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To the Graduate Council:

I am submitting a thesis written by William Butler Cowan, Jr. entitled "Variations in Land-Labor Resources and Optimum Enterprise Organizations of Farms in the Brown Soil Area of West Tennessee." I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

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VARIATIONS IN LAND-LABOR RESOURCES AND OPTIMUM ENTERPRISE
ORGANIZATIONS OF FARMS IN THE BROWN SOIL AREA
OF WEST TENNESSEE

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
William Butler Cowan, Jr.

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CHAPTER I

NATURE OF THE STUDY

I. INTRODUCTION

Substantial changes have occurred in the agricultural economy in recent years. Reduction in the size of the farm labor force is one of the most important changes. In Tennessee between 1954 and 1959, the number of farm family workers, including operators, decreased from 293,535 to 184,084, or approximately a 37 per cent decrease. On a per farm basis, the number of workers have decreased from 1.44 per farm to 1.17 per farm during this period.¹ Much of this decrease was probably due to increased productivity of labor in agriculture and more nonfarm employment opportunities.

The increased productivity per unit of labor has resulted, in part, from the adoption of technological advances, particularly farm machinery, which enables the labor resources to be used more efficiently. Generally, after the adoption of technological innovations, more acreage can be handled with the same labor force, or the same acreage can be operated with less labor. Fifty years ago one farmer produced enough food to feed only himself and 6 other people, while today one farmer produces, on the average, enough food to feed himself and 30 other people.²

¹United States Bureau of the Census, United States Census of Agriculture: 1959. Tennessee, Vol. I (Washington: Government Printing Office, 1961), pp. 184-191.

²United States Department of Agriculture, Changes in Farm Production and Efficiency, Statistical Bulletin 233 (Washington: Government Printing Office), July 1964.

Nonfarm employment opportunities have increased with the development of new industries and additions to old industries. With this increase in nonfarm industrial employment opportunities, many farmers have found it advantageous to sell or rent their farms and enter into new employment or to combine a nonfarm job with their farming operations.

Another area in which changes have occurred involves the goals of farmers. With the high costs of living in our economy, farmers have found it necessary to place more emphasis on obtaining higher net incomes in order to maintain and/or increase their levels of living in comparison to persons in other occupations. The cost-price squeeze that now confronts farmers makes it increasingly difficult for them to maintain their present levels of disposable income. Another goal that seems to be taking on more significance for farm people is the desire for more leisure time in order to pursue non-income producing activities such as recreation and community endeavors.

One of the first steps in attaining these goals involves the question of choosing the best allocation of resources and optimal combinations of enterprises that will maximize net farm income. The technological developments that are adopted change the optimum resource use and enterprise organization, thus requiring significant changes in farm operations if net returns are to be maximized.

II. STATEMENT OF THE PROBLEM

Farm resources are often classed into three broad groups--land, labor, and capital. Presently, farmers are finding it easier to obtain

capital requirements, since less emphasis is being placed on collateral and more emphasis is placed on repayment ability, which is a reflection of their managerial ability and integrity. Even though capital is available for borrowing, there are many farmers reluctant to borrow because of the risks involved. Regardless of the farmers' attitudes toward borrowing, the situation remains that if net returns are to be maximized, capital must be used in combination with a proper land-labor mix. Thus, with a reasonable amount of capital available, if farmers desire to maximize net returns, they should concentrate on using this capital with an optimum land-labor combination.

The technologies that have been adopted by most farmers have necessitated changes in either the labor force or the amount of land in operation, or both. With larger and more efficient equipment it is possible for the farmer to accomplish a particular job in less time. This leaves additional hours of labor available to apply to a larger farm operation or employment elsewhere. Thus, it behooves the farmer to analyze his land-labor mix carefully in order to approach the goal of maximum net returns.

The goal of maximizing income may conflict with achieving other goals held by the farmer, such as his desire for a certain amount of leisure time. Technically, the farmer's labor can be considered a fixed cost and any use of this labor which yields a positive return, be it small or large, will add to net farm income. Because of the value the farmer may place on leisure time, instances may occur where the farmer may prefer a farm organization which requires less labor even though it

provides a slightly lower income. In a sense it may be said that the farmer places a reservation price on the use of his labor for farm-production activities, and this reservation price is equal to the subjective value he places on leisure time.

III. OBJECTIVES

The objectives of this study can be stated as follows:

(1) To determine the effects of varying land-labor combinations on optimum enterprise organization of representative farms in the Brown Soil Area of West Tennessee.

(2) To determine the effects of varying reservation prices of operator labor on net returns and enterprise organization for specified land-labor combinations.

IV. PROCEDURE

In conducting this study, the following procedures were used:

(1) The basic data for this study were obtained from information available from a present regional research project pertaining to the Brown Soil Area of West Tennessee. These data were assembled for use in the S-42 Regional Project, Revised, "An Economic Appraisal of Farming Adjustment Opportunities in the Southern Region to Meet Changing Conditions."³ These data included the input requirements of resources and output levels

³Details of this project are found in Section V. of this chapter.

of enterprises. They also included the enterprise budgets, farm sizes, soil patterns, cotton allotments, and assumed prices.

(2) Five initial land-labor combinations were selected. The labor supply (on a man-equivalent basis) and the land available for the initial situations were: part-time--0 acres; one-man--54 acres; one-and-one-half-man--130 acres; two-man--214 acres; and three-man--600 acres. In order to provide for variations in these initial land-labor combinations, provisions were made for additional acreages of land to be purchased up to 75 and 50 per cent equity at an assumed annual cost. The equity positions did not apply to the part-time labor supply, since all land was assumed to be completely variable in combination with this labor supply. Thus, only one land-labor combination was considered for the part-time farm labor situation. The basic data and assumptions used in programming the land-labor combinations at the 50 per cent equity level were also used for determining the effects of five labor reservation prices on net returns and enterprise organizations.

(3) Linear programming techniques were used to determine the effects of the land-labor combinations and labor reservation prices on net returns and enterprise organizations.

V. PREVIOUS RESEARCH

The major portion of data used in this thesis was part of the S-42 Regional Project, Revised, "An Economic Appraisal of Farming Adjustment Opportunities in the Southern Region to Meet Changing Conditions." The general objective of Project S-42, Revised, is:

. . . to extend research findings from data and analysis designed to provide guides to farmers when choosing among alternative production opportunities, especially as those opportunities are affected by changes in factor prices and levels of allotment.⁴

There are fourteen agencies cooperating in order to attain the desired data. By compiling and aggregating the research of these agencies, analyses of area farm adjustments, the effects of acreage allotment programs on representative farm organizations, and a thorough evaluation of minimum resource requirements for specified levels of income may be accomplished.

W. J. Foreman published a study which attempted to find out how the quantities of the various farm inputs affected farm income.⁵ He found that variations of input levels of the five resources considered (land, labor, capital, machinery, and livestock and forage) were associated with approximately 85 per cent of the variations in income. It was found that in many cases adjustments in resource combinations could be made which would result in additional profits to the operator.

Another study, conducted by Fred B. Saunders, involved comparisons of the use of labor in farm and nonfarm opportunities.⁶ Results of this

⁴A Guide to procedures in Southern Research Project S-42, Revised, "An Economic Appraisal of Farming Adjustment Opportunities in the Southern Region to Meet Changing Conditions," (Unpublished, The University of Tennessee, Knoxville, 1963), pp. 1-9.

⁵W. J. Foreman, Resource Returns and Productivity Coefficients on Owner-Operated Farms in the Piedmont of Georgia, Tech. Bulletin N. S. 9 (Athens, Georgia: Georgia Agricultural Experiment Station, December 1956).

⁶Fred B. Saunders, Economics of Resource Use in Farm and Nonfarm Opportunities, Bulletin N. S. 43 (Athens, Georgia: Georgia Agricultural Experiment Station, July 1957).

study indicated that returns to farmers were greater if part of the labor were used on the farm and part used in nonfarm opportunities. When considering all farms, net returns were one and one-half times larger for those farms that had some labor in nonfarm work than those that did not. This study indicated that for many farmers to maximize their goals, labor use would involve some combination of farm and nonfarm employment.

Earl O. Heady has researched in the area of marginal rates of substitution between land, labor, and capital.⁷ He pointed out that even though it would be useful to know in exact amounts the marginal rates of substitution of capital in its various forms, labor in its skilled capacities, and land in various types, it is difficult because of decomposing aggregative data. However, Heady found that by using specific factor categories under specific conditions, certain information can provide some "gross" marginal rates of substitution. Heady selected fertilizer as the resource to use, in his analysis, since it substitutes for both land and labor. It substitutes for land in the sense that a given amount of product can be produced with less land if fertilizer is used, other things being equal. Fertilizer also substitutes for labor in that fertilization of an acre boosts yield but with only a small increase in the labor required. This small increase in labor is necessary to assist in harvesting the additional yield and for applying the greater quantities of fertilizer. The results indicated that fertilizer replaced large quantities of labor, but the marginal rate of substitution of land

⁷Earl O. Heady, "Marginal Rates of Substitution Between Technology, Land, and Labor," Journal of Farm Economics, Vol. 45, No. 1. (February 1963), pp. 137-141.

for labor declined sharply as the fertilizer-labor ratio increased. This "gross" marginal substitution concept has indicated that labor can operate additional acres of land under conditions of new technology and managerial conditions, but the rate of increasing additional acres decreases as the land-labor ratio increases.

Concluding from the research cited, there are optimum combinations of agricultural resources that result in highest net returns to land, labor, and capital. With the adoption of new technologies, the optimum resource combination changes. This makes it difficult when maximizing goals to maintain a permanent resource combination once it is achieved. As previously mentioned, the changes in resource combination affect the net returns and enterprise organization of a farm.

These resource changes and their effects are discussed in the remaining parts of this thesis. Characteristics and resource availability of the study area are discussed in Chapter II. The conditions and assumptions for programming the various situations are stated in Chapter III, and the results of this study are presented in Chapter IV. Finally, the summary and implications of the study are given in Chapter V.

CHAPTER II

DESCRIPTION OF THE AREA

I. INTRODUCTION

The area of study was the Brown Soil Area of West Tennessee (Figure 1) and has been referred to as such throughout this thesis. This area included all of Crockett, Fayette, Haywood, Gibson, and Madison counties and portions of Dyer (62%), Lauderdale (59%), Tipton (91%), and Shelby (81%) counties. The Delta portions of Dyer, Lauderdale, Tipton, and Shelby counties were excluded from the study area.

Of the 2,162,681 acres of land in the study area in 1959, approximately 72 per cent was open land. Woodland totaled 395,771 acres, or approximately 18 per cent. About ten per cent of the area was classed as wasteland.¹

II. CHARACTERISTICS OF THE STUDY AREA

Soil Type and Topography

Soils found in the study area consisted primarily of the Memphis, Loring, Grenada, Calloway, and Henry series. These soil types included most of the loessial silt type material that is characteristic of this area. This material averaged 18 to 24 inches in depth in the western portion of the study area but thinned out to the east.

¹United States Bureau of the Census, United States Census of Agriculture: 1959. Tennessee, Vol. I (Washington: Government Printing Office, 1961), pp. 184-191.

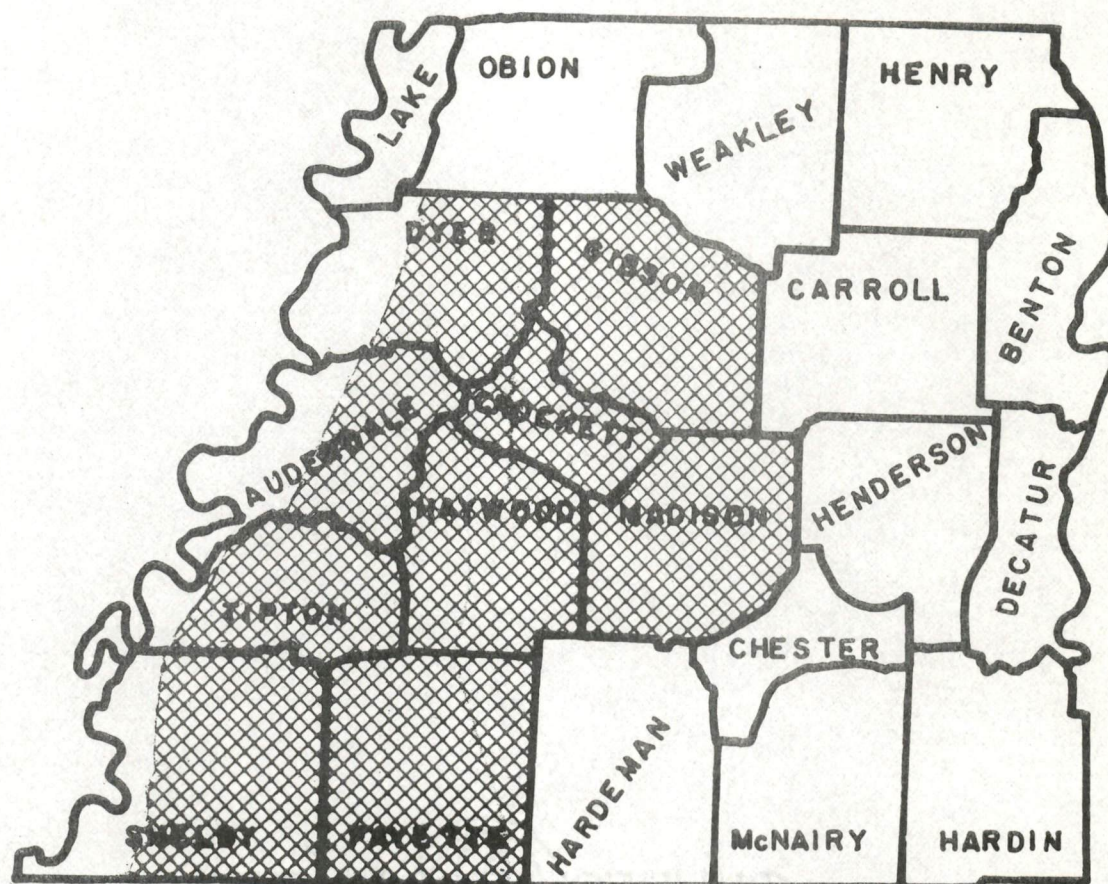


Figure 1. Location of Study Area, Brown Soil Area of West Tennessee.

