18.00
Investment capital	42.17	31.83	68.00

^aInterest charged @ 6 percent for 6 months.

^bInterest charged @ 6 percent for 4 months.

TABLE XII
ESTIMATED LABOR REQUIREMENTS BY SIZE OF FARM FOR
PRODUCING ONE ACRE OF CORN SILAGE

Labor period	Size of Farm		
	Small	Medium	Large
	----- Hours -----		
1	0.6	0.5	0.4
2	2.2	1.8	1.5
3	1.8	1.8	1.4
4	2.2	0.8	0.5
5	3.5	3.0	13.9
6	--	--	--

CRANES & CREST

the openland acreage. In Area II the tobacco allotment was assumed to be 0.5 percent of the openland acreage.

Forage Production Enterprises

Yields for various pasture production alternatives were expressed in terms of Cow Acre Days (CAD) and were derived from several sources [1, 2, 5, 7, 10]. Production expenses, capital requirements, and labor requirements were obtained from the unpublished budgets [24, pp. 10-28, 32-39].

Total forage production was divided into five periods in order to reflect the seasonal nature of pasture production. The percentages of total production by forage period are shown in Table XIII. The same values were used for Areas I and II, but adjusted for Area III because of the climatic differences between these areas. An activity was included in each forage period which permitted the forage produce to be harvested as hay. Each CAD was assumed to product 17.8 pounds of air dry hay.

All hays were converted to a common alfalfa equivalent using conversion factors of 0.85 for orchardgrass-red clover hay, 0.80 for lespedeza hay, and 0.75 for grass hay. Hay buying and selling was permitted in most of the situations analyzed. Hay expressed in alfalfa equivalents could be purchased for \$33.00 per ton or sold for \$31.35 per ton.

TABLE XIII
PERCENTAGE DISTRIBUTION OF FORAGE PRODUCTION BY FORAGE PERIOD AND AREA

Forage Period	Area I and II				Area III		
	Orchard- grass Ladino Clover	Fescue Ladino Clover	Lespedeza After Oats	Lespedeza Alone	Orchard- grass Ladino Clover	Fescue Ladino Clover	
I Nov. 16-Mar. 15	11	15	0	0	6	15	
II Mar. 16-May 31	41	52	0	3	36	42	
III June 1-July 31	26	10	47	47	31	15	
IV Aug. 1-Sept. 30	13	11	42	42	18	16	
V Oct. 1-Nov. 15	9	12	11	8	9	12	

Source: Adapted from Gerald Vincent Eagan, "Minimum Land Requirements for Specified Levels of Farm Income in the Eastern Highland Rim Area of Tennessee," unpublished M.S. thesis, University of Tennessee (1966).

CHAPTER V

RESULTS AND DISCUSSION OF THE PRIMARY ANALYSIS

In this chapter the optimum farming systems with and without inclusion of beef feeding as a production alternative are compared. Particular attention is given to comparing farm income, farm organization, and value of restricting resources in the various situations studied.

A. AREA I

Maximum Potential Income

General considerations. While there are other variables which might be maximized, net farm income offers the most useful overall evaluator of the desirability of organizing a given set of scarce resources in any given manner. As shown in Table XIV, introduction of beef cattle feeding systems as alternative enterprises resulted in an increase in net income to land, labor, and management for all the resource situations considered in Area I when capital was charged at an annual rate of 6 percent. Absolute increases in income ranged from \$6 on a Large farm with a 1-man labor supply to \$3,338 on a Small size farm with a 3-man labor supply. However, providing swine pasture on Soil Groups 3 and 4 contributed to the magnitude of the larger increase. Each of the swine production alternatives required a fixed amount of pasture from Soil Groups 3 and 4, respectively. Since both buying and

TABLE XIV

MAXIMUM POTENTIAL INCOME^a BY SIZE OF LABOR SUPPLY AND FARM SIZE
WITH AND WITHOUT BEEF FEEDING - AREA I

	With Beef Feeding	Without Beef Feeding	Increase with Beef Feeding	
			Total	Percent
<u>1-man labor</u>				
Small ^b	\$ 7,581	\$ 6,370	\$1,210	19.0
Medium ^b	9,250	8,488	762	9.0
Large ^b	12,608	12,602	6	0.0
<u>2-man labor</u>				
Small	11,159	10,015	1,143	11.4
Medium	15,891	13,611	2,280	16.8
Large	19,692	19,437	255	1.3
<u>3-man labor</u>				
Small	13,436	10,098	3,338	33.1
Medium	20,262	18,478	1,784	9.6
Large	26,055	25,535	520	2.0

^aIncome to land, labor, and management. Capital is charged at a market rate of 6 percent.

^bSmall = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

selling corn grain was permitted and swine enterprises are large users of corn grain, swine production became an efficient user of labor, especially when basic land resources were limiting.

The largest absolute increase in income from beef feeding was \$2,280 and occurred with a 2-man labor supply on a Medium size farm. The largest proportionate increase (19.0 percent) in income was on a Small farm with a 1-man labor supply

Size of labor supply. In all the resource situations observed the total income increased as the size of labor supply was increased. The addition of the third worker to a Small farm without beef feeding resulted in an increase of only \$83.01 in total income. Total returns to each additional unit of labor were increasing at a decreasing rate.

The respective marginal values of the second and third unit of labor for the various sizes of farm with beef feeding were: Small, \$3,578 and \$2,278; Medium, \$6,641 and \$4,371; and Large, \$7,084 and \$6,363.

The marginal value of the second worker on a Medium size farm was \$1,518 greater with beef feeding than when beef feeding was not permitted. Beef feeding appeared to be more effective in increasing income when the land:labor ratios were relatively small. As the number of acres of land per unit of labor measured in man years exceeded 250, the improvement in income resulting from adding beef feeding as an alternative was very small (Table XIV).

Size of farm. Income increased at a decreasing rate in this area as farm size increased and size of labor remained unchanged. There were, however, discernible differences observed in the rate income increased with and without beef feeding. The increase in income resulting from increasing available acreages approached linearity on farms in this area with 1- and 2-man labor supplies and no beef feeding. Both on an absolute and a percentage basis, farm incomes on Small and Medium size farms were increased more by beef feeding than farm incomes on Large size farms. This was probably due to the assumed increases in labor efficiency for crop production activities as farm size increased; whereas, beef feeding coefficients were based on a feedlot size of 450 head regardless of the amount of openland available.

Cost of annual capital. Since beef feeding requires large amounts of annual capital, optimum systems were derived with annual capital charged at 9 and 12 percent as well as the base rate of 6 percent. The higher rates were considered to reflect risks associated with the large capital outlay required for beef feeding alternatives. The improvements in income potential resulting from inclusion of beef cattle feeding alternatives at the three costs of annual capital are included in Table XV. No improvement in income was obtained for Large size farms when annual capital costs were at 9 and 12 percent.

The reason for the sensitivity of the beef cattle feeding enterprises to the annual capital charge becomes clear upon examining

TABLE XV

INCREASE IN OPTIMUM INCOME^a WITH BEEF CATTLE FEEDING BY COST OF ANNUAL CAPITAL,
LABOR SUPPLY, AND FARM SIZE -- AREA I

	Cost of Capital					
	6 Percent		9 Percent		12 Percent	
	Total	Percent	Total	Percent	Total	Percent
<u>1-man labor</u>						
<u>Small^b</u>	\$1,210	19.0	\$ 872	14.0	\$ 515	8.4
Medium ^b	762	9.0	439	5.2	128	1.5
Large ^b	6	0.0	--	0.0	--	0.0
<u>2-man labor</u>						
<u>Small</u>	1,143	11.4	807	8.2	594	6.1
Medium	2,280	16.8	1,563	11.7	845	6.4
Large	255	1.3	--	0.0	--	0.0
<u>3-man labor</u>						
<u>Small</u>	3,338	33.1	2,529	25.5	1,839	18.8
Medium	1,784	9.6	1,178	6.6	685	3.9
Large	520	2.0	--	0.0	--	0.0

^a Income to land, labor, and management.

^b Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

the annual capital requirements shown in Table XVI. When beef cattle feeding was included in the optimum solution, annual capital requirements ranged from \$2,068 to \$32,749 greater than comparable non-beef feeding situations for respective income improvements of \$6 and \$1,784. Investment capital requirements ranged from \$82 to \$8,952 greater for farms with beef feeding than for farms without beef feeding (Table XVII). Compared to no beef feeding, requirements for investment capital increased considerably less than requirements for annual capital in all cases when beef feeding centered the optimum product mix.

Farm Organization

Small size farm with beef feeding. Comparisons of the optimum organizations for a Small farm with and without beef feeding alternatives are shown in Table XVIII. Labor supply was varied at 1-, 2-, and 3-man levels while all capital was charged at 6 percent. Corn silage production increased in farms with beef feeding with increases in labor supply, alfalfa and lespedeza hay acreages declined, the amount of hay sold declined, and the amount of corn grain purchased increased. Oats for grain followed by lespedeza hay and cotton were included in the optimum organization only in the 1-man labor situation. With a cotton allotment of 10 acres, less than 8 acres was included for the 1-man labor supply while no cotton was included for the 2- and 3-man labor situations. The only livestock included for a 1-man labor supply was 158 head of beef heifers finished on System 2. With a 2-man labor supply the optimum

TABLE XVI

ANNUAL CAPITAL REQUIREMENTS BY SIZE OF FARM, SIZE OF LABOR SUPPLY, AND COST
OF ANNUAL CAPITAL WITH AND WITHOUT BEEF FEEDING -- AREA I

	With Beef Feeding			Without Beef Feeding		
	6 Percent	9 Percent	12 Percent	6 Percent	9 Percent	12 Percent
<u>Small^a</u>						
1-man	\$15,643	\$15,640	\$14,420	\$4,722	\$3,986	\$3,090
2-man	22,922	12,511	12,251	5,263	5,263	5,263
3-man	32,652	31,856	28,308	5,516	5,516	5,516
<u>Medium^a</u>						
1-man	12,237	12,237	10,230	1,487	1,487	1,487
2-man	31,452	31,452	31,452	7,536	7,536	5,879
3-man	49,428	33,718	27,081	16,679	16,679	15,511
<u>Large^a</u>						
1-man	5,552	3,484	3,215	3,484	3,484	3,215
2-man	29,076	5,797	5,641	5,797	5,797	5,641
3-man	38,447	6,723	6,722	6,722	6,722	6,722

^a Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

TABLE XVII

INVESTMENT CAPITAL REQUIREMENTS BY STUDY AREA, SIZE OF FARM, AND SIZE OF LABOR
SUPPLY WITH AND WITHOUT BEEF FEEDING^a

	With Beef Feeding			Without Beef Feeding		
	Area I	Area II	Area III	Area I	Area II	Area III
Small^b						
1-man	\$ 8,090	\$ 7,763	\$ 8,367	\$ 6,998	\$ 5,260	\$ 8,051
2-man	16,176	15,828	16,673	13,609	15,377	17,002
3-man	23,248	23,242	24,348	14,296	20,378	24,445
Medium^b						
1-man	8,347	8,341	8,324	5,509	5,880	7,640
2-man	18,439	16,447	17,125	13,956	10,862	16,271
3-man	26,610	26,789	25,760	24,388	21,159	24,931
Large^b						
1-man	9,987	10,308	10,200	9,806	10,308	8,683
2-man	21,839	22,237	21,592	18,747	15,824	18,214
3-man	32,628	25,165	27,332	23,750	19,574	26,957

^a Capital is charged at a market rate of 6 percent.

^b Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

TABLE XVIII

OPTIMUM FARM ORGANIZATION^a BY SIZE OF LABOR SUPPLY FOR A SMALL SIZE FARM
WITH AND WITHOUT BEEF FEEDING -- AREA I

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
Crop Enterprises, acres						
Cotton	7.8	--	--	3.3	7.1	10.0
Corn	--	--	--	8.2	1.7	--
Corn silage	24.3	28.9	41.6	--	--	--
Soybeans	--	--	--	24.9	--	--
Oats-lespedeza hay	15.6	--	--	--	--	--
Alfalfa hay	41.5	40.6	33.1	27.9	50.7	59.5
Lespedeza hay	5.2	--	--	14.8	5.2	--
Fescue-ladino pasture	--	5.2	--	--	--	9.2
Lespedeza pasture	--	--	--	--	--	1.6
Livestock Enterprises						
Manufacturing milk, cows	--	--	--	--	--	2
Swine I, b sows	--	32	--	22	--	--
Swine II, b sows	--	15	79	--	79	79
Beef feeding I, c head	--	155	--	--	--	--
Beef feeding II, c head	158	--	252	--	--	--
Beef feeding III, c head	--	--	48	--	--	--
Beef feeding V, c head	--	2	--	--	--	--

TABLE XVIII (Continued)

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Buying and Selling Activities</u>						
Sell hay, tons	124.9	114.1	56.6	127.7	237.2	225.0
Buy corn, bushels	2,672	8,136	10,046	3,450	3,498	3,679

^aCapital is charged at a market rate of 6 percent. Small size = 100 acres of openland.

^bSwine I is production of market hogs; Swine II is production of feeder pigs.

^cBeef feeding I, II, III, and V are feeding beef heifers on finishing Systems 1, 2, 3, and 5, respectively.

farm organization included 155 heifers finished with System 1, 32 sows producing market hogs, and 15 sows producing feeder pigs. Addition of the third man resulted in production of corn silage and alfalfa hay crops, 79 sows producing feeder pigs, 252 beef heifers finished on System 2, and 48 beef heifers finished on System 3. Thus, optimum farm organization on a Small farm with beef feeding included mainly livestock enterprises as income producers with relatively small quantities of hay grown for sale. Livestock increased in importance as the land:labor ratio decreased. Purchase of corn for feeding beef heifers and hogs was quite extensive, especially for the 3-man labor situation.

Small size farm without beef feeding. When beef feeding alternatives were excluded cotton, soybeans, hogs, and hay sales were the important sources of income with a 1-man labor supply. As the labor supply was increased to two men, cotton production increased but cotton acreages remained less than the allotment, corn production decreased, soybeans were not included, alfalfa hay increased, lespedeza hay decreased, hay sold increased, and swine production involved selling feeder pigs rather than market hogs. Sow numbers increased from 22 to 79. Little of the additional labor made available by adding the third man was utilized because all available land was expended.

Medium size farm with beef feeding. Cotton, corn silage, soybeans, oats for grain-lespedeza for hay, alfalfa hay, feeding beef heifers on System 1, selling hay, and buying corn were activities appearing in the optimum solution for a 1-man labor supply (Table XIX).

TABLE XIX

OPTIMUM FARM ORGANIZATION^a BY SIZE OF LABOR SUPPLY FOR A MEDIUM SIZE FARM
WITH AND WITHOUT BEEF FEEDING -- AREA I

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Crop Enterprises, acres</u>						
Cotton	25.0	25.0	2.4	25.0	25.0	25.0
Corn silage	17.7	47.2	88.7	--	--	--
Soybeans	48.4	18.9	--	66.1	66.1	66.1
Oats-lespedeza hay	11.1	34.8	48.4	--	--	--
Alfalfa hay	22.4	70.6	80.4	39.6	69.7	69.7
Lespedeza hay	--	--	13.0	12.6	21.3	14.8
<u>Livestock Enterprises</u>						
Swine I, ^b sows	--	--	--	--	31	83
Swine II, ^b sows	--	--	13	--	--	--
Beef feeding I, ^c head	117	314	407	--	--	--
Beef feeding II, ^c head	--	--	62	--	--	--
<u>Buying and Selling Activities</u>						
Sell hay, tons	59.9	201.2	203.9	171.5	299.1	290.8
Buy corn, bushels	1,995	5,322	5,509	--	5,790	15,317

^aCapital is charged at a market rate of 6 percent. Medium Size = 250 acres of openland.

