May 20, 1966

To the Graduate Council:

I am submitting herewith a thesis written by Roger Stanley Lyon entitled "The Economics of Forage and Concentrate Rations for East Tennessee Grade A Dairy Herds with High Production Records." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Curtis F. Lard
Major Professor

We have read this thesis and recommend its acceptance:

Charles L. Cleland

Troy W. Hunton

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

# THE ECONOMICS OF FORAGE AND CONCENTRATE RATIONS FOR EAST TENNESSEE GRADE A DAIRY HERDS WITH HIGH PRODUCTION RECORDS

---

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

Roger Stanley Lyon

August 1966

ACKNOWLEDGMENTS

A special note of appreciation goes to a person who has never failed me throughout this thesis. To my wife, Martha, for her perseverance, typing assistance, personal sacrifice, and unfailing faith in me, I am forever indebted.

The writer expresses his sincere thanks to Dr. T. J. Whatley for providing the financial assistance which made my continued education and this study possible.

Special appreciation is expressed to Dr. Curtis F. Lard for his unfaltering confidence in me, the assistance and guidance he has given me throughout my graduate program and this study and for the many hours spent reviewing this manuscript.

Special appreciation is also expressed to Drs. Charles L. Cleland and Troy W. Hinton for their assistance and cooperation throughout the preparation of this manuscript.

A vote of thanks goes to the secretaries and statistical clerks in the Department of Agricultural Economics and Rural Sociology for the cooperation they have continuously given throughout this study. Also, appreciation is extended to Mrs. Catherine W. Cole for typing the final manuscript.

Yet, it all began with my parents, Mr. and Mrs. Lawrence Lyon. Their consistent love, guidance, and confidence in me served as a



671404

stimulant throughout the years. To them, a debt is owed which can never be repaid.

My sincere gratitude goes to everyone who helped make this thesis possible.

The author takes full responsibility for any errors made in this thesis.

TABLE OF CONTENTS


| CHAPTER | | PAGE |
|---|---|---|
| I. | INTRODUCTION | 1 |
| | Objectives | 2 |
| | The Problem | 3 |
| | The Procedure | 4 |
| | The Assumptions | 5 |
| | Sources of Data | 8 |
| II. | RESOURCE REQUIREMENTS FOR GRADE A DAIRY FARMS IN EAST TENNESSEE BY HERD SIZE, FORAGE SYSTEM, AND HARVESTING POLICY | 9 |
| | Introduction | 9 |
| | Feed Requirements | 9 |
| | Land Requirements | 13 |
| | Building and Equipment Requirements | 15 |
| | Labor Requirements | 17 |
| | Annual Operating Capital Requirements | 22 |
| III. | A COMPARISON OF REVENUE AND COSTS FOR ALTERNATIVE FORAGE SYSTEMS ON GRADE A DAIRY FARMS IN EAST TENNESSEE | 26 |
| | Introduction | 26 |
| | Revenue | 26 |
| | Costs and Returns | 28 |
| | Costs per ton of hay and silage by harvesting policy | 28 |

CHAPTER PAGE

Costs by alternative forage systems . . . . . 30
Returns to land, investment capital, and management . . 34
Summary . . . . . 36
IV. LEAST COST COMBINATIONS OF FEED RATIONS FOR GRADE A DAIRY HERDS IN EAST TENNESSEE USING VARIOUS RESOURCE SITUATIONS . . . . . 37
Introduction . . . . . 37
Resource Situation . . . . . 37
Cropland and soil group assumptions . . . . . 38
Cropland enterprises considered and their assumed yields . . . . . 39
Labor situation . . . . . 41
Milk production requirements and feed composition . . . 41
The Estimated Variable and Fixed Expenses . . . . . 44
The Results . . . . . 47
Sixty-cow herd size . . . . . 48
Seventy-cow herd size . . . . . 52
Fifty-cow herd size . . . . . 55
Summary . . . . . 58
V. SUMMARY, CONCLUSIONS, AND IMPLICATIONS . . . . . 61
Summary . . . . . 61
Conclusions . . . . . 65
Limitations of the Results and Their Implications . . . . 66

CHAPTER PAGE

SELECTED BIBLIOGRAPHY . . . . . 68

APPENDIXES . . . . . 71

APPENDIX A. Building and Equipment Assumptions and Cost Estimates . . . . . 72

APPENDIX B. Labor Requirements for Three Forage Systems with Alternative Forage Harvesting Policies . . . 86

APPENDIX C. Assumed Prices of Products Sold and Items Purchased and Variable Cost of Crop Production for Three Forage Systems . . . . . 90

APPENDIX D. The Least Cost Combinations of Activities for Fifty, Sixty and Seventy Cow Herd Size Without a Tobacco Enterprise . . . . . 95

LIST OF TABLES


TABLE PAGE

I. Total Roughage and Concentrate Requirements for Grade A Dairies in East Tennessee by Forage System and Herd Size Using a 9,400 Pound Production Level Per Cow, 1965 . . . . . 11

II. Cropland Requirements for Three Alternative Forage Systems, and Three Herd Sizes on Grade A Dairies in East Tennessee, 1965 . . . . . 14

III. Total Investment Capital Requirements for Buildings, Equipment, and Machinery for Three Forage Systems and Alternative Harvesting Policies for Grade A Dairy Farms in East Tennessee, 1965 . . . . . 16

IV. Estimated Labor Requirements by Enterprise and Labor Period for Grade A Dairy Farms in East Tennessee, 1965 . . . . . 18

V. Annual Operating Capital Requirements for Three Dairy Herd Sizes, Three Forage Systems and Alternative Harvesting Policies for Grade A Dairy Farms in East Tennessee, 1965 . . . . . 24

VI. Assumed Revenue for Three Herd Sizes on Grade A Dairy Farms in East Tennessee, 1965 . . . . . 27

TABLE PAGE

VII. The Per Ton Costs of Producing Each Forage by Forage System, Acreage and Herd Size Where the Operator Owns All Harvesting Machinery for Three Systems on Grade A Dairies in East Tennessee, 1965 . . . . . 29

VIII. A Comparison of Costs for the Thirty-Cow Herd Size on Grade A Dairies in East Tennessee Using Three Forage Systems and Two Harvesting Policies, 1965 . . . . . 31

IX. A Comparison of Costs for the Sixty-Cow Herd Size on Grade A Dairies in East Tennessee Using Three Forage Systems and Two Harvesting Policies, 1965 . . . . . 32

X. A Comparison of Costs for the Ninety-Cow Herd Size on Grade A Dairies in East Tennessee Using Three Forage Systems and Two Harvesting Policies, 1965 . . . . . 33

XI. Assumed Crop and Pasture Yields Per Acre, by Soil Groups for Grade A Dairies in East Tennessee with High Production Records, 1965 . . . . . 40

XII. Hours of Labor Required Per Acre and Cow by Soil Group and Production Level for Each Labor Period on Grade A Dairies in East Tennessee, 1965 . . . . . 42

XIII. Total Feed and Bedding Requirements Per Cow for Each Production Level and the Composition of Feeds Used on Grade A Dairies in East Tennessee, 1965 . . . . . 45

XIV. Total Variable and Fixed Expenses Assumed Per Acre and Per Cow for Medium Size Grade A Dairies in East Tennessee, 1965 . . . . . 46

TABLE PAGE

XV. A Least Cost Combination of Activities for Alternative Production Levels and Labor Supplies on East Tennessee Grade A Dairy Farms Consisting of 150 Acres of Open Cropland and a Sixty-Cow Herd Size with a Tobacco Enterprise, 1965 . . . . . 49

XVI. Least Cost Feed Rations Per Cow for Alternative Production Levels, Labor Supplies and Crop Enterprises on East Tennessee Grade A Dairy Farms Consisting of 150 Acres of Cropland and a Sixty-Cow Herd Size, 1965 . . . 50

XVII. A Least Cost Combination of Activities for Alternative Production Levels and Labor Supplies on East Tennessee Grade A Dairy Farms Consisting of 150 Acres of Open Cropland and a Seventy-Cow Herd Size with a Tobacco Enterprise, 1965 . . . . . 53

XVIII. Least Cost Feed Rations Per Cow for Alternative Production Levels, Labor Supplies and Crop Enterprises on East Tennessee Grade A Dairy Farms Consisting of 150 Acres of Cropland and a Seventy-Cow Herd Size, 1965 . . 54

XIX. A Least Cost Combination of Activities for Alternative Production Levels and Labor Supplies on East Tennessee Grade A Dairy Farms Consisting of 150 Acres of Open Cropland and a Fifty-Cow Herd Size with a Tobacco Enterprise, 1965 . . . . . 56

TABLE PAGE

XX. Least Cost Feed Rations Per Cow for Alternative Production Levels, Labor Supplies and Crop Enterprises on East Tennessee Grade A Dairy Farms Consisting of 150 Acres of Cropland and a Fifty-Cow Herd Size, 1965 . . . 57

XXI. Assumed Buildings and Equipment with Annual Cost Estimates for Thirty-Cow Herd Using Custom Harvesting for Each Forage System on Grade A Dairies in East Tennessee, 1965 . . . . . 73

XXII. Assumed Buildings and Equipment with Annual Cost Estimates for Thirty-Cow Herd Using a Corn Silage Forage System and Alternative Harvesting Policies on Grade A Dairies in East Tennessee, 1965 . . . . . 74

XXIII. Assumed Buildings and Equipment with Annual Cost Estimates for Thirty-Cow Herd Using an All Alfalfa-Orchard Grass Hay Forage System and Alternative Harvesting Policies on Grade A Dairies in East Tennessee, 1965 . . 75

XXIV. Assumed Buildings and Equipment with Annual Cost Estimates for Thirty-Cow Herd Using a Corn Silage and Alfalfa-Orchard Grass Hay Forage System with Alternative Harvesting Policies on Grade A Dairies in East Tennessee, 1965 . . . . . 76

XXV. Assumed Buildings and Equipment with Annual Cost Estimates for Sixty-Cow Herd Using Custom Harvesting for Each Forage System on Grade A Dairies in East Tennessee, 1965 . . . . . 77

TABLE PAGE

XXVI. Assumed Buildings and Equipment with Annual Cost Estimates for Sixty-Cow Herd Using a Corn Silage Forage System and Alternative Harvesting Policies on Grade A Dairies in East Tennessee, 1965 . . . . . 78

XXVII. Assumed Buildings and Equipment with Annual Cost Estimates for Sixty-Cow Herd Using an All Alfalfa-Orchard Grass Hay Forage System and Alternative Harvesting Policies on Grade A Dairies in East Tennessee, 1965 . . 79

XXVIII. Assumed Buildings and Equipment with Annual Cost Estimates for Sixty-Cow Herd Using a Corn Silage and Alfalfa-Orchard Grass Hay Forage System with Alternative Harvesting Policies on Grade A Dairies in East Tennessee, 1965 . . . . . 80

XXIX. Assumed Buildings and Equipment with Annual Cost Estimates for Ninety-Cow Herd Using Custom Harvesting for Each Forage System on Grade A Dairies in East Tennessee, 1965 . . . . . 81

XXX. Assumed Buildings and Equipment with Annual Cost Estimates for Ninety-Cow Herd Using a Corn Silage Forage System and Alternate Harvesting Policies, 1965 . . . . 82

XXXI. Assumed Buildings and Equipment with Annual Cost Estimates for Ninety-Cow Herd Using an All Alfalfa-Orchard Grass Hay Forage System and Alternate Harvesting Policies, 1965 . . . . . 83

TABLE PAGE

XXXII. Assumed Buildings and Equipment with Annual Cost Estimates for Ninety-Cow Herd Using a Corn Silage and Alfalfa-Orchard Grass Hay Forage System with Alternative Harvesting Policies on Grade A Dairies in East Tennessee, 1965 . . . . . 84

XXXIII. Assumed Depreciation and Repairs Per Unit of Use for Buildings, Machinery and Replacement Stock on Grade A Dairies in East Tennessee, 1965 . . . . . 85

XXXIV. Estimated Labor Requirements for Thirty-Cow Dairy Herd Using Alternative Forage Systems and Harvesting Policies on Grade A Dairies in East Tennessee, 1965 . . 87

XXXV. Estimated Labor Requirements for Sixty-Cow Dairy Herd Using Alternative Forage Systems and Harvesting Policies on Grade A Dairies in East Tennessee, 1965 . . 88

XXXVI. Estimated Labor Requirements for Ninety-Cow Dairy Herd Using Alternative Forage Systems and Harvesting Policies on Grade A Dairies in East Tennessee, 1965 . . 89

XXXVII. Assumed Prices of Products Sold and Items Purchased for Grade A Dairy Farms in East Tennessee, 1965 . . . . 91

XXXVIII. Estimated Annual Variable Cost of Crop Production for Three Alternative Forage Systems on Grade A Dairies in East Tennessee, 1965 . . . . . 94

TABLE PAGE

XXXIX. A Least Cost Combination of Activities for Alternative Production Levels and Labor Supplies on East Tennessee Grade A Dairy Farms Consisting of 150 Acres of Open Cropland and a Sixty-Cow Herd Size Without a Tobacco Enterprise, 1965 . . . . . 96

XL. A Least Cost Combination of Activities for Alternative Production Levels and Labor Supplies on East Tennessee Grade A Dairy Farms Consisting of 150 Acres of Open Cropland and a Seventy-Cow Herd Size Without a Tobacco Enterprise, 1965 . . . . . 97

XLI. A Least Cost Combination of Activities for Alternative Production Levels and Labor Supplies on East Tennessee Grade A Dairy Farms Consisting of 150 Acres of Open Cropland and a Fifty-Cow Herd Size Without a Tobacco Enterprise, 1965 . . . . . 98

# CHAPTER I

## INTRODUCTION

The grade A milk industry has steadily developed into one of the major agricultural industries in Tennessee today. The volume of Grade A milk sold under Federal order increased 51 per cent between 1956 and 1963. Yet, along with this increase in milk production, the number of grade A milk producers has declined. The decline in the number of producers is due to the advancement of technology in dairying which has caused greater milk production per cow, larger herd sizes and a tremendous increase in capital investment. These factors have forced many small producers out of production.[1]

For years dairy farmers have used their own experiences and opinions as the primary basis for making important decisions, but with the recent advances in dairying technology, more scientific methods are needed. The most prevalent decisions concern machinery ownership and the most economical rations to feed under a given set of conditions. These decisions have become increasingly difficult to make in recent years. Dairy operations have become increasingly complicated with labor-saving devices and machinery whose costs tend to be dynamic in nature. They are dynamic because of the uncertainty of the many alternative

---

[1]William Dale Given, Tennessee Grade A Milk Producers, Present and Potential, unpublished Master's thesis, The University of Tennessee, Knoxville, June, 1964.

uses they have and the dependence they have upon the availability of complementary resources affecting the extent of their use. If the complementary resources were unrestricted and the exact opportunity cost of all the existing alternatives were known, then the costs of these advancements in technology would be more predictable and static rather than dynamic. Yet, these conditions are virtually impossible to obtain and, therefore, this makes the situation a dynamic one. In regard to milk supply, technological improvements tend to make grade A dairying more stable because of the added certainty they give to production. This added certainty is due to the replacement of human controls with mechanical controls and the presence of scientific knowledge in the operation of the dairies.

## I. OBJECTIVES

Although it is a well known fact that dairy farmers have several goals, only two were considered in this study. These were profit maximization and the efficient use of resources.

The objectives of this study were: (1) to determine the most economical forage system for different herd sizes at a given level of milk production; (2) to estimate the returns to scale with increases in herd size; (3) to determine the acreage needed in order to justify ownership of forage harvesting machinery; (4) to determine the resource requirements for each herd size and forage system; and (5) to obtain the most profitable forage rations for grade A dairy cows using specific resources and prices prevalent on East Tennessee grade A dairy farms.

## II. THE PROBLEM

Considerable controversy has arisen in respect to ownership of forage harvesting machinery and the economics of forage and concentrate rations for dairy cattle at different levels of production. This study was conducted to determine: (1) the acreages needed to economically justify ownership of forage harvesting machinery; (2) the cost and resource requirement differences between the most popular high quality forage rations; and (3) the least cost rations for grade A dairy cattle when using different production levels and specific resource situations found on grade A dairy farms in East Tennessee. The farms considered are those which have had production levels per cow ranging from the State DHIA average of 9,400 pounds (4 per cent butterfat) to 3,600 pounds above this average. The analytical techniques used in this study were budgeting and linear programming.

A recent survey revealed that alfalfa hay and corn silage were the most popular forages used by grade A dairy farmers in East Tennessee.[2] A mixture of orchard grass with the alfalfa hay is also very popular for increasing the total digestible nutrient content of the forage ration. The popularity of these forages is due to their high yield of nutrients produced per acre. These forages are commonly fed in three alternative rations. They are: (1) a ration consisting almost entirely of corn

---

[2] Thomas William Little, "An Economic Analysis of Alternative Replacement Policies on Grade A Dairy Farms in the Knoxville Milkshed," unpublished Master's thesis, The University of Tennessee, Knoxville, 1964, p. 19.

silage with a minimum of alfalfa-orchard grass hay and concentrates; (2) an all alfalfa-orchard grass hay forage ration and concentrates; or (3) a ration consisting of a mixture of the alfalfa-orchard grass hay and corn silage. Based upon the above information, a budgeting analysis of these three forage systems was performed in Chapters II and III of this thesis with emphasis being placed upon the costs of owning forage harvesting machinery. Chapter IV is devoted to obtaining a least cost feed ration for grade A dairy cows using three production levels and the resources and prices which are representative of grade A dairy farms in East Tennessee. Chapter V summarizes and draws conclusions from the findings of this study.

## III. THE PROCEDURE

The budgeting analysis in Chapters II and III analyzes and compares (1) a corn silage forage system; (2) an all alfalfa-orchard grass hay forage system; and (3) a corn silage and alfalfa-orchard grass hay forage system. The forage systems were analyzed for three herd sizes consisting of thirty, sixty, and ninety cows. For each herd size and forage system, the alternative of owning all forage harvesting machinery was compared with the alternative of hiring the forage crops custom harvested. Chapter II is devoted to a comparison of the total resource requirements for each forage system and harvesting policy using the different herd sizes. Chapter III involves a revenue and cost analysis that concludes with a summary of the essential differences in the forage systems.

Chapter IV involves finding a least cost feed ration for Grade A dairy cows in East Tennessee using the techniques of budgeting and linear programming. Budgeting was used to develop the resource requirements for each of the crops and levels of milk production considered. The alternatives of buying and selling straw, hay, and concentrates were considered as intermediate activities.

The resources which were considered as constraints, to East Tennessee grade A dairy farmers, were labor and land. Operator labor was assumed to be available in fixed, monthly amounts. In addition, an activity for hiring labor for $1.25 per hour was included in the linear programming model. Land was restricted to the total acreage of cropland and the percentage of each class of soil available on the selected representative farm situation. The initial supply of annual investment capital in the model was set at zero, however, an activity of borrowing annual investment capital at 6 per cent interest annually was included as the means of supplying investment capital in the model. Neither hired labor nor total investment capital was assumed to be restricted in supply.

## IV. THE ASSUMPTIONS

It was assumed that the dairy farm operators would possess the required managerial abilities for the various production levels.

Recent research by William Dale Givan has shown that upright silos are the most popular type of storage facility for silage on

grade A dairy farms in East Tennessee.[3] Also, upright silos have lower spoilage rates than trench and bunker silos. The estimated spoilage rate in upright silos is 5 to 10 per cent whereas it is 10 to 15 per cent in permanent trench and bunker silos.[4] Thus, upright silage storage was assumed throughout this study.

According to the findings of Thomas William Little, an opportunity cost for purchasing replacement heifers is involved when the grade A dairy farmer raises his own replacement stock. Little also revealed that 69 per cent of the grade A dairy farms in the Knoxville milkshed raised 100 per cent of their own replacement stock.[5] Since such a high proportion of the grade A dairy producers continue to raise their own replacement stock, all replacement heifers were assumed to be raised on the home farm in the budgeting analysis shown in Chapters II and III. In order to obtain a least cost feed ration for different production levels, it was assumed that all replacement heifers would be purchased in the linear programming analysis presented in Chapter IV.

Downen and Culver found that the average dairy heifer replacement rate used by Tennessee dairy farmers was approximately 20 per cent.[6]

---

[3]Givan, op. cit., p. 47.

[4]H. K. Welch, Jr., J. N. Maddux, and W. H. McKinney, Silages for Dairy Cattle, Cooperative Extension Service Bulletin 616, University of Georgia, Athens, 1962, p. 13.

[5]Little, op. cit., pp. 105-108.

[6]M. Lloyd Downen and David W. Culver, The Dairy Cattle Replacement Markets of Tennessee and Florida, The University of Tennessee, Agricultural Experiment Station Bulletin 318, Knoxville, 1960, p. 2.

Therefore, a 20 per cent replacement rate for the cows was assumed in this study.

All concentrates, bedding, and minerals were assumed to be bought at current market prices in the budgeting analysis. The dairy operations analyzed in the linear programming phase of this study were given the possibilities of either growing or buying forages, concentrates and bedding.

Most farmers, who own forage harvesting machinery, harvest forage crops for both themselves and other farmers. In this way, many farmers can profitably own harvesting machinery. But, for the purposes of the budgeting analysis, it was assumed that the farmer would not be permitted to harvest crops other than those pertinent to the maintenance of the particular herd size and forage system under consideration. This is due to the uncertainties of estimating the amount of custom work the farmer could do, and also, it simplified the task of determining the number of acres that are necessary to profitably own harvesting machinery.

Custom rates were assumed for harvesting costs of all crops grown on the grade A dairy farm in the linear programming phase of this study. This assumption was made because, when the operator owns harvesting machinery, he is still foregoing an opportunity cost that he might obtain from custom harvesting. This opportunity cost is in the form of revenue he could obtain from custom harvesting crops for other farmers while he is harvesting his own crops.

## V. SOURCES OF DATA

The data for this study were obtained from consultation with staff members in the Departments of Agricultural Economics, Agronomy, Agricultural Engineering, and Dairying at The University of Tennessee and from secondary sources.

The secondary data comes from unpublished data in the Department of Agricultural Economics at The University of Tennessee, bulletins and publications by The University of Tennessee Agricultural Experiment Station, theses written by graduate students as part of the requirements for an advance degree from The University of Tennessee, Department of Agricultural Economics, Morrison's Feeds and Feeding, and miscellaneous publications.