Of particular importance in connection with the soils in the study area were the fragipans, which are located at varying depths. These fragipans interfere with the movements of moisture and air through the soil. They also form a barrier to root penetration. These fragipans were not prevalent in the Memphis soil, but they became more evident in the Grenada, Calloway, and Henry soils. Since these fragipans do affect the adaptability of soils to various crops, they are important factors to consider in determining enterprise organization.

The topography of the study area ranges from a rather flat region to a gently rolling and easily eroded one. The eroded and hilly areas are more prominent in the eastern portion of the study area.

Land Use

Since the temperature, rainfall, and soil types are suitable, several crops can be grown in the area. The cash crops, mainly cotton and soybeans, are grown on the more productive soils, such as the Memphis and Loring series, while the forage crops, such as hay and pasture, are grown on the less productive soils, for example, the Grenada and Calloway series.

Major enterprises in the study area in 1949 and 1959, ranked according to value sold, are shown in Table I. In monetary terms, crops, and more specifically field crops, produced the largest share of income of the farms. Livestock and livestock products ranked second, while forestry products ranked third.

While receipts from crops represented the largest share of income, a further analysis indicated that an estimated 1.6 million acres were

TABLE I
VALUE OF FARM PRODUCTS SOLD IN THE BROWN SOIL AREA
OF WEST TENNESSEE, 1949 AND 1959

Type of product sold	1949		1959	
	Value (000 dollars)	% of total	Value (000 dollars)	% of total
Crops				
Field crops	54,815	75.0	79,601	75.2
Vegetables	973	1.3	1,555	1.5
Fruit and nuts	1,190	1.6	1,019	.9
Horticulture	1,133	1.6	1,995	1.9
Total	58,811	79.5	84,170	79.5
Livestock				
Dairy	2,809	3.8	2,697	2.5
Poultry and poultry products	924	1.3	1,911	1.8
Other livestock ^a	10,269	14.1	15,119	14.3
Total	14,002	19.2	19,727	18.6
Forest products	960	1.3	2,001	1.9
Total value of products	73,073	100.0	105,898	100.0

^aIncludes beef cattle, feeders, hogs, etc.

Source: United States Bureau of the Census, United States Census of Agriculture: 1959, Tennessee, Vol. 1 (Washington: Government Printing Office, 1961), pp. 176-183.

used in growing the important field crops in 1949 and 1.5 million acres in 1959 (Table II). Throughout this period cotton remained the top crop in both acreage (excluding pasture) and value in the study area. Cotton acreages for 1949 and 1959 were 462,273 acres, or approximately 28.4 per cent of the total acres of open land, and 295,097 acres, or approximately 19.1 per cent of the open land, respectively. Soybeans have shown the most significant change during the period 1949-1959, increasing from 61,280 acres in 1949 to 191,000 acres in 1959. This was an increase of approximately 210 per cent during this 10-year period.

Cotton has remained the dominant crop with respect to value in the area since the days of settlement and continues to dominate in this economy. However, recent estimates have indicated that soybean acreage has continued to increase significantly while cotton acreage has not. In the entire nine-county area in 1963, an estimated 297,400 acres of soybeans and 334,300 acres of cotton were harvested.⁹ Future adjustments in enterprise organizations in the study area will probably involve these two crops, particularly because of their relative importance to other crops in the area.

Number and Size of Farms

In 1949, there were 35,602 farms in the study area with an average size of 65.1 acres. However, by 1959 the number of farms had declined to

⁹S. T. Marsh, Cotton and Soybean County Estimates: 1963, Tennessee Crop Reporting Service, July 1964 (Mimeographed).

TABLE II

SPECIFIED ACRES OF IMPORTANT CROPS IN THE BROWN SOIL AREA
OF WEST TENNESSEE, 1949 AND 1959

Type of crop	1949		1959	
	Acres	% of total	Acres	% of total
Cotton	462,273	28.4	295,097	19.9
Corn	308,639	19.0	232,568	15.6
Soybeans	61,280	3.8	191,007	12.9
Hay	135,400	8.3	80,666	5.4
Small grain	10,808	.7	18,439	1.2
Sorghum	3,798	.2	10,026	.7
Seed	20,762	1.3	21,026	1.4
Pasture	604,306	37.1	609,771	41.0
Other ^a	18,999	1.2	27,854	1.9
Total	1,626,265	100.0	1,486,454	100.0

^aOther includes truck crops, horticultural crops and popcorn.

Source: United States Bureau of the Census, United States Census of Agriculture: 1959, Tennessee, Vol. 1 (Washington: Government Printing Office, 1961), pp. 176-183.

22,936, a decrease of 36 per cent.¹⁰ The average farm size, however, increased to 94.3 acres during the period 1949-1959 (Table III). This change in farm size coupled with the decline in the size of the farm labor force was evidence of the changing land-labor mix in the area. As previously mentioned, shifts in enterprise organizations in recent years reflect the efforts of farmers to adapt their operations to these changing conditions of technology and resource combinations.

Three-fourths of the farms in the study area were less than 100 acres in size, and two-fifths of the farms were less than 30 acres. Sharecroppers were included in these figures.

Population and Tenure

In 1960 approximately 112,539 people were living on farms in the study area.¹¹ This represented close to 13 per cent of the total population of the area. In 1950, 25 per cent of the total population was living on farms.¹² According to 1960 census data, Crockett and Fayette counties were classified as completely rural. Madison and Shelby counties were classified as predominantly urban, while the remaining counties were classified as predominantly rural (Table IV).

¹⁰Part of this decrease was due to the change in the Census' definition of farms. The effect of the change in definition was not available between 1949-1959; however, there was a decrease of 985 farms in the study area as a result of the change in definition between 1954-1959. These figures are for the entire nine counties.

¹¹The population figures in this section include the entire nine-county area.

¹²If Shelby County, in which Memphis is located, were excluded from the population data, the farm population in the remaining counties made up approximately 40 per cent of the total in 1960 and 55 per cent of the total in 1950.

TABLE III
DISTRIBUTION OF FARMS BY SIZE IN THE BROWN SOIL AREA
OF WEST TENNESSEE, 1959

Farm size (Acres)	Number	% of total	Average size (Acres)
Less than 30	9,156	39.9	14.8
30-99	8,120	35.4	54.3
100-179	2,926	12.8	130.3
180-259	1,128	4.9	213.8
260 and over	1,606	7.0	600.0
Total	22,936	100.0	94.3

Source: United States Bureau of the Census, United States Census of Agriculture: 1959, Tennessee, Vol. 1 (Washington: Government Printing Office, 1961), pp. 144-159.

TABLE IV
PER CENT DISTRIBUTION OF POPULATION IN THE
BROWN SOIL AREA OF WEST TENNESSEE, 1960

County	% Urban ^a	% Rural	% Rural Farm ^b
Crockett	--	100.0	56.5
Dyer	42.8	57.2	28.5
Fayette	--	100.0	66.8
Gibson	40.1	59.9	33.9
Haywood	23.2	76.8	65.4
Lauderdale	17.3	82.7	46.9
Madison	61.0	39.0	19.5
Shelby	87.8	12.2	2.2
Tipton	18.5	81.5	46.0
Total area	72.3	27.7	12.9

^aIncludes all persons living in incorporated places of 2,500 or more inhabitants.

^bIncludes all people living on farms with 10 acres or more or sales larger than \$250.

Source: United States Bureau of the Census, United States Census of Population: 1960, Tennessee (Washington: Government Printing Office, 1961), pp. 206-213, 255-263.



Of the three major groups of tenure in the study area, tenants represented the most significant change, percentage wise, between 1949 and 1959 (Table V). During this period there was approximately a 56 per cent decrease in the number of tenants. However, the proportion of tenants of the total farm operators decreased only eight per cent. Full owners decreased approximately 32 per cent, or 3371, while part owners increased about four per cent, or 142, during the period 1949-1959. The proportion of full owners of the total remained about the same, and part owners as a per cent of the total tenure increased about six per cent during the ten-year period.

Part-time farming in the study area has declined during the period 1949-1959. In 1949 there were 3041 farms classified as part time in the nine-county area, but in 1959 there were 2587 part-time farms. This was a decrease of approximately 15 per cent.¹³

As the farm population and number of tenants in the area decline and farm size increases, changes in the land-labor resource mix are inevitable. Farm operations and enterprise combinations must be adjusted to these changing conditions if the farmers expect to maximize returns to their labor, land, management, and capital resources.

¹³United States Bureau of the Census, United States Census of Agriculture: 1954 and 1959. Tennessee, Vol. 1 (Washington: Government Printing Office, 1961), pp. 94-101, 176-183.

TABLE V

DISTRIBUTION OF FARM OPERATORS BY TENURE GROUPS IN THE
BROWN SOIL AREA OF WEST TENNESSEE, 1949 AND 1959

Tenure group	<u>1949</u> Number	% of total	<u>1959</u> Number	% of total	% change (1949-1959)
Full owners	10,586	29.7	7,215	31.4	-31.9
Part owners	3,633	10.2	3,775	16.5	3.9
Tenants (All)	21,383	60.1	11,946	52.1	-55.8
Cash	1,056	3.0	359	1.6	-66.0
Share-cash	224	.6	234	1.0	4.5
Share tenants	8,853	24.9	3,855	16.8	-56.5
Croppers	8,808	24.7	5,796	25.3	-34.2
Total	35,602		22,936		

Source: United States Bureau of the Census, United States Census of Agriculture: 1959, Tennessee, Vol. 1 (Washington: Government Printing Office, 1961), pp. 160-167.

CHAPTER III

PROGRAMMING DATA AND PROCEDURE

The linear programming technique was used to determine optimum enterprise organizations under specified resource situations and assumptions. This technique specifies the optimum solution when given the objective, the processes for obtaining the objective, and the resource or other restrictions. Linear programming rests on four basic assumptions: (1) linearity, (2) divisibility, (3) additivity, and (4) finiteness.¹

The first assumption, linearity, means that resource inputs combine in fixed proportions for all levels of output; divisibility assumes resources can be used and products can be produced in fractional quantities; additivity means the total amount of resources used by enterprises must equal the sum of resources used by individual enterprises; and finiteness implies that a limit exists to the number of alternatives that can be considered.

This chapter includes the assumptions for the resource situations and a description of the enterprises considered. Also included are the coefficients representing the amounts of restricting resources required by a representative group of enterprises per unit of output and a condensed summary of the procedure for programming the various situations.

¹Earl O. Heady and Wilfred Candler, Linear Programming Methods (Ames, Iowa: Iowa State University Press, 1963), pp. 17-18.

I. LABOR RESOURCES

To obtain a range of combinations of labor and land, five labor supplies were selected to be used with varying quantities of land. The five labor supplies included a part-time, one-man, one-and-one-half-man, two-man, and three-man labor supply. The number of hours available by seasons of the year for each labor situation was estimated after considering the time of year, weather, and enterprise requirements. The availability of labor for the part-time labor supply was estimated after allowing for eight hours of nonfarm work, extreme weather conditions and travel time to and from nonfarm work.

Each labor supply was subsequently divided into six labor periods (see Table VI). Labor required for specific tasks for each of the enterprises was designated for a specific time period during the year, and labor could not be transferred from one period to another. The model was constructed in a manner so that labor required for a task such as cotton planting would only come from labor in that particular time period. The labor periods were designed to account for the seasonality of labor requirements and availability of labor. It was assumed that no labor could be hired.