^bSwine I is production of market hogs; Swine II is production of feeder pigs.

^cBeef feeding I and II are feeding beef weifers on finishing Systems 1 and 2, respectively.

The 25-acre cotton allotment was completely used with labor supplies of one and two men, but only 2.4 acres of cotton were included in the solution for a 3-man labor supply. Corn silage acreages were 17.7, 47.2, and 88.7, respectively, for the 1-, 2-, and 3-man labor situations. Alfalfa hay production increased as the labor supply increased. Beef heifer feeding on System 1 also increased with the labor supply. With a labor supply of three men, 62 head of beef heifers were fed on System 2 and 13 sows were used to produce feeder pigs. The amount of hay sold and corn purchased increased substantially as the second labor unit was added but changed little with the addition of the third unit of labor.

Medium size farm without beef feeding. Cotton, soybeans, alfalfa hay, and lespedeza hay were produced in all three labor situations. The production of alfalfa and lespedeza hay increased when the second unit of labor was added. Lespedeza hay production decreased with addition of the third unit of labor while alfalfa hay remained unchanged. Neither livestock production nor corn buying occurred with a 1-man labor supply. As the labor supply was increased to two and three men, production of market hogs and the amount of corn purchased increased substantially. Hay sold increased considerably with the second unit of labor and decreased slightly with the third unit of labor.

Large size farm with beef feeding. A farm of this size (600 acres of openland) with only a 1-man labor supply is an unlikely situation, but was retained for comparative purposes. Enterprises selected

were those which were efficient in the utilization of labor, especially in the critical labor periods. With a 1-man labor supply, enterprises included in the optimum system were: cotton, corn, soybeans, oats-lespedeza hay, fescue-ladino clover pasture, beef heifers fed on System 5, selling hay, and selling corn (Table XX). Corn silage was not included probably due to its relatively high labor requirements in Labor Period 5 (Table XII, page 43). Labor requirements for corn silage were based on the assumption that the farmer would own the equipment for harvesting and that no additional hired labor was available. Although Area I, as well as the entire state of Tennessee, is generally considered a corn deficit area, these results indicate that the more efficient, larger farmers may advantageously sell, rather than buy, corn grain. The optimum systems for the smaller farms discussed earlier included corn buying rather than corn selling.

As the labor supply was increased to two men, cotton production was the same, corn production increased, soybean acreage decreased, oats-lespedeza hay production remained about the same, production of alfalfa and lespedeza hay production began, fescue-ladino pasture was deleted, and orchardgrass- and bermuda-ladino clover pastures entered the optimum solution. The number of beef heifers fed on System 5 increased from 19 to 203 head, the hay tonnage sold increased, and the corn sold decreased.

Addition of the third man resulted in an increase in corn grain, oats-lespedeza hay, alfalfa hay acreages; entry of corn silage, fescue-ladino clover pasture, and lespedeza pasture activities; and no change

TABLE XX

OPTIMUM FARM ORGANIZATION^a BY SIZE OF LABOR SUPPLY FOR A LARGE SIZE FARM
WITH AND WITHOUT BEEF FEEDING -- AREA I

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Crop Enterprises, acres</u>						
Cotton	60.0	60.0	60.0	60.0	60.0	60.0
Corn	81.6	113.2	152.6	88.4	158.4	151.7
Corn silage	--	--	5.8	--	--	--
Soybeans	55.4	45.2	--	52.8	45.2	6.7
Oats-lespedeza hay	12.0	10.6	62.7	13.8	27.3	33.4
Alfalfa hay	--	32.1	98.8	--	64.0	133.6
Lespedeza hay	--	89.0	72.1	--	97.4	121.7
Fescue-ladino pasture	41.0	--	6.9	46.9	--	--
Orchardgrass-ladino pasture	--	90.5	31.1	--	--	--
Burmuda-ladino pasture	--	50.4	--	--	--	--
Lespedeza pasture	--	--	24.4	--	49.7	--
<u>Livestock Enterprises</u>						
Beef feeding II, ^b head	--	--	43	--	--	--
Beef feeding III, ^b head	--	--	206	--	--	--
Beef feeding V, ^b head	19	203	71	--	--	--
<u>Buying and Selling Activities</u>						
Sell hay, tons	23.2	208.2	408.2	44.9	407.9	677.9
Sell corn, bushels	6,107	4,613	--	7,073	11,994	11,556

^aCapital is charged at a market rate of 6 percent. Large size = 600 acres of openland.

^bBeef feeding II, III, and V are feeding beef heifers on finishing Systems 2, 3, and 5, respectively.

in cotton acreage. Beef feeding on System 5 declined from 203 to 71 head, but beef feeding on Systems 2 and 3 entered the solution with 43 and 206 head, respectively. Hay selling increased and corn was neither bought nor sold.

Large size farm without beef feeding. No livestock production was included in the optimum systems for any of the three labor situations utilized. Cotton acreage was included at the maximum of the allotment in each case. Hay tonnages sold were 44.9, 407.9, and 677.9 for 1-, 2-, and 3-man labor supplies, respectively. Bushels of corn sold increased from 7,073 to 11,994 with the second unit of labor and then declined slightly with the third unit of labor. Soybean production declined as the labor supply was increased.

Value of Restricting Resources

General comments. Solution of the income maximization primal simultaneously provides the solution to the maximization dual. The dual solution determines the value or "shadow price" of an additional unit for each of the restricting resources. These values are often referred to as marginal value products. If a resource is not limiting, then its "shadow price" is zero. Values determined from the dual do not indicate the range of resource quantity for which this shadow price would be stable.

For example, suppose that the marginal value of an additional acre of a given soil group is found to be \$12. For the given production

period of 1 year, an additional acre of this soil group would have a value of \$12, assuming no discounting and the conditions of the model as formulated continued to hold.

Small size farm. In most instances the value of an additional unit of land was greater with beef feeding than without beef feeding (Table XXI). Generally, the marginal value of land increased as the land:labor ratio decreased. For example, the marginal value product for Soil Group 1 was about \$70 per acre with a 1-man labor supply and about \$154 per acre with a 3-man labor supply. The extremely high value for Soil Group 4 in the 3-man labor situation (\$357.98) was the result of an indirect limitation of Soil Group 4 on swine production. Swine pasture was limited in the model to Soil Groups 3 and 4.

Labor was consistently limiting between March 1 and April 14 (Labor Period 2) in all labor supply situations with beef feeding. Without beef feeding labor tended to be more limiting between June 1 and September 30 (Labor Periods 4 and 5). Excess labor was available in all labor periods with a 3-man labor supply and without beef feeding. This was the only resource situation in which all available land was used.

The "shadow price" for corn was equal to the purchase price in each case. The values of an additional ton of corn silage expressed on the basis of a wet silage containing 33.3 percent air dry matter were \$9.07, \$9.54, and \$12.00 per ton for 1-, 2-, and 3-man labor supplies,

TABLE XXI

MARGINAL VALUE PRODUCTS FOR RESTRICTING RESOURCES BY SIZE OF LABOR SUPPLY
FOR A SMALL SIZE FARM WITH AND WITHOUT BEEF FEEDING^a -- AREA I

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
Land, per acre						
Soil group 1	\$70.13	\$82.90	\$153.70	\$50.21	\$ 66.87	\$ 90.30
Soil group 2	40.82	62.90	67.77	16.29	46.11	69.54
Row crop 2	8.55	3.88	64.28	13.16	--	--
Soil group 3	25.15	47.22	52.09	7.20	30.44	53.86
Row crop 3	--	--	45.16	7.25	--	--
Soil group 4	15.55	37.00	357.98	--	149.65	474.46
Soil group 5	2.22	5.12	48.50	7.20	4.12	18.72
Soil group 6	--	--	--	--	--	2.10
Labor, per hour						
Labor Period 2 (Mar. 1-Apr. 14)	8.51	11.07	2.95	--	--	--
Labor Period 3 (Apr. 15-May 31)	5.95	--	--	9.42	--	--
Labor Period 4 (June 1-Aug. 15)	--	--	--	1.98	2.12	--
Labor Period 5 (Aug. 16-Sept. 30)	0.96	--	--	4.36	5.86	--
Miscellaneous Values						
Corn, per bushel	1.25	1.25	1.25	1.25	1.25	1.25
Corn silage, per ton ^b	9.07	9.54	12.00	--	--	--
Cotton allotment, per acre	--	--	--	--	--	10.46

^aCapital is charged at a market rate of 6 percent. Small size = 100 acres of openland.

^bOn an as-fed basis.

respectively. This suggests that the size of the beef feeding operation would have been expanded if corn silage had been available for purchase, especially when the land:labor ratio was small. The cotton allotment was completely utilized only in the case of a 3-man labor supply with no beef feeding. The annual value of an additional acre of allotment was \$10.46.

Medium size farm. Addition of 150 acres in openland resulted in a general reduction of marginal values for land of various capabilities compared to the marginal value observed on a Small size farm (Table XXII). Soil groups continued to have higher "shadow prices" than row crop groups of the same soil capability when beef cattle were fed. However, row crop acreages were much more valuable than soil group acreages when beef cattle were not fed.

With beef feeding, labor was limiting between March 1 and May 31 and again between August 16 and September 30. Without beef feeding, labor was limiting from April 15 to May 31 and August 16 to September 30. Therefore, beef feeding permits utilization of some otherwise unused labor resources during Labor Period 2.

An additional ton of corn silage on an as-fed basis was worth between \$8.80 and \$9.13. An additional acre of cotton allotment was worth from \$5.97 to \$28.10 more annually when beef cattle were not fed than when they were fed. Marginal values for cotton allotments ranged from \$20.48 to \$29.35 per acre for those situations where cotton allotment was restrictive. Expressed in terms of marginal value per pound

TABLE XXII

MARGINAL VALUE PRODUCTS FOR RESTRICTING RESOURCES BY SIZE OF LABOR SUPPLY
FOR A MEDIUM SIZE FARM WITH AND WITHOUT BEEF FEEDING^a -- AREA I

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
Land, per acre						
Soil group 1	\$42.40	\$48.70	\$75.77	\$46.17	\$50.94	\$50.94
Soil group 2	--	15.59	41.21	--	9.52	9.52
Row crop 2	21.58	12.29	14.89	25.35	20.60	20.60
Soil group 3	--	--	25.62	--	--	--
Row crop 3	6.58	12.88	5.56	10.35	15.12	15.12
Soil group 4	--	--	16.02	--	--	--
Soil group 5	--	--	5.56	--	--	--
Labor, per hour						
Labor period 2 (Mar. 1-Apr. 14)	6.45	8.30	8.82	--	--	--
Labor period 3 (Apr. 15-May 31)	11.44	8.01	4.40	12.01	10.17	10.17
Labor period 5 (Aug. 16-Sept. 30)	6.99	5.30	0.42	8.19	7.14	7.14
Miscellaneous Values						
Corn, per bushel	1.25	1.25	1.25	1.19	1.25	1.25
Corn silage, per ton	8.80	8.72	9.13	--	--	--
Cotton allotment, per acre	23.42	20.48	--	29.35	28.10	28.10

^aCapital is charged at a market rate of 6 percent. Medium size = 250 acres of openland.

^bOn an as-fed basis.

of lint cotton, the range was from 2.9 to 4.2 cents. These values were somewhat lower than the lease value of 5.1 cents reported by Trevena and Keller in a survey of allotment buying and selling practices of 108 Tennessee cotton producers [40].

Large size farm. Returns to restricting resources on the Large size farm are shown in Table XXIII. Differences in marginal values for additional acreages between beef feeding and no beef feeding were small. For both situations only Soil Group 1 and Row Crop Group 2 were restricting with 1-man labor while all soil groups were restricting with a 3-man labor supply. In all instances except one, labor was limiting during Labor Periods 2 through 5 (March 1 through September 30).

Marginal values for corn are equal to the selling price of corn in all cases except a 3-man labor supply where no corn was sold. The marginal value of corn in this case was \$1.22 per bushel and all corn produced was used for feeding livestock. The value of an additional ton of corn silage on an as-fed basis ranged from \$9.20 to \$10.89 which was in the same general range as observed for Small and Medium size farms.

The value of an additional acre of cotton allotment ranged from \$34.07 to \$38.34 and was considerably higher than similar values on Small and Medium size farms. The marginal value of an additional pound of lint cotton ranged from 4.8 to 5.4 cents. This compares closely with the lease value of 5.1 cents found by Trevena and Keller in a study mentioned earlier [40].

TABLE XXIII

MARGINAL VALUE PRODUCTS FOR RESTRICTING RESOURCES BY SIZE OF LABOR SUPPLY
FOR A LARGE SIZE FARM WITH AND WITHOUT BEEF FEEDING^a -- AREA I

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
Land, per acre						
Soil group 1	\$35.76	\$41.84	\$46.87	\$35.76	\$44.37	\$45.38
Soil group 2	--	2.51	3.74	--	2.51	7.80
Row crop 2	15.00	18.58	21.59	15.00	21.10	16.82
Soil group 3	--	0.40	1.23	--	--	2.17
Row crop 3	--	4.54	5.86	--	5.76	4.60
Soil group 5	--	--	1.23	--	--	2.17
Labor, per hour						
Labor period 2 (Mar. 1-Apr. 14)	5.71	2.18	0.64	5.93	0.09	--
Labor period 3 (Apr. 15-May 31)	12.66	12.04	12.22	12.44	12.71	12.17
Labor period 4 (June 1-Aug. 15)	0.71	0.89	0.63	0.68	0.23	--
Labor period 5 (Aug. 16-Sept. 30)	8.09	7.73	7.95	8.11	8.72	7.95
Miscellaneous values						
Corn, per bushel	1.19	1.19	1.22	1.19	1.19	1.19
Corn silage, per ton ^b	9.20	10.53	10.89	--	--	--
Cotton allotment, per acre	36.34	35.39	34.07	36.46	37.38	38.34

^a Capital is charged at a market rate of 6 percent. Large size = 600 acres of openland.

^b On an as-fed basis.

Use of Basic Resources

Land. The proportion of openland left idle increased in Area I as the size of the farm under consideration increased with a given labor supply (Table XXIV). Inclusion of beef feeding alternatives had no consistent effect upon the proportion of total openland left idle.

Labor. As shown in Table XXV, labor was scarce in Periods 2, 3, and 5 with beef feeding and in Periods 3, 4, and 5 without beef feeding. In most instances feeding beef cattle resulted in a smaller proportion of the available labor going unused during a given labor period than when no beef cattle were fed. Decreasing the land:labor ratio by adding an additional man to the labor supply did not consistently result in an increase in the percent of unused labor within a given labor period. In fact, an opposite effect was found in several resources situations.

In all land:labor combinations excess quantities of labor were available between October 1 and February 28. Percentages of unused labor ranged from a low of 17.4 during Labor Period 6 on a Large farm with a 1-man labor supply and no beef feeding to a high of 97.7 during Labor Period 1 on a Medium size farm with a 1-man labor supply. These results suggest that additional research evaluating enterprises such as wintering stocker cattle or some similar labor-using activity is needed. This type of enterprise could contribute to utilization of a larger percentage of available land resources, especially in cases where the land:labor ratio is quite high. However, given the assumptions of this study and the alternative enterprises considered, the most profitable

TABLE XXIV
 UNUSED LAND RESOURCES BY SIZE OF FARM AND SIZE OF
 LABOR SUPPLY WITH AND WITHOUT BEEF FEEDING^a --
 AREA I

	With Beef Feeding		Without Beef Feeding	
	Total Acres Idle	Percent Idle	Total Acres Idle	Percent Idle
<u>Small</u> ^b				
1-man	5.5	5.5	9.9	9.9
2-man	5.5	5.5	5.5	5.5
3-man	5.5	5.5	0.0	0.0
<u>Medium</u> ^b				
1-man	125.4	50.1	106.7	42.7
2-man	53.6	21.4	52.2	20.9
3-man	13.8	5.5	33.0	13.2
<u>Large</u> ^b				
1-man	349.9	58.3	338.1	56.3
2-man	109.0	18.2	142.8	23.8
3-man	85.7	14.3	92.6	15.4

^aCapital is charged at a market rate of 6 percent.