# CHAPTER II

# RESOURCE REQUIREMENTS FOR GRADE A DAIRY FARMS IN EAST TENNESSEE BY HERD SIZE, FORAGE SYSTEM, AND HARVESTING POLICY

## I. INTRODUCTION

This part of the study is concerned with resource requirements for three forage systems, three herd sizes and two harvesting policies for grade A dairying. With changes in each herd size, forage system, and harvesting policy, many resource requirements change at a variable rate while others change at a constant rate. Consideration is given to both types of resources, but special attention is given to those which change at a variable rate. Also, there are resources, such as land, labor, and investment capital, whose supply tends to be fixed thereby limiting expansion of a highly profitable enterprise. Therefore, special consideration was given to these resources in Chapter IV.

Throughout the remainder of this thesis, where it was deemed practical to do so, the corn silage forage system was referred to as forage system A, the all alfalfa-orchard grass hay forage system as forage system B, and the corn silage and alfalfa-orchard grass hay forage system as forage system C.

## II. FEED REQUIREMENTS

As stated in the previous chapter, the three herd sizes were

thirty, sixty, and ninety cows using a 20 per cent cow replacement policy. With a 20 per cent replacement policy, six 900-pound bred heifers and six 500-pound yearling heifers would be required as the young stock or replacements for the thirty-cow herd. Each of these numbers was increased to twelve for the sixty-cow herd and eighteen for the ninety-cow herd. The mature milk cows were assumed to have an average weight of 1,250 pounds and have an average annual production of 9,400 pounds of 4 per cent butterfat milk. This annual production level was the same as the average milk production per cow on DHIA records for the State of Tennessee in 1964.[1]

The total feed requirements by herd size and forage system are shown in Table I. The winter feeding period was assumed to be from October 15 until April 15 (183 days). Adequate ladino clover and orchard grass pasture was assumed as the forage for the summer feeding period from April 16 through October 14. It was assumed that a high proportion of the dairy cows would be dry through the summer months of July and August. This assumption was made because September through January is normally the "base building" period for producers of grade A milk, and the producers tend to have a greater percentage of the herd freshen from mid-August through October in order to build a larger base. Ladino-orchard grass pasture is uaually an adequate ration for dry cows and the young stock throughout the summer feeding period. In addition to pasture, approximately nine pounds of corn per day would be needed to

---

[1]State of Tennessee Dairy Herd Improvement Association Summary, 1963-1964.

TABLE I

TOTAL ROUGHAGE AND CONCENTRATE REQUIREMENTS FOR GRADE A DAIRIES IN EAST TENNESSEE BY FORAGE SYSTEM AND HERD SIZE USING A 9,400 POUND PRODUCTION LEVEL PER COW, 1965

| System | Herd Size (Cows) | Total Amount of Feed Required[a] | | | | |
|---|---|---|---|---|---|---|
| | | Corn Silage (Tons) | Alfalfa-Orchard Grass Hay (Tons) | Corn, Dent, Grade 1 (Bu.) | Molasses, Cane (Lbs.) | Soybean Oil Meal 44% Protein (Lbs.) |
| (A) | 30 | 249 | 16 | 878 | --[b] | 10,980 |
| | 60 | 498 | 32 | 1,756 | -- | 21,960 |
| | 90 | 747 | 48 | 2,634 | -- | 32,940 |
| (B) | 30 | -- | 59 | 1,937 | 6,588 | -- |
| | 60 | -- | 118 | 3,874 | 13,176 | -- |
| | 90 | -- | 177 | 5,811 | 19,764 | -- |
| (C) | 30 | 180 | 47 | 878 | -- | -- |
| | 60 | 360 | 94 | 1,756 | -- | -- |
| | 90 | 540 | 141 | 2,634 | -- | -- |

[a]Feeding requirements and analysis of feeds were derived from Feeds and Feeding by Frank B. Morrison. Twenty-second edition; Clinton, Iowa: The Morrison Publishing Company, 1959.

[b]The dashes indicate that none of these ingredients were required.

provide ample energy requirements for the lactating cows during the remainder of the summer feeding period from September 1 to October 14. Following the arrangement for the cows to freshen in the late summer and early fall, milk production would tend to be low from April 16 until June 30. Approximately two pounds of corn per day, in addition to pasture, was needed to provide an adequate ration for the cows during this period. Throughout the summer feeding period, the rations were assumed to be the same for each forage system.

In the forage system A ration, it was necessary to include a minimum amount of alfalfa-orchard grass hay in order to provide adequate dry feed in a highly succulent forage ration for the winter feeding period, as shown in Table I.[2] The corn silage and alfalfa-orchard grass hay provided an adequate ration for the young stock throughout the winter feeding period. The lactating cows required from one to three pounds of soybean meal daily, depending upon the stage of lactation, to provide adequate digestible protein. Approximately two to five pounds of corn per day was mixed into the ration at the first of the lactation period to provide the energy requirements.

The forage system B ration required an average of nine pounds of corn daily throughout the winter feeding period to provide enough total digestible nutrients and energy in the ration for the lactating cows. The dairy young stock required a mixture of two pounds of corn and

---

[2]This minimum hay requirement was based upon consultation with personnel of the Dairy Department, The University of Tennessee, Knoxville, July, 1965.

three pounds of molasses daily to provide an adequate amount of total digestible nutrients.

A mixture of corn silage and alfalfa-orchard grass hay balanced the ration for the dairy young stock in forage system C. The ration for the freshly lactating cows was supplemented with two to five pounds of corn daily. As the cows advanced further along in the lactation period and daily milk production decreased, the silage and hay provided a balanced ration without concentrates. The concentrates were only needed at the first of the lactation period to provide enough energy to prevent excessive weight loss.

## III. LAND REQUIREMENTS

The land requirements were divided into cropland and pastureland acreages. No attempt was made to estimate other land requirements due to the lack of data indicating the amount of land East Tennessee dairy farmers devote to buildings, woodland, idle land, and for other purposes.

The pastureland was treated as a constant acreage for each forage system within a given herd size. The pastureland acreage required were as follows: (1) for the thirty-cow herd size, 50 acres; (2) the sixty-cow herd size, 100 acres, and (3) the ninety-cow herd size, 150 acres.

The cropland acreage varies with each forage system as well as herd size. A breakdown of the cropland requirements by crop, herd size, and forage system is given in Table II.

TABLE II

CROPLAND REQUIREMENTS FOR THREE ALTERNATIVE FORAGE SYSTEMS, AND THREE HERD SIZES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| System | Herd Size (Cows) | Crop | | | |
|---|---|---|---|---|---|
| | | Corn Silage (Acres) | Alfalfa-Orchard Grass Hay (Acres) | Ladino Clover-Orchard Grass Pasture (Acres) | Total All Crops (Acres) |
| (A) | 30 | 17[a] | 6[b] | 50 | 73 |
| | 60 | 34 | 11 | 100 | 145 |
| | 90 | 50 | 16 | 150 | 216 |
| (B) | 30 | -- | 20 | 50 | 70 |
| | 60 | -- | 40 | 100 | 140 |
| | 90 | -- | 59 | 150 | 209 |
| (C) | 30 | 12 | 16 | 50 | 78 |
| | 60 | 24 | 32 | 100 | 156 |
| | 90 | 36 | 47 | 150 | 233 |

[a]Assumes a yield of 16 tons per acre and 1 ton spoilage.

[b]Assumes a yield of 3.5 tons per acre and 0.5 ton spoilage.

# IV. BUILDING AND EQUIPMENT REQUIREMENTS

The building and equipment requirements vary with each assumed herd size, forage system, and harvesting policy.[3] The building and equipment requirements were analyzed by herd size, and the difference in such requirements with changes in the forage system and harvesting policy used are shown in Table III.

For each herd size, forage system C required the most investment capital and forage system B required the least amount of investment capital. This held true where custom harvesting was assumed or where it was assumed the operator owned all the harvesting machinery for the operation. The difference in building and equipment requirements for each forage system was greater where all harvesting machinery was assumed to be owned.

As herd size increased, the investment capital requirements for each forage system increased at a decreasing rate. The cost of harvesting equipment was assumed to remain constant at each herd size with one exception. With the ninety-cow herd, silage unloading equipment was necessary for two wagons rather than for one as was assumed for the other two herd sizes that used corn silage. Several other items, such as tillage equipment, were held constant for each herd size, forage system, and harvesting policy. Therefore, as herd size increased, average investment capital required per cow decreased.

---

[3]The assumed building and equipment requirements are itemized in Appendix A, Tables XXI through XXXII.

TABLE III

TOTAL INVESTMENT CAPITAL REQUIREMENTS FOR BUILDINGS, EQUIPMENT, AND MACHINERY FOR THREE FORAGE SYSTEMS AND ALTERNATIVE HARVESTING POLICIES FOR GRADE A DAIRY FARMS IN EAST TENNESSEE, 1965

| Size | Forage System | Alternative Harvesting Policy | |
|---|---|---|---|
| | | Custom Harvest | Own All Machinery |
| Thirty Cow Herd | (A)[a] | $12,840.00[b] | $14,362.50 |
| | (B) | 11,029.00 | 12,515.50 |
| | (C) | 13,030.00 | 16,039.00 |
| Sixty Cow Herd | (A) | 20,934.50 | 22,457.00 |
| | (B) | 17,462.00 | 18,948.50 |
| | (C) | 21,438.00 | 24,347.00 |
| Ninety Cow Herd | (A) | 28,179.00 | 29,951.50 |
| | (B) | 23,835.50 | 25,322.00 |
| | (C) | 28,775.50 | 32,034.50 |

[a]In each corn silage forage system, the hay requirement needed such small acreage that it would not be economical to own hay harvesting machinery. Therefore, hay was assumed to be custom harvested in each corn silage forage system.

[b]Average investment was equal to approximately one-half the new cost. For further information, see Appendix A, Tables XXI through XXXII.

## V. LABOR REQUIREMENTS

The labor requirements were computed on a man-equivalent basis. As in the investment capital requirements, the labor requirements per cow increased at a decreasing rate with increases in herd size. The factors responsible for this were labor for feeding, manure hauling, and milking (Table IV) which increased at a decreasing rate with increases in herd size. The remainder of the labor requirements, with a few exceptions, increased at a constant rate with additions in herd size. The exceptions were where the amount of labor was reduced in tillage operations with increased field size. As forage requirements increased, machinery use approached capacity and machinery repairs per acre decreased.

The total labor requirements were highest for forage system C, next highest for forage system A and lowest for forage system B. However, this is misleading. According to Morrison's Feeds and Feeding, one ton of alfalfa-orchard grass hay has approximately the same feed value as three tons of corn silage.[4] Using the assumed yields of fifteen tons of corn silage per acre and three tons of alfalfa-orchard grass hay per acre, after allowing for spoilage, corn silage from one acre would be equivalent in feed value to the production from 1.7 acres of alfalfa-orchard grass hay. Using custom harvesting, the labor requirements for corn silage were approximately the same as for alfalfa-orchard grass hay

---

[4] Frank B. Morrison, Feeds and Feeding, 22nd edition, The Morrison Publishing Company, Clinton, Iowa, 1959, Appendix.

TABLE IV

ESTIMATED LABOR REQUIREMENTS BY ENTERPRISE AND LABOR PERIOD FOR GRADE A DAIRY FARMS IN EAST TENNESSEE, 1965[a]

| Enterprise or Activity by Herd Size | No. Acres | Hours of Labor Required by Period of Year | | | | | | | | Total for Year |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Jan. and Feb. | Mar. and Apr. | May | June | July | Aug. | Sep. and Oct. | Nov. and Dec. | |
| Milk cows ) | -- | 400 | 330 | 168 | 168 | 168 | 169 | 340 | 410 | 2,153 |
| Dairy heifers) Thirty-cow | -- | 110 | 48 | -- | -- | -- | -- | 27 | 93 | 278 |
| Perm. pasture) herd size[b] | 50 | -- | 25 | -- | 30 | 47 | 41 | 22 | -- | 165 |
| Repairs ) | --[c] | 26 | 21 | 12 | 12 | 12 | 12 | 27 | 26 | 148 |
| Corn silage | | | | | | | | | | |
| Custom harvest | 10 | -- | 43 | 7 | 7 | -- | 30 | -- | -- | 87 |
| Own all machinery | 10 | -- | 43 | 7 | 7 | -- | 120 | -- | -- | 177 |
| Milk cows ) | -- | 648 | 534 | 255 | 255 | 259 | 260 | 533 | 666 | 3,410 |
| Dairy heifers) Sixty-cow | -- | 161 | 61 | -- | -- | -- | -- | 38 | 138 | 408 |
| Perm. pasture) herd size[b] | 100 | -- | 45 | -- | 55 | 88 | 76 | 40 | -- | 304 |
| Repairs ) | --[c] | 36 | 32 | 17 | 17 | 17 | 17 | 37 | 36 | 209 |
| Alfalfa-orchard grass hay | | | | | | | | | | |
| Custom harvest | 10 | 7 | -- | 18 | 18 | 5 | 20 | 22 | -- | 90 |
| Own all machinery | 10 | 7 | -- | 36 | 36 | 5 | 32 | 40 | -- | 156 |
| Milk cows ) | -- | 933 | 763 | 363 | 362 | 368 | 371 | 758 | 948 | 4,866 |
| Dairy heifers) Ninety-cow | -- | 167 | 71 | -- | -- | -- | -- | 38 | 138 | 414 |
| Perm. pasture) herd size[b] | 150 | -- | 67 | -- | 82 | 132 | 114 | 60 | -- | 455 |
| Repairs ) | --[c] | 44 | 38 | 21 | 21 | 21 | 21 | 44 | 43 | 253 |

[a]See footnote at the end of Table XXXIV., Appendix B, for source of data.

[b]Adjustments were made for systems where silage was not fed.

[c]This is an average of the forage systems and harvesting alternatives. Adjustments were based upon the amount of buildings and machinery maintained.

on a per acre basis. Using the own all harvesting machinery policy, the per acre labor requirements were slightly more for the corn silage system than for the alfalfa-orchard grass hay, approximately 17.7 hours versus 15.6 hours. Thus, it would take more labor to produce one pound of feed equivalent from alfalfa-orchard grass hay than from corn silage. The reason labor requirements were less for forage systems A and B was that these forage rations were supplemented heavier with concentrates. The heavier a ration was supplemented with concentrates the lower the forage requirements were. Thus, this lowered the acreage and labor requirements for producing the forage required.

As shown in Table IV, the labor requirements for each forage crop, harvesting policy and herd size are broken down bi-monthly for the non-critical months and monthly for the critical summer months. The labor requirements in the critical summer months are compared in Figure 1. The total labor requirements by forage system, herd size, and harvesting policy are shown in Appendix B, Tables XXXIV through XXXVI.

For all forage systems and harvesting policies, the labor requirements were assumed to be highest for the month of August. In the two systems using corn silage, due to the assumption that corn silage is harvested in August, the harvesting of corn silage accounted for the large increases in labor requirements for August. Where custom harvesting was used, the requirements were not so great because the only labor the operator furnished for harvesting was for packing the silage in the silo. But, where the operator owned all harvesting machinery and harvested the silage himself, labor requirements per acre were four times

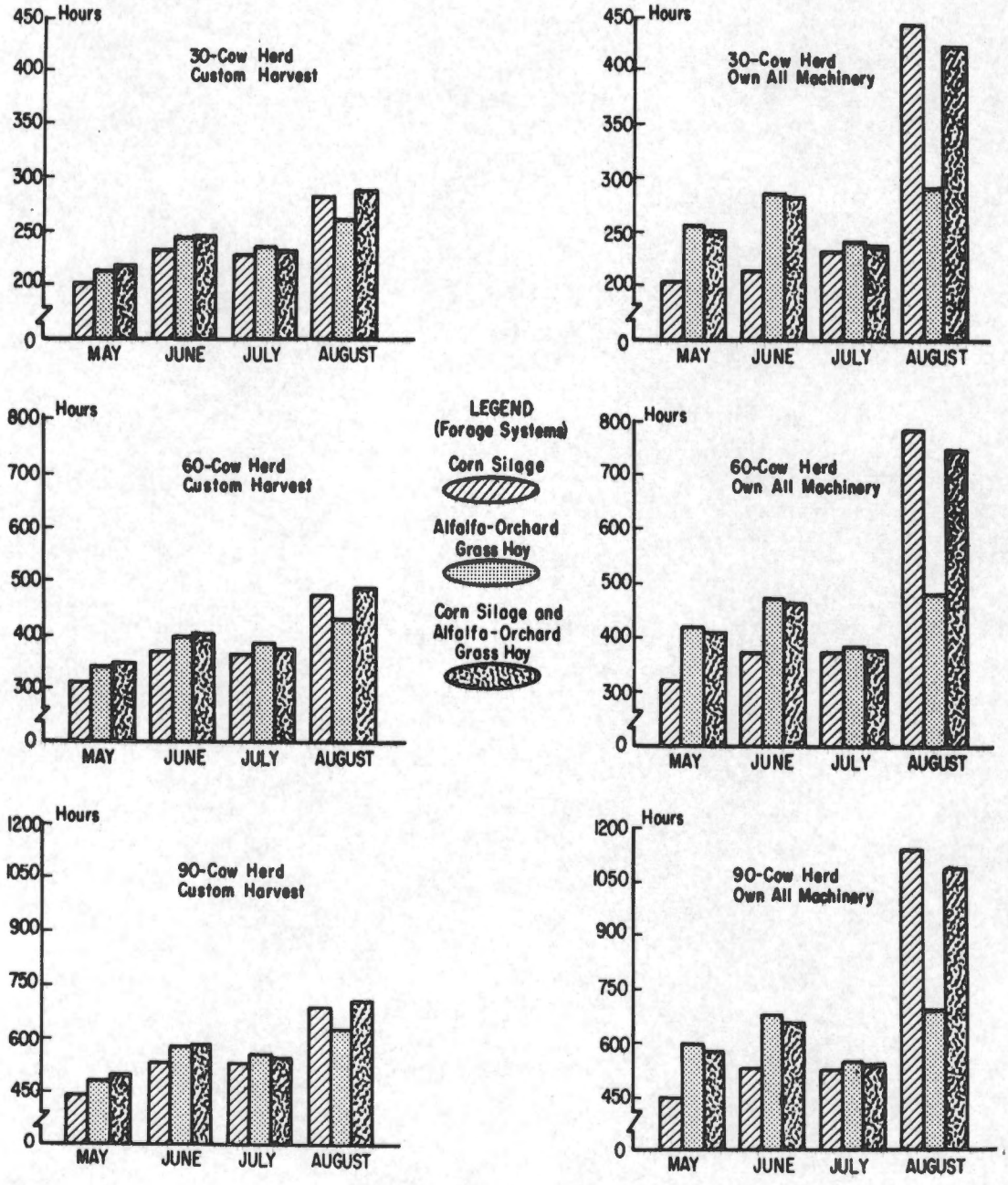



FIGURE 1

MONTHLY LABOR DISTRIBUTION THROUGHOUT THE SUMMER MONTHS BY HERD SIZE, FORAGE SYSTEM AND HARVESTING POLICY FOR GRADE A DAIRIES IN EAST TENNESSEE, 1965

as great as those where the silage was custom harvested. Assuming that March and April are the months for preparing the soil and planting corn, the majority of the remaining labor required for corn silage would come during March and April. At this time of the year, this should not present a large problem due to the decrease in the labor requirement for milking, feeding, and manure hauling which could release labor needed for planting corn for silage.

Although the labor requirements for alfalfa-orchard grass hay were very high in relation to those for corn silage, in terms of feed equivalents produced per acre, labor was evenly distributed throughout the summer months. It was assumed that alfalfa-orchard grass hay would be harvested four times a year with the first cutting in May, the second in June, the third in August, and the fourth in September. The yield was assumed to be highest for the first two cuttings and less for the remaining two cuttings. Thus, the labor requirements per acre for harvesting were greater for the first two cuttings than for the last two. In order to maintain a constant acreage of hay, each year new alfalfa-orchard grass hay must be sown to replace the old which died out. It is a common practice in East Tennessee to begin preparing the soil in July, periodically pulverize the soil throughout August and to sow alfalfa and orchard grass seed in September. This means that labor, in addition to that used for hay harvesting, was required for the months of August and September.[5]

---

[5]W. P. Ranney, Labor Requirements on Tennessee Farms, The University of Tennessee Agricultural Experiment Station Bulletin 316, Knoxville, 1960.

In the hay harvesting operation, approximately 35 per cent of the total labor required, depending upon the yield per acre, was for hay hauling. Using custom harvesting, it was assumed that the operator would cut and haul the hay. The conditioning, raking, and baling were all custom hired. Where the operator was assumed to own all hay harvesting machinery, additional labor was required for conditioning, raking, and baling the hay. Raking and baling hay consumed approximately 50 per cent of the total labor required for hay harvesting.[6]

The labor required for permanent pasture was very evenly distributed over the summer months. In Table IV, page 18, the labor for 50 acres of permanent pasture and labor for 100 acres are listed separately. The reason for this is that as acreage increased from 50 to 100 acres, the field size tends to increase and results in a decrease in time required per acre for machinery operations. Therefore, it was assumed that labor per acre decreased when acreage increased from 50 to 100 acres. It was assumed that when the acreage increased from 100 to 150 acres the per acre labor requirements for permanent pasture would not substantially decrease in East Tennessee because of terrain and general field size throughout the area. Thus, the per acre labor requirements for 150 acres of permanent pasture were the same as for 100 acres.

## VI. ANNUAL OPERATING CAPITAL REQUIREMENTS

Annual operating capital was assumed to be the cash expenses which the operator would be confronted with throughout the year. These

---

[6] Ibid.

expenses are usually regarded as variable costs. These expenses may occur at regular intervals, such as weekly or monthly, or they may occur only once a year. The arrangements for financing these expenses are many and thus are not discussed in this thesis.

East Tennessee grade A milk producers, who sell to commercial milk plants, receive payment for their milk every two weeks. Assuming the operator maintains a uniform milk production level throughout the year, these payments should represent an even flow of revenue. Most variable expenses on grade A dairy farms are spread over the year so that the operator can meet these expenses with revenue from the dairy operation. Those expenses which occur once or twice a year, such as fertilizer and seed, can usually be financed through the dealer by allowing the dairyman to pay for them in bi-weekly payments. Although annual operating capital is considered to be an important requirement by grade A milk producers, it is not a restricting production factor in most cases.

The annual operating capital required for each forage system, herd size, and harvesting policy are summarized in Table V. Many of these expenses, such as seed and fertilizer, require capital for only six to eight months rather than for the entire year. But, for the purpose of the first phase of this study, the expenses were computed for the entire year.