II. LAND RESOURCES

The soils in the Brown Soil Area were classed agronomically into six soil capability groups. Each of the six groups involved a combination of capability units and their characteristics and limitations in

TABLE VI
AVAILABILITY OF LABOR BY PERIODS

Period	Size of labor force (one-man equivalent)				
	Part-time	1	1½	2	3
		(Hours available)			
I. Dec. 1 - Feb. 28	129	616	924	1232	1848
II. Mar. 1 - Apr. 14	73	351	527	702	1053
III. Apr. 15 - May 31	82	390	585	780	1170
IV. June 1 - Aug. 15	136	650	975	1300	1950
V. Aug. 16 - Sept. 30	82	390	585	780	1170
VI. Oct. 1 - Nov. 30	98	468	702	936	1404
Total hours annually	600	2865	4298	5730	8595

CRANES & CREST

regard to use, as defined by the Soil Conservation Service.² The following is a breakdown of the soil groups into their capability groups classifications. Included will be the limitations of the particular groups.

Soil Group I contained capability groups I-1, I-2, II e-1, II w-1, III w-2, and II e-3. All groups but II e-1 were suited for continuous row cropping; II e-1 should not be row cropped oftener than one year out of two. Alfalfa should be restricted to I-1, I-2, II e-1, and II e-3. Soil Group I contained about 47 per cent of the open land acres in the area of study.

Soil Group II, which accounted for 10.7 per cent of the open land in the area, included capability groups II e-2 and II s-1. Restrictions placed on this soil group were (1) row crop, on the average, should be no more than one year out of three and (2) even though alfalfa may be grown in these soils, the yield would be too low for economical production.

Soil Group III, which represented approximately 9.5 per cent of the open land in the study area, contained soil capability group III e-4, which should not be cropped oftener than one year out of four.

Soil Group IV, which included capability groups III e-2, III e-4, and III w-1, could be cropped an average of one year out of five. Also, there should be no alfalfa on capability groups III e-4 or III w-1. Soil Group IV accounted for 9.5 per cent of the open land in the study area.

²Tennessee Conservation Needs Committee, Tennessee Soil and Water Conservation Needs Inventory, Tennessee State Soil Conservation Committee, 1961, pp. 36-56, 81-85.

Soil Group V contained capability groups IV e-1, IV e-2, IV e-3, IV s-1, IV w-1 and IV w-2. It represented 13 per cent of the open land in the study area.

Soil Group VI was suitable for permanent forage or timber. This group contained capability groups VI e-1, VI e-2, VI e-3, VII e-1, VII e-3, and VII s-1. Ten per cent of the open land in the study area was composed of Soil Group VI.

The suitability of these soils for crop use and the assumed yield levels of crops considered on each soil group are found in Table VII. Soil Group I contained the most productive soils, and it had a wide range of uses. However, expected yields of some crops were too low for economical production on some soil groups. The yield levels of the crops considered on the various soil groups were based on weighted averages of estimated yields for specific soils in the groups and were obtained from consultation with production specialists.

Initially, there was a designated amount of land in combination with each of the five labor supplies. This amount was governed by the size of the labor supply and also by an average of farm sizes computed from a classification of farms according to size and number in the study area. The average-size farm from the four size categories of farms with more than 30 acres, as shown in Table III, were selected as the initial land base for four of the labor situations. Farms in the category of less than 30 acres were excluded from the analysis on the assumption that the size of these units were too small for economical production.

TABLE VII

ESTIMATED YIELDS OF REPRESENTATIVE CROP ENTERPRISES CONSIDERED
ACCORDING TO SOIL GROUP SUITABILITY

Crop	Unit	Soil group					
		I	II	III	IV	V	VI
Cotton	lb. lint	700	650	575	600	a	a
Corn	bu.	80	65	65	46	a	a
Soybeans	bu.	33	28	28	25	a	a
Alfalfa	ton	2.9	2.0	2.8	a	a	a
Orchard grass-ladino pasture	CAD ^b	156	138	129	111	92	64
Orchard grass-ladino pasture and hay	CAD ^c ton	88 1.4	68 1.3	64 1.2	55 1.1	46 .8	32 a
Bermuda-ladino pasture	CAD	190	170	160	135	110	a
Lespedeza hay	ton	1.7	1.6	1.6	1.2	1.2	a
Oats	bu.	58	52	52	40	a	a
Lespedeza pasture	CAD	120	105	100	85	70	a
Red clover hay	ton	2.2	1.5	2.2	a	a	a

^aIt was assumed uneconomical to grow this specific crop on this soil group.

^bCow Acre Day = 25 lbs. hay equivalent and refers to the amount of forage available for one cow per acre per day.

^cThe pasture furnishes approximately one-half the CAD's if a hay crop is harvested.

Since the objectives of this thesis centered around the land-labor combinations, the following initial situations were selected: part-time--0 acres; one-man--54 acres; one-and-one-half-man--130 acres; two-man--214 acres; and three-man--600 acres. Henceforth, the 54-, 130-, 214-, and 600-acre farms will be referred to as small, medium, large and extra-large farms, respectively. These amounts of land represent total land and were the mean sizes of farms for the 30-99 acres, 100-179 acres, 180-259 acres, and 260 acres and over size groups, respectively.

The part-time labor supply, as previously indicated, was not allocated any land initially; this was in accordance with the assumptions of this thesis. However, provisions to purchase the amount of land needed to obtain an optimum land-labor combination for the part-time labor situation were included in the programming procedure. Provisions were also included in the programming procedure for additional purchases of land for combination with the one-, one-and-one-half-, two- and three-man labor supplies to attain the variations in land-labor combinations necessary for completing the objectives of this study. Additional information concerning land purchasing is found in the "SPECIAL FEATURES" section of this chapter.

The soil patterns and amounts of land available for row cropping for each of the initial farm sizes are shown in Table VIII. Also included in this table are the cotton allotments and soybean restrictions for the four farm situations. The percentages of acreages for soil types, row crops, allotments, and restrictions shown in this table are based on the existing conditions in the study area. These percentages were

TABLE VIII
LAND RESOURCES AND CROP ALLOTMENTS
ON FOUR REPRESENTATIVE FARMS

Resource	Per cent total acres	Farm size			
		54 A	130 A	214 A	600 A
		(Acres)			
Soil I	30.8	16.8	40.2	65.9	185.0
Row Crop I	24.1	13.1	31.3	51.4	144.2
Alfalfa restriction	15.2	8.3	19.9	32.6	91.6
Soil II	9.1	4.9	11.9	19.5	54.6
Row Crop II	2.9	1.6	4.0	6.5	18.2
Soil III	8.1	4.4	10.6	17.4	48.9
Row Crop III	2.0	1.1	2.7	4.4	12.2
Soil IV	8.1	4.4	10.6	17.4	48.9
Row Crop IV	1.8	1.0	2.3	3.8	10.6
Soil V	10.2	5.5	13.3	21.8	61.2
Soil VI	5.2	2.8	6.6	10.8	30.3
Cotton allotment	13.6	7.4	17.7	29.1	81.6
Soybean restriction	15.4 ^a	8.4	20.2	33.1	92.6
Total open acres		38.8	93.2	152.8	428.9
Total row crop		16.8	40.3	66.1	185.2

^aThe initial acreage allotment of soybeans was one-half the row crop land, but when one acre of land was purchased, only .154 acre of soybeans was added.

significant in this study, for they represented the amounts of each type of land resource or restriction that became available when an acre of land was added to the existing land-labor combination. When one acre of land was added, an additional .7 acre of open land, which included .3 acre of row crop, was available. Cotton allotment and soybean restriction were also increased by .136 acre and .154 acre, respectively, for each acre of land added.

III. MACHINERY RESOURCES

A set of farm machinery was assumed for each farm size. The farm size and probable use were two important factors considered when composing the machinery situations. If the estimated amount of use of a particular machine was too small to justify owning the machine, custom work was assumed to be available at a designated price. Custom work was allowed in several operations on the small, medium, and large farms. On the extra-large farm, it was assumed that all necessary equipment needed for production and harvesting was available. (See Appendix B for crop production practices and machine requirements per hour per acre.)

The costs associated with these machines depended upon the probable hours of use. These costs were divided into two classes: fixed and variable. The fixed costs included storage, insurance, depreciation, and interest; the variable costs included fuel, oil, and repairs. The cost per hour decreased as the fixed costs were spread over more hours of use. The cost per hour was considered in determining net returns from the

enterprise on which the equipment was used.³ The machines on each size farm and their expected hours of use are shown in Table IX, and the estimated cost per hour for these machines for each farm size is shown in Table X.

IV. CAPITAL SITUATION

The annual requirement of operating capital was estimated for each enterprise considered. The annual cost of this capital was assumed to be 6 per cent per year. If the operating capital was required for a period less than 12 months, the annual operating capital charge was adjusted accordingly.

The investment capital for such items as machines, long-life pas-
tures, and land was also charged at 6 per cent per year. For the pur-
poses of this study, investment capital was assumed to be unlimited. Al-
though it was recognized that capital restrictions are important on many

³ Machinery and equipment costs were calculated in the following manner:

Fuel and oil: Tractor--25 DBH (1.25 gal./hr.) = \$.35/hr.

35 DBH (2 gal./hr.) = \$.55/hr.

$$45 \text{ DBH (2.4 gal./hr.)} = \$.65/\text{hr.}$$

55 DBH (2.5 gal./hr.) = \$.47/hr. (diesel)

Combine (Self-propelled, 10 ft.) = \$.65/hr.

Insurance: \$50/year for truck; all other computed at \$5/\$1000 average value.

Repairs: Charged as percentage of new cost; percentage varied with type of machines.

Depreciation: $\frac{\text{new cost} - \text{salvage value}}{\text{years of life}}$

TABLE IX

MACHINES AVAILABLE AND ASSUMED HOURS OF USE FOR FOUR REPRESENTATIVE FARMS

Machine	Description	Farm size			
		54 A	130 A	214 A	600 A
		(Hours)			
Tractor	25 DBH	250		400	
	35 DBH		570		600
	45 DBH			500	
	55 DBH				800
Plow	1-2 bottom	40			
	2 bottom		90	100	
	3 bottom				225
Disk	7 foot	40			
	8 foot		90	150	125
	12 foot				200
Section harrow	2 section	20	45	75	
	3 section				250
Planter fertilizer	2 row	15	35	50	
	4 row				100
Cultivator	2 row	20	45	65	
	4 row				85
Fertilizer spreader (w/seed)	8 foot	25	55		
	12 foot			80	105
Sprayer	6 row			55	125
Mower	6 foot	30	65		
	7 foot			50	130
Side-delivery rake					70
Baler					75
Combine (w/corn header)	10 foot				130
Rotary mower	6 foot			50	120

TABLE X

COST PER HOUR OF MACHINES FOR FOUR REPRESENTATIVE FARMS

Machine	Description	Farm size			
		54 A	130 A	214 A	600 A
		(Cost per hour)			
Tractor	25 DBH	\$1.53		\$1.09	
	35 DBH		\$1.28		\$1.24
	45 DBH			1.74	
	55 DBH				1.43
Plow	1-2 bottom	.69			
	2 bottom		.46	.42	
	3 bottom				.31
Disk	7 foot	1.00			
	8 foot		.51	.30	.37
	12 foot				.49
Section harrow	2 section	.52	.23	.14	
	3 section				.06
Planter-fertilizer	2 row	2.90	1.24	.87	
	4 row				.86
Cultivator	2 row	2.35	1.04	.74	
	4 row				1.03
Fertilizer spreader (w/seeder)	8 foot	1.34	.61		
	12 foot			.42	.41
Sprayer				.65	.29
Mower	6 foot	1.66	.76		
	7 foot			1.13	.43
Side-delivery rake				1.70	.86
Baler					3.62
Combine (w/corn header)	10 foot				6.81
Rotary mower	6 foot			1.27	.53

farms, it was assumed that this problem was too broad to consider in the scope of this study.

V. ENTERPRISES CONSIDERED

Cotton

It was assumed that cotton could be grown on Soil Groups I, II, III, and IV. Cotton production was restricted by an acreage allotment based on acreage allotments in the area in 1963. This allotment amounted to 13.6 per cent of the total land operated. The selling price of this crop was assumed to be \$.312 per pound of lint and \$45 per ton for seed.

Corn

Corn could also be grown on Soil Groups I-IV, and it was used either for feed in the livestock enterprises or sold as cash grain. There was no restriction placed on corn other than available row crop acreage. The assumed selling price of corn was \$1.10 per bushel. Corn buying was not considered as an alternative.

Soybeans

Soybeans were assumed to be a cash crop and could be grown on Soil Groups I, II, III, and IV. Soybeans were restricted to one-half of the total row crop acres operated in order to prevent soil depletion and disease build up in the soils. The assumed selling price of this crop was \$2.30 per bushel.