^bSmall = 100 acres of openland; Medium = 250 acres of openland;
 and Large = 600 acres of openland.

TABLE XXV

PROPORTION OF LABOR UNUSED BY LABOR PERIOD, SIZE OF LABOR SUPPLY, AND SIZE OF FARM
WITH AND WITHOUT BEEF FEEDING^a -- AREA I

	With Beef Feeding						Without Beef Feeding					
	Labor Period						Labor Period					
	1	3 ^b	4	5	6	Percent	1	2	3	4	5	6
1-man labor												
Small ^c	50.7	--	0.0	--	66.9	51.2	--	7.5	--	--	--	51.9
Medium	62.1	--	15.1	--	71.4	97.7	--	40.1	--	3.5	--	94.7
Large	78.5	--	--	-	18.9	82.5	--	--	--	--	--	17.4
2-man labor												
Small	28.3	3.1	26.0	17.9	44.9	29.5	12.7	15.0	--	--	--	50.9
Medium	51.1	--	20.5	--	66.2	65.4	--	24.1	--	3.1	--	67.8
Large	59.4	--	--	--	28.7	90.6	--	--	--	--	--	31.0
3-man labor												
Small	24.0	32.3	44.8	24.7	48.3	49.2	39.2	40.8	27.7	32.5	64.6	
Medium	44.1	--	34.6	--	63.5	40.2	--	7.1	--	1.3	--	46.1
Large	61.7	--	--	--	34.3	93.8	--	30.9	--	5.4	--	55.8

^a Capital is charged at a market rate of 6 percent.

^b All of Labor Period 2 was expended in each resource situation.

^c Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

organization was achieved even though land and labor resources were often considerably under utilized.

Finishing Systems and Ration Components

One of the objectives of this study was to evaluate alternative beef feeding systems when considered within the context of given type farm situations. Enterprises considered included 10 beef finishing systems, five for feeding heifers and five for feeding steers. Cattle finished on Systems 1 and 2 were fed a ration consisting predominantly of corn silage. Using System 3, cattle were fed a full-feed grain ration and while Systems 4 and 5 involved wintered grazing of cattle on pasture and followed by a period of grain feeding.

Steer feeding was not included in the optimum systems for any farm situation although they were assumed to gain more rapidly than heifers. Steers required longer feeding periods; hence, they compete more intensively than heifers for labor during critical crop production periods. The margin between buying and selling price was much more favorable for heifers than for steers.

The optimum number of beef heifers varied considerably as the land:labor combination was varied (Table XXVI). For a given sized farm the number of heifers generally increased with increases in the labor supply. Numbers to be fed varied from 19 on the Large farm with 1-man labor to 469 on the Medium farm with 3-man labor.

Examination of the results in Table XXVI shows that when annual capital was charged at 6 percent, the predominant ration component for

TABLE XXVI

OPTIMUM NUMBER OF BEEF HEIFERS TO FEED BY SIZE OF FARM, LABOR SUPPLY, COST OF ANNUAL CAPITAL AND PREDOMINANT RATION COMPONENT -- AREA I

	Corn Silage			Pasture plus Grain			Corn Grain			Total		
	Percent			Percent			Percent			Percent		
	6	9	12	6	9	12	6	9	12	6	9	12
Small ^a												
1-man	158	158	143	--	--	--	--	--	--	158	158	143
2-man	155	71	72	2	2	--	--	--	--	157	79	72
3-man	252	252	252	--	--	--	48	38	--	300	290	252
Medium ^a												
1-man	117	117	96	--	--	--	--	--	--	117	117	96
2-man	314	314	314	--	--	--	--	--	--	314	314	314
3-man	469	304	227	--	--	--	--	--	--	469	304	227
Large ^a												
1-man	--	--	--	19	--	--	--	--	--	19	--	--
2-man	--	--	--	203	--	--	--	--	--	203	--	--
3-man	43	--	--	71	--	--	206	--	--	320	--	--

^aSmall = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

feeding beef heifers on Small and Medium farms was corn silage (Systems 1 and 2). With a 3-man labor supply on a Small size farm, it was profitable to purchase additional corn grain to finish beef heifers on System 3 (full grain feeding). In the case of a Large size farm, some beef heifers would be wintered on limited grain, fed grain on pasture, and then full fed grain in drylot (System 5) in all labor situations. However, on a Large farm with a 3-man labor supply most of the heifers (206 head) were fed on farm produced corn grain (System 3). Also, an additional 71 head were fed on System 5 and 43 head were fed on System 2.

None of the optimum systems included heifers finished on System 4 which involved wintering on limited corn silage, followed by pasturing with no supplemental grain, and later full-feeding of grain in drylot.

As the charge for annual capital was increased to 9 and 12 percent, the number of heifers fed generally declined. This was especially true on the Large size farm where no heifer feeding was included when annual capital was charged at rates greater than 6 percent.

B. AREA II

The primary differences between this area and Area I are: (1) the primary cash crop is tobacco rather than cotton; (2) crop yields are different as shown in Tables VIII (page 39) and IX (page 40); and (3) it was assumed that addition of phosphate fertilizers would not increase yields in Area II, and thus the crop budgets include no charges for phosphate fertilizer.

Maximum Potential Income

Maximum potential incomes for the various resource situations with and without beef feeding as well as the absolute and percentage increases in income resulting from beef feeding are shown in Table XXVII. Only in the case of a 1-man labor supply on a Large size farm did beef feeding fail to increase the net income potential. Aside from this exception, the range in income increases resulting from beef feeding was from a low of \$461 for a 2-man labor supply on a Small farm to a high of \$2,091 for a 3-man labor supply on a Medium size farm. The largest absolute and percentage increases in income for both a 2-man and a 3-man labor supply occurred on a Medium size farm. For a 1-man labor supply, the largest increase was for a Small size farm.

Size of labor supply. Regardless of whether or not beef cattle were fed, there was a clear distinction between marginal values of an additional unit of labor for the various size farms. Beef cattle feeding resulted in consistently larger marginal increases in income from an additional unit of labor on a Medium size farm.

If we assume that an additional man year of labor will cost \$5,000, then we can evaluate the size of the labor supply for the various size farms. Under the conditions of this study, a Small size farm could employ only 1 man-year of labor. On a Medium size farm without beef feeding, a labor supply of two men could be hired, while with beef feeding three men could be employed. The marginal incomes for additional units of labor on Large farms were above \$5,000 in each

TABLE XXVII
 MAXIMUM POTENTIAL INCOME^a BY SIZE OF LABOR SUPPLY
 AND FARM SIZE WITH AND WITHOUT BEEF FEEDING -
 AREA II

	With Beef Feeding	Without Beef Feeding	Increase with Beef Feeding	
			Total	Percent
<u>1-man labor</u>				
Small ^b	\$7,636	\$6,698	\$938	14.0
Medium ^b	9,371	8,668	702	8.1
Large ^b	10,639	10,639	--	0.0
<u>2-man labor</u>				
Small	11,699	11,238	461	4.1
Medium	15,873	14,209	1,664	11.7
Large	18,660	17,725	935	5.3
<u>3-man labor</u>				
Small	14,716	13,462	1,254	9.3
Medium	21,009	18,918	2,091	11.0
Large	25,038	24,208	831	3.4

^aIncome to land, labor, and management. Capital is charged at a market rate of 6 percent.

^bSmall = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

case indicating that at least three men would be justified on this size farm.

Cost of annual capital. As observed in Area I, the annual capital requirements were much greater when beef cattle feeding activities were included in the optimum solution than when these activities were excluded (Table XXVIII). As the cost of annual capital increases, income potential from adding beef feeding alternatives diminishes (Table XXIX). Increasing the cost of annual capital on Small size farms resulted in a much slower rate of decline in income effect by beef feeding than with either Medium or Large size farms. Apparently, the opportunity exists on Medium and Large size farms for including a larger porportion of enterprises with relatively low annual capital requirements as the cost of annual capital increases.

Farm Organization

Small size farm with beef feeding. Optimum farm organizations for Small size farms in Area II are shown in Table XXX. In the case where the labor supply was most limiting, a relatively large number of enterprises was included in the optimum organization. These included tobacco, corn silage, soybeans, oats-lespedeza hay, alfalfa hay, and lespedeza hay crops as well as finishing 158 head of beef heifers on finishing System 2.

Addition of the second unit of labor resulted in deletion of soybeans, oats-lespedeza hay, and lespedeza hay crop production; a slight decline in corn silage production; a large increase in alfalfa

TABLE XXVIII

ANNUAL CAPITAL REQUIREMENTS BY SIZE OF FARM, SIZE OF LABOR SUPPLY, AND COST
OF ANNUAL CAPITAL WITH AND WITHOUT BEEF FEEDING -- AREA II

	With Beef Feeding			Without Beef Feeding		
	6 percent	9 percent	12 percent	6 percent	9 percent	12 percent
<u>Small^a</u>						
1-man	\$15,297	\$15,297	\$11,857	\$ 3,085	\$ 3,085	\$ 2,857
2-man	17,302	16,426	16,332	11,828	11,828	11,828
3-man	18,219	18,219	18,145	7,678	7,678	7,642
<u>Medium^a</u>						
1-man	14,966	13,346	6,899	1,273	1,273	1,273
2-man	28,532	28,350	21,288	3,958	3,958	1,984
3-man	47,911	35,521	33,552	12,916	12,916	12,916
<u>Large^a</u>						
1-man	2,479	2,479	2,479	2,479	2,479	2,479
2-man	35,008	29,472	3,803	3,803	3,803	3,803
3-man	35,848	21,643	4,188	4,188	4,188	4,188

^a Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

TABLE XXIX

INCREASE IN OPTIMUM INCOME^a WITH BEEF CATTLE FEEDING BY COST OF ANNUAL CAPITAL,
LABOR SUPPLY, AND FARM SIZE -- AREA II

		Cost of Capital					
		6 percent		9 percent		12 percent	
		Total	Percent	Total	Percent	Total	Percent
<u>1-man labor</u>							
Small ^b	\$ 938	14.0		\$ 572	8.7	\$ 229	3.5
Medium ^b	702	8.1		321	3.7	16	0.1
Large ^b	--	0.0		--	0.0	--	0.0
<u>2-man labor</u>							
Small	461	4.1		318	2.9	182	1.7
Medium	1,664	11.7		931	6.6	206	1.5
Large	935	5.3		11	0.1	--	0.0
<u>3-man labor</u>							
Small	1,254	9.3		938	7.1	621	4.8
Medium	2,091	11.0		1,113	6.0	484	2.7
Large	831	3.4		8	0.0	--	0.0

^a Income to land, labor, and management.

^b Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

TABLE XXX

OPTIMUM FARM ORGANIZATION^a BY SIZE OF LABOR SUPPLY FOR A SMALL SIZE FARM
WITH AND WITHOUT BEEF FEEDING --- AREA II

Crop Enterprises, acres	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
Tobacco	0.5	0.5	0.5	0.5	0.5	0.5
Corn	--	--	--	2.6	--	--
Corn silage	26.2	24.0	21.5	--	--	--
Soybeans	12.2	--	--	35.8	13.7	5.6
Oats-lespedeza hay	7.8	--	--	--	--	--
Alfalfa hay	34.3	51.0	40.2	35.8	48.0	56.1
Lespedeza hay	2.2	--	--	2.2	2.2	--
Fescue-ladino pasture	--	2.2	2.2	--	--	4.4
Lespedeza pasture	--	--	--	--	--	0.7
<u>Livestock Enterprises</u>						
Manufacturing milk, cows	--	--	--	--	--	1
Swine I, b sows	--	12	4	13	60	--
Swine II, b sows	--	49	120	--	6	127
Beef feeding I, c head	--	117	105	--	--	--
Beef feeding II, c head	158	--	--	--	--	--
Beef feeding III, c head	--	1	1	--	--	--
<u>Buying and Selling Activities</u>						
Sell hay, tons	95.5	157.8	128.7	137.9	188.4	216.8
Buy corn, bushels	2,684	5,632	7,192	2,352	11,483	5,855

^aCapital is charged at a market rate of 6 percent. Small size = 100 acres of openland.

^bSwine I is production of market hogs; Swine II is production of feeder pigs.

^cBeef feeding I, II, and III are feeding beef heifers on finishing Systems 1, 2, and 3, respectively.

acreage; and a small amount of fescue-ladino pasture being produced. The number of beef cattle fed declined and the feeding regimen changed from System 2 to 1. The production of both market hogs and feeder pigs was included. In addition, more hay selling and corn buying was included in the optimal system. With the addition of the third unit of labor, the acreages of corn silage and alfalfa hay and the number of beef cattle and hogs fed declined, while the number of feeder pigs increased considerably. Livestock production, especially of feeder pigs, becomes an important contributor to net farm income as the land: labor ratio becomes very small.

Small size farm without beef feeding. Tobacco production was at the maximum allowable level in all labor situations. A small amount of corn was produced with one unit of labor but none with 2- and 3-man labor supply. Soybeans were produced extensively with one unit of labor, but soybean acreages declined as the land:labor ratio declined. Production of alfalfa hay increased alone with increases in the labor supply. Production of market hogs was important with 1- and 2-man labor supplies, but changed to feeder pig production with three units of labor. This switch to feeder pigs was due to the 50 percent less pasture required per sow-unit for feeder pig production relative to the production of market hogs.

Medium size farm with beef feeding. Soybean production was quite important with a 1-man labor supply and declined in acreage as the labor supply was increased while corn silage acreages increased considerably

as the labor supply increased (Table XXXI). Fescue-ladino clover pasture acreage totaled 66.1 with a 1-man labor supply. Tobacco was included in the optimum solution, but with less acres than permitted by the allotment limitation. Beef heifers were finished on both predominantly corn silage and pasture plus grain systems (Systems 2 and 5, respectively).

Addition of the second unit of labor resulted in complete utilization of the tobacco allotment, inclusion of alfalfa and lespedeza hay production, sharp reduction in fescue-ladino clover pasture acreages, an increase of 165 head in the number of beef heifers finished on System 2, and a decrease of 20 head in the number finished on System 5. The amount of hay sold and corn bought increased substantially with the second unit of labor.

With a 3-man labor supply oats-lespedeza hay production was included, alfalfa hay production increased, and lespedeza hay acreage declined. The number of beef heifers fed on System 2 increased to a total of 485 head and production of market hogs from 5 sows was also included in the optimal solution.

Beef cattle feeding and its accompanying productive enterprises were much more important on a Medium size farm than they were on a Small size farm. This observation again suggests that the ratio of land to labor availability is an important factor in determining the most profitable use of a given set of basic resources among several alternative production possibilities.

TABLE XXXI

OPTIMUM FARM ORGANIZATION^a BY SIZE OF LABOR SUPPLY FOR A MEDIUM SIZE FARM
WITH AND WITHOUT BEEF FEEDING -- AREA II

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
Crop Enterprises, acres						
Tobacco	0.8	1.2	1.2	--	1.2	1.2
Corn	--	--	--	--	--	9.7
Corn silage	19.7	47.7	80.8	--	--	--
Soybeans	76.7	48.3	15.2	97.2	96.0	86.2
Oats-lespedeza hay	--	--	32.5	--	--	--
Alfalfa hay	--	60.6	103.8	24.3	76.5	82.4
Lespedeza hay	--	30.8	5.5	--	--	--
Fescue-ladino pasture	66.1	5.5	--	96.6	60.7	29.7
Lespedeza pasture	--	--	--	22.4	--	--
Livestock Enterprises						
Swine I, ^b sows	--	--	5	--	12	62
Beef feeding II, ^c head	126	291	485	--	--	--
Beef feeding V, ^c head	22	2	--	--	--	--
Buying and Selling Activities						
Sell hay, tons	13.6	210.9	273.4	191.7	343.6	377.8
Buy corn, bushels	2,621	4,987	9,076	--	2,282	11,005

^aCapital is charged at a market rate of 6 percent. Medium size = 250 acres of openland.