For each herd size and forage system, the operating capital requirements were higher for the custom harvesting policy rather than for the own all harvesting machinery policy. For each herd size and

TABLE V

ANNUAL OPERATING CAPITAL REQUIREMENTS FOR THREE DAIRY HERD SIZES, THREE FORAGE SYSTEMS AND ALTERNATIVE HARVESTING POLICIES FOR GRADE A DAIRY FARMS IN EAST TENNESSEE, 1965

| Forage System | Herd Size (Cow) | Total Operating Capital Required[a] | |
|---|---|---|---|
| | | Custom Harvest | Own All Machinery |
| (A) | 30 | $ 9,791 | $ 9,603 |
| | 60 | 17,877 | 17,303 |
| | 90 | 25,970 | 24,960 |
| (B) | 30 | 10,284 | 10,206 |
| | 60 | 18,865 | 18,616 |
| | 90 | 27,633 | 27,240 |
| (C) | 30 | 9,474 | 9,248 |
| | 60 | 17,289 | 16,671 |
| | 90 | 25,142 | 24,064 |

[a]For itemized expenses, see Tables VIII through X in Chapter III.

harvesting policy, forage system B had the highest operating capital requirements and forage system C had the lowest. The major factor accounting for the differences in operating capital requirements, between forage systems, was the cost of concentrates. Concentrates were assumed to be purchased and thereby increased the operating expenses for the forage systems that required large amounts of concentrates. But, in the forage systems that required less concentrates, the forage crop acreage was greater to supply the extra silage and hay needed. From this comes the question of whether the expense for producing the extra forage was greater than the expense of buying the concentrates or vice versa. This question is discussed in the following chapter.

# CHAPTER III

## A COMPARISON OF REVENUE AND COSTS FOR ALTERNATIVE FORAGE SYSTEMS ON GRADE A DAIRY FARMS IN EAST TENNESSEE

### I. INTRODUCTION

Cost estimates were obtained for all variable expenses, annual depreciation and repairs on buildings and equipment. The values of the land, fencing, and dairy cows were not estimated due to the lack of adequate data. Thus, the returns were referred to as returns to land, investment capital, and management.

The annual depreciation and repairs on buildings and equipment were charged as part of the total costs for each forage system, herd size, and harvesting policy. The only costs charged for the replacement heifers were the expenses incurred in raising them.

### II. REVENUE

A summarization of the revenue is shown in Table VI. For each herd size, the revenue per cow was the same for each forage system and harvesting policy. With increases in herd size from thirty to sixty cows and from sixty to ninety cows, the revenue increases were assumed to be linear. Since gross revenues are assumed equal for each alternative, the system with the least costs has the greatest net revenue.

TABLE VI

ASSUMED REVENUE FOR THREE HERD SIZES ON GRADE A DAIRY FARMS IN EAST TENNESSEE, 1965

| Item | Unit | Price[a] | Quantity[a] | Value |
|---|---|---|---|---|
| THIRTY-COW HERD | | | | |
| Milk[b] | Cwt. | $ 4.60 | 2,844 | $13,082.40 |
| Seven-day old calves[c] | Hd. | 20.00 | 21 | 420.00 |
| Culled cows[d] | Hd. | 143.00 | 6 | 858.00 |
| Total | | | | $14,360.40 |
| SIXTY-COW HERD | | | | |
| Milk[b] | Cwt. | $ 4.60 | 5,688 | $26,164.80 |
| Seven-day old calves[c] | Hd. | 20.00 | 42 | 840.00 |
| Culled cows[d] | Hd. | 143.00 | 12 | 1,716.00 |
| Total | | | | $28,720.80 |
| NINETY-COW HERD | | | | |
| Milk[b] | Cwt. | $ 4.60 | 8,532 | $39,247.20 |
| Seven-day old calves[c] | Hd. | 20.00 | 63 | 1,260.00 |
| Culled cows[d] | Hd. | 143.00 | 18 | 2,574.00 |
| Total | | | | $43,081.20 |

[a] See footnote at end of Table XXXVII, Appendix C.

[b] 9,480 lb. production rate with 4 per cent butterfat was assumed for each cow per year. This was the DHIA average for Tennessee in 1964.

[c] A 90 per cent calf crop was assumed with enough heifer calves kept and raised to conduct a policy for culling 20 per cent of the cows each year. The remaining calves would be sold to other dairy farmers.

[d] It was assumed that each culled cow would weigh 1,300 lbs. and bring $0.11 per lb. when sold.

# III. COSTS AND RETURNS

The costs are itemized by herd size, forage system, and harvesting policy. Building and equipment costs were assumed to be the only fixed costs. The remainder of the expenses were considered as variable costs.

Costs per ton of hay and silage by harvesting policy. The cost of producing corn silage and hiring the silage custom harvested was $5.27 per ton for all acreages in this study. The custom rate of $2.25 per ton for harvesting corn silage included cutting the silage, hauling it and putting it in the silo. The farmer furnished labor for packing the silage in the silo and for applying preservatives where needed.

The cost of producing alfalfa-orchard grass hay and hiring the hay custom harvested was assumed to be $21.16 per ton for all acreages in this study. It was assumed that the farmer would mow, haul, and store the hay. The conditioning, raking, and baling of the hay would be done by the custom operator.

The per ton costs of producing hay and silage, where ownership of all harvesting machinery was assumed, are listed in Table VII. Using the assumed yields per acre, approximately 24 acres of corn silage and 50 acres of alfalfa-orchard grass hay were necessary to make ownership of the harvesting machinery profitable. At different yields per acre, the acreage required would change. This would necessitate using a tonnage basis for decision making. An operator would have to harvest at least 360 tons of silage annually to justify owning a one-row silage chopper,

TABLE VII

THE PER TON COSTS OF PRODUCING EACH FORAGE BY FORAGE SYSTEM, ACREAGE AND HERD SIZE WHERE THE OPERATOR OWNS ALL HARVESTING MACHINERY FOR THREE SYSTEMS ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Forage System | Forage | Quantity of Forage (Acres) | Herd Size (Head) | Cost Per Ton | Difference[a] in Cost |
|---|---|---|---|---|---|
| C | corn silage | 12 | 30 | $ 6.27 | $ +1.00 |
| A | corn silage | 17 | 30 | 5.71 | + .44 |
| C | corn silage | 24 | 60 | 5.13 | - .14 |
| A | corn silage | 34 | 60 | 4.85 | - .42 |
| C | corn silage | 36 | 90 | 4.78 | - .49 |
| A | corn silage | 50 | 90 | 4.57 | - .70 |
| C | alf.-orc. gr. hay | 16 | 30 | 25.48 | +4.36 |
| B | alf.-orc. gr. hay | 20 | 30 | 24.13 | +2.97 |
| C | alf.-orc. gr. hay | 32 | 60 | 22.24 | +1.08 |
| B | alf.-orc. gr. hay | 40 | 60 | 21.59 | + .43 |
| C | alf.-orc. gr. hay | 47 | 90 | 21.21 | + .05 |
| B | alf.-orc. gr. hay | 59 | 90 | 20.70 | - .46 |

[a]This is the difference in costs per ton where the operator owns all harvesting machinery rather than hiring the crops custom harvested. The plus sign signifies that the cost of owning all harvesting machinery is greater per ton than hiring the crop custom harvested and the minus sign indicates the cost is less per ton.

a silage blower, and silage unloading equipment. Approximately 150 tons of hay would have to be harvested annually to economically justify ownership of a hay baler, a rake, and a hay conditioner.

In the corn silage forage system, the hay acreage was so small that it was considered impractical to own hay harvesting machinery. Also, as shown in Tables VIII through X, it was assumed that the hay conditioner was used for only three of the four cuttings of hay. This assumption was made because drying conditions are sufficiently favorable for the August cutting of hay to eliminate use of the conditioner.

Costs by alternative forage systems. The factors causing differences in costs between forage systems (itemized in Tables VIII through X) were: (1) concentrates; (2) acreage required for corn silage and/or alfalfa-orchard grass hay; (3) tractor hours; (4) hired machinery; (5) custom harvesting; (6) electricity; (7) equipment; (8) buildings, and (9) labor. Concentrates and labor caused the major differences in costs. The entire amounts of each required were assumed to be purchased. Even though the farm operator furnished most of the labor, an opportunity cost was assumed for his labor, so a charge of $1.25 per hour was included for all labor. Therefore, the net returns are computed as returns to land, investment capital, and management.

Forage system B had the highest costs for each herd size and harvesting policy. This system required less of the factors listed in the above paragraph, with the exception of concentrates, than did either of the other two systems. The extra concentrates, required for forage

TABLE VIII

A COMPARISON OF COSTS FOR THE THIRTY-COW HERD SIZE ON GRADE A DAIRIES IN EAST TENNESSEE USING THREE FORAGE SYSTEMS AND TWO HARVESTING POLICIES, 1965

| Expense Item[a] | Harvesting Policy and Forage System | | | | | |
|---|---|---|---|---|---|---|
| | Custom Harvest | | | Own All Machinery | | |
| | A Value | B Value | C Value | A Value | B Value | C Value |
| Corn | $1,098 | $2,421 | $1,098 | $1,098 | $2,421 | $1,098 |
| Soybean oil meal, 44% | 549 | -- | -- | 549 | -- | -- |
| Molasses, cane | -- | 231 | -- | -- | 231 | -- |
| Salt | 12 | 12 | 12 | 12 | 12 | 12 |
| Corn silage (var.exp.)[b] | 419 | -- | 296 | 419 | -- | 296 |
| Alfalfa-orch. gr. hay (var. exp.)[b] | 140 | 466 | 373 | 140 | 466 | 373 |
| Permanent pasture (var. exp.)[b] | 590 | 590 | 590 | 590 | 590 | 590 |
| Milk replacer[c] | 51 | 51 | 51 | 51 | 51 | 51 |
| Breeding fees | 180 | 180 | 180 | 180 | 180 | 180 |
| DHIA testing | 197 | 197 | 197 | 197 | 197 | 197 |
| Milk hauling | 626 | 626 | 626 | 626 | 626 | 626 |
| Veterinary fees & drugs | 163 | 163 | 163 | 163 | 163 | 163 |
| Dairy supplies | 120 | 120 | 120 | 120 | 120 | 120 |
| Bedding | 720 | 720 | 720 | 720 | 720 | 720 |
| Electricity | 145 | 120 | 145 | 145 | 120 | 145 |
| Tractor: gas, etc. | 173 | 163 | 182 | 198 | 256 | 274 |
| Hired tractor (fill silo) | -- | -- | -- | 102 | -- | 72 |
| Hired silage wagon (fill silo) | -- | -- | -- | 38 | -- | 27 |
| Harvest silage (custom) | 612 | -- | 432 | -- | -- | -- |
| Harvest hay (custom) | 137 | 456 | 365 | 137 | -- | -- |
| Truck: gas, etc. | 160 | 160 | 160 | 200 | 200 | 200 |
| Baling twine | -- | -- | -- | -- | 40 | 32 |
| Marketing fees[d] | 38 | 38 | 38 | 38 | 38 | 38 |
| Equipment cost[e] | 1,149 | 1,149 | 1,149 | 1,492 | 1,460 | 1,805 |
| Building cost[e] | 811 | 623 | 835 | 811 | 623 | 835 |
| Labor | 3,661 | 3,570 | 3,726 | 3,880 | 3,775 | 4,034 |
| Total Expenses = | $11,751 | $12,056 | $11,458 | $11,906 | $12,289 | $11,888 |

[a]The prices used are shown in Appendix C, Table XXXVII.

[b]Variable costs of crop production, Appendix C, Table XXXVIII.

[c]Assumed to be fed for 60 days.

[d]Three per cent of gross value of culled cows, calves marketed.

[e]See Appendix A, Tables XXI through XXXII, for assumed needs and annual cost.

TABLE IX

A COMPARISON OF COSTS FOR THE SIXTY-COW HERD SIZE ON GRADE A DAIRIES IN EAST TENNESSEE USING THREE FORAGE SYSTEMS AND TWO HARVESTING POLICIES, 1965

| Expense Item[a] | Harvesting Policy and Forage System | | | | | |
|---|---|---|---|---|---|---|
| | Custom Harvest | | | Own All Machinery | | |
| | A | B | C | A | B | C |
| | Value | Value | Value | Value | Value | Value |
| Corn | $2,195 | $4,841 | $2,194 | $2,195 | $4,841 | $2,194 |
| Soybean oil meal, 44% | 1,098 | -- | -- | 1,098 | -- | -- |
| Molasses, cane | -- | 461 | -- | -- | 461 | -- |
| Salt | 24 | 24 | 24 | 24 | 24 | 24 |
| Corn silage (var.exp.)[b] | 838 | -- | 591 | 838 | -- | 591 |
| Alfalfa-orch. gr. hay (var. exp.)[b] | 257 | 933 | 746 | 257 | 933 | 746 |
| Permanent pasture (var. exp.)[b] | 1,180 | 1,180 | 1,180 | 1,180 | 1,180 | 1,180 |
| Milk replacer[c] | 102 | 102 | 102 | 102 | 102 | 102 |
| Breeding fees | 360 | 360 | 360 | 360 | 360 | 360 |
| DHIA testing | 328 | 328 | 328 | 328 | 328 | 328 |
| Milk hauling | 1,251 | 1,251 | 1,251 | 1,251 | 1,251 | 1,251 |
| Veterinary fees & drugs | 300 | 300 | 300 | 300 | 300 | 300 |
| Dairy supplies | 240 | 240 | 240 | 240 | 240 | 240 |
| Bedding | 1,440 | 1,440 | 1,440 | 1,440 | 1,440 | 1,440 |
| Electricity | 215 | 190 | 215 | 215 | 190 | 215 |
| Tractor: gas, etc. | 352 | 333 | 371 | 454 | 519 | 592 |
| Hired silage wagon (fill silo) | -- | -- | -- | 77 | -- | 54 |
| Harvest silage (custom) | 1,224 | -- | 864 | -- | -- | -- |
| Harvest hay (custom) | 251 | 912 | 730 | 251 | -- | -- |
| Truck: gas, etc. | 250 | 250 | 250 | 300 | 300 | 300 |
| Baling twine | -- | -- | -- | -- | 80 | 64 |
| Marketing fees[d] | 77 | 77 | 77 | 77 | 77 | 77 |
| Equipment cost[e] | 1,705 | 1,705 | 1,705 | 2,048 | 2,015 | 2,358 |
| Building cost[e] | 1,413 | 1,100 | 1,468 | 1,413 | 1,100 | 1,468 |
| Labor | 5,895 | 5,643 | 6,026 | 6,316 | 5,990 | 6,613 |
| Total Expenses = | $20,995 | $21,166 | $20,462 | $20,764 | $21,731 | $20,497 |

[a,b,c,d,e] Same as in Table VIII.

TABLE X

A COMPARISON OF COSTS FOR THE NINETY-COW HERD SIZE ON GRADE A DAIRIES IN EAST TENNESSEE USING THREE FORAGE SYSTEMS AND TWO HARVESTING POLICIES, 1965

| Expense Item[a] | Harvesting Policy and Forage System | | | | | |
|---|---|---|---|---|---|---|
| | Custom Harvest | | | Own All Machinery | | |
| | A Value | B Value | C Value | A Value | B Value | C Value |
| Corn | $3,293 | $7,264 | $3,293 | $3,293 | $7,264 | $3,293 |
| Soybean oil meal, 44% | 1,647 | -- | -- | 1,647 | -- | -- |
| Molasses, cane | -- | 692 | -- | -- | 692 | -- |
| Salt | 36 | 36 | 36 | 36 | 36 | 36 |
| Corn silage (var.exp.)[b] | 1,233 | -- | 887 | 1,233 | -- | 887 |
| Alfalfa-orch. gr. hay (var. exp.)[b] | 373 | 1,376 | 1,096 | 373 | 1,376 | 1,096 |
| Permanent pasture (var. exp.)[b] | 1,770 | 1,770 | 1,770 | 1,770 | 1,770 | 1,770 |
| Milk replacer[c] | 153 | 153 | 153 | 153 | 153 | 153 |
| Breeding fees | 540 | 540 | 540 | 540 | 540 | 540 |
| DHIA testing | 419 | 419 | 419 | 419 | 419 | 419 |
| Milk hauling | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 |
| Veterinary fees & drugs | 450 | 450 | 450 | 450 | 450 | 450 |
| Dairy supplies | 360 | 360 | 360 | 360 | 360 | 360 |
| Bedding | 2,160 | 2,160 | 2,160 | 2,160 | 2,160 | 2,160 |
| Electricity | 300 | 270 | 300 | 300 | 270 | 300 |
| Tractor: gas, etc. | 521 | 490 | 552 | 671 | 769 | 878 |
| Harvest silage (custom) | 1,800 | -- | 1,296 | -- | -- | -- |
| Harvest hay (custom) | 365 | 1,346 | 1,072 | 365 | -- | -- |
| Truck: gas, etc. | 360 | 360 | 360 | 420 | 420 | 420 |
| Baling twine | -- | -- | -- | -- | 108 | 94 |
| Marketing fees[d] | 115 | 115 | 115 | 115 | 115 | 115 |
| Equipment cost[e] | 2,284 | 2,319 | 2,318 | 2,628 | 2,629 | 3,020 |
| Building cost[e] | 1,950 | 1,527 | 1,983 | 1,950 | 1,527 | 1,983 |
| Labor | 8,198 | 7,955 | 8,406 | 8,778 | 8,461 | 9,216 |
| Total Expenses = | $30,204 | $31,479 | $29,443 | $29,538 | $31,396 | $29,067 |

[a,b,c,d,e] Same as in Table VIII.

system B, cost more than was saved on the reduced requirements for the other factors.

Forage system C had the lowest costs for each herd size and harvesting policy. The differences in concentrate requirements also caused this difference in costs. The requirements for each of the above listed factors, with the exception of concentrates, were higher for forage system C than for either of the other two forage systems. But, the difference in the costs of the concentrates was greater than the differences in the costs of other factors.

The feed costs per hundred weight of milk produced are shown in Figure 2. The most profitable harvesting alternative was used in each cost estimation.

Returns to land, investment capital, and management. Since the revenue was assumed (1) to be the same for each forage system and harvesting policy for a given herd size, and (2) to increase at a linear rate with increases in herd size, then the forage systems and harvesting policies having the lowest costs also had the highest net returns. Thus, forage system C had the highest net returns for each herd size and harvesting policy, whereas, forage system B had the lowest net returns for each herd size and harvesting policy. These results would not change even if a 6 per cent interest charge was included for the investment capital required.

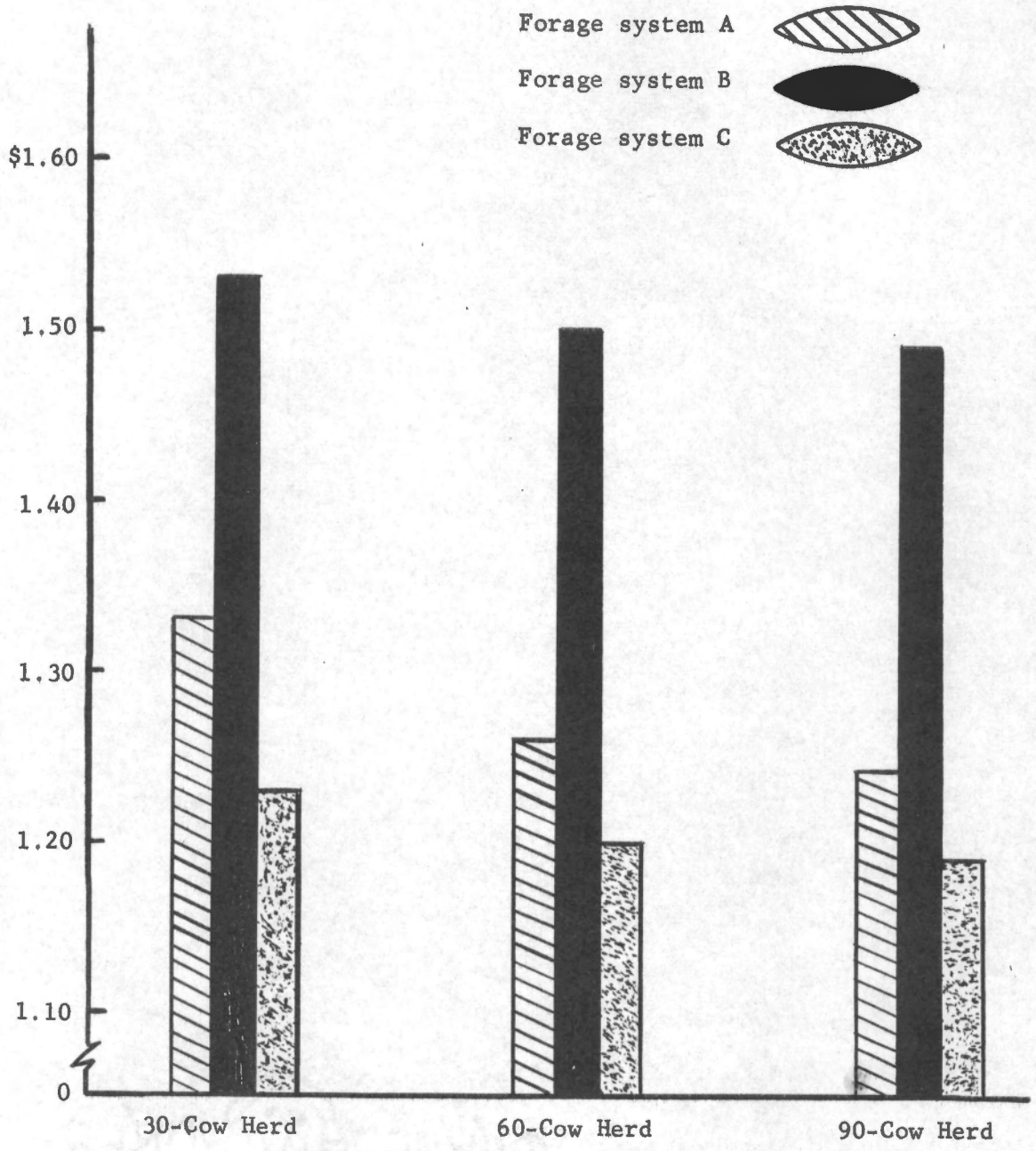



FIGURE 2

THE TOTAL FEED COST PER HUNDREDWEIGHT OF MILK PRODUCED FOR THREE FORAGE SYSTEMS, USING THE LEAST COST HARVESTING POLICIES AND ASSUMING A 9,400 POUND PER COW MILK PRODUCTION LEVEL, ON GRADE A DAIRY FARMS IN EAST TENNESSEE, 1965

# IV. SUMMARY

When the ration was balanced with either corn silage or alfalfa-orchard grass hay as the sole forage fed, purchase of the extra concentrates needed was more expensive than the cost of growing a mixture of the two forages where a greater tonnage was required but less concentrates were fed. Yet, where a mixture of corn silage and alfalfa-orchard grass hay was fed, the requirements for labor, land, and investment capital increased. And, the alternative of growing the concentrates, as well as the forages, on the home farm should be considered. If restrictions were placed upon the quantities of land and labor resources used, forage systems A and B could prove to be more profitable than forage system C. Also, there is the possibility that an entirely different feeding system could prove to be more profitable than either of the systems reported thus far in this study. Therefore, as a second phase of this study, the linear programming, farm planning technique was used to find a least cost ration for grade A dairy herds in East Tennessee using specified resource situations and production levels. The following chapter reports the findings of this phase of the study.