Oats

Oats could be grown on Soil Groups I, II, III, and IV and were followed by lespedeza hay or pasture. The oats were assumed to be used as grain for feed after being converted to a corn-equivalent basis. The conversion ratio was 2.1 bushels of oats to one bushel of corn.

Swine

Two swine enterprises were considered in this study. The costs and feed requirements for the operations were calculated on units of twelve sows each. One swine enterprise, which shall be referred to as Swine I, consisted of farrowing pigs and raising them for slaughter at a weight of approximately 210 pounds each. The other swine enterprise, Swine II, involved farrowing the pigs and selling them as feeders at weaning time. The slaughter hog price was assumed to be \$14.50 per hundredweight, while the feeder pig price was set at \$9 each.

It was assumed in each operation that there would be two litters per sow per year from which sixteen pigs were saved. A two per cent sow death loss per year and five gilts for replacements for the twelve sow unit were also assumed. Death loss was assumed to be three per cent between weaning and marketing.

Beef Cattle

Three alternative beef enterprises were considered in this study. Beef I consisted of units with 25 brood cows each. The calves were assumed to be born in late winter (February) and pastured with the cows during the summer. They were to be sold in the fall at weaning at a

weight of approximately 500 pounds at \$22.50 per hundredweight.

Another cattle operation, Beef II, was similar to Beef I except the steers and heifers were carried through the winter on a wintering ration of ground corn and cob, cottonseed meal, and hay. These animals were on this ration for 150 days at an assumed daily gain of 1.4 pounds per day. Then the animals were placed on a finishing ration consisting of the same elements as the wintering ration but at increased amounts. The heifers remained on this ration for fifty days, gaining an estimated two pounds per day. The steers were fed this ration for 116 days at an assumed gain of 2.5 pounds per day. Heifers were sold at about 800 pounds at \$23.50 per hundredweight, and the steers were sold at approximately 1000 pounds at \$23.50 per hundredweight.

Beef III involved the basic 25-cow herd, and the calves were handled in the same manner as in Beef I up through the wintering period. At the end of the wintering period, the heifers were fed for 50 days on a finishing ration and then sold, but the steers were pastured following the wintering ration for 91 days at an estimated gain of 1.1 pounds per day. Then these steers were placed on a finishing ration for 75 days, gaining an assumed 2.5 pounds daily. They were sold around September 15 at a weight of approximately 1000 pounds at \$23.50 per hundredweight.

One assumption regarding the beef enterprise was that each unit yielded a 90 per cent calf crop per year, or 22 calves (ten per cent for death). Four of these calves were kept to replace the four cows culled per unit per year. The remaining 18 calves were sold. In computing net returns per unit, there was an allowance of three per cent of the gross

value of sales for shrinkage and a charge of \$2.50 per head for hauling and selling. It was also assumed that whenever feeding rations were used, the necessary increase in equipment and facilities that were needed were acquired. These assumptions apply to all three beef enterprises.

Forage

The pasture requirements were furnished by the orchard grass-ladino, bermuda-ladino, and/or lespedeza enterprises while the hay was furnished by the red clover, lespedeza, alfalfa, and/or orchard grass-ladino enterprises.

In order to insure a sufficient amount of forage for the livestock, five forage periods were selected, mainly on the basis of growth patterns of the forage crops considered. The peak production of these forage crops varied; therefore, in order to bring in balance the forage demand and supply, a "forage transfer activity," which allowed for transfer of forage from one period to a later period with some reduction of the original feed value, was used. This allowed for delayed grazing, which is a common practice in the study area. It was assumed that forage could not be transferred to or from Period I, for feeding requirements during this period, which extends from November 1-March 15, were to be obtained only from hay. The percentage distribution of forage growth by periods for the various crops is shown in Table XI.

TABLE XI
PERCENTAGE DISTRIBUTION OF FORAGE BY PERIODS^a

Period	Orchard grass- ladino clover	Lespedeza following oats (Per cent)	Lespedeza alone	Bermuda ladino
I. Nov. 16 - Mar. 15	11	0	0	3
II. Mar. 16 - May 31	41	0	3	25
III. June 1 - July 31	26	47	47	36
IV. Aug. 1 - Sept. 30	13	42	42	28
V. Oct. 1 - Nov. 15	9	11	8	8

^aThe figures represent the per cent of Cow Acre Days in each period of the total days furnished by the particular enterprise.

VI. SPECIAL FEATURES

Land Purchase

As previously mentioned, there were five initial land-labor combinations (part-time--0 acres, one-man--54 acres, one-and-one-half-man--134 acres, two-man--214 acres, and three-man--600 acres) programmed for optimum enterprise organization and net returns. These land-labor combinations represented the 100 per cent equity level in this study, i.e., it was assumed that the farmers owned the land free of debt. In determining the effect of variations in land-labor combinations on the optimum enterprise organization and net returns, each of the initial land-labor combinations was reprogrammed with provisions for purchasing additional land, on credit, up to 75 per cent equity and again at 50 per cent equity. These equity positions were chosen to represent reasonably safe asset positions and to provide some rational basis for defining additional land-labor combinations.

The annual charge for land purchased included the interest on capital and property tax. A property tax charge of \$1.18, which was a 25 per cent assessment at \$3.00 per \$100 average value of land and buildings,⁴ and an interest charge of six per cent of \$100, which was the average value of land without buildings, gave a total annual cost of \$7.18 per acre of land.

⁴An average of the value of land and buildings was obtained from Census data. Excluding Shelby County, this average was \$158.

Non-Use of Labor

A non-use of labor activity was used in determining the effects of labor reservation prices on enterprise organization and net returns. The reservation prices were programmed at the 50 per cent equity level so as to have the maximum land-labor combination used in this study, and labor reservation prices of 0, 20, 40, 60, and 80 cents per hour were used. If labor did not return the assigned reservation price, it became idle labor in the optimum solution for that situation. Then after adjusting for the unused labor in the resulting solutions, the effects of these prices on farm organization and net returns could be ascertained.

The maximum price of 80 cents per hour of labor was chosen, for it was assumed that any price above this would approach the prices received for many of the nonfarm job opportunities. The reservation prices used were generally below those received in nonfarm opportunities in order to get reasonable indications of the effects of reservation prices on enterprise organization and net returns.

VII. RESOURCE REQUIREMENTS FOR PRODUCTION

Labor requirements for a selected group of enterprises considered are shown in Table XII. The labor coefficients were shown to illustrate the range of requirements as the size of farm changed. For example, cotton required 22.3 hours of labor on the small size farm but only 8.4 hours on the extra-large farm. This difference in labor requirement was

TABLE XII

TOTAL LABOR REQUIREMENTS PER UNIT FOR REPRESENTATIVE
ENTERPRISES CONSIDERED IN THE PROGRAMMING MODELS

Enterprise	Farm size			
	54 A	130 A	214 A	600 A
	(Hours)			
Cotton	22.3	21.8	9.7	8.4
Corn	10.2	9.3	6.9	6.8
Soybeans	7.7	7.1	6.4	6.4
Alfalfa	11.7	11.2	11.9	12.2
Orchard grass-ladino pasture	3.3	3.0	2.5	2.0
Orchard grass-ladino pasture and hay	6.5	6.0	5.8	5.5
Bermuda-ladino pasture	2.9	2.6	2.4	2.0
Lespedeza hay	4.3	4.0	4.1	4.1
Lespedeza pasture	2.7	2.5	2.2	1.9
Oats-lespedeza hay	12.8	12.4	11.6	12.2
Oats-lespedeza pasture	9.1	8.3	7.9	8.2
Red clover hay	9.1	8.2	8.1	8.8
Swine I	552.4	552.4	552.4	552.4
Swine II	407.9	407.9	407.9	407.9
Beef I	324.0	324.0	324.0	324.0
Beef II	450.0	450.0	450.0	450.0
Beef III	437.9	437.9	437.9	437.9

attributed to variations in production practices and changes in the size of equipment used for some operations.

The feed requirements for the livestock enterprises were based on the 12-sow unit for the swine enterprises and the 25-cow herd for the beef enterprises. The crop enterprises that furnished the feed requirements were discussed previously in this chapter. The largest grain requirement on a corn-equivalent basis was for the slaughter hog enterprise. There was some grain used in the beef enterprises in the wintering and finishing rations. The grain and forage requirements for the five livestock enterprises considered are shown in Table XIII.

VIII. SUMMARY OF PROCEDURES

In order to clarify the methods and procedures used in obtaining the optimum results, a summary of the situations used is shown in Table XIV. The terms small, medium, large and extra-large, which are shown in Table XIV, refer to the input-output coefficients used for the various land-labor combinations. They were developed for the small, medium, large, and extra-large farm classifications, respectively, as defined earlier in this chapter. The variations in the land-labor combinations were made by a land-buying provision of the programming model. As previously mentioned, the labor reservation prices that are shown were programmed at the 50 per cent equity level, which represents the largest land-labor combination for each of the five labor situations used in this thesis.

TABLE XIII
FEED REQUIREMENTS PER UNIT FOR LIVESTOCK ENTERPRISES
IN THE PROGRAMMING MODELS

Feed items	Unit	Livestock enterprises				
		Swine I	Swine II	Beef I	Beef II	Beef III
Hay equivalent ^a	ton	0	0	30.5	47.0	46.0
Corn equivalent	bu.	2224.3	550.3	0	579.4	469.4
Forage II	CAD	0	0	2128	2128	2664
Forage III	CAD	0	0	1708	1708	1972
Forage IV	CAD	0	0	1708	1708	1708
Forage V	CAD	0	0	1288	1288	1288

^aThe hay equivalent was based on the feed value of alfalfa hay. The conversion factors for the hay crops considered were: red clover = .9; lespedeza = .9; and orchard grass-ladino = .8.

TABLE XIV
SITUATIONS USED FOR PROGRAMMING EACH LABOR SUPPLY

Labor supply (One-man equivalent)	Maximum land available	Equity position (Per cent)	Coefficients ^a used	Reservation prices (Cents)
Part-time	b	c	Small	0, 20, 40, 60, and 80
One-man	54 acres	100	Small	
One-man	72 acres	75	Medium	
One-man	108 acres	50	Medium	0, 20, 40, 60, and 80
One-and-one-half-man	130 acres	100	Medium	
One-and-one-half-man	173 acres	75	Large	
One-and-one-half-man	260 acres	50	Large	0, 20, 40, 60, and 80
Two-man	214 acres	100	Large	
Two-man	285 acres	75	Large	
Two-man	428 acres	50	Large	0, 20, 40, 60, and 80
Three-man	600 acres	100	Extra large	
Three-man	800 acres	75	Extra large	
Three-man	1200 acres	50	Extra large	0, 20, 40, 60, and 80

^aThis refers to the group of the coefficient used; four different sets of coefficients representing the four farm sizes (54, 130, 214, and 600 acres) were used in the initial program.

^bAll land needed was to be purchased during the process of programming.

^cEquity position does not apply here.

CHAPTER IV

RESULTS OF THE ANALYSIS

The first portion of this chapter presents the results of the effects of the variations of land-labor combinations on optimum enterprise organizations and net returns. The second part contains the effects of the various labor reservation prices on the enterprise organization and net returns.

I. EFFECTS OF LAND-LABOR VARIATIONS

The effects on farm organization of variations in land-labor combinations will be discussed separately for each of the five assumed labor situations. The basic programming solutions will be presented without adjustments even though some of the fractional quantities would not be practical on an individual farm basis. Some minor adjustments would need to be made if one of these systems were placed into operation on an actual farm.

Part-Time Labor Supply

In the situation involving the part-time labor supply, it was assumed that 600 hours of labor were available (distributed seasonally as shown in Table VI, page 22) and that all land needed would be purchased. In other words, land was treated as a completely variable factor and the results shown in Table XV indicate the optimum quantity

TABLE XV

OPTIMUM ENTERPRISE ORGANIZATION, NET RETURNS, AND MARGINAL
VALUE PRODUCTIVITIES OF RESTRICTING RESOURCES WITH A
PART-TIME LABOR SUPPLY AND ALL LAND PURCHASED

Item	Unit	Amount
Total land	Acres	52.2
Open land		
Cotton	Acres	4.2
Corn	Acres	10.8
Soybeans	Acres	1.0
Hog pasture	Acres	2.3
Idle land	Acres	19.2
Total open land	Acres	37.5
Livestock		
Swine I	No. of sows	4.6
Labor		
Available	Hours	600
Used	Hours	427
Capital investment		
Annual operating capital	Dollars	520.47
Investment capital	Dollars	7,267.54
Net returns	Dollars	907.66
Marginal value products		
Row crop I	Dollars	27.22
Row crop II	Dollars	13.82
Row crop III	Dollars	13.34
Row crop IV	Dollars	1.34
Labor II	Dollars	4.23
Labor IV	Dollars	4.40

of land for this labor force under the conditions of production specified in Chapter III.