^bSwine I is production of market hogs.

^cBeef feeding II and V are feeding beef heifers on finishing Systems 2 and 5, respectively.

Medium size farm without beef feeding. Soybeans, fescue-ladino clover pasture, and alfalfa hay were produced in all three labor situations (Table XXXI). Acreages of the first two crops decreased as the size of the labor supply increased while the amount of alfalfa produced increased as the units of labor increased. Lespedeza hay was produced with a 1-man labor supply. The full tobacco allotment was utilized with labor supplies of two and three men. No tobacco was produced with a 1-man labor supply. Livestock production was limited to market hogs and consisted of 12 sows with a 2-man labor supply and 62 sows with a 3-man labor supply. No livestock was included in the system with a 1-man labor supply.

Large size farm with beef feeding. Tobacco was included only in the 3-man labor situation (Table XXXII). Corn acreages were greatest with a 1-man labor supply and declined to about the same value for 2- and 3-man labor supplies. Soybean production almost doubled with addition of the second unit of labor and declined slightly with the third unit. Fescue-ladino clover pasture production peaked with a 2-man labor supply and lespedeza pasture increased as the labor supply increased. Alfalfa hay was produced only with 2- and 3-man labor supplies.

The optimum system included the feeding of 272 and 274 head of beef heifers on System 5 with 2- and 3-man labor supplied, respectively. About the same amount of hay was sold with one and two units of labor, but the amount of hay sold increased by 138.3 tons when the third unit

TABLE XXXII

OPTIMUM FARM ORGANIZATION^a BY SIZE OF LABOR SUPPLY FOR A LARGE SIZE FARM
WITH AND WITHOUT BEEF FEEDING -- AREA II

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Crop Enterprises, acres</u>						
Tobacco	--	--	3.0	--	--	--
Corn	120.6	89.6	89.8	120.6	89.2	58.4
Soybeans	74.7	137.4	131.2	74.7	106.2	136.9
Alfalfa hay	--	16.6	69.4	--	70.6	142.8
Fescue-ladino pasture	80.9	197.4	120.0	80.9	95.4	95.4
Lespedeza pasture	20.8	96.1	163.9	20.8	215.9	143.7
<u>Livestock Enterprise</u>						
Beef feeding V, ^b head	--	272	274	--	--	--
<u>Buying and Selling Activities</u>						
Sell hay, tons	87.9	88.3	236.6	87.9	478.0	716.1
Sell corn, bushels	8,563	--	--	8,563	6,330	4,145

^a Capital is charged at a market rate of 6 percent. Large size farm = 600 acres of openland.

^b Beef feeding V is feeding beef heifers on finishing System 5.

of labor was added. Corn was sold with a 1-man labor supply but not with the 2- and 3-man labor supplies.

Large size farm without beef feeding. Since no beef feeding occurred on a Large farm with a 1-man labor supply, then the same optimum farm organizations were derived both with and without beef feeding. Corn, soybeans, alfalfa, and fescue-ladino and lespedeza pastures were crops produced in this resource situation. Except for corn which declined and lespedeza which increased and then decreased, the acreages of these crops increased as the labor supply increased. Pasture acreages were harvested as hay on a custom basis. The transfer activity from pasture to hay provided an implicit means of hiring additional labor by custom harvesting hay from pasture acreages. Also, pasture maintenance costs in Area II were small since phosphate fertilization was not required.

There was no livestock production at any labor level. Hay tonnage sold increased and the amount of corn sold decreased as the labor supply increased.

Removal of the beef feeding options in the 2-man labor situation resulted in larger acreages of alfalfa hay and lespedeza pasture and smaller acreages of soybeans and fescue-ladino clover pasture. When the third man was added to the labor force, corn, fescue-ladino clover and lespedeza pasture were produced on fewer acreages than when beef heifers were fed and alfalfa hay was produced on larger acreages.

Value of Restricting Resources

Small size farm. Labor was limiting between March 1 and April 14 and between August 16 and September 30 in all labor supply situations with beef feeding (Table XXXIII). In addition, labor was limiting between April 15 and May 31 with 1- and 2-man labor supplies and beef feeding. Without beef feeding labor was consistently limiting between August 16 and September 30 in all labor situations. As with beef feeding, labor was also limiting between April 15 and May 31 with 1- and 2-man labor supplies. The relatively high marginal value products for labor in many of the situations (as high as \$10.40 per hour) is indicative of the crucial nature of restrictions on availability of seasonal hired labor.

The value of an additional ton of corn silage increased as the labor supply increased and ranged between \$9.10 and \$9.94 per ton for the systems where beef feeding was allowed.

These results indicate that beef feeding and tobacco production tend to be complementary in resource utilization on a Small size farm. The marginal values of an additional acre of tobacco allotment ranged from \$23.03 to \$243.81 greater when beef cattle were fed than when no beef cattle were fed. The relatively large values in all cases for additional tobacco allotment indicates the importance of this crop to the income position of a farmer operating a Small size farm.

TABLE XXXIII

MARGINAL VALUE PRODUCTS FOR RESTRICTING RESOURCES BY SIZE OF LABOR SUPPLY
FOR A SMALL SIZE FARM WITH AND WITHOUT BEEF FEEDING^a -- AREA II

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
Land, per acre						
Soil group 1	\$43.96	\$67.54	\$79.66	\$40.31	\$50.56	\$63.65
Soil group 2	23.68	53.09	64.32	23.15	40.56	62.93
Row crop 2	6.64	--	--	7.15	--	--
Soil group 3	8.00	37.42	48.64	7.48	24.88	47.26
Row crop 3	4.81	--	--	5.33	--	--
Soil group 4	--	21.74	55.66	--	106.47	306.44
Soil group 5	2.95	6.03	8.56	1.64	5.58	11.34
Labor, per hour						
Labor period 2 (Mar. 1-Apr. 14)	6.09	8.32	9.29	--	--	--
Labor period 3 (Apr. 15-May 31)	10.40	3.33	--	8.22	4.64	--
Labor period 5 (Aug. 16-Sept. 30)	3.49	1.17	1.25	8.71	6.74	4.28
Miscellaneous Values						
Corn, per bushel	1.25	1.25	1.25	1.25	1.25	1.25
Corn silage, per ton ^b	9.10	9.50	9.94	--	--	--
Tobacco allotment, per acre	363.53	709.28	799.76	221.30	465.47	776.73

^aCapital is charged at a market rate of 6 percent. Small size = 100 acres of openland.

^bOn as as-fed basis.

Medium size farm. Marginal land values obtained in Area II were very similar to those observed in Area I when beef cattle were fed (Tables XXII, page 65, and XXXIV).

Labor was limiting during Labor Periods 2, 3, and 5 when beef cattle were fed and during Labor Periods 3 and 5 when beef cattle feeding was not allowed. Marginal values for corn silage were about \$9.60 per ton in all the labor situations considered when beef feeding alternatives were included.

All of the tobacco allotment was not expended with a 1-man labor supply regardless of whether beef cattle were fed or not. With a 2-man labor supply the annual value of an additional acre of allotment was about the same with beef feeding and with no beef feeding (\$146.98 and \$149.05 per acre, respectively). However, the addition of the third unit of labor resulted in sharply different effects on the observed marginal values for tobacco allotment. With beef feeding the marginal value per acre increased to \$599.49 per acre while without beef feeding the marginal value declined to \$140.05 per acre.

Large size farm. Since the solutions were the same for the 1-man situation with and without beef feeding, marginal earning rates of resources were identical (Table XXXV). With two and three men labor supplies marginal earning rates for the various soil categories were slightly higher for situations with beef feeding than with no beef feeding.

Both with and without beef feeding, labor was limiting in Periods 3 and 5 and magnitudes of the marginal values indicate that Period 3 is

TABLE XXXIV

MARGINAL VALUE PRODUCTS FOR RESTRICTING RESOURCES BY SIZE OF LABOR SUPPLY
FOR A MEDIUM SIZE FARM WITH AND WITHOUT BEEF FEEDING^a -- AREA II

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
Land, per acre						
Soil group 1	\$37.70	\$42.32	\$63.22	\$35.59	\$43.00	\$42.77
Soil group 2	0.03	2.51	37.21	2.86	19.10	19.81
Row crop 2	24.90	27.23	13.35	22.73	13.90	12.95
Soil group 3	--	--	21.60	1.16	3.42	4.14
Row crop 3	7.43	12.23	5.94	6.94	12.08	11.13
Soil group 4	--	--	5.93	0.45	2.71	2.98
Soil group 5	--	0.10	6.29	1.58	3.85	4.11
Labor, per hour						
Labor period 2 (Mar. 1-Apr. 14)	2.70	3.74	6.92	--	--	--
Labor period 3 (Apr. 15-May 31)	14.48	12.80	5.69	8.97	5.38	4.86
Labor period 5 (Aug. 16-Sept. 30)	7.89	6.18	1.97	12.66	11.53	11.98
Miscellaneous Values						
Corn, per bushel	1.25	1.25	1.25	1.25	1.25	1.25
Corn silage, per ton ^b	9.61	9.52	9.58	--	--	--
Tobacco allotment, per acre	--	146.98	599.49	--	149.05	140.05

^a Capital is charged at a market rate of 6 percent. Medium size = 250 acres of openland.

^b On an as-fed basis.

TABLE XXXV

MARGINAL VALUE PRODUCTS FOR RESTRICTING RESOURCES BY SIZE OF LABOR SUPPLY
FOR A LARGE SIZE FARM WITH AND WITHOUT BEEF FEEDING^a -- AREA II

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
Land, per acre						
Soil group 1	\$13.70	\$29.35	\$31.05	\$13.70	\$27.62	\$27.62
Soil group 2	--	4.28	6.13	--	3.43	3.43
Row crop 2	3.70	15.06	14.92	3.70	14.19	14.19
Soil group 3	--	3.18	4.99	--	2.44	2.44
Soil group 4	--	1.76	3.39	--	1.01	1.01
Soil group 5	--	3.18	4.99	--	2.44	2.44
Labor, per hour						
Labor period 2 (Mar. 1-Apr. 14)	3.11	1.37	--	3.11	--	--
Labor period 3 (Apr. 15-May 31)	19.21	12.63	12.46	19.21	12.61	12.61
Labor period 5 (Aug. 16-Sept. 30)	11.73	9.65	9.57	11.73	10.48	10.48
Miscellaneous Values						
Corn, per bushel	1.19	1.24	1.24	1.19	1.19	1.19
Corn silage, per ton ^b	9.04	10.41	10.96	--	--	--
Tobacco allotment, per acre	--	--	20.61	--	--	--

^aCapital is charged at a market rate of 6 percent. Large size = 600 acres of openland.

^bOn an as-fed basis.

the most restrictive. The marginal value of an additional hour of labor in Period 3 was over \$19 for the 1-man situation and over \$12 for the 3-man labor situation.

An additional acre of tobacco allotment had a positive value only when there was a 3-man labor supply and beef feeding. Relative to values obtained on Small and Medium size farms, the marginal value of \$20.61 per acre was very small.

Examination of marginal values for tobacco allotments on Small, Medium, and Large size farms reveals an inverse relationship between the land:labor ratio and the marginal value of an additional acre of allotment. The marginal value of an additional acre of tobacco allotment became positive between land:labor ratios of 250:1 and 200:1 when beef cattle feeding was permitted. As the land:labor ratio decreased to 125:1, 100:1, 83.3:1, 50:1, and 33:1, the marginal value of an additional acre increased to \$146.98, \$363.53, \$599.49, \$709.28, and \$799.76, respectively.

Without beef feeding a non-zero marginal value was obtained between land:labor ratios of 200:1 and 125:1. The inverse relationship continued to hold but with generally lower marginal values than when beef cattle were fed (Figure 5).

Use of Basic Resources

Land. Except for a Large and Small farm with a 1-man labor supply, more than 95 percent of the available land was utilized when no beef cattle were fed (Table XXXVI). Feeding beef cattle resulted in

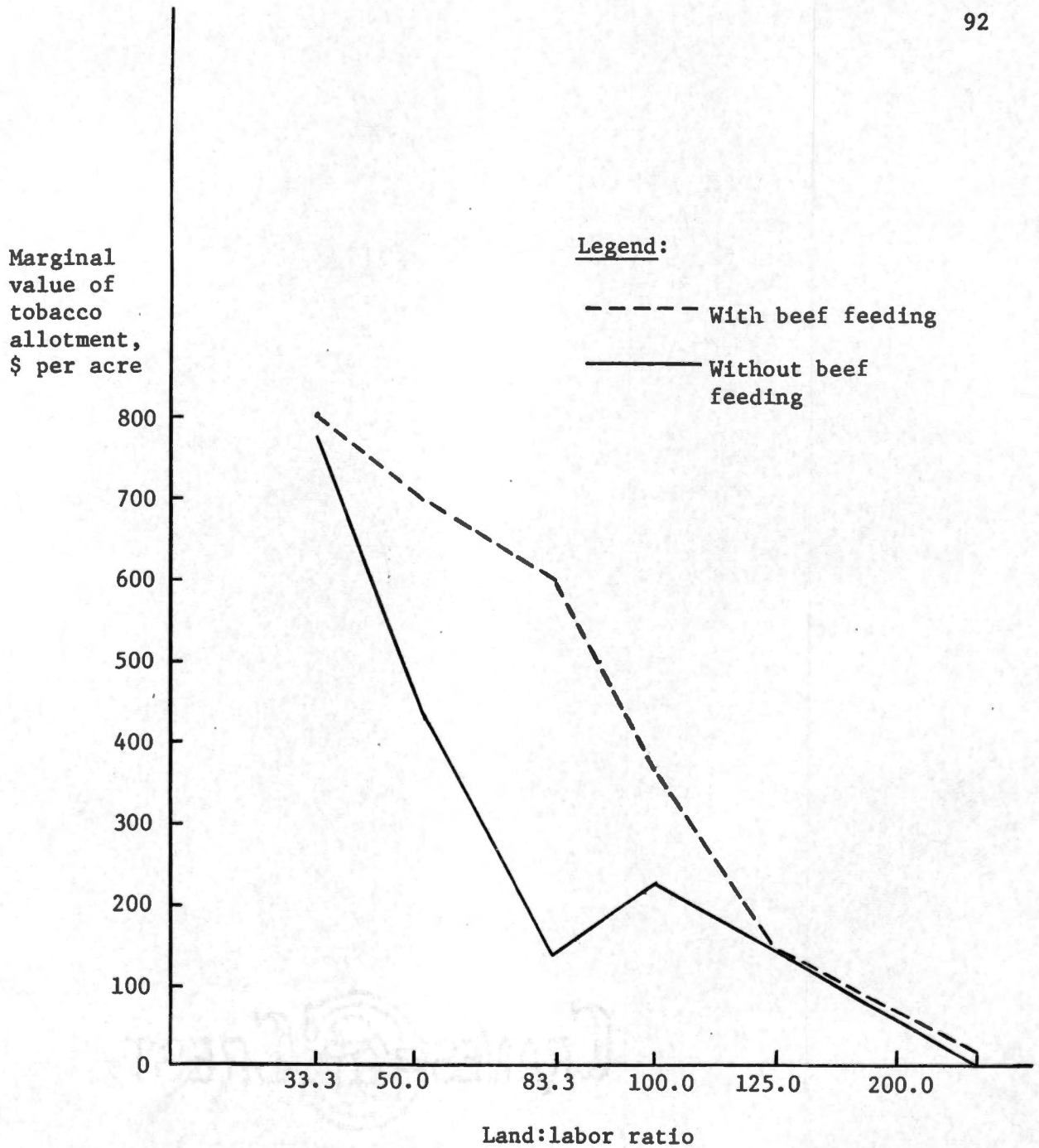


Figure 5. Relationship between the marginal values of tobacco allotments and land:labor ratios with and without beef feeding - Area II.