# CHAPTER IV

## LEAST COST COMBINATIONS OF FEED RATIONS FOR GRADE A DAIRY HERDS IN EAST TENNESSEE USING VARIOUS RESOURCE SITUATIONS

### I. INTRODUCTION

Using the techniques of budgeting and linear programming, least cost feed rations were determined for grade A dairy cows in East Tennessee. Consideration was given to changes in milk production level and herd size, hired seasonal labor availability, and the inclusion of a tobacco enterprise. All other resources in the model were set at specified levels and were assumed to have the same use and input-output coefficients throughout the study.

The grade A dairy model was considered on an entire farm basis. It was assumed that the entire farming operation would be built around the dairying enterprise with the cropland used primarily for producing feed for the dairy herd. However, the opportunity to sell feed produced on the farm was included as an alternative activity. Also, the opportunity to buy feeds was included in the programming model. The only cash crops grown were soybeans and tobacco. A list of prices for all resources and products used in this analysis are listed in Appendix C, Table XXXVII.

### II. RESOURCE SITUATION

The resource situation was designed to represent the medium size grade A dairy farms in East Tennessee with milk production per cow at

levels of 9,000, 11,000, and 13,000 pounds per year. Herd size was set at sixty cows, increased to seventy cows, and decreased to fifty cows to show the effects of resource limitations on the optimal feed rations.

Cropland and soil group assumptions. A typical medium size grade A dairy farm in East Tennessee consists of approximately 150 acres of open cropland.[1] This open cropland is composed of several different soil groups and land use patterns. For this study, the total soil groups and land uses were divided into five classifications. They are as follows:[2]

Soil I - Level to undulating, high in water-supplying capacity, well-drained, no erosion evident and 0 to 5 per cent slope.

Soil II - Level to undulating, medium to high in water-supplying capacity, not well-drained or subject to overflow, no erosion evident and 0 to 3 per cent slope.

Soil III - Level to undulating, medium in water-supplying capacity, well-drained, eroded phase and 5 to 12 per cent slope.

Soil IV - Level to undulating, low to medium in water-supplying capacity, eroded phase and 12 to 25 per cent slope or severely eroded phase and 5 to 12 per cent slope.

Soil V - Rolling to hilly, low to medium in water-supplying capacity, eroded phase and 25 to 60 per cent slope or severely eroded phase and 12 to 25 per cent slope.

---

[1]Thomas Little, "An Economic Analysis of Alternative Replacement Policies on Grade A Dairy Farms in the Knoxville Milkshed," unpublished Master's thesis, The University of Tennessee, Knoxville, 1964, p. 19.

[2]W. P. Ranney, Expected Returns from Selected Specialized Farming Systems in the Northern Highland Rim Area of Tennessee, Agricultural Experiment Station Bulletin No. 357, The University of Tennessee, Knoxville, 1963, p. 45.

The percentage of the total open cropland in each soil group was derived from two grade A dairy farms considered to be representative of the East Tennessee area. Farm "A" was located in Bradley County and Farm "B" in Marion County.[3] The percentage of land in each soil group was estimated through use of the Soil Survey by the United States Department of Agriculture for each of these counties.[4]

An average of the two farms showed that their total open cropland consisted of: 12 per cent Soil I, 12 per cent Soil II, 36 per cent Soil III, 20 per cent Soil IV, and 20 per cent Soil V. By relating these to the 150 acres of open cropland restriction, the acreages for each soil group would be: Soil I = 18 acres; Soil II = 18 acres; Soil III = 54 acres; Soil IV = 30 acres, and Soil V = 30 acres. The acreage in each soil group was held constant at these levels throughout the study.

Crop enterprises considered and their assumed yields. The crops considered for this analysis and their yields are listed in Table XI. Although it was assumed that all the grain, straw, and hay produced could be sold, Burley tobacco and soybeans were the only cash crops included in the model.

The average Burley tobacco allotment on medium size grade A dairy

---

[3]Dick Wayland Smith, "Economic Levels of Forage and Grain Production on Dairy Farms in East Tennessee," unpublished Master's thesis, The University of Tennessee, Knoxville, 1956, pp. 22-24.

[4]United States Department of Agriculture, Soil Survey of Bradley and Marion Counties, Tennessee (Washington: Government Printing Office, 1961 and 1958).

TABLE XI

ASSUMED CROP AND PASTURE YIELDS PER ACRE, BY SOIL GROUPS FOR GRADE A DAIRIES IN EAST TENNESSEE WITH HIGH PRODUCTION RECORDS, 1965

| Crop or Pasture | Unit | Soil Groups | | | | |
|---|---|---|---|---|---|---|
| | | I | II | III | IV | V |
| Corn for grain | bu. | 90.0 | 80.0 | 85.0 | 65.0 | -- |
| Corn silage[a] | tons | 16.0 | 14.0 | 15.0 | 12.0 | -- |
| Barley for grain) | bu. | 50.0 | -- | 45.0 | 35.0 | 30.0 |
| barley straw ) double | tons | 1.0 | -- | 0.8 | 0.7 | 0.6 |
| lespedeza hay ) crop | tons | 1.0 | -- | 0.8 | 0.7 | 0.6 |
| Alfalfa hay | tons | 3.5 | -- | 3.2 | -- | -- |
| Ladino clover & orchard) | | | | | | |
| grass hay ) | tons | 2.8 | 3.0 | 2.6 | 2.3 | 2.0 |
| Alfalfa hay) | tons | 1.5 | -- | 1.3 | -- | -- |
| & silage ) | tons | 5.0 | -- | 4.6 | -- | -- |
| Lespedeza hay | tons | 2.0 | 1.8 | 1.6 | 1.4 | 1.2 |
| Oats for grain) | bu. | 65.0 | -- | 60.0 | 50.0 | 45.0 |
| oat straw ) double | tons | 1.2 | -- | 1.0 | 0.8 | 0.7 |
| lespedeza hay) crop | tons | 1.0 | -- | 0.8 | 0.7 | 0.6 |
| Millet hay | tons | 3.0 | 2.9 | 2.7 | 2.2 | 1.8 |
| Soybeans for grain | bu. | 35.0 | 32.0 | 27.0 | 20.0 | -- |
| Millet pasture[b] | tons | 8.0 | 7.7 | 7.0 | 5.8 | 4.8 |
| Ladino clover & orchard) | | | | | | |
| grass pasture ) | tons | 7.5 | 8.0 | 7.0 | 6.0 | 5.5 |
| Crimson clover-oats) | | | | | | |
| pasture & )double | tons | 4.8 | -- | 4.3 | 3.7 | 2.6 |
| lespedeza pasture)crop | tons | 4.3 | -- | 3.7 | 3.2 | 2.6 |
| Millet silage | tons | 8.3 | 8.0 | 7.4 | 6.1 | 5.0 |
| Ladino clover & orchard) | | | | | | |
| grass hay ) | tons | 1.2 | 1.2 | 1.1 | 0.9 | 0.8 |
| & pasture ) | tons | 4.3 | 4.8 | 4.0 | 3.7 | 3.2 |
| Red clover & orchard) | | | | | | |
| grass hay ) | tons | 2.8 | 3.0 | 2.6 | 2.2 | 1.8 |
| Ladino clover & orchard) | | | | | | |
| grass silage ) | tons | 4.8 | 5.4 | 4.5 | 4.2 | 3.6 |
| & pasture ) | tons | 3.2 | 3.2 | 2.9 | 2.4 | 2.2 |

Source: Unpublished data from The University of Tennessee Department of Agricultural Economics, Knoxville, 1965, and Expected Returns from Selected Specialized Farming Systems in the Northern Highland Rim Area of Tennessee, by W. P. Ranney, University of Tennessee Agricultural Experiment Station Bulletin 357, Knoxville, 1963.

[a]The silage yields allow for 7 per cent spoilage and the hay yields allow 10 per cent loss due to weather and barn shrinkage.

[b]The pasture yields allow 33.3 per cent loss of the total growth due to trampling and desiccation of the plants. The tonnage is computed on a green weight basis.

farms in East Tennessee is 1.2 acres.[5] This allotment acreage was assumed for the study. The model was first set up with tobacco as a possible enterprise and then set up without the tobacco enterprise.

Labor situation. According to a survey taken by Thomas Little in 1964, a two-man full-time labor force is typical of the medium size grade A dairy farms in East Tennessee.[6] It was assumed that each man could work a maximum of 240 hours per month or approximately 2,865 hours per year.

As in Table IV, page 18, the labor resources and requirements for the linear programming analysis were divided into eight labor periods. The months of May, June, July, and August were regarded as the months where labor would be most critical and were thereby listed as separate labor periods. In the first labor situation, it was assumed that seasonal labor could be hired at $1.25 per hour in unlimited amounts for any of these four months. In the second labor situation, it was assumed that no seasonal labor could be hired and the two full-time men would be the only labor available.

The labor requirements by periods for each crop enterprise and milk production level used in the model are shown in Table XII.

Milk production requirements and feed composition. For the purposes of estimating the total feed requirements per cow, for each production level, it was assumed that the cows producing 9,000 pounds of milk

---

[5]Little, loc. cit. [6]Ibid.

TABLE XII

HOURS OF LABOR REQUIRED PER ACRE AND COW BY SOIL GROUP AND PRODUCTION LEVEL FOR EACH LABOR PERIOD ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Enterprises by Soil Group | Labor Period by Months | | | | | | | | Total Labor |
|---|---|---|---|---|---|---|---|---|---|
| | J-F | M-A | M | J | J | A | S-O | N-D | |
| | Hours per acre[a] | | | | | | | | |
| SOIL GROUP I | | | | | | | | | |
| Soybeans | -- | 1.6 | 1.6 | 1.2 | -- | -- | 2.0 | -- | 6.4 |
| Corn for grain | -- | 3.9 | .9 | .6 | -- | -- | 2.0 | -- | 7.4 |
| Corn silage | -- | 3.9 | .9 | .6 | -- | 4.8 | -- | -- | 10.2 |
| Barley gn., les. hay | .5 | .5 | -- | 3.6 | -- | 1.9 | 3.4 | -- | 9.9 |
| Oats gn., les. hay | .5 | .5 | -- | 3.9 | -- | 1.9 | 3.4 | -- | 10.2 |
| Alfalfa hay | .5 | -- | 2.5 | 2.7 | .4 | 2.1 | 1.8 | -- | 10.0 |
| Alfalfa hay & silage | .5 | -- | 1.2 | 1.1 | .4 | 2.1 | 1.8 | -- | 7.1 |
| Millet pasture | -- | 1.6 | 2.2 | .3 | -- | -- | -- | -- | 4.1 |
| Millet hay | -- | 1.6 | 2.2 | 3.3 | -- | 3.0 | -- | -- | 10.4 |
| Millet silage | -- | 1.6 | 2.2 | 1.6 | -- | 1.2 | -- | -- | 6.6 |
| Cr. c.-oats & l. p. | .5 | .5 | -- | -- | -- | -- | 3.1 | -- | 4.1 |
| Burley tobacco | 16.5 | 4.5 | 30.4 | 18.2 | 14.7 | 99.4 | 6.0 | 157.0 | 346.7 |
| SOIL GROUP II | | | | | | | | | |
| Soybeans | -- | 1.6 | 1.6 | 1.2 | -- | -- | 2.0 | -- | 6.4 |
| Corn for grain | -- | 3.9 | .9 | .6 | -- | -- | 2.0 | -- | 7.4 |
| Corn for silage | -- | 3.9 | .0 | .6 | -- | 4.8 | -- | -- | 10.2 |
| Lespedeza hay | .5 | 1.0 | -- | .6 | -- | 3.0 | -- | -- | 5.1 |
| Millet pasture | -- | 1.6 | 2.2 | .3 | -- | -- | -- | -- | 4.1 |
| Millet hay | -- | 1.6 | 2.2 | 3.3 | -- | 2.8 | -- | -- | 9.9 |
| Millet silage | -- | 1.6 | 2.2 | 1.5 | -- | 1.2 | -- | -- | 6.5 |
| Lad.cl.-orc.gr. hay | .5 | -- | 3.6 | -- | .7 | 2.4 | .5 | -- | 7.7 |
| Lad.cl.-orc.gr. past. | .4 | -- | -- | .6 | .7 | 1.3 | .5 | -- | 3.5 |
| Lad.cl.-orc.gr. hay and past. | .4 | -- | 2.5 | -- | .7 | 1.3 | .5 | -- | 5.4 |
| Lad.cl.-orc.gr. sil. and past. | .4 | -- | 1.6 | -- | .7 | 1.3 | .5 | -- | 4.5 |
| Red cl.-or.gr. hay | .3 | .8 | 4.0 | -- | -- | 3.0 | -- | -- | 8.1 |
| SOIL GROUP III | | | | | | | | | |
| Soybeans | -- | 1.6 | 1.6 | 1.2 | -- | -- | 2.0 | -- | 6.4 |
| Corn for grain | -- | 3.9 | .9 | .6 | -- | -- | 2.0 | -- | 7.4 |
| Corn silage | -- | 3.9 | .9 | .6 | -- | 4.8 | -- | -- | 10.2 |
| Barley gn., les. hay | .5 | .5 | -- | 3.3 | -- | 1.6 | 3.4 | -- | 9.3 |
| Oats gn., les. hay | .5 | .5 | -- | 3.6 | -- | 1.6 | 3.4 | -- | 9.6 |
| Alfalfa hay | .5 | -- | 2.4 | 2.5 | .4 | 2.0 | 1.7 | -- | 9.5 |
| Alfalfa hay & silage | .5 | -- | 1.0 | .9 | .5 | 2.0 | 1.7 | -- | 6.6 |
| Lespedeza hay | .5 | 1.0 | -- | .6 | -- | 2.7 | -- | -- | 4.8 |
| Millet pasture | -- | 1.6 | 2.2 | .3 | -- | -- | -- | -- | 4.1 |

TABLE XII (continued)

| Enterprises by Soil Group | Labor Period by Months J-F | M-A | M | J | J | A | S-O | N-D | Total Labor |
|---|---|---|---|---|---|---|---|---|---|
| SOIL GROUP III (cont.) | Hours per acre[a] | | | | | | | | |
| Millet hay | -- | 1.6 | 2.2 | 3.1 | -- | 2.7 | -- | -- | 9.6 |
| Millet silage | -- | 1.6 | 2.2 | 1.4 | -- | 1.1 | -- | -- | 6.3 |
| Lad.cl.-or.gr. hay | .5 | -- | 3.3 | -- | .7 | 2.0 | .5 | -- | 7.0 |
| Lad.cl.or.gr. past. | .4 | -- | -- | .6 | .7 | 1.3 | .5 | -- | 3.5 |
| Lad.cl.-or.gr. hay and past. | .4 | -- | 2.3 | -- | .7 | 1.3 | .5 | -- | 5.2 |
| Lad.cl.-or.gr. sil. and past. | .4 | -- | 1.4 | -- | .7 | 1.3 | .5 | -- | 4.3 |
| Cr. cl.-oats & l. p. | .5 | .5 | -- | -- | -- | -- | 3.1 | -- | 4.1 |
| Red. cl.-or.gr. hay | .3 | .8 | 3.6 | -- | -- | 2.8 | -- | -- | 7.5 |
| Burley tobacco | 16.5 | 4.5 | 30.4 | 18.2 | 14.7 | 99.4 | 6.0 | 157.0 | 346.7 |
| SOIL GROUP IV | | | | | | | | | |
| Barley gn. & les. hay | .5 | .5 | -- | 3.2 | -- | 1.4 | 3.4 | -- | 9.0 |
| Oats gn. & les. hay | .5 | .5 | -- | 3.4 | -- | 1.4 | 3.4 | -- | 9.2 |
| Millet pasture | -- | 1.6 | 2.2 | .3 | -- | -- | -- | -- | 4.1 |
| Millet hay | -- | 1.6 | 2.2 | 3.0 | -- | 2.0 | -- | -- | 8.8 |
| Millet silage | -- | 1.6 | 2.2 | 1.4 | -- | 1.1 | -- | -- | 6.4 |
| Cr. cl.-oats & l. p. | .5 | .5 | -- | -- | -- | -- | 3.1 | -- | 4.1 |
| Red cl.-or.gr. hay | .3 | .8 | 3.3 | -- | -- | 2.5 | -- | -- | 6.9 |
| Lad. cl.-or.gr. hay | .5 | -- | 3.1 | -- | .7 | 1.8 | 1.5 | -- | 7.6 |
| Lad. cl.-or.gr. past. | .4 | -- | -- | .6 | .7 | 1.3 | .5 | -- | 3.5 |
| Lad. cl.-or.gr. hay and past. | .4 | -- | 2.1 | -- | .7 | 1.3 | .5 | -- | 5.0 |
| Lad. cl.-or.gr. sil. and past. | .4 | -- | 1.3 | -- | .7 | 1.3 | .5 | -- | 4.2 |
| Lespedeza hay | .5 | 1.0 | -- | .6 | -- | 2.4 | -- | -- | 4.5 |
| SOIL GROUP V | | | | | | | | | |
| Barley gn. & les. hay | .5 | .5 | -- | 3.0 | -- | 1.3 | 3.4 | -- | 8.7 |
| Oats gn. & les. hay | .5 | .5 | -- | 3.2 | -- | 1.3 | 3.4 | -- | 8.9 |
| Lespedeza hay | .5 | 1.0 | -- | .6 | -- | 2.1 | -- | -- | 4.2 |
| Red cl.-or.gr. hay | .3 | .8 | 2.9 | -- | -- | 2.3 | -- | -- | 6.3 |
| Lad.cl.-or.gr. hay | .5 | -- | 2.8 | -- | .7 | 1.6 | .5 | -- | 6.1 |
| Lad.cl.-or.gr. past. | .4 | -- | -- | .6 | .7 | 1.3 | .5 | -- | 3.5 |
| Lad.cl.-or.gr. hay and past. | .4 | -- | 1.9 | -- | .7 | 1.3 | .5 | -- | 4.8 |
| Lad.cl.-or.gr. sil. and past. | .4 | -- | 1.1 | -- | .7 | 1.3 | .5 | -- | 4.0 |
| Annual Milk production Per Cow | Hours per cow | | | | | | | | |
| 9,000 lbs.(4% BFCM) | 10.8 | 8.9 | 4.3 | 4.3 | 4.3 | 4.3 | 8.9 | 11.1 | 56.9 |
| 11,000 lbs.(4% BFCM) | 11.3 | 9.4 | 4.6 | 4.6 | 4.6 | 4.6 | 9.4 | 11.6 | 60.1 |
| 13,000 lbs.(4% BFCM) | 11.8 | 9.9 | 4.8 | 4.8 | 4.8 | 4.8 | 9.9 | 12.1 | 62.9 |

[a]For the source, see footnotes in Tables XI and XXXIV.

would weigh 1,200 pounds, those producing 11,000 pounds would weigh 1,450 pounds and those producing 13,000 pounds would weigh 1,700 pounds.[7] The estimated annual nutrient and bedding requirements per cow are listed in Table XIII. Also, all feeds considered in the linear programming model and their estimated composition are shown in Table XIII.

## III. THE ESTIMATED VARIABLE AND FIXED EXPENSES

The variable expenses are those expenses which vary with the amount of production and production factors used. These expenses include the cost of items such as seed, fertilizer, gasoline, grease, oil, and hired labor.

The fixed expenses are those expenses which, regardless of production, are constant for the production period. These expenses are computed as annual depreciation on buildings, equipment and livestock and annual repairs to the buildings and equipment. The total costs for repairs and depreciation assumed for each unit of enterprise are shown in Table XIV. These estimated expenses are based upon the proportion a unit of the enterprise is of the total annual use capacity of the machine or building.

In the model, the variable expenses were charged against each individual enterprise. A 6 per cent interest charge was made against each individual enterprise for the total fixed expenses the enterprise

---

[7] "Milk production is more nearly proportional to the .75 power of the live weight." Source: Kleiher and Mead, Cal., Journal of Dairy Science, Volume 28, 1945, pp. 49-55.

TABLE XIII

TOTAL FEED AND BEDDING REQUIREMENTS PER COW FOR EACH PRODUCTION LEVEL AND THE COMPOSITION OF FEEDS USED ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Nutrient Required[a] | Unit | Milk Production Level Per Cow | | |
|---|---|---|---|---|
| | | 9,000 | 11,000 | 13,000 |
| Total digestible nutrients (TDN) | lbs. | 6,405 | 7,474 | 8,578 |
| Digestible protein (DP) | lbs. | 775 | 914 | 1,073 |
| Energy | therms | 5,542 | 6,401 | 7,458 |
| Bedding (straw)[b] | lbs. | 2,000 | 2,000 | 2,000 |
| Minimum amount of alfalfa hay | lbs. | 800 | 1,100 | 1,400 |

| Feed Used[a] | Consumption[c] | | |
|---|---|---|---|
| | TDN | DP | Energy |
| Corn, dent, grade no. 1 | 80.1 | 6.7 | 80.1 |
| Corn silage, dent, well eared | 19.8 | 1.3 | 15.2 |
| Barley, common, not incl. Pacific St. | 77.7 | 10.0 | 80.1 |
| Lespedeza hay, before bloom, annual | 46.4 | 6.4 | 36.5 |
| Alfalfa hay, all analyses | 50.7 | 10.9 | 40.6 |
| Ladino clover-orchard grass hay | 57.4 | 11.3 | 45.9 |
| Alfalfa silage, wilted | 21.5 | 4.3 | 17.6 |
| Oats, not incl. Pacific coast states | 70.1 | 9.4 | 72.1 |
| Millet hay, pearl or cat-tail | 49.8 | 4.2 | 37.4 |
| Millet pasture, pearl or cat-tail | 12.8 | 1.3 | 12.2 |
| Ladino clover-orchard grass pasture | 14.2 | 3.3 | 12.5 |
| Crimson clover-oats pasture | 13.4 | 2.4 | 9.0 |
| Millet silage, wilted | 19.9 | 1.7 | 15.0 |
| Lespedeza pasture, annual, before bloom | 14.2 | 2.0 | 12.4 |
| Red clover-orchard grass hay | 52.2 | 6.1 | 39.8 |
| Ladino clover-orchard grass silage | 21.4 | 3.9 | 18.2 |
| Soybean oil meal, 44% protein | 78.0 | 42.0 | 79.6 |

[a]The Feed requirements and the composition of feeds were adapted from: Feeds and Feeding, by F. B. Morrison and Associates. Twenty-second edition; Clinton Iowa: Morrison Publishing Company, 1959.