Under these assumptions, there were 52.2 total acres of land purchased. Cotton, corn, soybeans, and hog pasture comprised the crop enterprises with acreages of 4.2, 10.8, 1.0, and 2.3, respectively. There were 19.2 acres of idle open land. This indicated that the land was purchased mainly for the row-crop acreage due to the relative profitability of row-crop production as compared to forage production. This was indicated by the fact that all of the available row-crop acreage was used for the above crop enterprises. Only one livestock enterprise was in the solution. This was Swine I, or the slaughter hog operation, at a level of 4.6 sows, or approximately 69 market hogs.

With 600 hours of labor available, approximately 71 per cent, or 427 hours, was used to carry on the livestock and crop enterprises. The labor availability proved to be a limiting factor insofar as additional purchases of land were concerned, since two periods of labor, II and IV, were exhausted of their supply.

A net return to land, labor, and management of \$907.66 was possible under the assumed conditions. These returns required an operating capital expense of \$520.47 and an investment capital outlay of \$7267.54, which included \$5220 for the purchase of land.

The marginal value product (MVP) of a limiting resource is the value of the product of the last unit of resource used in production.¹ For example, if the available land supply in a given situation were exhausted, an amount equal to the value of the product produced on the last acre used in production could be added to or subtracted from net returns if an additional acre of land were acquired, under the given situation. The MVP's of the limiting resources used in this study are of interest, for they indicate possible gains in returns through the acquisition of additional units of scarce resources. The high MVP's for labor in Periods II and IV, \$4.23 and \$4.40 per hour, respectively, indicated that net returns could be increased if additional labor could be acquired during these periods. It is assumed that net returns could be further increased if labor were available to operate an additional acreage of row crop.

¹Even though the interpretation of the MVP is somewhat similar in linear programming and in production function analysis, the derivation is different. The value of the MVP of a resource which is computed from a production function is independent of the use of the other resources involved, and it can be computed at any level of use. However, in linear programming the MVP's are computed only for resources that are restricting, and the value of the MVP is a result of a complementary effect among the resources. For example, if there is a combination of resources such as land, labor, and capital, and labor is the restricting resource, the values of land and capital are assumed to be free. These free resources facilitate the computing of the MVP for labor and partly explain the higher MVP since only the one resource was restricting. But if land and labor were restricting, there is an interaction among the restricting resources insofar as the computation of their MVP's are concerned. It should be pointed out that the MVP of a resource is constant only for the addition of one unit of the resource. In addition, as another resource becomes restricting, the MVP's of other restricting resources may change.

One-Man Labor Supply

An initial land-labor combination of 54 acres and 2865 hours of labor was assumed for programming the situation involving the one-man labor supply. When additional land could be purchased up to 75 and 50 per cent equity, the maximum land in combination with the one-man labor supply was 72 and 108 acres, respectively. The basic solution and the effects of variations in land-labor combinations on this solution are presented in Table XVI.

The crop enterprises in the optimum organization were cotton, corn, forage, and hog pasture. These crops represented 38.8 acres, which was all the available open land. The entire cotton allotment of 7.4 acres was utilized. These same crops were included in the solutions at both the 75 and 50 per cent equity level but at total acreages of 51.8 and 77.5, respectively. Three of the crops increased in approximately the same proportion as the land acreage increased. For example, when land increased from 54 to 108 acres, cotton acreage increased from 7.4 to 14.8 acres.

The feeder-pig enterprise, Swine II, and the beef enterprise in which calves were sold at weaning (Beef I), constituted the livestock enterprises in the optimum solution at the 100 per cent equity level. The solution contained 20.7 sows and 3.6 cows. The solutions at the 75 and 50 per cent equity levels also included the Beef I enterprise but at levels of 4.8 and 7.1 cows, respectively. The Swine I enterprise, or the slaughter-hog operation, replaced Swine II in both of the new land-

TABLE XVI
OPTIMUM ENTERPRISE ORGANIZATION, NET RETURNS, AND MARGINAL VALUE
PRODUCTIVITIES OF RESTRICTING RESOURCES WITH A ONE-MAN
LABOR SUPPLY AND THREE EQUITY POSITIONS

Item	Unit	Equity	
		100%	50%
Total land	Acres	54.0	108.0
Open land			
Cotton	Acres	7.4	14.8
Corn	Acres	9.4	18.7
Orchard grass-ladino pasture	Acres	8.3	16.6
Oats-lespedeza hay	Acres	1.9	7.9
Oats-lespedeza pasture	Acres	6.7	14.1
Hog pasture	Acres	5.1	5.4
Total open land	Acres	38.8	77.5
Livestock			
Swine I	No. of sows	0	10.79
Swine II	No. of sows	20.7	0
Beef I	No. of cows	3.6	7.12
Labor			
Available	Hours	2,865	2,865
Used	Hours	1,116	1,332

TABLE XVI (CONTINUED)

Item	Unit	Equity	
		100%	50%
Investment capital			
Annual operating capital	Dollars	866.60	1,010.03
Capital investment	Dollars	10,986.35	11,186.55
Net returns	Dollars	1,878.61	2,457.85
			3,482.56
Marginal value products			
Soil I	Dollars	30.63	30.07
Row crop I	Dollars	52.28	52.83
Soil II	Dollars	24.25	24.26
Row crop II	Dollars	45.26	45.25
Soil III	Dollars	24.25	24.26
Row crop III	Dollars	37.32	39.04
Soil IV	Dollars	13.63	14.62
Row crop IV	Dollars	43.40	42.40
Soil V	Dollars	5.71	6.43
Soil VI	Dollars	4.91	5.67
Cotton allotment	Dollars	25.76	33.51
Land purchasing	Dollars	27.24	28.46

labor combinations. At the 75 per cent equity level, Swine I entered the solution at the level of 7.2 sows, while this operation contained 10.8 sows at the 50 per cent equity level.

Thirty-nine per cent, or 1116 hours, of the 2865 available hours of labor was used at the 100 per cent equity level. At the 75 per cent equity level, only 890 hours were used. This decrease in labor used, even though acreage increased 18 acres, can be explained in terms of the input-output coefficients used. As mentioned previously, when the combination of one-man labor force and the 54-acre farm was programmed, the small farm input-output coefficients were used, but when the addition of land was possible, the medium farm input-output coefficients were used. This change reduced the labor requirements due to the assumed increased efficiency of machine use. When land was increased from the 75 per cent equity level to the 50 per cent equity level, the amount of labor used increased by 442 hours. This increase in labor used can be explained by the increases in acres of crops and livestock numbers. There was an adequate amount of labor available in each labor period, since several hours of labor were unused in every period after each solution was obtained.

Net returns of \$1878.61 at the 100 per cent equity level required \$866.60 in annual operating capital and \$10,986.35 in investment capital.² When eighteen acres of additional land could be purchased

²This investment capital figure included the value of the land purchased.

(the 75 per cent equity level), net returns increased \$579.24. This new net returns required \$1010.03 in annual operating capital and \$11,186.55 in investment capital. At the 50 per cent equity position, net returns were \$3482.56. This involved \$1544.59 in operating capital and \$16,773.23 in investment capital.

The profitability of acquiring more land for each equity position was indicated by the MVP's of soil and row crop groups. The MVP's indicated that \$52.28 could be added to net returns if an additional acre of Row Crop I were acquired. Row Crop III had a MVP of \$37.32, which indicated the need for still more row-crop acreage, even of the less productive nature. These figures are representative of all three equity positions, for there was very little variation in the MVP's for a particular restricting resource among the three equity levels. Ordinarily, it is expected in this type of problem that as land acreage increases, assuming the labor supply and other factors constant, the MVP of land should decrease, but in this given situation there was very little change in the MVP's of this resource. This was due in most part to the changes in input-output coefficients used. As previously mentioned, the medium farm input-output coefficients replaced the small farm input-output coefficients between the 100 and 75 per cent equity levels. The MVP's of the restricting resources were equal at the 75 and 50 per cent equity levels, since adequate labor was available for all periods.

One-and-One-Half-Man Labor Supply

In determining the optimum combination of enterprises for the one-and-one-half-man labor supply, an initial land-labor combination of 130 acres and 4298 hours was assumed. When the land-labor combination was varied, land was purchased up to the 75 and 50 per cent equity levels. This permitted additional acreages of 43 acres and 130 acres, respectively, to be used in combination with the 4298 hours of labor. The medium farm input-output coefficients were used at the 100 per cent equity level, but the large farm input-output coefficients were used at the 75 and 50 per cent equity positions. The optimum net returns and enterprise organization and the effect of the land-labor variations are shown in Table XVII.

Cotton, corn, forage, and hog pasture amounted to a combined acreage of 93.5 acres at the 100 per cent equity level, which was the entire open-land acreage. The entire open-land acreage at the 75 and 50 per cent equity levels was also utilized. Acreages of particular crops increased in approximately the same proportion as the increase in total land acreage. The entire cotton allotment was utilized at each equity level.

Swine I, the slaughter hog enterprise, and Beef I, the enterprise in which calves were sold at weaning, were the livestock enterprises included in the optimum solution at the 100 per cent equity level. The solution at the 75 per cent equity position included the feeder pig enterprise (Swine II) and Beef I; and at the 50 per cent equity level,

TABLE XVII

OPTIMUM ENTERPRISE ORGANIZATION, NET RETURNS, AND MARGINAL VALUE
PRODUCTIVITIES OF RESTRICTING RESOURCES WITH A ONE-AND-ONE-
HALF-MAN LABOR SUPPLY AND THREE EQUITY POSITIONS

Item	Unit	Equity	
		100%	50%
Total land	Acres	130.0	260.0
Open land			
Cotton	Acres	17.7	35.4
Corn	Acres	22.6	45.0
Orchard grass-ladino pasture	Acres	19.9	39.9
Oats-lespedeza hay	Acres	9.4	17.9
Oats-lespedeza pasture	Acres	17.0	29.7
Hog pasture	Acres	6.9	18.4
Total open land	Acres	93.5	186.3
Livestock			
Swine I	No. of sows	13.1	14.2
Swine II	No. of sows	0	45.1
Beef I	No. of cows	8.5	16.4
Labor			
Available	Hours	4,298	4,298
Used	Hours	1,606	3,537

TABLE XVII (CONTINUED)

Item	Unit	Equity		
		100%	75%	50%
Investment capital				
Annual operating capital	Dollars	1,786.26	2,866.84	4,047.58
Capital investment	Dollars	20,202.97	32,009.13	43,711.06
Net returns	Dollars	4,662.55	6,112.35	8,407.23
Marginal value products				
Soil I	Dollars	30.07	32.78	27.35
Row crop I	Dollars	52.83	54.54	44.58
Soil II	Dollars	24.26	26.78	21.44
Row crop II	Dollars	45.25	47.13	37.10
Soil III	Dollars	24.26	26.78	21.44
Row crop III	Dollars	39.04	39.41	31.71
Soil IV	Dollars	14.62	16.44	12.93
Row crop IV	Dollars	42.40	45.00	33.13
Soil V	Dollars	6.43	6.32	5.09
Soil VI	Dollars	5.67	5.43	4.56
Labor II	Dollars	0	0	1.64
Cotton allotment	Dollars	33.51	28.63	41.22
Land purchasing	Dollars	28.46	29.71	25.32

both swine enterprises, along with Beef I, were included in the live-stock system.

Two factors were mainly responsible for the increase of 1521 hours in labor used when additional land (43 acres) could be purchased up to 75 per cent equity. One factor was the additional labor required for the increase in acres of crops. Even though the large input-output coefficients replaced the medium coefficients, the increased acreage was sufficient to offset the increase in machinery efficiency accounted for in the coefficients. Another factor was the increase of approximately 67 sows in the Swine II enterprise. This swine enterprise replaced Swine I, even though on a per unit basis the labor requirements for Swine I were assumed to be higher. There was slightly over one unit of Swine I at the 100 per cent equity level. The increase in crop enterprises and also the change in livestock enterprises accounted for the additional increase in labor used between the 75 and 50 per cent equity level. There was a surplus of labor in all periods, except Period II at the 50 per cent equity level.

Net returns to land, labor and management at the 100, 75, and 50 per cent equity positions were \$4662.55, \$6112.35, and \$8407.23, respectively. These net returns required operating capital in the amounts of \$1786.26, \$2866.84, and \$4047.58, while investment capital required was \$20,202.97, \$32,009.13, and \$43,711.06, respectively. The large increases in investment capital can be attributed mainly to the additional purchases of land.

In analyzing the MVP's of the scarce resources, it is necessary to explain the behavior of the MVP's along the three equity positions. There was an increase in the MVP's of most land resource categories between the 100 and 75 per cent equity levels. This increase was due in most part to the change in the coefficients from the medium farm coefficients to the large farm coefficients between these two equity levels. The decrease in the MVP's of land between the 75 and 50 per cent equity levels was expected because labor became restrictive in Period II as the amount of land increased. Even though the MVP's for row crop decreased, additional row-crop acreage would have been highly profitable.