TABLE XXXVI
UNUSED LAND RESOURCES BY SIZE OF FARM AND SIZE OF LABOR SUPPLY
WITH AND WITHOUT BEEF FEEDING^a - AREA II

	<u>With Beef Feeding</u>		<u>Without Beef Feeding</u>	
	<u>Total Acres Idle</u>	<u>Percent Idle</u>	<u>Total Acres Idle</u>	<u>Percent Idle</u>
<u>Small</u> ^b				
1-man	16.8	16.8	16.3	16.3
2-man	3.8	3.8	3.8	3.8
3-man	0.8	0.8	0.8	0.8
<u>Medium</u> ^b				
1-man	86.7	34.7	9.5	3.8
2-man	55.8	22.4	9.5	3.8
3-man	9.5	3.8	9.5	3.8
<u>Large</u> ^b				
1-man	303.0	50.5	303.0	50.5
2-man	25.8	4.1	25.8	4.1
3-man	22.8	3.8	25.8	4.1

^a Capital is charged at a market rate of 6 percent.

^b Small = 100 acres of openland; Medium - 250 acres of openland; and Large = 600 acres of openland.

77.2 and 46.3 additional acres of land going unused on a Medium size farm with 1- and 2-man labor supplies, respectively. Aside from these variations, land utilization was about the same with or without beef feeding.

Labor. When beef feeding was a part of the farm organization, labor was generally completely used during Labor Period 2, 3, and 5 (Table XXXVII). Beef feeding results in a larger proportion of available labor being utilized during Periods 1, 2, and 6 than when no beef feeding occurred. In situations with no beef feeding, labor was generally expended in Periods 3 and 5. A greater percentage of the labor was used in Period 4 when no beef feeding took place.

Finishing Systems and Ration Components

Beef heifer feeding systems were the only beef feeding alternatives to appear in the optimal solutions for Area II (Table XXXVIII). Corn silage was the predominant ration component in Systems 1 and 2, the principal beef feeding systems included in the optimal solutions for the Small and Medium size farms. On the Small size farm when annual capital was charged at 6 percent the number of heifers fed declined as the labor force increased; whereas, on the Medium size farm the number of heifers fed increased as the labor supply increased.

No heifers were fed on a Large farm with a 1-man labor supply, but 272 and 274 head, respectively, were fed on a pasture plus grain regimen (System 5). Systems 3 and 4 were not utilized in any of the optimum farm organizations.

TABLE XXXVII

PROPORTION OF LABOR UNUSED BY LABOR PERIOD, SIZE OF LABOR SUPPLY, AND SIZE OF FARM
WITH AND WITHOUT BEEF FEEDING^a -- AREA II

	With Beef Feeding						Without Beef Feeding					
	Labor Period						Labor Period					
	1	2	3	4	6 ^b	Percent	1	2	3	4	6 ^b	Percent
1-man labor												
Small ^c	45.7	--	--	30.2	55.9	64.3	33.2	--	--	12.5	60.1	
Medium ^c	36.8	--	--	34.8	50.1	85.7	43.4	--	--	8.7	100.0	
Large ^c	82.1	--	--	54.5	4.5	82.1	--	--	--	54.4	4.5	
2-man labor												
Small	22.1	--	--	14.7	40.6	23.0	6.8	--	--	3.4	32.6	
Medium	48.5	--	--	39.9	55.1	74.2	49.9	--	--	9.5	72.5	
Large	48.0	--	--	17.5	37.5	91.4	4.8	--	--	15.9	64.7	
3-man labor												
Small	13.8	--	17.9	20.0	38.2	21.1	13.9	22.7	16.2	43.3		
Medium	42.7	--	--	32.7	54.5	48.2	22.9	--	--	6.9	48.3	
Large	55.0	19.6	--	11.2	32.8	95.1	42.3	--	--	18.8	94.6	

^a Capital is charged at a market rate of 6 percent.

^b All of Labor Period 5 was expended in each resource situation.

^c Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

TABLE XXXVIII

OPTIMUM NUMBER OF BEEF HEIFERS TO FEED BY SIZE OF FARM, LABOR SUPPLY, COST
OF ANNUAL CAPITAL AND PREDOMINANT RATION COMPONENT -- AREA II

	Corn Silage			Pasture plus Grain			Total		
	Percent			Percent			Percent		
	6	9	12	6	9	12	6	9	12
Small^a									
1-man	158	158	117	--	--	--	158	158	117
2-man	117	89	85	1	1	--	118	90	85
3-man	105	105	106	1	1	--	106	106	106
Medium^a									
1-man	126	135	63	22	--	--	148	135	63
2-man	291	292	212	2	--	--	293	292	212
3-man	485	338	315	--	--	--	485	338	315
Large^a									
1-man	--	--	--	--	--	--	--	--	--
2-man	--	--	--	272	225	--	272	225	--
3-man	--	--	--	274	153	--	274	153	--

^a Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

Corn silage was an important ration component when land area was somewhat limiting, but as land became more readily available to a constant labor supply, wintering on limited grain, grain on pasture and grain in drylot became the most profitable feeding system.

Generally, fewer heifers were fed as the charge for annual capital was increased. Some feeding occurred on Small and Medium size farms at all three capital charges. Beef feeding did not appear any in the optimum solutions of the Large farms when annual capital was charged at a rate greater than 9 percent.

C. AREA III

The primary differences between this area and Areas I and II were: (1) no primary cash crop such as cotton or tobacco was considered; (2) assumed crop yields were considerably different between areas (Tables VII, IX, and X); (3) a smaller number of potential production possibilities was considered; and (4) the proportion of the more productive soil groups was much smaller in this area (Table I, page 15).

Maximum Potential Income

Incomes ranged from a low of \$5,137 on a Small farm with a 1-man labor supply and no beef feeding to a high of \$19,804 on a Large farm with a 3-man labor supply and beef feeding (Table XXXIX).

Optimum incomes were increased in all cases when beef feeding alternatives were added. The income effect of adding beef alternatives was least on a Small size farm and greatest on the Large farm. The

TABLE XXXIX

MAXIMUM POTENTIAL INCOME^a BY SIZE OF LABOR SUPPLY AND FARM SIZE
WITH AND WITHOUT BEEF FEEDING - AREA III

	With Beef Feeding	Without Beef Feeding	Increase with Beef Feeding	
			Total	Percent
<u>1-man labor</u>				
Small ^b	\$ 5,881	\$ 5,137	\$ 744	14.5
Medium ^b	6,367	5,351	1,061	19.0
Large ^b	7,842	6,234	1,608	25.8
<u>2-man labor</u>				
Small	9,937	9,646	291	3.0
Medium	11,892	10,233	1,659	16.2
Large	14,069	11,591	2,478	21.4
<u>3-man labor</u>				
Small	13,205	12,963	242	1.9
Medium	16,516	14,773	1,743	11.8
Large	19,804	16,778	3,026	18.0

^aIncome to land, labor, and management. Capital is charged at a market rate of 6 percent.

^bSmall = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

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effect on income increased both on an absolute and a percentage basis as the size of farm was increased. The percentage effect became smaller on each size farm for each incremental increase in labor supply. The largest percentage increase (25.1) in income from beef feeding occurred on a Large farm with a 1-man labor supply and the largest absolute increase (\$3,026) was on a Large farm with a 3-man labor supply.

Size of labor supply. Income to land, labor, and management increased in all resource situations as the size of the labor force was increased. Compared to no beef feeding, the increases in income from an additional unit of labor were greater with beef heifer feeding, except on the Small size farm. Addition of the third unit of labor on a Small farm with beef feeding resulted in the smallest incremental increase in income, \$3,268. The greatest addition to income (\$6,227) resulted when the second unit of labor was added to the labor force of a Large farm with beef feeding.

Size of farm. Given the labor supply, total income increased as the farm size increased. Beef heifer feeding resulted in larger and larger total incomes as farm size increased regardless of the size of the labor supply. This is in contrast to Areas I and II where increases in total income resulting from beef feeding declined as the farm size increased.

Cost of annual capital. Increases in optimum income with beef heifer feeding by cost of annual capital, labor supply, and farm size for Area III are shown in Table XL. As the cost of annual capital

TABLE XL

INCREASE IN OPTIMUM INCOME^a WITH BEEF CATTLE FEEDING BY COST OF ANNUAL CAPITAL,
LABOR SUPPLY, AND FARM SIZE -- AREA III

	Cost of Capital					
	6 Percent		9 Percent		12 Percent	
	Total	Percent	Total	Percent	Total	Percent
<u>1-man Labor</u>						
Small ^b	\$ 744	14.5	\$ 334	6.6	\$ --	0.0
Medium ^b	1,061	19.0	565	10.8	102	2.0
Large ^b	1,068	25.8	1,300	21.1	997	16.4
<u>2-man Labor</u>						
Small	291	3.0	134	1.4	73	0.8
Medium	1,659	16.2	673	6.7	--	0.0
Large	2,478	21.4	1,818	15.9	1,244	11.1
<u>3-man Labor</u>						
Small	242	1.9	28	0.2	18	0.2
Medium	1,743	11.8	702	4.8	--	0.0
Large	3,026	18.0	2,130	12.9	1,343	8.3

^a Income to land, labor, and management.

^b Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

increased to 9 and 12 percent, the increases in income decreased both absolutely and proportionately. With a 12 percent charge for annual capital, beef feeding resulted in no improvement in income in these resource situations: A Small size farm with a 1-man labor supply and a Medium size farm with 2- or 3-man labor supplies. Only very small improvements (2.0 percent or less) were noted in the other resource situations with Small and Medium size farms. However, Large size farm incomes were improved substantially (from 8.3 to 16.4 percent) by beef feeding even when annual capital was charged at 12 percent.

Increasing the charge for annual capital from 6 to 9 percent without beef feeding resulted in a decrease in the total annual capital requirement in only one resource situation, a Medium size farm with a 1-man labor supply (Table XLI). Further increase to 12 percent in the charge for annual capital without beef feeding also resulted in a decrease in the annual capital requirement in one situation, a Small size farm with a 2-man labor supply. Therefore, optimum farm organizations without beef feeding were not very sensitive to changes in the charge for annual capital.

When beef feeding was permitted the total annual capital requirements were very large (up to \$36,679 greater than without beef feeding) when annual capital was charged at 6 percent. However, in contrast to no beef feeding, the total annual capital requirements decreased sharply as the cost of annual capital was increased from 6 to 12 percent.

TABLE XLI

ANNUAL CAPITAL REQUIREMENTS BY SIZE OF FARM, SIZE OF LABOR SUPPLY, AND COST OF
ANNUAL CAPITAL WITH AND WITHOUT BEEF FEEDING -- AREA III

	With Beef Feeding			Without Beef Feeding		
	6 Percent	9 Percent	12 Percent	6 Percent	9 Percent	12 Percent
<u>Small^a</u>						
1-man	\$16,650	\$16,650	\$ 2,984	\$ 2,984	\$ 2,984	\$ 2,984
2-man	22,297	11,776	11,776	9,989	9,989	8,958
3-man	29,322	12,572	12,572	12,244	12,244	12,244
<u>Medium^a</u>						
1-man	18,356	18,356	18,356	4,188	2,947	2,947
2-man	38,970	38,970	6,081	6,081	6,081	6,081
3-man	43,914	43,914	9,215	9,215	9,215	9,215
<u>Large^a</u>						
1-man	12,984	12,984	12,496	2,714	2,714	2,714
2-man	34,937	25,307	25,307	6,170	6,170	6,170
3-man	43,365	35,510	35,510	9,292	9,292	9,292

^a Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

In all but two of the resource situations studied, both with and without beef feeding, the total amount of annual capital required increased as the labor supply increased.

Farm Organization

Small size farm with beef feeding. Optimum farm organizations on a Small farm in Area III included only two crop enterprises -- corn for silage and orchardgrass-red clover hay (Table XLII). Corn silage acreages remain about the same as the labor supply increased. Orchardgrass-red clover hay production declined following the addition of the third unit of labor.

With a 1-man labor supply the optimum system included a 7-sow unit producing feeder pigs and the feeding out of 171 beef heifers. With the addition of another unit of labor, the sow unit was expanded and shifted to production of market hogs. The number of beef animals fed declined. Thus, as the land:labor ratio declined from 100:1 to 50:1, production of market hogs became relatively more profitable than the feeding of beef heifers.

Hay selling increased with the second unit of labor and declined as the third unit of labor was added. Buying of corn increased considerably as the labor supply was increased.

Small size farm without beef feeding. Corn production declined from 16.9 to 1.4 acres with the addition of the second unit of labor. Orchardgrass-red clover hay increased from 29.6 to 51.6 acres with the

TABLE XLII

OPTIMUM FARM ORGANIZATION^a BY SIZE OF LABOR SUPPLY FOR A SMALL SIZE FARM
WITH AND WITHOUT BEEF FEEDING -- AREA III

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Crop Enterprises, acres</u>						
Corn	--	--	--	16.9	1.4	1.1
Corn silage	28.9	26.2	28.4	--	--	--
Orchardgrass-red clover hay	37.7	39.8	23.1	29.6	51.6	45.6
<u>Livestock Enterprises</u>						
Swine I, ^b sows	--	52	90	--	36	30
Swine II, ^b sows	7	--	--	47	59	120
Beef feeding II, ^c head	171	126	130	--	--	--
<u>Buying and Selling Activities</u>						
Sell hay, tons	47.0	54.3	22.3	69.8	123.3	110.5
Buy corn, bushels	3,213	10,821	17,968	832	9,200	11,038

^aCapital is charged at a market rate of 6 percent. Small size = 100 acres of openland.

^bSwine I is production of market hogs; Swine II is production of feeder pigs.

^cBeef feeding II is feeding beef heifers on finishing System 2.

addition of the second unit of labor and then declined to 45.6 acres with the addition of the third unit.

With a 1-man labor supply the optimum system included the production of feeder pigs from 47 sows. Adding the second and third units of labor resulted in the expansion of feeder pig production as well as production of market hogs.

Hay selling was proportionate to the orchardgrass-red clover acreages. Corn was purchased, but quantities purchased were considerably less than when beef cattle were fed.

Medium size farm with beef feeding. Corn was produced for feeding beef cattle on a Medium size farm with a 1-man labor supply (Table XLIII). None was produced with labor supplies of two and three men. Both corn silage and orchardgrass-red clover acreages increased as the labor supply increased.

Beef heifer feeding on System 2 increased from 192 to 410 and to 433 head as the labor force was expanded from one to two and to three men. The small increase in beef feeding resulting from the addition of the third unit of labor was due to a 48-sow unit producing feeder pigs entering the optimum solution.

Selling hay and buying corn increased as the labor supply increased.

Medium size farm without beef feeding. Corn production for grain was constant at 42.2 acres for all labor situations. This was produced by utilizing all of the available row crop acreages in Soil Groups 1

TABLE XLIII

OPTIMUM FARM ORGANIZATION^a BY SIZE OF LABOR SUPPLY FOR A MEDIUM SIZE FARM
WITH AND WITHOUT BEEF FEEDING -- AREA III

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Crop Enterprises, acres</u>						
Corn	12.2	--	--	42.2	42.2	42.2
Corn silage	30.8	68.9	73.2	--	--	--
Orchardgrass-red clover hay	30.5	64.9	93.4	17.9	49.2	77.3
<u>Livestock Enterprises</u>						
Swine I, ^b sows	--	--	--	12	--	--
Swine II, ^b sows	--	--	48	22	93	147
Beef feeding II, ^c head	192	410	433	--	--	--
<u>Buying and Selling Activities</u>						
Sell hay, tons	33.0	59.2	114.3	45.5	122.0	181.6
Buy corn, bushels	2,297	6,963	9,542	--	1,000	3,477

^a Capital is charged at a market rate of 6 percent. Medium size = 250 acres of openland.