[b]Bedding requirements were adapted from: Expected Returns from Selected Specialized Farming Systems in the Northern Highland Rim Area of Tennessee, by W. P. Ranney, Tennessee Agricultural Experiment Station Bulletin 357, January, 1963, p. 55.

[c]The figures for TDN and DP are the percentages per pound of dry feed. The figures for energy are the therms of energy per pound of dry feed.

TABLE XIV

TOTAL VARIABLE AND FIXED EXPENSES ASSUMED PER ACRE AND PER COW FOR MEDIUM SIZE GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Enterprise | Soil Group I | | II | | III | | IV | | V | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Var. | Fixed | Var. | Fixed | Var. | Fixed | Var. | Fixed | Var. | Fixed |
| | $ Per Acre | | | | | | | | | |
| Corn for grain | $ 45 | $ 14[a] | $ 42 | $ 13 | $ 44 | $ 14 | $ --[b] | $ -- | $ -- | $ -- |
| Corn silage | 74 | 9 | 67 | 9 | 71 | 9 | -- | -- | -- | -- |
| Soybeans | 20 | 7 | 20 | 7 | 20 | 7 | -- | -- | -- | -- |
| Barley gr. & lesp. hay | 45 | 13 | -- | -- | 41 | 12 | 36 | 10 | 32 | 9 |
| Oats gr. & lesp. hay | 46 | 15 | -- | -- | 42 | 14 | 37 | 12 | 33 | 11 |
| Alfalfa hay | 56 | 10 | -- | -- | 52 | 9 | -- | -- | -- | -- |
| Alfalfa hay & silage | 51 | 7 | -- | -- | 47 | 6 | -- | -- | -- | -- |
| Lespedeza hay | -- | -- | 20 | 5 | 17 | 5 | 16 | 4 | 14 | 4 |
| Millet pasture | 19 | 3 | 19 | 3 | 18 | 3 | 16 | 3 | -- | -- |
| Millet hay | 41 | 10 | 41 | 9 | 38 | 9 | 33 | 8 | -- | -- |
| Millet silage | 38 | 6 | 37 | 6 | 25 | 5 | 30 | 5 | -- | -- |
| Cr.cl.-oats & lesp. past. | 33 | 3 | -- | -- | 31 | 3 | 29 | 3 | -- | -- |
| Red.cl.-or.gr. hay | -- | -- | 37 | 8 | 34 | 7 | 28 | 7 | 27 | 6 |
| Lad.cl.-or.gr. hay | -- | -- | 46 | 8 | 41 | 7 | 37 | 7 | 32 | 6 |
| Lad.cl.-or.gr. past. | -- | -- | 24 | 3 | 22 | 3 | 20 | 3 | 16 | 3 |
| Lad.cl.-or.gr. hay & past. | -- | -- | 31 | 5 | 29 | 5 | 26 | 5 | 21 | 5 |
| Lad.cl.-or.gr. sil. & past. | -- | -- | 36 | 4 | 32 | 4 | 30 | 4 | 24 | 4 |
| Burley tobacco | 228 | 54 | -- | -- | 225 | 54 | -- | -- | -- | -- |
| | Milk Production Level Per Cow | | | | | | | | | |
| | 9,000 | | | | 11,000 | | | | 13,000 | |
| Total Expenses Per Cow = | 49 | 87 | | | 53 | 97 | | | 58 | 107 |

[a]The assumed costs per unit of use are shown in Appendix A, Table XXXIII.

[b]The dashes indicate that the crop or pasture is not considered practical for this particular soil.

required. The total fixed expenses were charged against the entire operation when the net returns to land, labor, investment capital, and management were computed.

The total variable and fixed expenses for each enterprise are shown in Table XIV.

## IV. THE RESULTS

In this study, three milk production levels and three herd sizes were used. Each milk production level and herd size was programmed with and without the opportunity to hire seasonal labor for the months of May, June, July, and August. These situations were then compared with and without a tobacco enterprise. First, herd size was alloted to a maximum of sixty cows and each of the milk production levels were programmed for each of the seasonal labor and tobacco enterprise alternatives. Second, maximum herd size was increased to seventy cows and each of the resource situations contrasted on the same basis as above in order to compare the differences encountered with an increase in herd size. Third, herd size was decreased to a maximum of fifty cows and the differences caused by a decrease in herd size were measured.

The optimum solution for each herd size, milk production level, and seasonal labor and tobacco enterprise alternative yielded a least cost feed ration per cow. When the assumption was made that no tobacco enterprise was present, the optimum solutions differed very little from those where tobacco was assumed as a possible enterprise. For this reason, the least cost combinations of activities, assuming no tobacco

enterprise, are shown in Appendix D, Tables XXXIX through XLI. Each of the least cost combinations of activities, assuming a tobacco enterprise, and all of the least cost feed rations are presented by individual herd sizes and the essential differences are discussed in the following pages.

Sixty-cow herd size. The least cost combinations of activities, when maximum herd size was alloted to sixty cows, is shown in Table XV. The least cost feed rations per cow are shown in Table XVI.

As milk production per cow increased, each feed ration required more concentrates. Where seasonal labor was available, barley was purchased to furnish these concentrate requirements. Without seasonal labor, the extra concentrates were furnished by additional corn acreage harvested for grain and by the purchase of corn. The additional corn acreage replaced the acreage used for soybeans as a cash crop. The ladino clover-orchard grass silage and pasture acreage also increased as milk production increased. In both labor situations, oats for grain double cropped with lespedeza hay and, in the situation assuming no seasonal labor, millet silage were replaced by the ladino clover-orchard grass silage and pasture.

High acreages of corn silage came into the optimum solutions where hiring of seasonal labor was assumed to be unlimited. When seasonal labor was not available, corn silage was replaced by millet silage, corn for grain acreage replaced corn silage acreage, and oats for grain double cropped with lespedeza hay increased at the lower milk production levels.

TABLE XV

A LEAST COST COMBINATION OF ACTIVITIES FOR ALTERNATIVE PRODUCTION LEVELS AND LABOR SUPPLIES ON EAST TENNESSEE GRADE A DAIRY FARMS CONSISTING OF 150 ACRES OF OPEN CROPLAND AND A SIXTY-COW HERD SIZE WITH A TOBACCO ENTERPRISE, 1965

| Activity | Soil Group | Unit | Milk Production Per Cow in Pounds (4% BFC) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | With Seasonal Labor | | | Without Seasonal Labor | | |
| | | | 9,000 | 11,000 | 13,000 | 9,000 | 11,000 | 13,000 |
| Soybeans for grain | II | acre | 5.7 | -- | -- | 10.8 | -- | -- |
| Corn for grain | I | acre | -- | -- | -- | 17.0 | 17.2 | 17.4 |
| Corn for grain | II | acre | 12.3 | 18.0 | 18.0 | 7.1 | 18.0 | 18.0 |
| Corn for grain | III | acre | 15.0 | 9.3 | 8.3 | 21.0 | 21.0 | 21.0 |
| Corn silage | I | acre | 16.8 | 16.8 | 16.8 | -- | -- | -- |
| Corn silage | III | acre | 6.0 | 11.7 | 12.7 | -- | -- | -- |
| Alfalfa hay | III | acre | 15.0 | 14.6 | 11.8 | 7.5 | 10.3 | 13.1 |
| Alfalfa hay & silage | III | acre | -- | 0.4 | 3.1 | -- | -- | -- |
| Oats (grain) & lesp. hay | III | acre | 18.0 | 18.0 | 18.0 | -- | 0.7 | 10.3 |
| Oats (grain) & lesp. hay | IV | acre | 8.1 | -- | -- | -- | -- | -- |
| Oats (grain) & lesp. hay | V | acre | -- | -- | -- | 17.0 | 14.1 | 3.0 |
| Millet silage | III | acre | -- | -- | -- | 25.5 | 22.0 | 9.6 |
| Millet silage | IV | acre | -- | -- | -- | 4.2 | -- | -- |
| Lad.cl.-or.gr. sil. & p. | IV | acre | 21.9 | 30.0 | 30.0 | 25.8 | 30.0 | 30.0 |
| Lad.cl.-or.gr. sil. & p. | V | acre | 30.0 | 30.0 | 30.0 | 13.0 | 15.9 | 27.0 |
| Bor. annual invest. cap. | - | $ | 6,575.5 | 7,125.7 | 7,721.1 | 6,528.9 | 7,185.3 | 7,792.5 |
| Hire August labor | - | hr. | 146.4 | 188.0 | 207.7 | -- | -- | -- |
| Sell oats | - | bu. | 1,483.6 | 1,080.0 | 1,080.0 | 763.7 | 675.5 | 752.9 |
| Sell alfalfa hay | - | ton | 24.0 | 14.2 | -- | -- | -- | -- |
| Sell lespedeza hay | - | ton | 20.1 | 14.4 | 13.5 | -- | -- | -- |
| Buy straw | - | ton | 35.5 | 42.0 | 42.0 | 48.1 | 49.4 | 47.6 |
| Buy corn | - | bu. | -- | -- | -- | -- | 457.6 | 1,994.6 |
| Buy barley | - | bu. | -- | 47.1 | 1,353.9 | -- | -- | -- |
| Burley tobacco | I | acre | 1.2 | 1.2 | 1.2 | 1.0 | 0.8 | 0.6 |
| Net Returns to Land, Labor, Investment. Cap. & Mgt. | = | | $14,641 | $17,363 | $20,962 | $13,852 | $16,140 | $19,579 |

TABLE XVI

LEAST COST FEED RATIONS PER COW FOR ALTERNATIVE PRODUCTION LEVELS, LABOR SUPPLIES AND CROP ENTERPRISES ON EAST TENNESSEE GRADE A DAIRY FARMS CONSISTING OF 150 ACRES OF CROPLAND AND A SIXTY-COW HERD SIZE, 1965

| Feed Per Cow | Unit | Milk Production Per Cow in Pounds (4% BFC) | | | | | |
|---|---|---|---|---|---|---|---|
| | | With Seasonal Labor | | | Without Seasonal Labor | | |
| | | 9,000 | 11,000 | 13,000 | 9,000 | 11,000 | 13,000 |
| WITH TOBACCO ENTERPRISE | | | | | | | |
| Corn (grain) | bu. | 37.68 | 37.14 | 37.14 | 64.76 | 87.15 | 113.10 |
| Barley (grain) | bu. | -- | 0.78 | 22.56 | -- | -- | -- |
| Corn silage | ton | 5.98 | 7.41 | 7.65 | -- | -- | -- |
| Millet silage | ton | -- | -- | -- | 3.57 | 2.71 | 1.18 |
| Alfalfa silage | ton | -- | 0.03 | 0.23 | -- | -- | -- |
| Lad.cl.-or.gr. silage | ton | 3.33 | 3.90 | 3.90 | 2.58 | 3.05 | 3.72 |
| Lad.cl.-or.gr. pasture | ton | 1.97 | 2.30 | 2.30 | 1.50 | 1.78 | 2.19 |
| Alfalfa hay | ton | 0.40 | 0.55 | 0.70 | 0.40 | 0.55 | 0.70 |
| Lespedeza hay | ton | -- | -- | 0.01 | 0.17 | 0.15 | 0.16 |
| WITHOUT TOBACCO ENTERPRISE | | | | | | | |
| Corn (grain) | bu. | 37.67 | 37.83 | 35.16 | 43.33 | 57.37 | 92.21 |
| Barley (grain) | bu. | -- | -- | 23.31 | -- | -- | -- |
| Corn silage | ton | 5.97 | 7.37 | 7.70 | 4.80 | 4.16 | 2.98 |
| Millet silage | ton | -- | -- | -- | -- | 1.16 | -- |
| Alfalfa silage | ton | -- | 0.05 | 0.24 | -- | -- | 0.01 |
| Lad.cl.-or.gr. silage | ton | 3.33 | 3.90 | 3.90 | 2.87 | 3.41 | 3.90 |
| Lad.cl.-or.gr. pasture | ton | 1.97 | 2.30 | 2.30 | 1.67 | 2.00 | 2.30 |
| Alfalfa hay | ton | 0.40 | 0.55 | 0.70 | 0.40 | 0.55 | 0.70 |
| Lespedeza hay | ton | -- | -- | -- | 0.51 | 0.25 | 0.25 |

This forced part of the ladino clover-orchard grass silage and pasture acreage out of the optimal organization. All of the lespedeza hay produced was fed when seasonal labor could not be hired, whereas lespedeza hay was sold when seasonal labor could be hired. With the assumption of no seasonal labor, as milk production increased, less tobacco was grown and the ladino clover-orchard grass silage and pasture replaced the oats for grain and lespedeza hay acreage. Another important observation is that, when seasonal labor was available, alfalfa was grown on Soil III to the full extent of the rotation allotment set up for alfalfa and, when the amount of alfalfa hay produced exceeded the minimum alfalfa hay requirements for the dairy herd, the remaining tonnage was sold. Without seasonal labor, the alfalfa hay acreage was decreased to one-half the amount at the 9,000 pound milk production level, but steadily increased as milk production increased. This acreage was interchanged with millet silage as a result of higher digestible protein requirements per cow as milk production increased.

Tobacco competed with each of the enterprises for seasonal labor. The feed rations remained essentially the same regardless whether seasonal labor was available or not and a tobacco enterprise was present or not. But, when seasonal labor was not available and a tobacco enterprise was present, less of the tobacco allotment was produced and corn silage was replaced by corn for grain and millet silage. Without the tobacco enterprise, corn silage again was produced thereby decreasing the corn for grain acreage. Also, oats for grain double cropped with lespedeza hay

and ladino clover-orchard grass silage and pasture replaced most of the millet silage acreage.

As land and labor were the most restrictive factors, whenever one of the two was not as restrictive as before, the value of an extra unit of the other increased. For instance, the value of another unit of Soil I was approximately $66 when seasonal labor was available and decreased approximately $1 to $2 per acre when seasonal labor was not available. The value of each of the other soils varies progressively more extensively, as one goes from Soil I through V, and the value of an additional unit of Soil V decreases from $35.48 to $20.73 per acre with a decrease in the labor supply.

Labor was only restrictive for the months of May and August with August the most restrictive because of the high demand corn silage had for August labor. Whenever seasonal labor was available, corn silage was the predominant ration and was profitable enough that $1.25 could be paid for each hour of August labor hired. Without the availability of seasonal labor, the value of another hour of August labor went as high as $10.87 for the sixty-cow herd size.

Seventy-cow herd size. The least cost combination of activities and the least cost feed rations per cow are shown in Tables XVII and XVIII.

With an increase in maximum herd size from sixty to seventy cows, labor became more restrictive and land tended to be less restrictive than at the sixty-cow herd size. In each resource situation, more

TABLE XVII

A LEAST COST COMBINATION OF ACTIVITIES FOR ALTERNATIVE PRODUCTION LEVELS AND LABOR SUPPLIES ON EAST TENNESSEE GRADE A DAIRY FARMS CONSISTING OF 150 ACRES OF OPEN CROPLAND AND A SEVENTY-COW HERD SIZE WITH A TOBACCO ENTERPRISE, 1965

| Activity | Soil Group | Unit | Milk Production Per Cow in Pounds (4% BFC) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | With Seasonal Labor | | | Without Seasonal Labor | | |
| | | | 9,000 | 11,000 | 13,000 | 9,000 | 11,000 | 13,000 |
| Corn for grain | I | acre | -- | -- | -- | 17.5 | 17.7 | 17.8 |
| Corn for grain | II | acre | 18.0 | 18.0 | 16.8 | 18.0 | 18.0 | 18.0 |
| Corn for grain | III | acre | 11.2 | 2.6 | 2.4 | 21.0 | 21.0 | 21.0 |
| Corn silage | I | acre | 16.9 | 17.1 | 17.3 | -- | -- | -- |
| Corn silage | III | acre | 9.8 | 18.4 | 18.6 | -- | -- | -- |
| Alfalfa hay | III | acre | 8.8 | 10.4 | 15.0 | 8.8 | 12.0 | 6.6 |
| Alfalfa hay & silage | III | acre | -- | 4.1 | -- | -- | -- | 8.4 |
| Oats (grain) & lesp. hay | III | acre | 24.3 | 18.5 | 16.1 | 8.6 | 16.9 | 5.9 |
| Oats (grain) & lesp. hay | V | acre | -- | -- | -- | 15.1 | 7.5 | 11.7 |
| Cr.cl.-oats & lesp. past. | III | acre | -- | -- | -- | -- | 0.6 | 12.1 |
| Millet silage | III | acre | -- | -- | -- | 15.6 | 3.5 | -- |
| Lad.cl.-or.gr. sil. & p. | II | acre | -- | -- | 1.2 | -- | -- | -- |
| Lad.cl.-or.gr. sil. & p. | III | acre | -- | -- | 1.9 | -- | -- | -- |
| Lad.cl.-or.gr. sil. & p. | IV | acre | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 |
| Lad.cl.-or.gr. sil. & p. | V | acre | 30.0 | 30.0 | 30.0 | 14.9 | 22.5 | 18.3 |
| Bor. annual invest. cap. | - | $ | 7,424.5 | 8,045.1 | 8,725.4 | 7,500.8 | 8,224.1 | 8,832.9 |
| Hire May labor | - | hr. | -- | 19.6 | 41.1 | -- | -- | -- |
| Hire August labor | - | hr. | 198.1 | 238.2 | 236.6 | -- | -- | -- |
| Sell oats | - | bu. | 1,483.7 | 1,112.2 | 965.3 | 1,199.1 | 1,348.7 | 881.6 |
| Sell lespedeza hay | - | ton | 19.8 | 14.8 | -- | -- | -- | -- |
| Buy straw | - | ton | 45.3 | 51.5 | 53.9 | 50.8 | 47.8 | 55.9 |
| Buy corn | - | bu. | 186.6 | -- | -- | 863.5 | 2,645.2 | 3,749.5 |
| Buy barley | - | bu. | 113.6 | 1,273.2 | 2,780.7 | -- | -- | -- |
| Buy alfalfa hay | - | ton | -- | -- | 1.0 | -- | -- | 16.9 |
| Burley tobacco | I | acre | 1.1 | 0.9 | 0.7 | 0.5 | 0.3 | 0.2 |
| Net Returns to Land, Labor, Invest. Cap. & Mgt. | | = | $15,774 | $18,716 | $22,679 | $14,381 | $17,067 | $21,129 |

TABLE XVIII

LEAST COST FEED RATIONS PER COW FOR ALTERNATIVE PRODUCTION LEVELS, LABOR SUPPLIES AND CROP ENTERPRISES ON EAST TENNESSEE GRADE A DAIRY FARMS CONSISTING OF 150 ACRES OF CROPLAND AND A SEVENTY-COW HERD SIZE, 1965

| Feed Per Cow | Unit | Milk Production Per Cow in Pounds (4% BFC) | | | | | |
|---|---|---|---|---|---|---|---|
| | | With Seasonal Labor | | | Without Seasonal Labor | | |
| | | 9,000 | 11,000 | 13,000 | 9,000 | 11,000 | 13,000 |
| WITH TOBACCO ENTERPRISE | | | | | | | |
| Corn (grain) | bu | 36.82 | 23.67 | 22.08 | 80.89 | 106.65 | 122.46 |
| Barley (grain) | bu. | 1.62 | 18.18 | 39.72 | -- | -- | -- |
| Corn silage | ton | 5.96 | 7.85 | 7.94 | -- | -- | -- |
| Millet silage | ton | -- | -- | -- | 1.64 | 0.37 | -- |
| Alfalfa silage | ton | -- | 0.27 | -- | -- | -- | 0.55 |
| Lad.cl.-or.gr. silage | ton | 3.34 | 3.34 | 3.55 | 2.56 | 2.95 | 2.74 |
| Lad.cl.-or.gr. pasture | ton | 1.97 | 1.97 | 2.10 | 1.49 | 1.73 | 1.60 |
| Crimson cl.-oats pasture | ton | -- | -- | -- | -- | 0.03 | 0.74 |
| Lespedeza pasture | ton | -- | -- | -- | -- | 0.03 | 0.64 |
| Alfalfa hay | ton | 0.40 | 0.55 | 0.70 | 0.40 | 0.55 | 0.70 |
| Lespedeza hay | ton | -- | -- | 0.18 | 0.22 | 0.25 | 0.16 |
| WITHOUT TOBACCO ENTERPRISE | | | | | | | |
| Corn (grain) | bu. | 38.10 | 25.21 | 21.63 | 55.47 | 92.81 | 120.22 |
| Barley (grain) | bu. | 0.07 | 16.43 | 40.33 | -- | -- | -- |
| Corn silage | ton | 5.91 | 7.80 | 7.92 | 2.44 | 1.25 | 0.25 |
| Millet silage | ton | -- | -- | -- | 1.81 | 0.55 | -- |
| Alfalfa silage | ton | -- | 0.32 | -- | -- | -- | 0.68 |
| Lad.cl.-or.gr. silage | ton | 3.34 | 3.34 | 3.52 | 2.86 | 3.14 | 3.21 |
| Lad.cl.-or.gr. pasture | ton | 1.97 | 1.97 | 2.08 | 1.67 | 1.85 | 1.89 |
| Alfalfa hay | ton | 0.40 | 0.55 | 0.70 | 0.40 | 0.55 | 0.70 |
| Lespedeza hay | ton | -- | -- | 0.20 | 0.16 | 0.21 | 0.22 |

concentrates per cow were fed in the feed rations for the seventy-cow herd size than for the sixty-cow herd size. A large part, in some cases as much as nearly one-half, of these concentrates were purchased. Where seasonal labor was available, barley was purchased, and without seasonal labor, corn was purchased. Also, in the two resource situations in which labor was the most restricting, crimson clover-oats pasture double cropped with lespedeza pasture was produced. This definitely indicated that labor was very restrictive.

A very interesting observation is made in regard to the tobacco enterprise. Where a tobacco enterprise was permitted to enter the optimal farm organization, the full 1.2 acres of tobacco allotment was not used in any combination of activities at the seventy-cow herd size. The November-December labor was restrictive in the cases where seasonal labor was not as the dairy cow enterprise took almost all of the November-December labor to reach the maximum herd size of seventy and the tobacco enterprise competed for the remainder. This indicated that the dairy enterprise, up to seventy-cow herd size, was more profitable than the tobacco, in terms of the value of an hour of November-December lator, and that some of the other crop enterprises could possibly utilize an hour of seasonal labor more profitably than could tobacco.