Two-Man Labor Supply

The initial land-labor combination involving the two-man labor supply included 214 acres of land and 5730 hours of labor. Then land acreage was allowed to increase by 71 and then 214 acres in combination with the same labor supply in order to determine the effect of variations in the land-labor mix on optimum enterprise organization and net returns. The input-output coefficients for the large farm were used in each case. Results from programming under the above assumptions are found in Table XVIII.

In the basic solution (100 per cent equity level), the entire open-land acreage was utilized. There were 152.9 acres of land in the crops of cotton, corn, hay and pasture for beef, and hog pasture. These same crops were also included in the solutions at the 75 and 50 per cent equity levels. Again, the entire open-land acreage

TABLE XVIII

OPTIMUM ENTERPRISE ORGANIZATION, NET RETURNS, AND MARGINAL VALUE
PRODUCTIVITIES OF RESTRICTING RESOURCES WITH A TWO-MAN
LABOR SUPPLY AND THREE EQUITY POSITIONS

Item	Unit	Equity	
		100%	75% 50%
Total land	Acres	214.0	285.0 428.0
Open land			
Cotton	Acres	29.1	38.8 58.2
Corn	Acres	37.0	49.3 73.8
Orchard grass-ladino pasture	Acres	32.6	44.2 65.6
Oats-lespedeza hay	Acres	13.7	18.7 30.5
Oats-lespedeza pasture	Acres	20.0	28.6 53.7
Hog pasture	Acres	20.5	24.9 24.0
Total open land	Acres	152.9	204.4 305.8
Livestock			
Swine I	No. of sows	0	5.2 36.9
Swine II	No. of sows	81.8	89.0 22.3
Beef I	No. of cows	12.8	17.4 27.8
Labor			
Available	Hours	5,730	5,730 5,730
Used	Hours	3,848	4,708 4,717

TABLE XVIII (CONTINUED)

Item	Unit	Equity	
		100%	75% 50%
Investment capital			
Annual operating capital	Dollars	3,466.25	4,584.79
Capital investment	Dollars	39,460.95	51,033.62
Net returns	Dollars	7,917.62	9,932.87
			13,546.28
Marginal value products			
Soil I	Dollars	32.78	27.00
Row crop I	Dollars	54.54	44.93
Soil II	Dollars	26.78	21.52
Row crop II	Dollars	47.13	37.01
Soil III	Dollars	26.78	21.52
Row crop III	Dollars	39.41	31.62
Soil IV	Dollars	16.44	13.00
Row crop IV	Dollars	45.00	33.05
Soil V	Dollars	6.32	5.20
Soil VI	Dollars	5.43	4.63
Labor II	Dollars	0	1.64
Cotton allotment	Dollars	28.63	41.23
Land purchasing	Dollars	29.71	25.33
			25.32

was utilized at each equity level. All of the available cotton allotment was exhausted in each solution.

Swine II, the feeder pig enterprise, and Beef I were included as the livestock enterprises in the basic solution at approximate levels of 82 sows and 13 cows. Swine I and II and Beef I were the livestock enterprises included in the optimal organizations at the 75 and 50 per cent equity levels. The Beef I enterprise increased in number as more land was purchased, but Swine II decreased approximately 67 sows between the 75 and 50 per cent equity level, as compared to a 32-sow increase in the Swine I enterprise.

Labor use, under the given assumptions, amounted to 67 per cent, or 3848 hours, of the available labor in the optimum solution at the 100 per cent equity position. When the 75 and 50 per cent equity levels were programmed, each required slightly more than 4700 hours of labor. The increase in labor required by more acres of crop, and the addition of sows to the Swine I enterprise was offset by the decrease in the Swine II enterprise.

The net return to land, labor, and management at the 100 per cent equity position was \$7912.62. The investments required for this return were \$3466.25 for annual operating capital and \$39,460.95 for investment capital. When land acreage increased due to variations in the land-labor combinations, the net return and capital requirements increased approximately proportionately. At the 50 per cent equity position (428 total acres), net returns were \$13,546.28 and operating capital amounted to \$6339.94 and capital investment required was \$67,809.84.

The MVP's for row crop at the 100 per cent equity level ranged from approximately \$55 for Row Crop I to \$39 for Row Crop III. At the 75 and 50 per cent equity levels, the MVP's for row crop land ranged from \$45 to \$33 for Row Crop I and Row Crop III. The land purchase resource, which was a restricting resource insofar as additional purchases of land was concerned, had a MVP of \$29.71 at the 100 per cent equity and a MVP of \$25.32 at the 50 per cent equity level. One reason for this decrease was that the labor supply was exhausted in Period II, and as a result, the MVP for labor affected the MVP for land.

Three-Man Labor Supply

The initial assumptions for this situation (100 per cent equity level) included a three-man labor supply, or 8595 hours, and 600 acres of land. Two hundred additional acres could be purchased at the 75 per cent equity position, while 600 additional acres could be obtained at the 50 per cent equity level. The extra-large farm coefficients were used in each situation. The programming results are presented in Table XIX.

Cotton, corn, and forage crops were included in the optimum solutions for all three equity levels. Soybeans were included as a cash crop at the 75 and 50 per cent equity levels. In addition, the effect of the variations in land-labor mixes was also evident in the varied composition of the forage crops.

Swine I and Beef I comprised the livestock operations in the optimum solutions at all equity levels. As the land acreage increased,

TABLE XIX

OPTIMUM ENTERPRISE ORGANIZATION, NET RETURNS, AND MARGINAL VALUE
PRODUCTIVITIES OF RESTRICTING RESOURCES WITH A THREE-
MAN LABOR SUPPLY AND THREE EQUITY POSITIONS

Item	Unit	Equity		
		100%	75%	50%
Total land	Acres	600.0	800.0	1,200.0
Open land				
Cotton	Acres	81.6	108.8	163.2
Corn	Acres	103.6	131.6	44.3
Soybeans	Acres	0	6.5	162.5
Alfalfa	Acres	6.3	0	0
Orchard grass-ladino pasture	Acres	91.5	149.5	298.4
Orchard grass-ladino pasture and hay	Acres	0	35.4	77.4
Lespedeza hay	Acres	0	0	31.3
Oats-lespedeza hay	Acres	33.8	0	0
Oats-lespedeza pasture	Acres	82.6	87.9	66.3
Red clover hay	Acres	0	18.1	0
Hog pasture	Acres	29.5	34.3	14.5
Total open land	Acres	428.9	571.9	857.5
Livestock				
Swine I	No. of sows	59.2	68.6	29.0
Beef I	No. of cows	41.6	71.9	135.0
Labor				
Available	Hours	8,595	8,595	8,595
Used	Hours	5,943	7,288	7,457

TABLE XIX (CONTINUED)

Item	Unit	Equity	
		100%	50%
Investment capital			
Annual operating capital	Dollars	8,297.70	10,095.64
Capital investment	Dollars	96,137.29	128,055.87
Net returns	Dollars	21,606.98	26,737.09
			32,835.35
Marginal value products			
Soil I	Dollars	28.61	14.47
Row crop I	Dollars	49.63	35.57
Soil II	Dollars	23.54	10.11
Row crop II	Dollars	41.30	26.53
Soil III	Dollars	23.54	10.11
Row crop III	Dollars	35.16	23.91
Soil IV	Dollars	18.84	6.67
Row crop IV	Dollars	33.52	17.50
Soil V	Dollars	11.84	3.39
Soil VI	Dollars	9.01	.48
Labor II	Dollars	0	.56
Labor III	Dollars	0	5.18
Labor IV	Dollars	0	1.36
Cotton allotment	Dollars	40.02	.99
Land purchasing	Dollars	28.72	55.81
			17.71
			14.24

livestock numbers increased with the exception of a decrease in Swine I at the 50 per cent equity level. A decrease from 59 sows in the basic solution to 29 sows at the 50 per cent equity level resulted. However, brood cows in the feeder calf operation increased from 41.6 to 135 between these equity positions.

The percentage of labor used ranged from 69 to 87 per cent, or 5943-7457 hours, of the available 8595 hours. All of the labor periods contained surplus hours at the 100 per cent equity level, but at the 75 per cent equity level two periods were exhausted, and three periods were exhausted at the 50 per cent equity position.

Net returns increased from \$21,606.98 at the 100 per cent equity position to \$32,835.35 at the 50 per cent equity level. Total investment capital for these two equity levels amounted to \$104,435 and \$190,530, respectively. All of the 600 additional acres were purchased.

An analysis of the MVP's of labor indicated that labor was very restrictive, particularly labor in Period II. At the 75 per cent equity position labor in Period II had a MVP of \$5.95, and at the 50 per cent equity level the MVP for this labor was \$5.18. Increases in the quantity of labor, particularly in Period II, would have resulted in significantly higher net returns.

However, the MVP's for land decreased significantly as more land was purchased. For example, between the 100 and 50 per cent equity levels, the MVP for Soil I decreased from \$28.61 to \$6.48 and the MVP for Soil VI decreased from \$9.10 to \$.56. The MVP of the land purchase

resource decreased from \$28.72 to \$14.24 between these two levels. The generally low MVP's for land are explained to a large extent by the shortage of labor, particularly at the 50 per cent equity level. That is, the changing MVP's of labor, which became the more restrictive resource, had an effect on the MVP's of land.

Summary of effects of variations in land-labor combinations. The analysis indicated that variations in land-labor combinations did have significant effects on each of the five initial enterprise organizations and net returns. The effects in each enterprise organization were indicated in both the composition of enterprises and the amounts produced. With the one-man, one-and-one-half-man, and two-man labor supplies, the only cash crop included in the enterprise organization was cotton. Soybeans were included in addition to cotton when the land-labor combination was altered by additions of land with the three-man labor supply. The amount of soybeans included in the solution for the three-man labor supply and 1200 acres was 162.5 acres, which was approximately 20 acres less than the soybean acreage restriction. The acreage of cotton, which was included in the solution for each initial land-labor combination, increased in approximately the same proportion as the increase in land. The beef enterprise that involved selling the calves at weaning was included in all of the optimum solutions at the 100 per cent equity level except that of the part-time land-labor combination. It also tended to increase in somewhat the same proportion as the increase in land. As the ratio of land to labor increased with the addition of land

relative to labor, the results indicated that of the two swine enterprises considered, the one in which slaughter hogs were sold seemed to be the more profitable one, for it usually increased in number, while Swine II, the feeder pig enterprise, decreased in number as additional land was added to a fixed labor supply.

More of the available labor was used as the land-labor combinations were altered by increases in land. For example, with the combination of 108 acres of land and the one-man labor supply (or a land-labor ratio of 1:27), 49 per cent of the labor was used, and with the land-labor combination of 1200 acres and a three-man labor supply (or a land-labor ratio of 1:7), 89 per cent of the available labor was used. The MVP's of labor indicated that the relative value of labor increased as the land-labor ratio increased. With the part-time labor supply, the labor supply was exhausted in two periods. The MVP's of labor in these periods were relatively high, \$4.23 and \$4.40 per hour, which indicated that for additional acreages of row crop (which was also exhausted) to be used profitably, additional labor would have to be acquired in the periods in which the supply was exhausted. With the one-man labor supply, labor was not a restricting resource, and it was not restricting in the one-and-one-half-man labor supply until the 50 per cent equity level was programmed. With the two-man labor supply, labor was restricting, insofar as the profitability of acquiring additional land was concerned, at the 75 and 50 per cent equity levels. With the three-man labor supply, labor was not restricting at the 100 per cent equity level

but was restrictive in two periods at the 75 per cent equity level and three periods at the 50 per cent equity level. The MVP of labor in Period II was \$1.64 per hour for the combination of one-and-one-half-man labor supply and 260 acres of land (land-labor ratio of 1:17) but increased to \$5.18 for the combination of the three-man labor supply and 1200 acres of land (land-labor ratio of 1:7). This further indicated that labor became more restricting as compared to land when the land-labor ratio increased.

Even though labor was restricting in many land-labor combinations analyzed, all of the available open land was used except for the land-labor combination involving the part-time labor supply. With this land-labor combination only the row-crop acreage was exhausted, and approximately 52 per cent of the open land was idle. The MVP's of row crop land remained relatively high in all land-labor combinations as compared to the MVP's for open land. Even though the MVP's for land in general remained high, there were decreases in the MVP's as the land-labor ratios were increased by additions of land relative to labor. The MVP of the land purchase activity has very little variation among the several land-labor combinations except for land-labor combinations involving the three-man labor supply. This indicated that the net returns from the additional land resources remained approximately the same until the supply of labor became rather restrictive. This is further supported by the finding that the MVP's of land declined while the MVP's of labor increased as the land-labor ratio increased due to additions of land relative to labor.