^b Swine I is production of market hogs; Swine II is production of feeder pigs.

^c Beef feeding II is feeding beef heifers on finishing System 2.

and 2. Orchardgrass-red clover hay acreages increased as the labor supply increased.

Production of both market hogs and feeder pigs occurred with a 1-man labor force. Additional labor units resulted in increased production of feeder pigs and no production of market hogs.

Hay selling increased as the number of labor units increased. Corn produced on the farm would be utilized for hog production with a 1-man labor situation. Corn buying was significant with 2- and 3-man labor supplies.

Large size farm with beef feeding. Corn acreages increased with the addition of the second unit of labor and declined with the addition of the third unit of labor (Table XLIV). Corn production included some row crop acreages from Soil Group 3 which had an assumed yield of 63 bushels per acre. Corn silage and orchardgrass-red clover hay production increased as the labor supply increased. Orchardgrass-ladino clover pasture was included with labor supplies of two and three men.

Livestock enterprises were limited to beef heifer feeding on Systems 2, 3, and 5. The number of heifers fed on System 2 increased as the labor supply increased. Beef feeding on System 5 was proportionate to the orchardgrass-ladino clover pasture acreages. Twenty-six head of heifers were fed using System 3 with a 3-man labor force.

Quantities of hay sold were small, except for a 3-man labor supply. About the same amount of corn was sold with one and two units of labor. No corn was sold with three units of labor.

TABLE XLIV

OPTIMUM FARM ORGANIZATION^a BY SIZE OF LABOR SUPPLY FOR A LARGE SIZE FARM
WITH AND WITHOUT BEEF FEEDING -- AREA III

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Crop Enterprises, acres</u>						
Corn	78.2	134.3	118.0	101.2	101.2	101.2
Corn silage	19.0	37.9	55.3	--	--	--
Orchardgrass-red clover hay	22.3	34.6	98.3	22.0	42.7	69.4
Orchardgrass-ladino pasture	--	63.7	35.5	--	--	--
<u>Livestock Enterprises</u>						
Swine II, ^b sows	--	--	--	16	78	132
Beef feeding II, ^c head	123	244	356	--	--	--
Beef feeding III, ^c head	--	--	36	--	--	--
Beef feeding V, ^c head	--	79	40	--	--	--
<u>Buying and Selling Enterprises</u>						
Sell hay, tons	27.9	15.4	153.7	56.2	109.0	177.0
Sell corn, bushels	3,923	3,465	--	7,062	4,251	1,773

^aCapital is charged at a market rate of 6 percent. Large size = 600 acres of openland.

^bSwine II is production of feeder pigs

^cBeef feeding II, III, and V are feeding beef helpers on finishing Systems 2, 3, and 5, respectively.

Large farm without beef feeding. Acreage of corn was 101.2 for all three labor levels. Corn was produced only on Soil Groups 1 and 2. Production of orchardgrass-red clover hay increased as the labor supply increased.

Feeder pig production and hay selling increased as the labor supply increased. The amount of corn sold declined as labor supply increased. This reflects the increase in hog production utilizing corn produced on a constant number of acres.

Value of Restricting Resources

Small size farm. Generally, marginal values for the various qualities of land resources were greater when beef cattle were fed than when beef feeding was not permitted (Table XLV). One exception is indicated by the large marginal value product of \$155.96 per acre for Soil Group 4 in the 3-man labor situation without beef feeding. Since hog pasture was limited to Soil Groups 3 and 4, this large marginal value indirectly reflects a restriction on sow numbers. The marginal value of additional land increased considerably in most cases as more labor was added to the fixed land supply of 100 acres of openland. When no beef feeding was allowed, the marginal value product of several of the land categories was zero indicating an excess supply of this particular resource.

Labor was limiting during Period 2 in all resource situations and the marginal value of an additional hour of labor varied from \$2.18 to \$6.39 when no beef feeding was allowed and from \$6.39 to \$11.24 when

TABLE XLV

MARGINAL VALUE PRODUCTS FOR RESTRICTING RESOURCES BY SIZE OF LABOR SUPPLY FOR
A SMALL SIZE FARM WITH AND WITHOUT BEEF FEEDING^a -- AREA III

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
Land, per acre						
Soil group 1	\$58.33	\$63.02	\$74.61	\$25.58	\$30.60	\$53.48
Soil group 2	13.32	39.13	48.50	13.32	19.35	42.23
Row crop 2	29.91	8.79	10.12	1.01	--	--
Soil group 3	--	25.80	35.18	--	6.03	28.90
Row crop 3	21.14	--	--	--	--	--
Soil group 4	--	12.48	44.39	--	--	155.96
Soil group 5	--	--	1.40	--	--	--
Labor, per hour						
Labor period 2 (Mar. 1-Apr. 14)	6.39	10.52	11.24	6.39	5.98	2.18
Labor period 3 (Apr. 15-May 31)	10.35	2.76	--	10.35	8.06	--
Labor period 5 (Aug. 16-Sept. 30)	--	--	--	--	1.73	6.28
Miscellaneous Values						
Corn, per bushel	1.25	1.25	1.25	1.25	1.25	1.25
Corn silage, per ton ^b	9.00	9.00	9.40	--	--	--

^aCapital is charged at a market rate of 6 percent. Small size = 100 acres of openland.

^bOn an as-fed basis.

beef feeding was included. Labor was limiting both with and without beef feeding during Period 3 when there were 1- and 2-man labor supplies, but not with a 3-man labor supply. Also, labor was limiting during Period 5 with 2- and 3-man labor supplies and no beef feeding. Interestingly, in some cases increasing the labor supply resulted in an increase in the marginal value of labor in a particular period.

Corn was purchased in each resource situation and as a result the marginal value was equal to the purchase price, \$1.25 per bushel. Corn silage was worth between \$9.00 and \$9.40 per additional ton.

Medium size farm. Except for row crop acreage on Soil Groups 2 and 3 with a 3-man labor supply and beef feeding, marginal values for additional acreages were much smaller in Area III than either in Areas I or II. This implies that more extensive use had to be made of live-stock production in Area III in order to attain marginal land values similar to the other areas.

Marginal value products for a land:labor ratio of 100:1 on a Small farm with a 1-man labor supply (Table XLV) and those for a land:labor ratio of 83:1 on a Medium size farm with a 3-man labor supply (Table XLVI) were remarkably similar and generally approach the value of the marginal products found in the other study areas.

Labor was limiting in Labor Periods 2 and 3 for all resource situations on a Medium size farm and the marginal value of an additional unit of labor was quite high. Corn was bought in all cases except when there was no beef feeding and a 1-man labor supply where corn produced

TABLE XLVI

MARGINAL VALUE PRODUCTS FOR RESTRICTING RESOURCES BY SIZE OF LABOR SUPPLY
FOR A MEDIUM SIZE FARM WITH AND WITHOUT BEEF FEEDING^a -- AREA III

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Land, per acre</u>						
Soil group 1	\$14.48	\$29.80	\$54.21	\$17.74	\$25.32	\$25.32
Soil group 2	--	13.32	13.32	--	13.32	13.32
Row crop 2	3.23	5.56	27.90	6.97	0.75	0.75
Row crop 3	--	--	19.19	--	--	--
<u>Labor, per hour</u>						
Labor period 2 (Mar. 1-Apr. 14)	9.71	9.88	7.20	5.38	7.20	7.20
Labor period 3 (Apr. 15-May 31)	12.62	9.12	9.12	12.62	9.12	9.12
<u>Miscellaneous Values</u>						
Corn, per bushel	1.25	1.25	1.25	1.20	1.25	1.25
Corn silage, per ton ^b	7.48	7.99	8.92	--	--	--

^aCapital is charged at a market rate of 6 percent. Medium size = 250 acres of openland.

^bOn an as-fed basis.

on the farm was used in hog production. An additional ton of corn silage was worth between \$7.48 and \$8.92.

Large size farm. Row crop acreages were very important relative to non-row crop acreages as indicated by the much larger marginal values for soil groups capable of producing row crops (Table XLVII). Also, in all cases additional acreages were more valuable when beef cattle feeding was permitted.

With beef feeding, labor was limiting during Labor Periods 3 and 5 for all labor supplies and during Labor Period 2 in cases of 1- and 2-man labor forces. Marginal value products for labor varied from \$1.81 to \$13.52. Without beef feeding, labor was limiting during Labor Period 3 for all labor conditions, during Labor Period 2 for 2- and 3-man labor supplies, and during Labor Period 6 for a 1-man labor supply. Marginal value products in limiting periods varied from \$4.69 to \$13.79.

Corn was sold in all cases, except with a 3-man labor supply and beef feeding where corn was produced on the farm and fed to livestock with a resulting marginal value of \$1.24 per bushel. Value of additional units of corn silage varied widely ranging from \$6.62 to \$11.13 per ton. This was probably the primary factor in explaining the relatively large marginal values for row crop acreages discussed above.

Use of Basic Resources

Land. The proportion of idle land in the optimal systems was much greater in Area III than in either Areas I or II (Table XLVIII).

TABLE XLVII

MARGINAL VALUE PRODUCTS FOR RESTRICTING RESOURCES BY SIZE OF LABOR SUPPLY
FOR A LARGE SIZE FARM WITH AND WITHOUT BEEF FEEDING^a -- AREA III

	With Beef Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Land, per acre</u>						
Soil group 1	\$14.98	\$40.08	\$50.96	\$14.06	\$22.45	\$22.45
Soil group 2	--	0.01	5.18	--	--	--
Row crop 2	--	16.65	20.59	3.35	11.74	11.74
Row crop 3	--	--	8.45	--	--	--
<u>Labor, per hour</u>						
Labor period 2 (Mar. 1-Apr. 14)	12.77	2.37	--	--	4.69	4.69
Labor period 3 (Apr. 15-May 31)	13.52	12.76	11.35	13.79	13.79	13.79
Labor period 5 (Aug. 16-Sept. 30)	1.81	6.83	7.63	--	--	--
Labor period 6 (Oct. 1-Nov. 30)	--	--	--	5.14	--	--
<u>Miscellaneous Values</u>						
Corn, per bushel	1.19	1.19	1.24	1.19	1.19	1.19
Corn silage, per ton	6.62	10.35	11.13	--	--	--

^a Capital is charged at a market rate of 6 percent. Large size = 600 acres of openland.

^b On an as-fed basis.

TABLE XLVIII

UNUSED LAND RESOURCES BY SIZE OF FARM AND SIZE OF LABOR SUPPLY
WITH AND WITHOUT BEEF FEEDING^a - AREA III

	With Beef Feeding		Without Beef Feeding	
	Total Acres Idle	Percent Idle	Total Acres Idle	Percent Idle
<u>Small</u> ^b				
1-man	31.7	31.7	41.9	41.9
2-man	8.1	8.1	14.4	14.4
3-man	3.3	3.3	8.1	8.1
<u>Medium</u> ^b				
1-man	177.3	70.9	178.3	71.3
2-man	116.2	46.5	135.4	54.1
3-man	71.5	28.6	93.8	37.5
<u>Large</u> ^b				
1-man	480.6	80.1	472.6	78.8
2-man	329.6	54.9	436.6	72.8
3-man	292.9	48.8	396.4	66.1

^aCapital is charged at a market rate of 6 percent.

^bSmall = 100 acres of openland; Medium = 250 acres of openland;
and Large = 600 acres of openland.

When beef feeding was allowed, the proportion of unused land ranged from 3.3 percent with a 33:1 land:labor ratio to 80.1 percent with a 600:1 land:labor ratio. Without beef feeding, the proportion of unused land ranged from 8.1 percent on the Small farm with a 3-man labor supply to 78.8 percent on the Large farm with a 1-man labor supply.

This area apparently required a lower land:labor ratio in order to utilize land resources because of the smaller proportion of more productive soils, somewhat lower crop yields, fewer choices of crops to grow, and the resulting important contribution to farm income made by livestock enterprises.

Labor. The proportion of unused labor is shown by resource situation in Table XLIX. Labor was most restrictive in Labor Periods 2 and 3 (March 31 to May 31) in most situations. Labor Period 5 (August 16 to September 30) was a critical period on Large farms when beef feeding was allowed. The proportion of labor that was unused was rather high in Periods 1 and 4 in situations with beef feeding.

Compared to Areas I and II both with and without beef feeding, labor in Area III was generally used least efficiently during Labor Periods 4 and 5, most efficiently in Labor Period 1, and about the same in the other periods.

Finishing Systems and Ration Components

System 2 (full feeding corn silage, plus 5 pounds of corn grain per head per day) was the only feeding system utilizing corn silage to appear in the optimum solutions for this area (Table L). With annual

TABLE XLIX

PROPORTION OF LABOR UNUSED BY LABOR PERIOD, SIZE OF LABOR SUPPLY, AND SIZE
OF FARM WITH AND WITHOUT BEEF FEEDING^a -- AREA III

	With Beef Feeding						Without Beef Feeding					
	Labor Period						Labor Period					
	1	2	3	4	5	6	1	2	3	4	5	6
<u>1-man labor</u>												
Small ^b	35.3	--	--	47.8	37.5	57.9	14.1	--	--	3.6	3.5	32.6
Medium ^b	41.1	--	--	67.8	57.6	55.5	29.6	--	--	22.4	28.1	27.9
Large ^b	57.3	--	--	70.4	--	13.6	62.2	13.5	--	47.0	64.9	--
<u>2-man labor</u>												
Small	24.2	--	--	24.3	22.9	38.2	8.3	--	--	2.8	--	30.3
Medium	37.9	--	--	67.6	52.2	59.3	14.5	--	--	11.0	6.5	32.8
Large	44.2	--	--	63.0	--	14.7	26.4	--	--	21.5	23.8	13.0
<u>3-man labor</u>												
Small	21.9	--	14.3	27.7	23.3	34.4	6.6	--	15.6	11.5	--	32.3
Medium	27.6	--	--	48.0	34.1	52.1	10.7	--	--	7.8	1.5	33.5
Large	53.6	18.2	--	61.2	--	40.9	18.5	--	--	14.7	14.1	20.3

^a Capital is charged at a market rate of 6 percent.

^b Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

TABLE I

OPTIMUM NUMBER OF BEEF HEIFERS TO FEED BY SIZE OF FARM, LABOR SUPPLY, COST OF ANNUAL CAPITAL AND PREDOMINANT RATION COMPONENT -- AREA III

	Corn Silage			Pasture/plus Grain			Corn Grain			Total		
	Percent			Percent			Percent			Percent		
	6	9	12	6	9	12	6	9	12	6	9	12
Small^a												
1-man	171	171	--	--	--	--	--	--	--	171	171	--
2-man	126	53	53	--	--	--	--	--	--	126	53	53
3-man	130	3	3	--	--	--	--	--	--	130	3	3
Medium^a												
1-man	192	192	192	--	--	--	--	--	--	192	192	192
2-man	410	410	--	--	--	--	--	--	--	410	410	--
3-man	433	433	--	--	--	--	--	--	--	433	433	--
Large^a												
1-man	123	123	117	--	--	--	--	--	--	123	123	117
2-man	244	243	243	79	--	--	--	--	--	323	243	243
3-man	356	329	329	40	--	--	26	--	--	422	329	329

^a Small = 100 acres of openland; Medium = 250 acres of openland; and Large = 600 acres of openland.

capital charged at 6 percent, the number of heifers fed ranged from 126 to 130, from 192 to 433, and from 123 to 356 on Small, Medium, and Large size farms, respectively. The largest number of heifers were fed on a Medium size farm in all labor supply situations with an annual capital charge of 9 percent and on a Medium size farm with a 1-man labor supply when capital was charged at 12 percent. With 2- and 3-man labor supplies and capital charged at 12 percent, however, the largest number of heifers was fed on a Large size farm. No beef steers were fed in any resource situation.