Fifty-cow herd size. The least cost combinations of activities and the least cost feed rations are shown in Tables XIX and XX. When maximum herd size was decreased to fifty cows, land became more restrictive than labor as the cash crops, such as soybeans, were grown in

TABLE XIX

A LEAST COST COMBINATION OF ACTIVITIES FOR ALTERNATIVE PRODUCTION LEVELS AND LABOR SUPPLIES ON EAST TENNESSEE GRADE A DAIRY FARMS CONSISTING OF 150 ACRES OF OPEN CROPLAND AND A FIFTY-COW HERD SIZE WITH A TOBACCO ENTERPRISE, 1965

| Activity | Soil Group | Unit | Milk Production Per Cow in Pounds (4% BFC) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | With Seasonal Labor | | | Without Seasonal Labor | | |
| | | | 9,000 | 11,000 | 13,000 | 9,000 | 11,000 | 13,000 |
| Dairy cows | - | cow | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 |
| Soybeans for grain | II | acre | 14.6 | 9.6 | 1.0 | 11.3 | -- | 4.0 |
| Corn for grain | I | acre | -- | -- | -- | 13.9 | 16.6 | 16.8 |
| Corn for grain | II | acre | 3.4 | 8.4 | 17.0 | 6.7 | 18.0 | 14.0 |
| Corn for grain | III | acre | 18.6 | 13.9 | 15.3 | 21.0 | 21.0 | 21.0 |
| Corn silage | I | acre | 16.8 | 16.8 | 16.8 | 2.9 | 0.2 | -- |
| Corn silage | III | acre | 2.4 | 7.1 | 5.7 | -- | -- | -- |
| Alfalfa hay | III | acre | 15.0 | 15.0 | 15.0 | 6.3 | 8.6 | 10.9 |
| Oats (grain) & lesp. hay | III | acre | 18.0 | 18.0 | 18.0 | 21.9 | 16.2 | -- |
| Oats (grain) & lesp. hay | IV | acre | 16.2 | 8.9 | 1.1 | -- | -- | -- |
| Oats (grain) & lesp. hay | V | acre | -- | -- | -- | 30.0 | 26.3 | 3.9 |
| Millet silage | III | acre | -- | -- | -- | 4.8 | 8.2 | 22.1 |
| Millet silage | IV | acre | -- | -- | -- | 2.2 | -- | 7.5 |
| Lad.cl.-or.gr. sil. & p. | IV | acre | 13.8 | 21.1 | 28.9 | 27.8 | 30.0 | 22.5 |
| Lad.cl.-or.gr. sil. & p. | V | acre | 30.0 | 30.0 | 30.0 | -- | 3.7 | 26.1 |
| Bor. annual invest. cap. | - | $ | 5,734.3 | 6,191.8 | 6,692.8 | 5,919.9 | 6,439.9 | 6,642.1 |
| Hire August labor | - | hr. | 86.9 | 121.1 | 126.3 | -- | -- | -- |
| Sell oats | - | bu. | 1,888.4 | 1,527.3 | 1,136.8 | 2,664.4 | 2,157.5 | 176.8 |
| Sell alfalfa hay | - | ton | 28.0 | 20.5 | 13.0 | -- | -- | -- |
| Sell lespedeza hay | - | ton | 25.7 | 20.7 | 15.2 | -- | -- | -- |
| Buy straw | - | ton | 19.1 | 24.8 | 31.1 | 7.1 | 15.4 | 47.2 |
| Burley tobacco | I | acre | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| Net Returns to Land, Labor, Invest. Cap. & Mgt. | = | | $13,426 | $15,696 | $18,714 | $12,853 | $14,850 | $18,073 |

TABLE XX

LEAST COST FEED RATIONS PER COW FOR ALTERNATIVE PRODUCTION LEVELS, LABOR SUPPLIES AND CROP ENTERPRISES ON EAST TENNESSEE GRADE A DAIRY FARMS CONSISTING OF 150 ACRES OF CROPLAND AND A FIFTY-COW HERD SIZE, 1965

| Feed Per Cow | Unit | Milk Production Per Cow in Pounds (4% BFC) | | | | | |
|---|---|---|---|---|---|---|---|
| | | With Seasonal Labor | | | Without Seasonal Labor | | |
| | | 9,000 | 11,000 | 13,000 | 9,000 | 11,000 | 13,000 |
| WITH TOBACCO ENTERPRISE | | | | | | | |
| Corn (grain) | bu. | 36.99 | 37.05 | 53.24 | 71.48 | 94.34 | 88.46 |
| Corn silage | ton | 6.09 | 7.50 | 7.08 | 0.92 | 0.06 | -- |
| Millet silage | ton | -- | -- | -- | 0.98 | 1.21 | 4.19 |
| Lad.cl.-or.gr. silage | ton | 3.32 | 3.93 | 4.59 | 2.34 | 2.79 | 3.77 |
| Lad.cl.-or.gr. pasture | ton | 1.98 | 2.33 | 2.71 | 1.33 | 1.60 | 2.23 |
| Alfalfa hay | ton | 0.40 | 0.55 | 0.70 | 0.40 | 0.55 | 0.70 |
| Lespedeza hay | ton | -- | -- | -- | 0.71 | 0.57 | 0.04 |
| WITHOUT TOBACCO ENTERPRISE | | | | | | | |
| Corn (grain) | bu. | 36.99 | 37.05 | 53.24 | 36.99 | 37.26 | 54.22 |
| Corn silage | ton | 6.09 | 7.50 | 7.08 | 6.09 | 7.41 | 6.66 |
| Lad.cl.-or.gr. silage | ton | 3.32 | 3.32 | 4.59 | 3.32 | 3.87 | 4.28 |
| Lad.cl.-or.gr. pasture | ton | 1.98 | 1.98 | 2.71 | 1.98 | 2.29 | 2.53 |
| Alfalfa hay | ton | 0.40 | 0.55 | 0.70 | 0.40 | 0.55 | 0.70 |
| Lespedeza hay | ton | -- | -- | -- | -- | 0.07 | 0.32 |

larger quantities. Along with the appearance of sizable acreages of soybeans, oats for grain double cropped with lespedeza hay were grown on a much larger acreage for the fifty-cow herd size than for the sixty-cow herd size, and in every case the tobacco enterprise was permitted to enter the model, the entire allotment was grown. All lespedeza hay was sold in the resource situations where labor was not as restrictive, but was fed where labor was restrictive. In every optimum solution in the study, including the sixty- and seventy-cow herd sizes, all of the oats produced would be sold, thereby indicating that it was more profitable to sell oats and purchase corn and barley.

The most significant difference in the feed rations, when herd size was decreased from sixty to fifty cows, was the sharp decrease in the amount of concentrates fed per cow for each resource situation. Further, all of the concentrates fed were grown on the home farm and none were purchased.

## V. SUMMARY

The feed costs per hundredweight of milk produced are shown in Figure III. The costs were obtained only for the assumptions that seasonal labor and a tobacco enterprise are present.

In the cases where labor was not the restricting factor, a ration consisting of corn silage, ladino clover-orchard grass silage, and pasture and the minimum amount of alfalfa hay required in the feed rations was the forage ration used. Also, as labor became less restrictive, soybeans and oats for grain double cropped with lespedeza hay

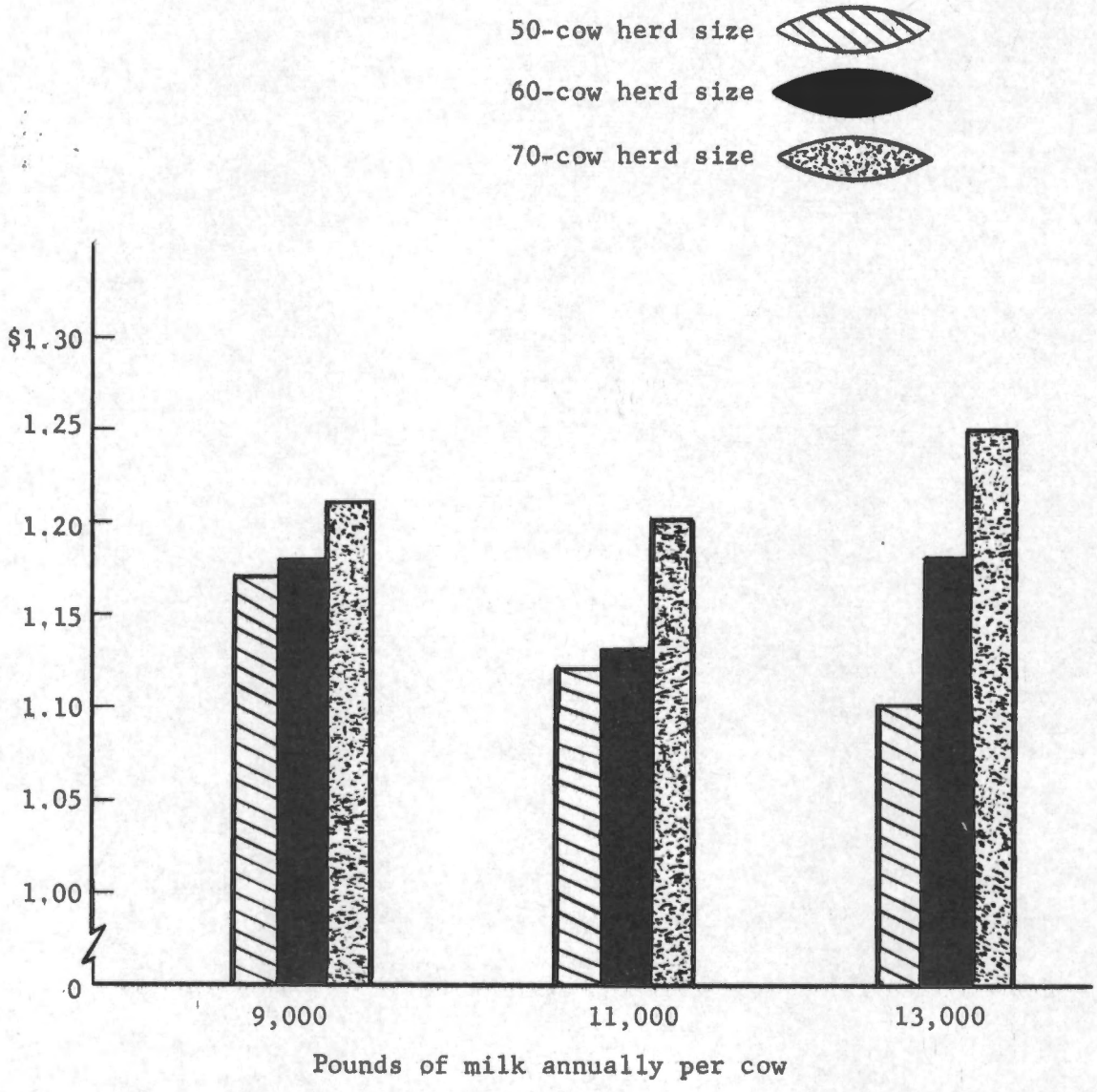



FIGURE 3

TOTAL FEED COST PER HUNDREDWEIGHT OF MILK PRODUCED, ASSUMING AVAILABILITY OF SEASONAL LABOR AND A TOBACCO ENTERPRISE, FOR THREE HERD SIZES AND THREE MILK PRODUCTION LEVELS ON GRADE A DAIRY FARMS IN EAST TENNESSEE, 1965

acreage became larger. With the exception of straw, which was used to furnish part of the bedding requirements, the soybeans, oats for grain, and lespedeza hay were used entirely as cash crops.

As labor became more restrictive in the resource situations, the corn silage, soybeans, and oats for grain double cropped with lespedeza hay acreage on Soils I, II, and III tended to be replaced by corn for grain, millet silage, and crimson clover-oats pasture double cropped with lespedeza pasture. This yielded a forage ration consisting of millet and ladino clover-orchard grass silage, crimson clover-oats, lespedeza hay and the minimum amount of alfalfa hay required in the rations. It was noted that, when seasonal labor was not available, all the lespedeza hay produced was fed instead of sold. Also, concentrates were fed in larger amounts with as much as one-half of the concentrates being purchased in the cases where labor was the most restrictive and milk production was the highest.

Pursuing the labor restrictions further, whenever labor was very restrictive, the dairy enterprise and the crop enterprises used to produce feed for the dairy herd would force the tobacco enterprise out of the optimum solutions. An hour of seasonal labor or November-December labor was worth more when applied to the dairy operations than when applied to the tobacco enterprise.

# CHAPTER V

## SUMMARY, CONCLUSIONS, AND IMPLICATIONS

The primary objective of this study was to determine the most economical forage and concentrate rations for highly productive grade A dairy herds in the East Tennessee area where the operators have alternative resource situations, machinery ownership patterns, herd sizes, and milk production levels. Also, special attention was given to resource requirements and the economies or diseconomies of scale with increases in herd size.

The techniques of budgeting and linear programming were used to obtain the objectives of this study. Three forage rations, namely, corn silage with a minimum of hay, all alfalfa-orchard grass hay and a combination of both, were evaluated to determine the resource requirements, production costs and which of the three forage rations would be the most economical if resources were unlimited. By using those feed and crop enterprises normally used and/or grown on grade A dairy farms in East Tennessee, linear programming was employed to determine the least cost feed rations for different resource situations, herd sizes, and milk production levels.

### I. SUMMARY

When only considering the three forage rations named above, with the assumptions that all concentrates would be purchased and land and

labor resources were unlimited, the most economical forage ration was a mixture of corn silage and alfalfa-orchard grass hay. When the assumptions were changed to allow the alternatives of growing concentrates, purchasing them and fixing land and labor supplies, different forage rations were found to be the most economical. When seasonal labor could be hired, corn silage fed with ladino-orchard grass silage and pasture was found to be the most economical forage ration. If seasonal labor was not permitted to be hired, millet silage and lespedeza hay would substitute for corn silage in the forage rations as labor became more restrictive. Also, concentrates would be fed in heavier amounts. In each forage ration, a minimum amount of alfalfa hay was required. Only the minimum requirement of alfalfa hay was fed in all of the optimum forage rations in the linear programming solutions.

When resources were not limited, the net returns to land, investment capital and management increased from $97 per cow to $156 per cow as herd size increased from thirty to ninety cows. When limitations were assumed for land and labor, the net returns to land, labor, investment capital and management decreased from $374 per cow to $324 per cow with an increase in herd size from fifty to seventy cows. In each of the above calculations, the net returns are calculated from the most profitable resource situation for that particular herd size.

The budgeting phase of this study indicated that ownership of silage harvesting machinery would be profitable if a minimum of 360 tons of silage was harvested annually. Also, a minimum of 150 tons of hay harvested annually would be needed for profitable ownership of hay

harvesting machinery. Throughout the analysis, it was assumed that all machinery would be purchased new.

The land and labor resource requirements were found to be restrictive to the grade A dairies in East Tennessee. For dairymen who are just beginning, investment capital would be the major restricting resource. But, once the dairyman is established, as assumed in this study, the investment capital required annually would not be a restriction, as shown in this study. Annual operating capital is a restriction in many other types of farming operations, but the even flow of revenue from dairying would furnish the required annual operating capital in each resource situation considered in this study.

Corn silage has a high labor requirement for the month of August. In cases where seasonal labor could not be hired, the corn silage enterprise was forced out of the optimum solution because of this high labor requirement. The labor requirements for alfalfa hay were also high but were evenly spread out over the summer months. In the linear programming model, corn for grain replaced alfalfa hay acreage in several resource situations. Throughout the linear programming phase of the study, corn for grain was constantly a major crop enterprise and large acreages were specified in the solution whenever seasonal labor could not be hired. Ladino clover-orchard grass silage and pasture tended to be predominant on Soils IV and V. Oats for grain double cropped with lespedeza hay and millet silage were competitive for these soils, but the high productivity of nutrients and low labor requirements characteristic of ladino

clover-orchard grass silage and pasture continually caused ladino clover-orchard grass silage and pasture to replace these crops on Soils IV and V.

The least cost feed rations for grade A dairy farms in East Tennessee, consisting of 150 acres of open cropland and a labor force of two full-time men, varied with seasonal labor availability, milk production per cow, herd size and the availability of a tobacco enterprise.

When seasonal labor was available, corn silage was the major forage fed in the rations. Without the availability of seasonal labor, corn silage was eliminated from the rations in most cases and millet silage and lespedeza hay entered into the rations in moderate amounts. This change was accompanied by increased quantities of corn and barley specified for the rations.

As milk production increased from 9,000 pounds per cow to 13,000 pounds per cow, the only major change in the rations was an increase in the quantity of concentrates included in the optimal ration.

The increase in herd size was accompanied by a change in the rations fed as labor became more restrictive. Labor restrictions necessitated the substitution of millet silage and additional concentrates in place of corn silage. As herd size decreased, the solution specified a maximum amount of corn silage in the optimum rations. As the feed requirements were met by corn silage and the other feeds, any extra Soil II acreage was used for soybeans for grain. This indicated that only a set portion of the ration could consist of corn silage because of the ratio of nutrients required. This is because corn silage is high in

total digestible nutrients and energy and low in digestible protein. This means, for a ration with a high digestible protein requirement, the corn silage must be fed as a mixture with another feed which is high in digestible protein. The feed used in the optimal rations for this study, which was high in digestible protein, was found to be ladino clover-orchard grass silage and pasture.

The tobacco enterprise competed with corn silage for Soil I and August labor. When the tobacco enterprise was not allowed, the corn silage acreage increased and the corn for grain acreage decreased. When tobacco was allowed, the corn silage acreage decreased and the corn for grain acreage increased. Whenever corn silage or corn for grain was not grown, the other was grown on the acreage to provide the extra nutrients.

## II. CONCLUSIONS

The evidence from this study indicates that corn silage, corn for grain and ladino clover-orchard grass silage and pasture are the most economical feed crops to grow on grade A dairy farms in East Tennessee that have high milk production records. But, whenever labor becomes restrictive, different crop enterprises enter the optimum solution and the forage and concentrate rations change. Millet silage, lespedeza hay, and corn for grain are substituted for corn silage as labor becomes restrictive. Also, oats for grain double cropped with lespedeza hay serves as an important rotation crop with emphasis placed upon the cash value of oats and lespedeza hay and the amount of straw the oats furnish for bedding purposes. As herd size decreases and more land becomes

available for row crops, soybeans become an important cash crop as sizable acreages enter into the optimum solutions. Tobacco is a very profitable cash crop and will likely continue to be grown on these farms as long as labor is available and market conditions remain favorable. But, wherever farm labor is not available in a sufficient quantity, a highly productive grade A dairy enterprise in East Tennessee would probably eliminate the tobacco enterprise from the most profitable farm organization.

## III. LIMITATIONS OF THE RESULTS AND THEIR IMPLICATIONS

There are limitations to the application of the results of this study to actual farm situations. One must remember that these results are based upon and restricted by the assumptions of the study and the particular resource situations described. Yet, when the resource situations and conditions of a particular producer differ from those made in this study, one may have to make adjustments and allowances in order to obtain a feasible program recommendation. There are many reasons why the optimum farm organizations, combinations of activities, and optimal feed rations specified in this study may differ from what farmers will actually do. First of all, farmers may have goals other than profit maximization and efficient resource use. He may also have goals such as maximum milk production per cow, maximum beautification of the farm landscape by having a large acreage of pastures and meadows, and prize winning. Also, farmers often have beliefs and values which would hinder the application of the most economical farming program. Further, as

perfect knowledge does not exist, risk and uncertainty will affect the extent to which farmers are willing to undertake change.

The results of the analyses indicate that more emphasis could be placed upon the linear programming phase of this study for further research. Additional activities and restrictions would need to be included in the model to give more precision to the predictions and to analyze other situations which may be present on grade A dairy farms in East Tennessee. In order to obtain a more comprehensive analysis of dairying, the research should also be expanded to include other areas of the State to give an estimate of the effects of changes in resource situations and other conditions.

# SELECTED BIBLIOGRAPHY

## SELECTED BIBLIOGRAPHY


Downen, M. Lloyd, and David W. Culver. The Dairy Cattle Replacement Markets of Tennessee and Florida. Agricultural Experiment Station Bulletin 318. Knoxville: The University of Tennessee, 1960.

Elder, Joe A., and others. Loudon County, Tennessee, Soil Survey. Soil Conservation Service, U. S. Department of Agriculture. Washington: Government Printing Office, 1961.

_____. Marion County, Tennessee, Soil Survey. Soil Conservation Service, U. S. Department of Agriculture. Washington: Government Printing Office, 1958.

Ellis, Theo H., and Earl J. Partenheimer. Costs and Returns from Livestock Production in the Limestone Areas of Alabama. Agricultural Experiment Station. Alabama: Auburn University, 1960.

Givan, William Dale. "Tennessee Grade A Milk Producers, Present and Potential." Unpublished Master's thesis, The University of Tennessee, Knoxville, 1964.

Hudson, Estel H., and Robert M. Ray. Farm Planning Manual. Agricultural Economics Extension Service. Knoxville: The University of Tennessee, 1964.

Johnson, John M. The Cost and Use of Machinery and Equipment in a Silage Feeding Program. Agricultural Engineering Extension Circular No. 550. Knoxville: The University of Tennessee, 1959.

Kleiher and Mead. California, Journal of Dairy Science. Volume 28, University of California, 1945.

Little, Thomas William. "An Economic Analysis of Alternative Replacement Policies on Grade A Dairy Farms in the Knoxville Milkshed." Unpublished Master's thesis, The University of Tennessee, Knoxville, 1964.

Morrison, Frank B. Feeds and Feeding. Twenty-second edition. Clinton, Iowa: The Morrison Publishing Company, 1959.

National Farm Power Equipment Dealer's Association. Official Tractor and Farm Equipment Guide. St. Louis, Missouri: NRFEA Publications, Incorporated, 1965.

Ranney, W. P. Expected Returns from Selected Specialized Farming Systems in the Northern Highland Rim Area of Tennessee. Agricultural Experiment Station Bulletin No. 357. Knoxville: The University of Tennessee, 1963.

_____. Labor Requirements on Tennessee Farms. Agricultural Experiment Station Bulletin No. 316. Knoxville: The University of Tennessee, 1960.

Smith, Dick Wayland. "Economic Levels of Forage and Grain Production on Dairy Farms in East Tennessee." Unpublished Master's thesis, The University of Tennessee, Knoxville, 1956.

United States Department of Agriculture, Statistical Reporting Service. Agricultural Prices. Washington: Government Printing Office, 1965.