In order to analyze the effects of the variations in land-labor combinations on net returns, the net return per man equivalent were calculated (Table XX). The figures in Table XX indicate that the percentage changes in net returns were generally in less proportion as compared to the percentage changes in land for each labor supply. For example, when land acreage in combination with the two-man labor supply increased 100 per cent, net returns increased 88 per cent. Even though net returns in the one-man and one-and-one-half-man labor supplies increased more than the change in land (percentage wise), it should be pointed out that greater efficiency of machine use and less cost per hour of operation for these machines were permitted because of the change in input-output coefficients used. For example, when land acreage increased 100 per cent in combination with the one-man labor supply, the per cent increase in net returns was more than 100 per cent. Generally, it is reasonable to expect that the per cent change in net returns will be less than the per cent change in the input of land resources with the labor supply fixed.

None of the land-labor combinations was optimum in the sense that each acre of land should be in combination with so many hours of labor, for net returns continued to increase as the land-labor ratio increased due to the addition of land relative to labor.

TABLE XX
 VARIATIONS IN LAND-LABOR COMBINATIONS AND NET RETURNS
 TO LABOR IN THE BROWN SOIL AREA OF WEST TENNESSEE

Labor supply	100% equity		75% equity		50% equity	
	Land-labor ratio ^a	Net returns to labor per man equivalent	Land-labor ratio	Net returns to labor per man equivalent	Land-labor ratio	Net returns to labor per man equivalent
1-man	1:53	\$1490.89	1:40	\$2070.13	1:27	\$3094.84
1½-man	1:33	2486.10	1:25	3452.63	1:17	4982.55
2-man	1:27	3190.55	1:20	4198.17	1:14	6005.00
3-man	1:14	5766.33	1:11	7476.36	1:7	9509.11

^aAcres of land in combination with hours of operator labor.

II. EFFECTS OF RESERVATION PRICES ON ENTERPRISE

ORGANIZATION AND NET RETURNS

This portion of Chapter IV gives the effects of reservation prices on enterprise organization and net returns. Each labor supply was programmed for optimum enterprise organization at the 50 per cent equity position, except the part-time labor supply in which all land was purchased. A zero reservation price for labor was used in determining the initial optimum organization. Then labor reservation prices of 20, 40, 60, and 80 cents were successively placed on operator labor and new optimal solutions were obtained for each of these reservation prices.

Part-Time Labor Supply

The results of programming the part-time labor supply at five reservation prices are found in Table XXI. The assumptions for programming included 600 hours of available labor, and all land needed for combination with the available labor was to be purchased during the programming.

Of the various reservation prices used, the only effect on net returns and enterprise organization occurred at 40 cents. The optimal organization at the 20-cent reservation price was the same as the organization with the zero price, and the optimal organization with the 60- and 80-cent price was the same as the 40-cent reservation price. The change at the 40-cent price amounted to 6.4 additional hours of unused labor and a decrease in net returns of \$1.80 as compared to the 0 labor reservation price. Compared to the lower reservation prices, changes in the

TABLE XXI

THE EFFECTS OF LABOR RESERVATION PRICES ON NET RETURNS AND
ENTERPRISE ORGANIZATION WITH A PART-TIME LABOR SUPPLY

Item	Unit	Optimum organization with 0 price	Amount change from optimum level			
			Labor reservation price (cents per hour)			
			20	40	60	80
Non-use of labor	Hours	173.1		6.4	a	a
Net returns	Dollars	907.66		-1.80		
Total land	Acres	52.2		6.4		
Open land						
Cotton	Acres	4.2		.1		
Corn	Acres	10.8		-1.0		
Soybeans	Acres	1.0		2.9		
Hog pasture	Acres	2.3		-.2		
Idle	Acres	19.2		2.8		
Total open land	Acres	37.5		4.6		
Livestock						
Swine I	No. of sows	4.7		-.4		

^aSame change as shown for 40-cent reservation price of labor.

enterprise organization at the 40-cent price included increases of 2.9 acres of soybeans, 2.8 acres in idle land, and about .1 acre of cotton. There was a reduction of one acre of corn, .2 acre of hog pasture, and .4 sow. The optimum solutions at the reservation prices of 60 and 80 cents per hour were the same as the 40-cent price. Since no other changes in net returns or enterprise organization occurred with the remaining reservation prices, it is assumed that labor is returning at least the amount of the reservation prices per hour when used in production under the given conditions.

One-Man Labor Supply

The assumptions for obtaining the optimum solution for the one-man labor supply included 2865 hours of labor and 54 acres of land and provisions for purchasing 54 additional acres. The initial enterprise organization and net returns were determined at a zero reservation price. Then optimal solutions were derived using the labor reservation prices of 20, 40, 60, and 80 cents per hour, in order to determine the effects of these prices on optimum enterprise organization and net returns. The results are found in Table XXII.

No changes in enterprise organization and net returns under the above assumptions occurred except at the 80-cent labor reservation price. This indicated that labor used in the initial solution at the zero reservation price was returning at least 60 cents per hour of use.

The effects of the 80-cent reservation price was not very large, for only 23 additional hours of labor became unused, and net returns

TABLE XXII

THE EFFECTS OF LABOR RESERVATION PRICES ON NET RETURNS AND ENTERPRISE
ORGANIZATION WITH A ONE-MAN LABOR SUPPLY

Item	Unit	Optimum organization with 0 price	Amount change from optimum level Labor reservation price (cents per hour)		
			20	40	60
Non-use of labor	Hours	1532.7			22.8
Net returns	Dollars	3482.56			-16.7
Total land	Acres	108.0			0
Open land					
Cotton	Acres	14.8			0
Corn	Acres	18.6			0
Orchard grass-ladino pasture	Acres	16.6			4.2
Oats-lespedeza hay	Acres	7.9			.6
Oats-lespedeza pasture	Acres	14.1			- 4.6
Hog pasture	Acres	5.4			- .2
Total open land	Acres	77.5			0
Livestock					
Swine I	No. of sows	10.8			- .4
Beef I	No. of cows	7.1			.9

decreased \$16.77. The row-crop enterprises remained unchanged at the 80-cent price. As compared to the optimum solution at the lower reservation price, there was a .4 acre decrease in pasture, .6 acre increase in hay, .2 acre decrease in hog pasture, and a .4 sow decrease in Swine I. Beef I, however, increased by one cow. As indicated by the results, the returns per hour to most of the labor were at least 80 cents in the initial solution at the zero reservation price.

One-and-One-Half-Man Labor Supply

The programming assumptions for the one-and-one-half-man labor supply included 4298 hours of labor in combination with an initial land supply of 130 acres and an additional 130 acres could be purchased. The optimum solution was derived at a zero labor reservation price, and then varied at 20-, 40-, 60-, and 80-cent reservation prices to determine the effect of these prices on the optimum solutions. The results are shown in Table XXIII.

Using the above assumptions, all of the labor in the initial solution with no reservation prices was returning at least 20 cents per hour. When the 40-cent labor reservation price was used, a large amount of labor, 952 hours, became idle because it was not returning the required 40 cents per hour. Most of this increase in unused labor was the result of changes in the Swine II enterprise. That is, when the 40-cent price was used, Swine I replaced Swine II in the optimum enterprise organization. The row-crop enterprises were not affected by the change in this reservation price, but increases in the slaughter-hog operation

TABLE XXIII

THE EFFECTS OF LABOR RESERVATION PRICES ON NET RETURNS AND ENTERPRISE ORGANIZATION
WITH A ONE-AND-ONE-HALF-MAN LABOR SUPPLY

Item	Unit	Optimum organization with 0 price	Amount change from optimum level Labor reservation price (cents per hour)		
			20	40	60
Non-use of labor	Hours	760.65		952.20	a
Net returns	Dollars	8407.23		-233.75	
Total land	Acres	260.0		0	
Open land					
Cotton	Acres	35.4		0	
Corn	Acres	45.0		0	
Orchard grass-ladino pasture	Acres	39.9		0	
Oats-lespedeza hay	Acres	17.8		1.0	
Oats-lespedeza pasture	Acres	29.7		4.3	
Hog pasture	Acres	18.4		- 5.4	
Total open land	Acres	186.3		0	
Livestock					
Swine I	No. of sows	14.2		11.8	
Swine II	No. of sows	45.1		- 45.1	
Beef I	No. of cows	16.4		.7	

^aSame change as shown for 40-cent reservation price of labor.

(Swine I) of 11.8 sows and in the Beef I enterprise of .7 cow did result. Oats followed by lespedeza hay, and oats followed by lespedeza pasture increased by one acre and 4.3 acres, respectively.

Two-Man Labor Supply

The effects of the labor reservation prices on enterprise organization and net returns for the two-man labor supply are found in Table XXIV. The assumptions for programming this labor supply included 5730 hours of labor and a maximum of 428 acres of land. The optimum organization was determined for a zero reservation price, while prices of 20, 40, 60, and 80 cents were used in determining the effect of variations in reservation prices of labor on the enterprise organization and net returns.

A decrease of \$115.74 in net returns occurred when the 40-cent labor reservation price was used in programming as compared to the initial solution. There were no changes, however, at the lower price of 20 cents or the higher prices of 60 and 80 cents. The amount of idle labor increased by 472 hours at the 40-cent reservation price as compared to the 0- and 20-cent prices. As indicated in the results, most of the labor not returning 40 cents per hour was used in the feeder pig enterprise in the initial solution. The feeder pig operation was completely replaced in the results at the 40-cent reservation price level. Increases, as compared to the initial solution, occurred in the amounts of 5.8 sows in the slaughter-hog enterprise (Swine I) and .3 cow in the beef enterprise (Beef I). Forage crops increased by 4.2 acres, while cash crops remained unaffected.

TABLE XXIV

THE EFFECTS OF LABOR RESERVATION PRICES ON NET RETURNS AND ENTERPRISE ORGANIZATION
WITH A TWO-MAN LABOR SUPPLY

Item	Unit	Optimum organization with 0 price	Amount change from optimum level Labor reservation price (cents per hour)			
			20	40	60	80
Non-use of labor	Hours	1,012.57		471.64	a	a
Net returns	Dollars	13,546.28		-115.74		
Total land	Acres	428.0		0		
Open land						
Cotton	Acres	58.2		0		
Corn	Acres	73.8		0		
Orchard grass-ladino pasture	Acres	65.6		0		
Oats-lespedeza hay	Acres	30.5		.5		
Oats-lespedeza pasture	Acres	53.7		2.1		
Hog pasture	Acres	24.0		- 2.6		
Total open land	Acres	305.8		0		
Livestock						
Swine I	No. of sows	36.9		5.8		
Swine II	No. of sows	22.3		- 22.3		
Beef I	No. of cows	27.8		.3		

^aSame change as shown for 40-cent reservation price of labor.

Three-Man Labor Supply

For the initial situation with a zero labor reservation price, the assumptions included a three-man labor supply (8595 hours annually) in combination with 1200 acres of land. Successive variations in labor reservation prices were made at 20, 40, 60, and 80 cents per hour to determine the effects on net returns and farm organization. The results are presented in Table XXV.

Placing a labor reservation price of 20, 40, and 60 cents per hour had no effect on the optimum solution. Changes in enterprise organization and net returns did occur, however, when the labor reservation price was increased to 80 cents per hour. An addition of 103 hours of unused labor and a reduction of \$64.22 in net returns occurred at the 80-cent reservation price.

Even though the change in amount of unused labor was relatively small, there were significant changes in the enterprise organization. The number of beef cows was reduced by 35 and the number of sows (Swine I) increased by approximately 14. Since the total effect on income was only \$64.22, it seemed obvious that Beef I and Swine I were close competitors for labor and land resources; and that for this land-labor combination, one of these livestock enterprises could be substituted for another over a relatively wide range with only small effects on net returns.

The crop enterprises were also significantly affected by the 80-cent reservation price with major changes in acreages of corn, soybeans, pasture, and idle land. There was a net decrease of 138 acres in

TABLE XXV

THE EFFECTS OF LABOR RESERVATION PRICES ON NET RETURNS AND ENTERPRISE ORGANIZATION
WITH A THREE-MAN LABOR SUPPLY

Item	Unit	Optimum organization with 0 price	Amount change from optimum level Labor reservation price (cents per hour)			
			20	40	60	80
Non-use of labor	Hours	1,138.23				103.15
Net returns	Dollars	32,835.30				- 64.22
Total land	Acres	1,200.0				0
Open land						
Cotton	Acres	163.2				0
Corn	Acres	44.3				29.9
Soybeans	Acres	162.5				- 29.9
Orchard grass-ladino pasture	Acres	298.4				-121.4
Orchard grass-ladino pasture and hay	Acres	77.4				- .5
Lespedeza hay	Acres	31.3				- 21.8
Oats-lespedeza pasture	Acres	66.3				5.7
Hog pasture	Acres	14.5				6.9
Idle	Acres	0				131.1
Total open land	Acres	857.5				0
Livestock						
Swine I	No. of sows	29.0				13.7
Beef I	No. of cows	135.0				- 35.5

forage as a result of the decrease in the Beef I enterprise. Hog pasture increased 6.9 acres. Soybeans decreased 29.9 acres, but corn acreage increased by 29.9 acres to supply grain for the additional hogs in the Swine I enterprise. Most of the large decrease in crop acreage resulted in idle land. This idle land amounted to 131 acres, which included Soil Groups V and VI.