A relatively small number (26 head with a 3-man labor supply and annual capital at 6 percent) of heifers were fed on System 3 (full feeding of corn grain). System 5 (pasture plus grain) was utilized for feeding 70 and 40 head of heifers on a Large size farm with 2- and 3-man labor supplies, respectively, and annual capital charged at 6 percent. Systems 3 and 5 were not utilized in any resource situation when annual capital charges exceeded 6 percent.

Neither Systems 1 (full feeding corn silage followed by a full feeding grain phase) nor 4 (pasture only followed by a full feeding grain phase) were included in any of the optimum farm organizations of Area III.



CHAPTER VI

RESULTS AND DISCUSSION OF SPECIAL ANALYSES

Observations from the primary analysis in Chapter V resulted in the decision to acquire additional data with the following modifications: (1) removal of swine enterprises as production alternatives on a Medium size farm in Area III; (2) removal of heifer finishing systems as production alternatives on a Medium size farm in Area II; and (3) removal of hay selling as a production alternative on a Medium size farm in Area II.

A. AREA III -- NO SWINE PRODUCTION ON A MEDIUM SIZE FARM

This particular analysis was designed in an attempt to determine, more precisely, the effect of beef cattle feeding and hog production upon the proportion of unused land resources. As indicated in the earlier analysis, idle or unused land was relatively important in some of the resource situations, especially in Area III. Combined with results from the earlier analysis, the effect of swine production on income without beef feeding and the proportion of basic land resources utilized in all combinations with and without beef feeding and swine production can be evaluated.

Maximum Potential Income

Without beef feeding, swine production resulted in increased income in every resource situation considered. Potential income ranged from \$5,351 to \$14,773 with swine production and from \$4,261 to \$8,327 without swine production (Table LI). The effects of swine production on income increased very rapidly as the labor supply increased. Percentage increase in income increased about the same amount (25 to 27 percent) for each additional unit of labor. It appears that swine enterprises without beef feeding could be important contributors to farm income in the Cumberland Plateau Area.

Capital Requirements

Without swine production, investment and annual capital requirements ranged from \$3,736 to \$10,480 and from \$1,521 to \$2,889, respectively, and were less in all cases than when swine enterprises were included in the farm product mix. Increases in requirements resulting from swine production ranged from \$3,904 to \$14,451 for investment capital and from \$2,667 to \$6,326 for annual capital. Hence, absolute requirements for investment capital were considerably greater than for annual capital when swine were produced.

Farm Organization

Detailed optimum farm organizations, both with and without swine production, are included in Table LII. Crop production with swine production includes a constant 42.2 acres of corn for all labor situations

TABLE LI

MAXIMUM POTENTIAL INCOME^a AND CAPITAL REQUIREMENTS BY SIZE
OF LABOR SUPPLY FOR A MEDIUM^b SIZE FARM WITH AND
WITHOUT SWINE PRODUCTION -- AREA III

	With Swine Production	Without Swine Production	Increase With Swine Production	
			Total	Percent
<u>Income</u>				
1-man	\$ 5,351	\$ 4,261	\$ 1,090	25.6
2-man	10,233	6,701	3,532	52.7
3-man	14,773	8,327	6,446	77.4
<u>Investment Capital</u>				
1-man	7,640	3,736	3,904	104.5
2-man	16,271	6,028	10,243	169.9
3-man	24,931	10,480	14,451	137.9
<u>Annual Capital</u>				
1-man	4,188	1,521	2,667	175.3
2-man	6,081	1,887	4,194	222.3
3-man	9,215	2,889	6,326	219.0

^aIncome to land, labor, and management without beef feeding.
Capital is charged at a market rate of 6 percent.

^bMedium = 250 acres of openland.

TABLE LII

OPTIMUM FARM ORGANIZATION BY SIZE OF LABOR SUPPLY FOR A MEDIUM SIZE FARM
WITH AND WITHOUT SWINE PRODUCTION^a -- AREA III

	With Swine Production			Without Swine Production		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Crop Enterprises, acres</u>						
Corn	42.2	42.2	42.2	71.2	45.3	23.1
Alfalfa hay	--	--	--	--	--	56.4
Orchardgrass-red clover hay	17.9	49.2	77.3	41.0	128.0	150.2
Fescue-ladino pasture	--	--	--	--	--	12.0
<u>Livestock Enterprises^b</u>						
Manufacturing milk, cows	--	--	--	--	--	3
Swine I, ^c sows	12	--	--	--	--	--
Swine II, ^c sows	22	93	147	--	--	--
<u>Buying and Selling Activities</u>						
Sell hay, tons	45.5	122.0	181.6	104.6	289.5	484.5
Sell corn, bushels	--	--	--	5,089	3,454	1,729
Buy corn, bushels	--	1,000	3,477	--	--	--

^aCapital is charged at a market rate of 6 percent. Medium size = 250 acres of openland.

^bBeef feeding is not permitted.

^cSwine I is production of market hogs; Swine II is production of feeder pigs.

and 17.9, 49.2, and 77.3 acres of orchardgrass-red clover hay for the 1-, 2-, and 3-man labor supplies.

With a 1-man labor supply, swine production is divided into a 12-sow unit producing market hogs and a 22-sow unit producing feeder pigs. Additional labor results in production of only feeder pigs with 93 and 147 sow units for the 2- and 3-man labor supplies, respectively. Hay selling increases with hay acreages and corn buying increases with increases in hog numbers.

Elimination of swine production alternatives results in corn acreages declining from 71.2 to 45.3 to 23.1 as the labor supply increases from one to two to three men. Orchardgrass-ladino clover hay acreages were much larger than they were with swine production and ranged from 41.0 to 150.2 acres. Also, 56.4 acres of alfalfa hay and 12.0 acres of fescue pasture were included with a 3-man labor supply.

Selling hay and corn were the primary sources of income without swine production.

Use of Basic Resources

Both swine production and beef cattle feeding had considerable influence on use of land and labor resources as shown in Table LIII. On a Medium size farm in Area III the largest proportion of available land resources going unused regardless of the size of the labor supply occurred with swine production and no beef feeding. Allowing beef feeding as well as swine production resulted in some reduction in unused land resources in all labor situations compared to no beef

TABLE LIII

UNUSED LAND AND LABOR RESOURCES BY SIZE OF LABOR SUPPLY
WITH AND WITHOUT BOTH SWINE PRODUCTION AND BEEF
FEEDING ON A MEDIUM SIZE FARM^a -- AREA III

	Land					Labor				
	With		Without			With		Without		
	Beef Feeding		Beef Feeding			Beef Feeding		Beef Feeding		
	Total	Acres	Total	Acres	Percent	Total	Hours	Total	Hours	Percent
	Idle	Idle	Idle	Idle	Idle	Unused	Unused	Unused	Unused	Unused
<u>With Swine Production</u>										
1-man	177.3	70.9	178.3	71.3		903	40.9	446	20.2	
2-man	116.2	46.5	135.4	54.1		1768	40.0	543	12.3	
3-man	71.5	28.6	93.8	37.5		1984	29.9	672	10.1	
<u>Without Swine Production</u>										
1-man	117.3	70.9	137.8	55.1		903	40.9	1362	61.6	
2-man	116.2	46.5	76.7	30.7		1768	40.0	2994	67.7	
3-man	29.6	11.8	8.3	3.3		2499	37.7	4220	63.6	

^aCapital is charged at a market rate of 6 percent. Medium size = 250 acres of openland.

feeding with swine production. The smallest percentage of idle land resulted when neither swine production nor beef feeding occurred.

Including either beef feeding or swine production activities reduced the amount of unused labor. The largest proportion of available labor was used (more than 79 percent) with swine production and no beef feeding while the smallest amount of labor was used (less than 40 percent) with no swine production or beef feeding. As the size of the labor force increased, the proportion of available labor used increased when swine production and/or beef feeding was permitted, but remained about the same when neither of these alternatives were permitted.

Thus, in Area III neither swine production nor beef feeding would be included in the farm organization if the objective was to maximize the proportion of land used. However, if the objective was maximization of labor use during a production year, swine production and no beef feeding would be included in the farm plan.

B. AREA II -- NO BEEF HEIFER FEEDING ON A MEDIUM SIZE FARM

In the earlier analysis all of the beef feeding activities in the optimum systems involved feeding of heifers rather than steers. Obviously, in the aggregate many of the beef cattle fed for the slaughter market must be steers. In the following analysis all of the heifer finishing systems were excluded as production alternatives. The objectives were to determine the feasibility of steer feeding and to compare the relative farm incomes from heifer and steer feeding with farm incomes where no beef feeding was permitted. This analysis was done

only for the Medium size farm (250 acres of openland) in Area II. This particular resource situation was chosen because of the large number of beef heifers fed in optimum solution of the earlier analysis.

Maximum Potential Income

Comparisons of the optimum farm incomes resulting from beef heifer feeding, beef steer feeding, and no beef feeding are shown in Table LIV. Steer feeding resulted in income increases (above systems with no beef feeding) of 3.0, 5.0, and 5.4 percent while beef heifer feeding increased income by 8.1, 11.7, and 11.0 percent for 1-, 2-, and 3-man labor supplies, respectively. Thus, while steer feeding does not appear to be as profitable as beef heifer feeding given the data and assumptions of this study, incomes were improved in each labor situation by the inclusion of the steer feeding alternatives in the optimum systems.

Capital Requirements

Investment capital requirements were slightly lower in resource situations involving steer feeding than they were in similar situations involving heifer feeding because of the smaller number of head fed. Annual capital requirements were larger for steer feeding than for heifer feeding with labor supplies of two and three men because steer feeding requires the use of annual capital over a longer time period than does heifer feeding.

TABLE LIV

MAXIMUM POTENTIAL INCOME^a AND CAPITAL REQUIREMENTS BY SIZE OF
 LABOR SUPPLY FOR A MEDIUM^b SIZE FARM WITH AND
 WITHOUT BEEF STEER AND HEIFER FEEDING --
 AREA II

	With Heifer Feeding	With Steer Feeding	Without Beef Feeding
<u>Income</u>			
1-man	\$ 9,731	\$ 8,927	\$ 8,668
2-man	15,873	14,920	14,209
3-man	21,009	19,942	18,918
<u>Investment capital</u>			
1-man	8,341	7,051	7,640
2-man	16,447	15,065	16,271
3-man	26,789	24,593	24,931
<u>Annual capital</u>			
1-man	14,966	12,902	1,273
2-man	28,532	36,263	3,958
3-man	47,911	56,802	12,916

^aIncome to land, labor, and management. Capital is charged at a market rate of 6 percent.

^bMedium size = 250 acres of openland.

Farm Organization

The primary changes in farm organization that occurred by feeding beef steers rather than heifers were a reduction in alfalfa acreages, an increase in lespedeza and pasture acreages, a smaller number of cattle fed (92 steers versus 148 heifers, 268 steers versus 293 heifers, and 413 steers versus 485 heifers for the 1-, 2-, and 3-man labor supplies, respectively), more feeder pigs produced, and a smaller range in the quantity of hay sold. These adjustments were probably due to the added time required for finishing beef steers as compared to beef heifers; hence, production of labor intensive crops such as alfalfa hay declined and production of labor extensive crops such as lespedeza for hay increased. It should be noted that one finished steer represents 500 pounds of beef produced while one finished heifer represents 400 pounds of beef produced.

As shown in Table LV, steer feeding results in production of more corn silage, less soybeans, more oats-lespedeza hay, less alfalfa hay, more lespedeza hay, less fescue-ladino clover pasture, and more lespedeza pasture than no beef feeding in all the labor situations considered. Fewer hogs were produced and less hay was sold when steers were fed. Corn was purchased both with and without steer feeding, except with a 1-man labor supply and no steer feeding.

Only System 2 (full feeding corn silage, plus 5 pounds of corn grain per head per day) was utilized for finishing beef steers. Although most of the heifers were finished on System 2 in the earlier

TABLE IV

OPTIMUM FARM ORGANIZATION BY SIZE OF LABOR SUPPLY FOR A MEDIUM SIZE FARM WITH
AND WITHOUT BEEF STEER FEEDING^a -- AREA II

	With Steer Feeding			Without Beef Feeding		
	1-man	2-man	3-man	1-man	2-man	3-man
<u>Crop Enterprises, acres</u>						
Tobacco	0.9	1.2	1.2	--	1.2	1.2
Corn	--	--	--	--	--	9.7
Corn silage	16.5	51.5	80.0	--	--	--
Soybeans	79.8	44.5	15.9	97.2	96.0	86.2
Oats-lespedeza hay	--	--	22.1	--	--	--
Alfalfa hay	--	42.5	66.1	24.3	76.5	82.4
Lespedeza hay	--	49.2	34.8	--	--	--
Fescue-ladino pasture	64.9	--	5.6	96.6	60.7	29.7
Lespedeza pasture	38.6	11.8	--	22.4	--	--
<u>Livestock Enterprises</u>						
Swine I, ^b sows	--	--	--	--	12	62
Swine II, ^b sows	--	--	21	--	--	--
Beef feeding II, ^c head	92	268	413	--	--	--
<u>Buying and Selling Activities</u>						
Sell hay, tons	57.0	164.1	194.4	191.7	343.6	337.8
Buy corn, bushels	1,872	5,461	9,365	--	2,282	11,005

^a Capital is charged at a market rate of 6 percent. Medium size = 250 acres of openland.

^b Swine I is production of market hogs; Swine II is production of feeder pigs.

^c Beef feeding II is feeding beef steers on finishing System 2.

analysis, some were also finished on System 5 (pasture, plus grain) with 1- and 2-man labor supplies.

C. AREA II -- MEDIUM SIZE FARM WITH AND WITHOUT
HAY SELLING AND NO BEEF FEEDING

Although this study was designed as an analysis of individual firm resource situations, the appearance of hay selling in all of the optimum solutions indicated that adoption of the optimum farm organizations by a large segment of the industry would result in a substantially reduced market for hay. Therefore, this special analysis was designed to determine the effect on income and capital requirements of eliminating hay selling as a production alternative. This particular resource situation was selected because of the very large quantities of hay sold in each of the labor situations.

Maximum Potential Income and Capital Requirements

Income to land, labor, and management increased by 9.2 to 14.1 percent when hay selling was permitted on a Medium size farm in Area II (Table LVI). This represents absolute increases in income of \$727, \$1,756, and \$1,980 for labor supplies of one, two, and three men.

Excluding the hay selling alternative resulted in increased investment and annual capital requirements. Percentage increases in investment capital ranged from 25.6 to 32.5 and percentage increases in annual capital ranged from 29.5 to 64.3.

TABLE LVI

MAXIMUM POTENTIAL INCOME^a AND CAPITAL REQUIREMENTS BY SIZE
OF LABOR SUPPLY FOR A MEDIUM^b SIZE FARM WITH
AND WITHOUT HAY SELLING -- AREA II

	With Hay Selling	Without Hay Selling	Increase With Hay Selling	
			Total	Percent
<u>Income</u>				
1-man	\$ 8,668	\$ 7,941	\$ 727	9.2
2-man	14,209	12,453	1,756	14.1
3-man	18,918	16,938	1,980	11.7
<u>Investment Capital</u>				
1-man	5,880	7,902	-2,022	-25.6
2-man	10,862	14,927	-4,065	-27.2
3-man	15,824	23,441	-7,617	-32.5
<u>Annual Capital</u>				
1-man	1,273	3,383	-2,110	-62.4
2-man	3,958	11,097	-7,139	-64.3
3-man	12,916	18,316	-5,400	-29.5

^aIncome to land, labor, and management without beef feeding.
Capital is charged at a market rate of 6 percent.