University of Tennessee, Department of Agricultural Economics. Unpublished data, 1965.

University of Tennessee. Tennessee's 1965 Fertilizer Recommendations. Agricultural Experiment Station Publication 381 (revised). Knoxville: The University of Tennessee, 1965.

# APPENDIXES

# APPENDIX A

## BUILDING AND EQUIPMENT ASSUMPTIONS AND COST ESTIMATES

TABLE XXI

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR THIRTY-COW HERD USING CUSTOM HARVESTING FOR EACH FORAGE SYSTEM ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | New Cost[b] | Salv. Value | Yrs. Life | Depre. Per Year | Reps. Per Yr. | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Milking parlor (2-stall) | $2,000 | $ 200 | 15 | $ 120 | $ 24 | $ 144 |
| Milker: double unit | 435 | 44 | 15 | 26 | 21 | 47 |
| Bulk tank: 300 gal. | 2,300 | 230 | 20 | 104 | 29 | 133 |
| Water heater | 65 | 7 | 16 | 4 | 3 | 7 |
| Loafing area (paved) | 300 | -- | 30 | 10 | 4 | 14 |
| Loafing shed 30x60 ft. | 2,000 | 200 | 30 | 60 | 20 | 80 |
| Calf barn | 300 | 30 | 30 | 9 | 4 | 13 |
| Water system | 400 | -- | 20 | 20 | 8 | 28 |
| Tool shed | 450 | 45 | 30 | 14 | 6 | 20 |
| Tractor 40-45 DHP | 3,556 | 356 | 15 | 213 | 256 | 469 |
| Moldboard plow 3-bottom | 420 | 42 | 15 | 25 | 20 | 45 |
| Disk (tandem) 8 ft. | 500 | 50 | 15 | 29 | 12 | 41 |
| Cultipacker 8 ft. | 300 | 30 | 20 | 14 | 2 | 16 |
| Fertilizer distr. 8 ft. | 275 | 28 | 12 | 20 | 7 | 27 |
| Grain drill 8 ft. | 860 | 86 | 15 | 51 | 18 | 69 |
| Corn planter 2-row | 435 | 44 | 20 | 19 | 8 | 27 |
| Cultivater 2-row | 225 | 23 | 15 | 28 | 12 | 40 |
| Mower 7 ft. no pitman | 450 | 45 | 15 | 27 | 21 | 48 |
| Wagon 5-ton | 334 | 33 | 15 | 20 | 11 | 31 |
| Spray rig 21 ft. boom | 198 | 20 | 10 | 18 | 6 | 24 |
| Manure spreader | 475 | 48 | 15 | 29 | 9 | 38 |
| Truck 1/2 ton | 2,000 | 200 | 10 | 180 | 60 | 240 |
| Hammer mill | 450 | 45 | 15 | 27 | 7 | 34 |
| TOTALS = | $18,953 | $1,825 | | $1,066 | $567 | $1,634 |

[a]Assumptions and estimates were synthesized from the following references: "An Economic Analysis of Alternative Dairy Herd Replacement Policies on Grade A Dairy Farms in the Knoxville Milkshed," by Thomas William Little, unpublished Master's thesis, The University of Tennessee, Knoxville, 1964; Consultation with S. A. Hinton, Associate Professor, Dairy Department, The University of Tennessee, Knoxville, July, 1965; Farm Planning Manual, by Estel H. Hudson and Robert M. Ray, University of Tennessee Agricultural Economics Extension Service, Knoxville, 1964; National Farm Power Equipment Dealer's Association Official Tractor and Farm Equipment Guide, published by NRFEA Publications, Inc., St. Louis, Missouri; and The Cost and Use of Machinery and Equipment in a Silage Feeding Program, by John M. Johnson, University of Tennessee Agricultural Engineering Extension Circular No. 550, Knoxville, 1959.

[b]Investment at any given time will equal approximately one-half the total estimated new cost.

TABLE XXII

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR THIRTY-COW HERD USING A CORN SILAGE FORAGE SYSTEM AND ALTERNATIVE HARVESTING POLICIES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Standard buildings & equipment assumed[c] | $18,953 | $1,825 | -- | $1,066 | $567 | $1,634 |
| Silo 48x18 ft. (279 tons) | 2,580 | -- | 40 | 65 | 15 | 80 |
| Silage shed 40x20 ft., concrete, open pole type | 1,080 | 108 | 30 | 32 | 10 | 42 |
| Silage bunker 40 ft. | 200 | 20 | 20 | 9 | 5 | 14 |
| Silo unloader & auger | 1,832 | 183 | 15 | 110 | 35 | 145 |
| Hay shed 15x46x13 ft., concrete, open pole type with feed racks & shed on either side | 1,035 | 104 | 30 | 31 | 15 | 46 |
| Forage harvester PTO 1-row | 1,945 | 195 | 12 | 146 | 87 | 232 |
| Silage blower | 600 | 60 | 12 | 45 | 17 | 62 |
| Silage equipment for wagon, false tailgate with ratchet on blower | 500 | 50 | 15 | 30 | 18 | 48 |
| TOTALS (own all machinery) = | $28,725 | $2,545 | | $1,534 | $770 | $2,303 |
| (minus harvesting equipment) TOTALS (custom harvest) = | $25,680 | $2,240 | | $1,313 | $647 | $1,960 |

[a,b] See the footnotes in Table XXI.

[c] See Table XXI.

TABLE XXIII

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR THIRTY-COW HERD USING AN ALL ALFALFA-ORCHARD GRASS HAY FORAGE SYSTEM AND ALTERNATIVE HARVESTING POLICIES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Standard buildings & equipment assumed[c] | $18,953 | $1,825 | -- | $1,066 | $567 | $1,634 |
| Hay shed 45x46x13 ft., concrete, open pole type with feed racks & shed on either side | 3,105 | 310 | 30 | 93 | 45 | 138 |
| Hay baler PTO 18x14 bale | 1,667 | 167 | 12 | 125 | 50 | 175 |
| Rake 7 ft., side delivery | 556 | 56 | 15 | 32 | 17 | 49 |
| Hay conditioner, 7 ft. | 750 | 75 | 10 | 67 | 19 | 86 |
| TOTALS (own all machinery) = | $25,031 | $2,443 | | $1,383 | $699 | $2,082 |
| (minus harvesting equipment) = TOTALS (custom harvest) | $22,058 | $2,135 | | $1,159 | $613 | $1,772 |

[a,b] See the footnotes in Table XXI.

[c] See Table XXI.

TABLE XXIV

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR THIRTY-COW HERD USING A CORN SILAGE AND ALFALFA-ORCHARD GRASS HAY FORAGE SYSTEM WITH ALTERNATIVE HARVESTING POLICIES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Standard buildings & equipment assumed[c] | $18,953 | $1,825 | -- | $1,066 | $567 | $1,634 |
| Silo 44x16 ft. (198 tons) | 1,971 | -- | 40 | 49 | 12 | 61 |
| Silage shed 40x20 ft., concrete, open pole type | 1,080 | 108 | 30 | 32 | 10 | 42 |
| Silage bunker 40 ft. | 200 | 20 | 20 | 9 | 5 | 14 |
| Silo unloader & auger | 1,786 | 179 | 15 | 107 | 34 | 141 |
| Hay shed 30x46x13 ft., concrete, open pole type with feed racks & shed on either side | 2,070 | 207 | 30 | 62 | 30 | 92 |
| Rake 7 ft., side delivery | 556 | 56 | 15 | 32 | 17 | 49 |
| Hay conditioner 7 ft. | 750 | 75 | 10 | 67 | 19 | 86 |
| Forage harvester PTO 1-row | 1,945 | 194 | 12 | 146 | 87 | 233 |
| Silage blower | 600 | 60 | 12 | 45 | 17 | 62 |
| Silage equipment for wagon, false tailgate with ratchet on blower | 500 | 50 | 15 | 30 | 18 | 48 |
| TOTALS (own all machinery) = | $32,078 | $2,941 | | $1,771 | $867 | $2,638 |
| (minus harvesting equipment) TOTALS (custom harvest) = | $26,060 | $2,339 | | $1,326 | $658 | $1,984 |

[a,b] See the footnotes in Table XXI.

[c] See Table XXI.

TABLE XXV

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR SIXTY-COW HERD USING CUSTOM HARVESTING FOR EACH FORAGE SYSTEM ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Milking parlor (4 stalls) | $ 3,500 | $ 350 | 15 | $ 210 | $ 42 | $ 252 |
| Pipeline milker | 2,150 | 215 | 15 | 129 | 45 | 174 |
| Bulk tank: 600 gal. | 2,800 | 280 | 20 | 126 | 33 | 159 |
| Water heater | 65 | 6 | 16 | 4 | 3 | 7 |
| Loafing area (paved) | 600 | -- | 30 | 20 | 8 | 28 |
| Loafing shed 30x120 ft., concrete | 4,000 | 400 | 30 | 120 | 40 | 160 |
| Calf barn | 600 | 60 | 30 | 18 | 8 | 26 |
| Water system | 600 | -- | 20 | 30 | 10 | 40 |
| Tool shed | 600 | 60 | 30 | 18 | 7 | 25 |
| Tractors 40-45 DHP (2) | 7,112 | 711 | 15 | 427 | 512 | 939 |
| Moldboard plow 3-bottom | 420 | 42 | 15 | 25 | 20 | 45 |
| Disk (tandem) 8 ft. | 500 | 50 | 15 | 26 | 12 | 41 |
| Cultipacker 8 ft. | 300 | 30 | 20 | 14 | 2 | 16 |
| Fertilizer distributer 8 ft. | 275 | 27 | 12 | 20 | 7 | 27 |
| Grain drill 8 ft. | 860 | 86 | 15 | 51 | 18 | 69 |
| Corn planter 2-row | 435 | 43 | 20 | 19 | 8 | 27 |
| Cultivater 2-row | 225 | 23 | 15 | 28 | 12 | 40 |
| Mower 7 ft., no pitman | 450 | 45 | 15 | 27 | 21 | 48 |
| Wagon 5-ton | 334 | 33 | 15 | 20 | 11 | 31 |
| Spray rig 21 ft. boom | 198 | 20 | 10 | 18 | 6 | 24 |
| Manure spreader | 475 | 48 | 15 | 28 | 10 | 38 |
| Manure loader | 400 | 40 | 12 | 30 | 8 | 38 |
| Truck 1-ton | 2,400 | 240 | 10 | 216 | 72 | 288 |
| Hammer mill | 450 | 45 | 15 | 27 | 7 | 34 |
| TOTALS = | $29,749 | $2,854 | | $1,655 | $920 | $2,575 |

[a,b] See the footnotes in Table XXI.

TABLE XXVI

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR SIXTY-COW HERD USING A CORN SILAGE FORAGE SYSTEM AND ALTERNATIVE HARVESTING POLICIES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Standard buildings & equipment assumed[c] | $29,749 | $2,854 | -- | $1,655 | $ 920 | $2,575 |
| Silos (2) 48x18 ft. (279 tons ea.) | 5,160 | -- | 40 | 129 | 30 | 159 |
| Silage shed 80x20 ft., concrete, open pole type | 2,160 | 216 | 30 | 65 | 20 | 85 |
| Silage bunker 80 ft. | 400 | 40 | 20 | 18 | 9 | 27 |
| Silo unloader & auger | 2,330 | 233 | 15 | 140 | 40 | 180 |
| Hay shed 30x46x13 ft., concrete, open pole type with feed racks & shed on either side | 2,070 | 207 | 30 | 62 | 30 | 92 |
| Forage harvester PTO 1-row | 1,945 | 194 | 12 | 146 | 87 | 233 |
| Silage blower | 600 | 60 | 12 | 45 | 17 | 62 |
| Silage equipment for wagon, false tailgate with ratchet on blower | 500 | 50 | 15 | 30 | 18 | 48 |
| TOTALS (own all machinery) = | $44,914 | $3,855 | | $2,289 | $1,193 | $3,461 |
| (minus harvesting equipment) TOTALS (custom harvest) = | $41,869 | $3,551 | | $2,068 | $1,049 | $3,118 |

[a,b] See the footnotes in Table XXI.

[c] See Table XXV.

TABLE XXVII

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR SIXTY-COW HERD USING AN ALL ALFALFA-ORCHARD GRASS HAY FORAGE SYSTEM AND ALTERNATIVE HARVESTING POLICIES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Standard buildings & equipment assumed[c] | $29,749 | $2,854 | -- | $1,655 | $920 | $2,575 |
| Hay shed 75x46x13 ft., concrete, open pole type with feed racks & shed on either side | 5,175 | 517 | 30 | 155 | 75 | 230 |
| Hay baler PTO 18x14 bale | 1,667 | 167 | 12 | 125 | 50 | 175 |
| Rake 7 ft., side delivery | 556 | 56 | 15 | 32 | 17 | 49 |
| Hay conditioner | 750 | 75 | 10 | 67 | 19 | 86 |
| TOTALS (own all machinery) = | $37,897 | $3,669 | | $2,034 | $1,081 | $3,115 |
| (minus harvesting equipment) TOTALS (custom harvest) = | $34,924 | $3,372 | | $1,809 | $ 995 | $2,805 |

[a,b] See the footnotes in Table XXI.

[c] See Table XXV.

TABLE XXVIII

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR SIXTY-COW HERD USING A CORN SILAGE AND ALFALFA-ORCHARD GRASS HAY FORAGE SYSTEM WITH ALTERNATIVE HARVESTING POLICIES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Standard buildings & equipment assumed[a] | $29,749 | $2,854 | -- | $1,655 | $ 920 | $2,575 |
| Silos (2) 44x16 ft. (198 tons ea.) | 3,942 | -- | 40 | 99 | 23 | 122 |
| Silage shed 80x20 ft., concrete, open pole type | 2,160 | 216 | 30 | 65 | 20 | 85 |
| Silage bunker 80 ft. | 400 | 40 | 20 | 18 | 9 | 27 |
| Silo unloader & auger | 2,285 | 228 | 15 | 138 | 40 | 178 |
| Hay shed 60x46x13 ft., concrete, open pole type with feed racks & shed on either side | 4,140 | 414 | 30 | 124 | 60 | 184 |
| Hay baler PTO 18x14 bale | 1,667 | 167 | 12 | 125 | 50 | 175 |
| Rake 7 ft., side delivery | 556 | 56 | 15 | 32 | 17 | 49 |
| Hay conditioner 7 ft. | 750 | 75 | 10 | 67 | 19 | 86 |
| Forage harvester PTO 1-row | 1,945 | 194 | 12 | 146 | 87 | 233 |
| Silage blower | 600 | 60 | 12 | 45 | 17 | 62 |
| Silage equipment for wagon, false tailgate with ratchet on blower | 500 | 50 | 15 | 30 | 18 | 48 |
| TOTALS (own all machinery) = | $48,694 | $4,355 | ... | $2,544 | $1,282 | $3,826 |
| (minus harvesting equipment) TOTALS (custom harvest) = | $42,676 | $3,748 | | $2,099 | $1,074 | $3,173 |

[a,b] See the footnotes in Table XXI.

[c] See Table XXV.

TABLE XXIX

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR NINETY-COW HERD USING CUSTOM HARVESTING FOR EACH FORAGE SYSTEM ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Milking parlor (6 stalls) | $ 5,000 | $ 500 | 15 | $ 300 | $ 60 | $ 360 |
| Pipeline milker | 3,150 | 315 | 15 | 190 | 65 | 255 |
| Bulk tank: 750 gal. | 3,100 | 310 | 20 | 139 | 36 | 175 |
| Water heater | 90 | 9 | 16 | 5 | 4 | 9 |
| Loafing area (paved) | 900 | -- | 30 | 30 | 12 | 42 |
| Loafing shed 60x120 ft., concrete | 6,000 | 600 | 30 | 180 | 60 | 240 |
| Calf barn | 900 | 90 | 30 | 27 | 12 | 39 |
| Water system | 800 | -- | 20 | 40 | 12 | 52 |
| Tool shed | 750 | 75 | 30 | 24 | 8 | 32 |
| Tractors (3) 40-45 DHP | 10,668 | 1,067 | 15 | 640 | 768 | 1,408 |
| Moldboard plows (2) 3-bottom | 840 | 84 | 15 | 51 | 40 | 91 |
| Disk (tandem) 8 ft. | 500 | 50 | 15 | 29 | 12 | 41 |
| Cultipacker 8 ft. | 300 | 30 | 20 | 14 | 2 | 16 |
| Fertilizer distributer 8 ft. | 275 | 28 | 12 | 20 | 7 | 27 |
| Grain drill 8 ft. | 860 | 86 | 15 | 51 | 17 | 68 |
| Corn planter 2-row | 435 | 44 | 20 | 19 | 8 | 27 |
| Cultivater 2-row | 225 | 23 | 15 | 28 | 12 | 40 |
| Mower 7 ft., no pitman | 450 | 45 | 15 | 27 | 21 | 48 |
| Wagons (2) 5-ton | 668 | 67 | 15 | 40 | 22 | 62 |
| Spray rig 21 ft. boom | 198 | 20 | 10 | 18 | 6 | 24 |
| Manure spreader | 475 | 47 | 15 | 28 | 10 | 38 |
| Manure loader | 400 | 40 | 12 | 30 | 8 | 38 |
| Truck 2-ton | 3,000 | 300 | 10 | 270 | 86 | 356 |
| Hammer mill | 450 | 45 | 15 | 27 | 7 | 34 |
| TOTALS | $40,426 | $3,873 | | $2,227 | $1,296 | $3,512 |

[a,b] See the footnotes in Table XXI.

TABLE XXX

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR NINETY-COW HERD USING A CORN SILAGE FORAGE SYSTEM AND ALTERNATE HARVESTING POLICIES, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Standard buildings & equipment assumed[c] | $40,426 | $3,873 | -- | $2,227 | $1,295 | $3,523 |
| Silos (2) 56x20 ft. (412 t. ea.) | 7,090 | -- | 40 | 177 | 42 | 220 |
| Silage shed 120x20 ft. (conc.) open pole type | 3,240 | 324 | 30 | 97 | 30 | 127 |
| Silage bunker 120 ft. | 600 | 60 | 20 | 27 | 14 | 40 |
| Silo unloader and auger | 2,832 | 283 | 15 | 170 | 50 | 220 |
| Hay shed 30x46x13 ft. (conc.) open pole type with feed racks & shed on either side | 3,105 | 311 | 30 | 93 | 45 | 138 |
| Forage harvester PTO 1-row | 1,945 | 195 | 12 | 145 | 88 | 233 |
| Silage blower | 600 | 60 | 12 | 45 | 18 | 63 |
| Silage equipment for 2 wagons, false tailgate with ratchet on blower | 1,000 | 100 | 15 | 30 | 18 | 48 |
| TOTALS (owns all machinery) = | $60,938 | $5,206 | | $3,013 | $1,600 | $4,612 |
| (minus harvesting equipment) TOTALS (custom harvest) = | $56,993 | $4,852 | | $2,792 | $1,478 | $4,268 |

[a,b] See the footnotes in Table XXI.

[c] See Table XXIX.

TABLE XXXI

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR NINETY-COW HERD USING AN ALL ALFALFA-ORCHARD GRASS HAY FORAGE SYSTEM AND ALTERNATE HARVESTING POLICIES, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Standard buildings & equipment assumed[c] | $40,426 | $3,873 | -- | $2,227 | $1,296 | $3,523 |
| Hay shed 105x46x13 ft. (conc.) open pole type with feed racks & shed on either side | 7,245 | 725 | 30 | 217 | 105 | 322 |
| Hay baler PTO 18x14 | 1,667 | 167 | 12 | 125 | 50 | 175 |
| Rake 7 ft. side delivery | 556 | 55 | 15 | 32 | 17 | 49 |
| Hay conditioner 7 ft. | 750 | 75 | 10 | 67 | 19 | 86 |
| TOTALS (own all machinery) = | $50,644 | $4,895 | | $2,669 | $1,487 | $4,156 |
| (minus harvesting equipment) TOTALS (custom harvest) = | $47,671 | $4,598 | | $2,445 | $1,401 | $3,845 |

[a,b] See the footnotes in Table XXI.

[c] See Table XXIX.

TABLE XXXII

ASSUMED BUILDINGS AND EQUIPMENT WITH ANNUAL COST ESTIMATES FOR NINETY-COW HERD USING A CORN SILAGE AND ALFALFA-ORCHARD GRASS HAY FORAGE SYSTEM WITH ALTERNATIVE HARVESTING POLICIES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | New Cost[b] | Salvage Value | Years Life | Deprec. Per Year | Repairs Per Year | Tot. Cost Per Year |
|---|---|---|---|---|---|---|
| Standard buildings & equipment assumed[c] | $40,426 | $3,873 | -- | $2,227 | $1,296 | $3,523 |
| Silos (2) 50x18 ft. (293 t. ea.) | 5,350 | -- | 40 | 134 | 32 | 166 |
| Silage shed 120x20 ft., concrete, open pole type | 3,240 | 324 | 30 | 97 | 30 | 127 |
| Silage bunker 120 ft. | 600 | 60 | 20 | 27 | 14 | 41 |
| Silo unloader & auger | 2,760 | 276 | 15 | 166 | 48 | 214 |
| Hay shed 75x46x13 ft., concrete, open pole type with feed racks & shed on either side | 4,175 | 517 | 30 | 155 | 75 | 230 |
| Hay baler PTO 18x14 bale | 1,667 | 167 | 12 | 125 | 50 | 175 |
| Rake 7 ft., side delivery | 556 | 56 | 15 | 32 | 17 | 49 |
| Hay conditioner 7 ft. | 750 | 75 | 10 | 67 | 19 | 86 |
| Forage harvester PTO 1-row | 1,945 | 194 | 12 | 146 | 87 | 233 |
| Silage blower | 600 | 60 | 12 | 45 | 17 | 62 |
| Silage equipment for 2 wagons, false tailgate with ratchet on blower | 1,000 | 100 | 15 | 60 | 36 | 96 |
| TOTALS (own all machinery) = | $64,069 | $5,703 | | $3,281 | $1,722 | $5,003 |
| (minus harvesting equipment) TOTALS (custom harvest) = | $57,556 | $5,051 | | $2,806 | $1,495 | $4,301 |

[a,b] See the footnotes in Table XXI.

[c] See Table XXIX.