Summary of effects of variations in labor reservation prices. The results of the effects of labor reservation prices on enterprise organization and net returns indicated that the majority of labor used in the optimum organization was returning more than 80 cents per hour under the assumed conditions. Only in the land-labor combination of one-and-one-half-man labor supply and 260 acres of land, as compared to the other land-labor combinations used, was there a large number of hours of labor not returning 80 cents. In this situation 952 hours of labor became idle when the reservation price increased to 40 cents and above. The results also indicated that, in each land-labor combination, returns from labor used in row-crop enterprises were greater than returns from labor used in the livestock enterprises. If a labor reservation price were raised to successively higher levels, the adjustment usually occurred in the livestock enterprises and associated forage crops, rather than in the cash crops of cotton and soybeans. The major exception to this was indicated in the solution of the three-man labor supply in combination with 1200 acres of land. In this land-labor combination soybeans decreased in acreage when the 80-cent reservation price was

placed on labor. When the labor reservation price was increased to 80 cents per hour, the number of beef cows was reduced and the production of slaughter hogs was increased. This increase in the production of slaughter hogs was accompanied by an increase in corn acreage which furnished the grain for the feed requirements. Since there was no idle land available for the increased corn acreages, the most profitable alternative was for the soybean acreage to be utilized in corn production.

CHAPTER V

SUMMARY AND IMPLICATIONS

There were two objectives considered in this thesis. They were: (1) to determine the effects of variations in land-labor combinations on optimum enterprise organization and net returns on representative farms in the Brown Soil Area of West Tennessee and (2) to determine the effects of reservation prices placed on labor on the optimum enterprise organization and net returns of farms. Linear programming was the technique used to determine the optimum enterprise organizations for the various assumed representative farm situations and the effects of variations in land-labor combinations and labor reservation prices on optimum enterprise organizations.

Five labor supplies were used in combination with specified quantities of land in determining the optimum enterprise organizations. The labor supplies were determined on a man-equivalent basis. The five labor situations and initial quantity of land were: part-time--0 acres; one-man--54 acres; one-and-one-half-man--130 acres; two-man--214 acres; and three-man--600 acres. All land needed for the optimum organization with the part-time labor supply was purchased through a land purchasing provision in the programming model. A land purchasing activity was also the means for obtaining the variations in the land in combination with the one-, one-and-one-half-, two-, and three-man labor supplies so that the effects of these variations could be analyzed. For the part-time

situation, no restriction was placed on the amount of land to be purchased. For the other labor situations, the land and labor combinations given above were used as an initial point and were assumed to represent a situation of 100 per cent equity for the farm operator. Variations in land-labor ratios were provided for by allowing purchases of additional land up to 75 and 50 per cent equity with the labor supply being held constant for each of the four sizes of labor force.

In order to determine the effects of labor reservation price on optimum enterprise organization and net returns, prices of 0, 20, 40, 60, and 80 cents per hour were used. The initial optimum organization was determined by using the 0 reservation price, and the remaining prices were used in determining the effects of variations in labor reservation prices on enterprise organization and net returns.

The results indicated that variations in land-labor combinations did have effects on enterprise organization and net returns. As each land-labor ratio was increased by the addition of land, the net returns also increased, as compared to the initial land-labor ratio, but, generally, the returns increased proportionately less than the increases in land. For the one-man and one-and-one-half-man labor supplies, the increases in net returns were more than proportionate to the increases in land primarily because input-output coefficients representing greater efficiency of machine and labor use were used when land was added to the initial land-labor combination.

Acreages of specific crops also generally increased in approximately the same proportion as increases in the land-labor ratio. In each

of the situations where land was added to a fixed labor supply, the increase in cotton acreage was proportionate to the increases in the land; and with the exception of the land-labor combination involving the three-man labor situation, increases in corn acreage were also proportionate to the increases in land. The most significant change in crop enterprises occurred in the land-labor combination involving the three-man labor supply. Corn acreage decreased from 103.6 to 44.3 acres, but soybean acreage increased from 0 to 162.5 acres between the 100 and 50 per cent equity levels (which would mean doubling of land acreage). A pattern of changes in forage crops was not obvious as land-labor ratios were increased. However, there were major shifts in kinds of forage crops in the land-labor organization involving the three-man labor supply. As the land-labor ratio increased due to the addition of land, the composition of forage crop enterprises changed considerably. There were seven different forage crops included in the solutions for the 100, 75, and 50 per cent equity levels, and only two of these seven, orchard grass-ladino pasture and oats followed by lespedeza pasture, appeared consistently in each solution.

There were three beef enterprises and two swine enterprises considered in this study. Variations in land-labor combinations affected both the number and/or kind of animals included in the optimum systems. The optimal solution for the land-labor combination involving the part-time labor supply did not include a beef enterprise, and the optimal solutions for the four remaining labor supplies contained only the beef enterprise that involved the selling of feeder calves at weaning (Beef

I). With the exception of the land-labor combination involving the three-man labor supply, the increase in the beef enterprise was proportionate or slightly more than proportionate to the increase in land. When the land-labor ratio involving the three-man labor supply increased from 1:14 to 1:7, or when land increased from 600 acres to 1200 acres, the beef enterprise increased from 42 cows to 135 cows. In the initial solutions (100 per cent equity) for the land-labor combinations involving the one-man and two-man labor situations, the feeder pig operation was the only swine enterprise included. This enterprise was also the most profitable of the two swine enterprises considered at the 75 per cent equity level for the two-man labor situation. But for the remaining land-labor combinations, the swine enterprise involving the sale of slaughter hogs appeared to be more profitable than the feeder pig operation as the land-labor ratio for each labor supply increased due to the addition of land.

The results indicated that as the land-labor ratio increased, the MVP of labor tended to increase while the MVP of land tended to decrease. For example, the MVP's of an acre of land and an hour of labor in Period II for a land-labor ratio of 1:17 (260 acres of land and 4298 hours of labor) were \$25.32 and \$1.64, respectively, while the MVP's of land and labor in Period II for a land-labor ratio of 1:7 (1200 acres of land and 8595 hours of labor) were \$14.24 per acre and \$5.18 per hour, respectively.

When the effects of the variations in labor reservation prices were analyzed, the results indicated that most of the labor used in the

optimum programs for each labor situation was returning at least 80 cents per hour of use. A major exception to this observation occurred in the land-labor ratio of 1:17 (260 acres of land and 4298 hours of labor). As compared to the initial solution, 952 additional hours of labor became idle and a decrease of \$213 in net returns resulted when the 40-cent reservation price was placed on labor. Prices below 40 cents had no effects and the higher prices of 60 and 80 cents per hour had no further effects. Generally speaking, the changes in enterprise organization that resulted from the introduction of the labor reservation prices involved the livestock enterprises rather than the cash crops.

A significant change in enterprise organization occurred when the 80-cent reservation price was placed on labor in the land-labor combination of 1200 acres of land and 8595 hours of labor. Even though only 103 additional hours of labor became idle and net returns decreased \$64, the soybean, forage, and livestock enterprises changed considerably. The net changes in enterprise organization involved decreases of 30 acres of soybeans, 153.7 acres of forage, and 36 cows in Beef I. There were increases of 30 acres of corn, 131 acres of idle land, and 14 sows in Swine I.

For the thirteen land-labor combinations used in this study, income per-man equivalent was highest for the combination involving the three-man labor supply and 1200 acres of land. However, the modal farm size group in the study area in 1959 was from 36-99 acres, and the average farm size was only 94 acres. This would seem to imply that there is too little land in combination with the available labor supply

for the most profitable operation on many of the farms in the area. Also, recent increases in mechanization in the area have increased the productivity of labor and made it possible for a given labor supply to handle a larger operation. This often makes it necessary for the farmer to increase the quantity of land in order to realize the full benefit of the mechanization.

These results are to be considered as "normative" estimates of what would be profitable under the assumed conditions rather than serve as predictions of what farmers are actually doing. If perfect knowledge of prices and costs were known and the assumed efficiency of production were employed, the results would reflect the optimum organization of the enterprises considered but should not be interpreted as the actual adjustments farmers might make when facing the assumed conditions.

In conclusion, it should be pointed out that results pertain primarily to the study area but perhaps have general implications for other areas. Additional research is needed to identify some of the obstacles to land-labor adjustments and also of the aggregate effects of the adjustments on an area or regional basis.

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APPENDIXES

APPENDIX A

PRODUCT AND INPUT PRICES

TABLE XXVI

SELECTED SAMPLE OF PROJECTED PRICES RECEIVED AND PAID
BY FARMERS IN THE BROWN SOIL AREA OF WEST TENNESSEE

Item	Unit	Price
PRICES RECEIVED		
Cotton lint	lb.	\$.312
Cotton seed	ton	45.00
Corn, shelled	bu.	1.10
Soybeans	bu.	2.30
Calves at 400 lbs.	cwt.	22.50
Steers at 1000 lbs.	cwt.	23.50
Heifers at 810 lbs.	cwt.	23.50
Hogs at 210 lbs.	cwt.	14.50
Pigs at 40 lbs.	each	9.00
PRICES PAID		
Seed:		
Cotton	lb.	.12
Soybeans	bu.	4.25
Corn	bu.	10.00
Orchard grass	lb.	.32
Ladino clover	lb.	.65
Red clover	lb.	.45
Lespedeza	lb.	.22
Oats	bu.	1.40
Alfalfa	lb.	.45
Feed:		
Mineralized salt	cwt.	2.00
Hog supplement	cwt.	4.30
Fertilizer:		
6-12-12	ton	52.00
0-20-30	ton	59.00
Lime	ton	5.00
Atrazine	lb.	3.00
3-12-12	ton	38.60
0-20-20	lb.	49.00
Nitrogen	lb.	.12

TABLE XXVI (CONTINUED)

Item	Unit	Price
PRICES PAID (Continued)		
Custom Work:		
Bermuda sprigging	acre	\$20.00
Corn picking	acre	6.00
Soybean combining		6.50
Poisoning and defoliation (without material)	acre	2.10
Baling	ton	5.00
Raking	acre	1.50

APPENDIX B

PRODUCTION PRACTICES

TABLE XXVII

PRODUCTION PRACTICES AND MACHINE HOURS PER ACRE FOR MAJOR CROPS IN
THE BROWN SOIL AREA OF WEST TENNESSEE

Crop and production practice	Hours per acre			
	54 A	130 A	214 A	600 A
Cotton				
Cut stalks	.6 (disk)	.6 (disk)	.5	.4
Turn	1.8	1.4	1.1	.9
Fertilize	.8	.8	.7	.6
Disk (drag) (2 times)	1.2	1.2	1.0	.8
Plant-fertilize-pre-emerge	.6	.6	.8	.6
Cultivate and sidedress	.6	.6	.6	.3
Cultivate (2 X)	.6	.6	a	a
Post-emerge	a	a	.4	.3
Poison (5 times)	cw ^b	cw	2.0	1.4
Chop-thinning	5.0	5.0	5.0	5.0
Defoliation	cw	cw	.4	.3
Harvest	cw	cw	cw	cw
Haul to gin	1.0	.9	.8	.8
Corn				
Cut stalks	.6 (disk)	.6 (disk)	.5	.4
Turn	1.8	1.4	1.1	.9
Fertilize	.5	.5	.4	.3
Disk (drag) (2 X)	1.2	1.2	1.0	.8
Plant-fertilize-pre-emerge	.6	.6	.5	.4
Sidedress	.6	.6	.6	.3
Harvest	cw	cw	cw	1.2
Haul	2.5	2.0	1.5	1.4
Soybeans				
Turn	1.8	1.4	1.1	.9
Disk (drag)	.6	.6	.5	.4
Plant-fertilize	.6	.6	.5	.4
Cultivate (3 X)	1.8	1.8	1.8	.9
Poison	cw	cw	.4	.3
Combine	cw	cw	cw	.8
Haul	2.0	1.8	1.6	1.6

TABLE XXVII (CONTINUED)

Crop and production practice	Hours per acre			
	54 A	130 A	214 A	600 A
Forage				
Mower (mow hay and clip pasture)	.7	.6	.6	.5
Rake			.5	.4
Combine (corn, oats, soybeans) 10 ft.				.7
Baler (per ton)				.5
Haul hay (per acre - 2-man wagon, 1 cutting)	1.6	1.5	1.4	1.2

^aThis practice was not applicable to this situation.

^b_{cw} = custom work.