^bMedium size = 250 acres of openland.

Thus, not only does the hay selling alternative result in larger optimum incomes in these resource situations, but it also substantially reduces both the investment and annual capital requirements.

Farm Organization

When hay selling was excluded as an alternative, these changes in farm organization were noted for the 1-man labor situation: tobacco acreage increased to the limit of the allotment, corn production was expanded considerably, soybean production declined, alfalfa hay was not produced, fescue-ladino clover and lespedeza pasture acreages declined, a 13-sow unit producing market hogs was added, and beef cow-calf production was included for the first time in any of the analyses of this study (see Table LVII).

Addition of the second unit of labor without hay selling resulted in pasture production being eliminated and production of market hogs increasing to a 58-sow unit of 46 sows more than when hay selling was permitted. Less corn was grown and a large quantity of corn was purchased. Production of soybeans increased slightly.

With a 3-man labor supply and no hay selling, crop production consisted of 1.2 acres of tobacco, 7.2 acres of corn, and 88.8 acres of soybeans. A 100-sow unit producing market hogs and purchasing 18,051 bushels of corn completed the optimum farm plan.

Thus, elimination of hay selling as a production alternative generally eliminated forage production from the farm plan and replaced these activities to a great extent with production of market hogs.

TABLE LVII

OPTIMUM FARM ORGANIZATION BY SIZE OF LABOR SUPPLY FOR A MEDIUM SIZE FARM
WITH AND WITHOUT HAY SELLING^a -- AREA II

	With Hay Selling			Without Hay Selling		
	1-man	2-man	3-man	1-man	2-man	3-man
Crop Enterprises, acres						
Tobacco	--	1.2	1.2	1.2	1.2	1.2
Corn	--	--	9.7	38.9	26.5	7.2
Soybeans	97.2	96.0	86.2	57.0	69.5	88.8
Alfalfa hay	24.3	76.5	82.4	--	--	--
Fescue-ladino pasture	96.6	60.7	29.7	20.7	--	--
Orchardgrass-ladino pasture	--	--	--	0.4	--	--
Lespedeza pasture	22.4	--	--	4.6	--	--
Livestock Enterprises^b						
Beef cow-calf, cows	--	--	--	7	--	--
Swine I, ^c sows	--	12	62	13	58	100
Buying and Selling Activities						
Sell hay, tons	191.7	343.6	337.8	--	--	--
Buy corn, bushels	--	2,282	11,005	--	9,009	18,051
Sell corn, bushels	--	--	--	200	--	--

^aCapital is charged at a market rate of 6 percent. Medium size = 250 acres of openland.

^bNo beef feeding was permitted.

^cSwine I is production of market hogs.

Use of Basic Resources

As shown in Table LVIII, a much smaller proportion of the available land area was utilized when hay was not sold. Only the least productive soils (Soil Group 6) remained idle in all labor situations when hay was sold, but nearly one-half of the land resources remained unused with elimination of hay selling.

Without hay selling, a much greater proportion of the available labor was utilized during Labor Periods 1, 2, and 6 than was the case when hay selling occurred. However, elimination of hay selling resulted in less complete utilization of available labor in Periods 3 and 4.

Thus, elimination of hay selling resulted in a larger percent of the available land resources being unused and in a more uniform and complete utilization of available labor throughout the year.

TABLE LVIII
 UNUSED LAND AND LABOR RESOURCES BY SIZE OF LABOR SUPPLY
 WITH AND WITHOUT HAY SELLING ON A MEDIUM SIZE
 FARM^a -- AREA II

	Unused Land	Unused Labor				
		Labor Period ^b				
		1	2	3	4	5
-----Percent-----						
<u>With Hay Selling</u>						
1-man	3.8	85.7	43.4	--	8.7	100.0
2-man	3.8	74.2	49.9	--	9.5	72.5
3-man	3.8	48.2	22.9	--	6.9	48.3
<u>Without Hay Selling</u>						
1-man	48.3	42.3	--	--	17.9	19.1
2-man	49.5	28.4	--	9.8	15.6	22.2
3-man	41.2	23.2	--	13.9	14.6	25.3

^aCapital is charged at a market rate of 6 percent. Medium size = 250 acres of openland.

^bOmitted labor periods were expended in all resource situations.

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CHAPTER VII

SUMMARY AND CONCLUSIONS

A. SUMMARY

The primary objective of this study was to determine the effects that alternative beef cattle finishing systems have on farm income potential and resource utilization in three agricultural areas of Tennessee with three sizes of farm, three levels of labor availability, and three levels of annual capital availability in each area. The basic feeding systems included were: (1) feeding corn grain and/or corn silage as the primary ration ingredient(s), varying the proportion of each in order to obtain the desired finished product, or (2) limited corn grain or corn silage during the winter months followed by either: (a) limited grain plus pasture and a short feedlot, or (b) no grain on pasture, plus a longer feedlot period than in (a) above.

Technical coefficients were generally derived from experiment station data gathered in the respective areas and from available budgets for the various enterprises. Since the functional relationships between corn grain, corn silage, and beef cattle gain have not been developed, this became the first step in the analysis. The following production function for corn grain and corn silage fed to beef cattle was fitted from results of 304 different groups of beef cattle fed at several experiment station locations:

$$\hat{Y} = 0.9159 + 0.1479X_1 - 0.002754X_1^2 + 0.1160X_2 + 0.001629X_2^2 \\ - 0.0001102X_2X_4 - 0.0007262X_3 - 0.1010X_5 .$$

where $\hat{Y}$ = estimated daily gain, pounds;

X_1 = daily ration of corn grain, pounds;

X_2 = daily ration of corn silage, pounds of air dry matter;

X_3 = length of feeding period, days;

X_4 = initial weight, pounds; and

X_5 = dummy variable for heifers.

The R^2 value for this equation was 66.75 percent.

The estimating equation above was the basis for the following conclusions: (1) the relationship between beef gains and corn grain fed was one of diminishing returns characteristic of Stage II of the classical production function and was in general agreement with those reported by other workers [20]; (2) the relationship between beef gain and corn silage fed indicated that observations were in the increasing returns sector of the production function; (3) at a given level of feeding corn silage, increases in initial weight resulted in less daily gain; (4) the longer the feeding period, the less the daily gain; and (5) steers gain an average of 0.101 pound per day more than heifers.

Future research could more accurately define these relationships by explicitly considering the following additional variables: year, breed of cattle, level and source of protein feed, location, and temperatures prevailing during the feeding period. Ideally, an experiment or experiments designed specifically for evaluation of the functional

relationships between corn grain and corn silage fed to beef cattle being finished for market would provide the most accurate estimates of the desired functional relationships.

Linear programming techniques were utilized to maximize net income to land, labor, and management for the assumed technical and price relationships for all possible combinations of the following variables with and without beef feeding: Large (600 acres of openland), Medium (250 acres of openland), and Small (100 acres of openland) size farms; 1-, 2-, and 3-man year labor supplies; and annual capital costing 6, 9, and 12 percent. The varying rates of capital charge were included to provide a means of evaluating risk aspects of beef feeding alternatives. Differentials in optimum income levels between situations permitting beef feeding and situations where beef feeding alternatives were excluded indicate the potential role of beef feeding in farming systems in the various areas studied.

B. AREA I (SOUTHERN PLATEAU SLOPE)

Maximum potential income was greater when beef heifer feeding was included for all land and labor situations, with improvements in income ranging from \$6 to \$3,338. The greatest influence on income occurred on Small and Medium size farms regardless of the labor supply. Increasing the charge for annual capital to 9 percent resulted in beef cattle feeding having no effect on Large farm income and less effect on Small and Medium size farm incomes. Incremental increases in income

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became smaller and smaller as the labor supply was increased on a given size farm.

Investment capital requirements were slightly greater when beef cattle were fed and annual capital requirements were much greater for farm organizations including beef cattle feeding. The large annual capital requirements for feeding beef cattle and the associated high risk are undoubtedly important factors restricting the expansion of beef cattle feeding in Tennessee. The relatively small annual capital requirements and lower risk for beef cow-calf production make this enterprise a more attractive alternative in situations where capital restrictions are present or where risk aversion is very important to the decision maker.

Optimum farm organization on a Small farm included mainly livestock enterprises, especially as the land:labor ratio became very small. Production of feeder pigs was limited only by available pasture on Soil Group 4 in cases where a relatively large amount of labor was available on both Small and Medium size farms. In all instances where livestock were included in the optimum solutions for Small and Medium farms, corn was purchased. Hay was sold in every resource situation considered in this area.

In most instances increased labor on a given sized farm resulted in more alfalfa, less soybeans, more corn silage (with beef feeding), and more corn grain (on Large size farms) being produced.

Corn production for sale was included in all optimum systems except one case on Large size farms and hay quantities produced and sold

were much greater on the Large farms. The analysis here suggests that, as farm size continues to increase, the greater the tendency will be for this area to become self-sufficient in production of corn given the price relationships of this study.

In all resource situations except one, cotton allotments were not completely expended on Small size farms and in one case cotton allotment was not completely used on a Medium size farm. An additional acre of cotton allotment was much more valuable on the Medium and Large size farms. In situations where cotton allotment was limiting, the annual values for an additional pound of lint cotton on a Medium farm ranged from 2.9 to 4.2 cents and on a Large farm from 4.8 to 5.4 cents. These results suggest that cotton production on larger farms tends to be more advantageous for the farm sizes considered in this study.

The marginal value products for an additional ton of corn silage (assumed dry matter content, 33.3 percent) ranged from \$8.73 to \$12.00 per ton in this area when beef cattle feeding was permitted.

Beef cattle feeding had no consistent effect upon the proportion of total available land which was left idle. In most instances beef feeding resulted in a smaller proportion of the available labor going unused during a given labor period. Since excess labor was available in all resource situations during Labor Periods 1 and 6 and excess land existed in most cases, further research is needed to determine if other enterprises could be added as alternatives to more efficiently utilize the available labor and land resources.

Beef steer feeding did not occur in any resource situation where beef heifer feeding was permitted. When capital was charged at 6 percent, 92 and 100 percent of the heifers fed on Small and Medium size farms, respectively, were finished on a system composed predominantly of corn silage (Systems 1 and 2). Most of the heifers fed on a Large size farm were finished on System 5 (pasture, plus supplemental grain).

As the charge for annual capital was increased above 6 percent, the number of heifers fed generally declined, especially when systems were utilizing feedstuffs other than corn silage as the predominant ration component.

C. AREA II (CENTRAL BASIN)

The addition of beef feeding alternatives increased the income potential in all situations except on a Large size farm with a 1-man labor supply. Estimated income increases from beef feeding ranged from \$461 to \$2,091.

Compared to Area I, incomes in Area II were slightly greater in all resource situations considered on Small and Medium size farms and considerably less on Large size farms.

The marginal value product of an additional acre of tobacco allotment decreased as the land labor:ratio increased. Marginal values reached the zero level at a land:labor ratio of about 200:1.

The generally larger magnitude of the marginal values of tobacco allotment acreages when beef cattle feeding occurred suggested that these enterprises are, to some degree, complementary.

In most instances, a larger percentage of the total available land was utilized in Area II than in Area I reflecting the inherent extensive production capabilities of non-row crop soils in Area II. The results in Area II supported the observation made in Area I relative to the need for some labor intensive enterprise or enterprises during the time period from October 1 to February 28.

As in Area I, no beef steers were fed in this area when beef heifer feeding was allowed. Almost all of the heifers (1,282 out of 1,308) finished on Small and Medium size farms when annual capital was charged at 6 percent were fed a predominantly corn silage ration (Systems 1 and 2). System 5 (pasture plus grain) was used exclusively for finishing beef heifers on Large size farms. Systems 3 and 4 were not utilized in any resource situation in this area. Generally, fewer heifers were fed as the charge for annual capital was increased above 6 percent.

D. AREA III (CUMBERLAND PLATEAU)

Optimum incomes in Area III were increased in all cases when beef cattle were fed. The effect on income increased both on an absolute and a percentage basis as farm size increased. The percentage increase in income became smaller for each incremental increase in labor supply on a given size farm. The largest percentage increase in income from beef feeding (25.1 percent) occurred on a Large farm with a 1-man labor supply and the largest absolute increase (\$3,026) was on

a Large farm with a 3-man labor supply. Optimum incomes were consistently lower in Area III relative to Area I and Area II incomes.

Compared to Areas I and II, the marginal values for additional units of labor declined at a much slower rate in Area III, primarily because of the important contribution made to farm income by the beef feeding and swine enterprises.

The proportion of unused land in this area was greater than in either Area I or Area II with as much as 80.1 percent of the land area remaining idle. Labor utilization was considerably different in this area with less efficient labor utilization during Labor Periods 4 and 5 and more efficient utilization in Labor Period 1.

System 2 (full feeding corn silage, plus 5 pounds of corn grain per head per day) was the only finishing system utilizing corn silage to appear in the optimum solutions for this area, and the only system included for feeding heifers on Small and Medium size farms. A few head of heifers were fed on Systems 3 and 5 on a Large size farm. No beef steers were fed in any resource situation in this area.

E. SPECIAL ANALYSES

Elimination of the swine production alternatives on a Medium size farm in Area III resulted in: (1) lower attainable incomes; (2) a sharp increase in marginal values for land, especially row crop acreages; (3) increases of 16.2 to 34.2 percent in the proportion of land resources utilized; and (4) a larger proportion of available labor going unused.

Feeding only beef steers rather than beef heifers on a Medium size farm in Area II resulted in: (1) reduction of the difference between potential incomes in beef feeding and no beef feeding situations; (2) increased production of feeder pigs; (3) reduced alfalfa and increased lespedeza hay acreages; and (4) a decrease in the marginal value of an additional acre of tobacco allotment. Under the assumptions of this study, feeding beef heifers resulted in a greater increase in potential income than did the feeding of beef steers.

Deletion of hay selling as a production alternative on a Medium size farm in Area II without beef feeding resulted in: (1) smaller potential incomes in all the labor situations considered; (2) substantially larger requirements for both investment and annual capital; (3) the first appearance of beef cow-calf production in an optimum solution; (4) a smaller proportion of the land resources utilized; and (5) the annual labor supply being more uniformly and completely utilized.

B. CONCLUSIONS

Based upon the assumption and the results of this study, least improvement in income potential from beef feeding can be expected in areas with many crop alternatives and relatively large land:labor ratios and in areas with few crop alternatives and relatively small land:labor ratios. The influence of beef feeding on farm income is greater than previous research has indicated because earlier research has generally included only grain rations fed to beef steers. Feeding beef heifers results in greater improvement in farm income than does beef steer

feeding, yet both are capable of contributing to greater farm income. As the charge for annual capital increases, the relative profitability of beef feeding enterprises declines significantly. Increasing the size of the labor supply on a given size farm will generally result in larger absolute, but smaller proportionate increases in income when beef heifers are fed.

Beef feeding has a varied effect on utilization of available land, but generally reduces the proportion of labor which is unused.

The potential for increasing farm incomes seems to be best for beef feeding systems using corn silage as the primary ration component, especially on the smaller size farms. Feeding regimens which permit the feeding of a constant level of grain over the entire feeding period appeared most often in the optimum solutions.

Beef heifer feeding utilizing a system which includes a phase of pasture plus supplemental grain is most effective for increasing the potential incomes of very large farms with rather limited labor supplies. Beef feeding with a grain only type system was advantageous in only a few of the farm resource situations considered. Feeding systems which include a pasture only phase do not appear to be as profitable as other beef finishing systems considered for resource situations similar to those found in Tennessee.

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