TABLE XXXIII

ASSUMED DEPRECIATION AND REPAIRS PER UNIT OF USE FOR BUILDINGS, MACHINERY AND REPLACEMENT STOCK ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Item[a] | Unit | Cost/Unit |
|---|---|---|
| Tractor 3-bottom | hr. | $ .56 |
| Plow 3-bottom | hr. | .34 |
| Disk, tandem | hr. | .31 |
| Cultipacker | hr. | .16 |
| Fertilizer distributor 8 ft. | hr. | .27 |
| Grain drill 8 ft. | hr. | .86 |
| Corn planter 2-row | hr. | .45 |
| Cultivator | hr. | .13 |
| Mower 7 ft., no pitman | hr. | .36 |
| Wagon 5 ton | hr. | .09 |
| Spray rig 21 ft. | hr. | .16 |
| Harrow 2 section | hr. | .17 |
| Grain storage | bu. | .10 |
| Hay storage | ton | 1.64 |
| Silage storage | ton | .31 |
| Tobacco storage[b] | acre | 43.33 |
| Milking parlor | cow | 4.20 |
| Pipeline milker | cow | 2.90 |
| Bulk tank | cwt. | .0075 |
| Water heater & system | cow | .77 |
| Loafing shed & area | cow | 3.13 |
| Tool shed | cow | .42 |
| Manure spreader & loader | cow | 1.28 |
| Truck 1-ton | cow | 4.80 |
| Hammer mill | cow | .56 |
| Silage shed | cow | 1.41 |
| Silo unloader & auger | cow | 3.00 |
| Replacement stock/yr. 9,000 prod. level | cow | 60.00 |
| Replacement stock/yr. 11,000 prod. level | cow | 70.00 |
| Replacement stock/yr. 13,000 prod. level | cow | 80.00 |

[a]The machinery and building costs are based upon a sixty-cow herd size. The new cost, depreciation and repair estimates for the machinery and buildings are shown in Appendix A, Tables XXI through XXXII.

[b]The costs for a tobacco shed are not shown in Appendix A. The figures assumed for the tobacco shed per acre are: $2,000 initial cost with an expected life of 20 years. The salvage value would be $200 and repairs over the life of the building would equal 40 per cent of the initial cost.

# APPENDIX B

## LABOR REQUIREMENTS FOR THREE FORAGE SYSTEMS WITH ALTERNATIVE FORAGE HARVESTING POLICIES

TABLE XXXIV

ESTIMATED LABOR REQUIREMENTS FOR THIRTY-COW DAIRY HERD USING ALTERNATIVE FORAGE SYSTEMS AND HARVESTING POLICIES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965[a]

| Alternative Forage System and Harvesting Policy | Hours of Labor Required by Period of Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan. and Feb. | Mar. and Apr. | May | June | July | Aug. | Sep. and Oct. | Nov. and Dec. | Total for Year |
| Corn silage | | | | | | | | | |
| Custom harvest | 539 | 496 | 201 | 231 | 228 | 283 | 427 | 528 | 2,929 |
| Own all machinery | 541 | 498 | 204 | 234 | 231 | 441 | 429 | 530 | 3,104 |
| Alfalfa-orchard grass hay | | | | | | | | | |
| Custom harvest | 534 | 407 | 214 | 244 | 235 | 260 | 450 | 512 | 2,856 |
| Own all machinery | 536 | 409 | 255 | 285 | 240 | 291 | 490 | 514 | 3,020 |
| Corn silage and alfalfa-orchard grass hay | | | | | | | | | |
| Custom harvest | 546 | 475 | 216 | 246 | 233 | 288 | 449 | 528 | 2,981 |
| Own all machinery | 548 | 477 | 250 | 280 | 238 | 422 | 482 | 530 | 3,227 |

[a]Adapted from Labor Requirements on Tennessee Farms, by W. P. Ranney, University of Tennessee Agricultural Experiment Station Bulletin No. 316, Knoxville, 1960, and Farm Planning Manual, by Estel H. Hudson and Robert M. Ray, University of Tennessee Agricultural Extension Service, Knoxville, April, 1964.

TABLE XXXV

ESTIMATED LABOR REQUIREMENTS FOR SIXTY-COW DAIRY HERD USING ALTERNATIVE FORAGE SYSTEMS AND HARVESTING POLICIES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965[a]

| Alternative Forage System and Harvesting Policy | Hours of Labor Required by Period of Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan. and Feb. | Mar. and Apr. | May | June | July | Aug. | Sep. and Oct. | Nov. and Dec. | Total for Year |
| Corn silage | | | | | | | | | |
| Custom harvest | 852 | 826 | 315 | 370 | 369 | 476 | 670 | 839 | 4,716 |
| Own all machinery | 857 | 831 | 317 | 372 | 371 | 786 | 675 | 844 | 5,053 |
| Alfalfa-orchard grass hay | | | | | | | | | |
| Custom harvest | 824 | 623 | 343 | 398 | 383 | 432 | 716 | 795 | 4,514 |
| Own all machinery | 824 | 625 | 416 | 472 | 385 | 482 | 790 | 797 | 4,792 |
| Corn silage and alfalfa-orchard grass hay | | | | | | | | | |
| Custom harvest | 866 | 784 | 347 | 402 | 379 | 488 | 716 | 839 | 4,821 |
| Own all machinery | 871 | 794 | 408 | 461 | 381 | 746 | 774 | 844 | 5,290 |

[a]See Table V, page 24.

TABLE XXXVI

ESTIMATED LABOR REQUIREMENTS FOR NINETY-COW DAIRY HERD USING ALTERNATIVE FORAGE SYSTEMS AND HARVESTING POLICIES ON GRADE A DAIRIES IN EAST TENNESSEE, 1965[a]

| Alternative Forage System and Harvesting Policy | Hours of Labor Required by Period of Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan. and Feb. | Mar. and Apr. | May | June | July | Aug. | Sep. and Oct. | Nov. and Dec. | Total for Year |
| Corn silage | | | | | | | | | |
| Custom harvest | 1,156 | 1,148 | 447 | 528 | 528 | 687 | 936 | 1,128 | 6,558 |
| Own all machinery | 1,156 | 1,151 | 449 | 530 | 530 | 1,139 | 936 | 1,131 | 7,022 |
| Alfalfa-orchard grass hay | | | | | | | | | |
| Custom harvest | 1,137 | 898 | 489 | 570 | 550 | 623 | 1,011 | 1,086 | 6,364 |
| Own all machinery | 1,139 | 900 | 597 | 678 | 552 | 696 | 1,119 | 1,088 | 6,769 |
| Corn silage and alfalfa-orchard grass hay | | | | | | | | | |
| Custom harvest | 1,178 | 1,094 | 495 | 576 | 544 | 707 | 1,004 | 1,128 | 6,725 |
| Own all machinery | 1,178 | 1,097 | 581 | 662 | 546 | 1,089 | 1,089 | 1,131 | 7,373 |

[a]See Table V, page 24.

# APPENDIX C

## ASSUMED PRICES OF PRODUCTS SOLD AND ITEMS PURCHASED AND VARIABLE COST OF CROP PRODUCTION FOR THREE FORAGE SYSTEMS

TABLE XXXVII

ASSUMED PRICES OF PRODUCTS SOLD AND ITEMS PURCHASED FOR GRADE A DAIRY FARMS IN EAST TENNESSEE, 1965[a]

| | Unit | Price |
|---|---|---|
| PRODUCTS SOLD | | |
| Grade A milk (4% butterfat) | cwt. | $ 4.60 |
| 7-day old calves | head | 20.00 |
| Culled cows | cwt. | 11.50 |
| Corn (grain) | bu. | 1.15 |
| Oats (grain) | bu. | .80 |
| Barley (grain) | bu. | 1.00 |
| Soybeans (grain) | bu. | 2.40 |
| Alfalfa hay | ton | 32.00 |
| Lespedeza hay | ton | 24.00 |
| Straw | ton | 20.00 |
| Ladino clover & orchard grass hay | ton | 25.00 |
| Red clover & orchard grass hay | ton | 25.00 |
| Tobacco | cwt. | 60.00 |
| ITEMS PURCHASED | | |
| Barley seed | bu. | 2.50 |
| Oat seed | bu. | 1.25 |
| Hybrid seed corn | bu. | 10.08 |
| Alfalfa seed | lb. | .45 |
| Orchard grass seed | lb. | .50 |
| Ladino clover seed | lb. | .75 |
| Crimson clover seed | lb. | .20 |
| Lespedeza seed | lb. | .20 |
| Millet seed | lb. | .18 |
| Inoculation of legume seeds | acre | .50 |
| Limestone | ton | 4.00 |
| Fertilizer 6-12-12 | ton | 53.00 |
| Fertilizer 5-20-20 | ton | 60.00 |
| Fertilizer 0-9-27 | ton | 56.00 |
| Fertilizer 30-0-0 | ton | 84.00 |
| Fertilizer 0-20-20 | ton | 44.00 |
| Borax | cwt. | 4.25 |
| Salt | cwt. | 1.64 |
| Soybean oil meal, 44% protein | cwt. | 5.00 |
| Molasses, cane | cwt. | 3.50 |
| Milk replacer | cwt. | 17.00 |
| Corn (grain) | bu. | 1.25 |
| Barley (grain) | bu. | 1.10 |
| Oats (grain | bu. | .90 |

TABLE XXXVII (continued)

| | Unit | Price |
|---|---|---|
| ITEMS PURCHASED (continued) | | |
| Straw | ton | $ 24.00 |
| Alfalfa hay | ton | 36.00 |
| Lespedeza hay | ton | 28.00 |
| Red clover & orchard grass hay | ton | 29,00 |
| Labor (seasonal & full time) | hr. | 1.25 |
| Labor | hr. | 1.25 |
| Interest on capital | $1.00 | .06 |
| Dairy cows (wt. = 1,200 lb.;prod. = 9,000) | head | 300.00 |
| Dairy cows (wt. = 1,450 lb.;prod. = 11,000) | head | 350.00 |
| Dairy cows (wt. = 1,700 lb.;prod. = 13,000) | head | 400.00 |
| Milk hauling | cwt. | .22 |
| Breeding fees | cow | 6.00 |
| Tractor: gas, oil & grease | hr. | .50 |
| Truck, 1/2-ton: gas, oil & grease | mile | .08 |
| Truck, 1-ton: gas, oil & grease | mile | .10 |
| Truck, 2-ton: gas, oil & grease | mile | .12 |
| Hired tractor | hr. | 2.00 |
| Hired silage wagon | hr. | .75 |
| Harvest silage (custom) | ton | 2.25 |
| Condition hay (custom) | acre | 2.10 |
| Rake & bale hay (custom) | ton | 5.50 |
| Tobacco setting (custom) | acre | 6.00 |
| Combining grain (custom) | acre | 6.00 |
| Pick corn (custom) | acre | 6.00 |
| Plastic for tobacco bed | sq. yd. | .10 |
| Cheesecloth for tobacco bed | sq. yd. | .05 |
| Tobacco seed | acre | 1.50 |
| D.D.T. | lb. | .07 |
| Fermate | lb. | .15 |
| Tobacco insecticides | lb. | .60 |
| Tobacco insurance | acre | 25.00 |
| Tobacco marketing fees | acre | 50.60 |

[a]Estimates of the prices and quantities were adapted from the following sources: Unpublished data of the Department of Agricultural Economics, The University of Tennessee; Agricultural Prices, Statistical Reporting Service, United States Department of Agriculture; "An Economic Analysis of Alternative Dairy Herd Replacement Policies on Grade A Dairy Farms in the Knoxville Milkshed," by Thomas William Little, unpublished Master's thesis, The University of Tennessee, Knoxville, 1964; Costs and

TABLE XXXVII (continued)

Returns from Livestock Production in the Limestone Valley Areas of Alabama, Agricultural Experiment Station, Auburn University; Farm Planning Manual, by Estel H. Hudson and Robert M. Ray, University of Tennessee Agricultural Economics Extension Service, Knoxville, April, 1964; and Labor Requirements on Tennessee Farms, by W. P. Ranney, University of Tennessee Agricultural Experiment Station Bulletin No. 316, Knoxville, 1960.

TABLE XXXVIII

ESTIMATED ANNUAL VARIABLE COST OF CROP PRODUCTION FOR THREE ALTERNATIVE FORAGE SYSTEMS ON GRADE A DAIRIES IN EAST TENNESSEE, 1965

| Crop | Item | Quantity Per Acre[a] (lbs.) | Prorated Cost Per Acre Per Year |
|---|---|---|---|
| Alfalfa-orchard grass hay 3.0 tons/acre[b] (5-year stand) | Seed: | | |
| | Alfalfa | 20 | $ 1.80 |
| | Orchard grass | 10 | 1.00 |
| | Fertilizer: | | |
| | Establishment (5-20-20) | 500 | 3.00 |
| | Maintenance (0-9-27) | 2,000 | 11.20 |
| | Insecticide | | 3.85 |
| | Borax | 100 | .85 |
| | Lime | 4,000 | 1.60 |
| | | Total Cost = | $23.32 |
| Corn silage 15 tons/acre[c] | Seed: | | |
| | Corn | 12 | $ 2.16 |
| | Fertilizer: | | |
| | 6-12-12 | 500 | 13.25 |
| | 30-0-0 | 160 | 7.64 |
| | Lime | 800 | 1.60 |
| | | Total Cost = | $24.65 |
| Permanent pasture Ladino clover-orchard grass 2.5 tons/acre or 6 months grazing (5-year stand) | Seed: | | |
| | Ladino clover | 2 | $ .30 |
| | Orchard grass | 10 | 1.00 |
| | Fertilizer: | | |
| | Establishment (5-20-20) | 500 | 3.00 |
| | Maintenance (0-20-20) | 1,350 | 5.94 |
| | Lime | 4,000 | 1.60 |
| | | Total Cost = | $11.80 |

[a]Adapted from Tennessee's 1965 Fertilizer Recommendations, Agricultural Experiment Station, Publication 381 (revised), The University of Tennessee, Knoxville, January, 1965.

[b]Assumed that 0.5 tons/acre will be lost due to weather, spoilage, and so forth.

[c]Assumed that 1 ton/acre will be lost due to spoilage.

# APPENDIX D

## THE LEAST COST COMBINATIONS OF ACTIVITIES FOR FIFTY, SIXTY AND SEVENTY COW HERD SIZE WITHOUT A TOBACCO ENTERPRISE

TABLE XXXIX

A LEAST COST COMBINATION OF ACTIVITIES FOR ALTERNATIVE PRODUCTION LEVELS AND LABOR SUPPLIES ON EAST TENNESSEE GRADE A DAIRY FARMS CONSISTING OF 150 ACRES OF OPEN CROPLAND AND A SIXTY-COW HERD SIZE WITHOUT A TOBACCO ENTERPRISE, 1965

| Activity | Soil Group | Unit | Milk Production Per Cow in Pounds (4% BFC) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | With Seasonal Labor | | | Without Seasonal Labor | | |
| | | | 9,000 | 11,000 | 13,000 | 9,000 | 11,000 | 13,000 |
| Soybeans for grain | II | acre | 7.0 | 1.0 | 1.6 | 7.9 | -- | -- |
| Corn for grain | I | acre | -- | -- | -- | -- | 2.4 | 6.8 |
| Corn for grain | II | acre | 11.0 | 17.0 | 16.4 | 10.2 | 18.0 | 18.0 |
| Corn for grain | III | acre | 16.3 | 10.7 | 9.4 | 21.0 | 21.0 | 21.0 |
| Corn silage | I | acre | 18.0 | 18.0 | 18.0 | 18.0 | 15.6 | 11.2 |
| Corn silage | III | acre | 4.7 | 10.3 | 11.6 | -- | -- | -- |
| Alfalfa hay | III | acre | 15.0 | 14.3 | 11.8 | 7.5 | 10.3 | 12.6 |
| Alfalfa hay & silage | III | acre | -- | 0.7 | 3.2 | -- | -- | 1.3 |
| Oats (grain) & lesp. hay | III | acre | 18.0 | 18.0 | 18.0 | 25.5 | 13.2 | 19.1 |
| Oats (grain) & lesp. hay | IV | acre | 8.1 | -- | -- | -- | -- | -- |
| Oats (grain) & lesp. hay | V | acre | -- | -- | -- | 17.1 | 8.1 | -- |
| Millet silage | III | acre | -- | -- | -- | -- | 9.4 | -- |
| Lad.cl.-or.gr. sil. & p. | IV | acre | 21.9 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 |
| Lad.cl.-or.gr. sil. & p. | V | acre | 30.0 | 30.0 | 30.0 | 12.9 | 21.9 | 30.0 |
| Bor. annual invest. cap. | - | $ | 6,519.0 | 7,071.9 | 7,663.0 | 6,628.7 | 7,139.3 | 7,766.3 |
| Hire August labor | - | hr. | 26.7 | 67.8 | 88.9 | -- | -- | -- |
| Sell oats | - | bu. | 1,483.4 | 1,080.0 | 1,080.0 | 2,298.7 | 1,158.5 | 1,146.3 |
| Sell alfalfa hay | - | ton | 24.0 | 13.7 | -- | -- | -- | -- |
| Sell lespedeza hay | - | ton | 20.0 | 14.4 | 14.4 | -- | -- | -- |
| Buy straw | - | ton | 35.5 | 42.0 | 42.0 | 22.5 | 41.1 | 40.9 |
| Buy corn | - | bu. | -- | -- | -- | -- | -- | 1,693.7 |
| Buy barley | - | bu. | -- | -- | 1,392.7 | -- | -- | -- |
| Net Returns to Land, Labor, Invest. Cap. & Mgt. = | | | $13,547 | $16,267 | $19,872 | $13,375 | $15,878 | $19,381 |

TABLE XL

A LEAST COST COMBINATION OF ACTIVITIES FOR ALTERNATIVE PRODUCTION LEVELS AND LABOR SUPPLIES ON EAST TENNESSEE GRADE A DAIRY FARMS CONSISTING OF 150 ACRES OF OPEN CROPLAND AND A SEVENTY-COW HERD SIZE WITHOUT A TOBACCO ENTERPRISE, 1965

| Activity | Soil Group | Unit | Milk Production Per Cow in Pounds (4% BFC) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | With Seasonal Labor | | | Without Seasonal Labor | | |
| | | | 9,000 | 11,000 | 13,000 | 9,000 | 11,000 | 13,000 |
| Corn for grain | I | acre | -- | -- | -- | 7.3 | 12.5 | 16.9 |
| Corn for grain | II | acre | 18.0 | 18.0 | 15.6 | 18.0 | 18.0 | 18.0 |
| Corn for grain | III | acre | 12.6 | 3.8 | 3.2 | 21.0 | 21.0 | 21.0 |
| Corn for silage | I | acre | 18.0 | 18.0 | 18.0 | 10.7 | 5.5 | 1.1 |
| Corn for silage | III | acre | 8.4 | 17.2 | 17.8 | -- | -- | -- |
| Alfalfa hay | III | acre | 15.0 | 10.1 | 15.0 | 8.8 | 12.0 | 4.6 |
| Alfalfa hay & silage | III | acre | -- | 4.9 | -- | -- | -- | 10.4 |
| Oats (grain) & lesp. hay | III | acre | 18.0 | 18.0 | 18.0 | 7.1 | 15.7 | 18.0 |
| Oats (grain) & lesp. hay | V | acre | -- | -- | -- | 9.4 | 3.8 | 2.5 |
| Millet silage | III | acre | -- | -- | -- | 17.2 | 5.2 | -- |
| Lad.cl.-or.gr. sil. & p. | II | acre | -- | -- | 2.4 | -- | -- | -- |
| Lad.cl.-or.gr. sil. & p. | IV | acre | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 |
| Lad.cl.-or.gr. sil. & p. | V | acre | 30.0 | 30.0 | 30.0 | 20.6 | 26.2 | 27.5 |
| Bor. annual invest. cap. | - | $ | 7,349.5 | 8,005.7 | 8,706.1 | 7,375.6 | 8,152.8 | 8,871.6 |
| Hire May labor | - | hr. | -- | -- | 19.0 | -- | -- | -- |
| Hire August labor | - | hr. | 86.4 | 182.7 | 170.0 | -- | -- | -- |
| Sell oats | - | bu. | 1,080.0 | 1,080.0 | 1,080.0 | 846.7 | 1,115.4 | 1,193.6 |
| Sell alfalfa hay | - | ton | 20.0 | 0.3 | -- | -- | -- | -- |
| Sell lespedeza hay | - | ton | 14.4 | 14.4 | -- | -- | -- | -- |
| Buy straw | - | ton | 51.7 | 52.0 | 52.0 | 56.4 | 51.7 | 50.2 |
| Buy corn | - | bu. | 153.3 | -- | -- | -- | 2,148.7 | 3,668.0 |
| Buy barley | - | bu. | 5.4 | 1,150.6 | 2,823.4 | -- | -- | -- |
| Buy alfalfa hay | - | ton | -- | -- | 1.0 | -- | -- | 20.7 |
| Net Returns to Land, Labor, Invest. Cap. & Mgt. = | | | $14,772 | $17,908 | $22,067 | $14,316 | $17,042 | $21,074 |

TABLE XLI

A LEAST COST COMBINATION OF ACTIVITIES FOR ALTERNATIVE PRODUCTION LEVELS AND LABOR SUPPLIES ON EAST TENNESSEE GRADE A DAIRY FARMS CONSISTING OF 150 ACRES OF OPEN CROPLAND AND A FIFTY-COW HERD SIZE WITHOUT A TOBACCO ENTERPRISE, 1965

| Activity | Soil Group | Unit | Milk Production Per Cow in Pounds (4% BFC) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | With Seasonal Labor | | | Without Seasonal Labor | | |
| | | | 9,000 | 11,000 | 13,000 | 9,000 | 11,000 | 13,000 |
| Soybeans for grain | II | acre | 16.0 | 11.0 | 2.3 | 16.0 | 11.2 | 3.2 |
| Corn for grain | II | acre | 2.0 | 7.0 | 15.7 | 2.0 | 6.8 | 14.8 |
| Corn for grain | III | acre | 19.9 | 15.2 | 16.6 | 19.9 | 15.5 | 18.0 |
| Corn silage | I | acre | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 |
| Corn silage | III | acre | 1.1 | 5.8 | 4.4 | 1.1 | 5.5 | 3.0 |
| Alfalfa hay | III | acre | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| Oats (grain) & lesp. hay | III | acre | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 |
| Oats (grain) & lesp. hay | IV | acre | 16.2 | 8.9 | 1.1 | 16.2 | 9.7 | 4.7 |
| Lad.cl.-or.gr. sil. & p. | IV | acre | 13.8 | 21.1 | 28.9 | 13.8 | 20.3 | 25.3 |
| Lad.cl.-or.gr. sil. & p. | V | acre | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 |
| Bor. annual invest. cap. | - | $ | 5,678.6 | 6,136.1 | 6,637.0 | 5,678.6 | 6,142.6 | 6,667.0 |
| Hire August labor | - | hr. | -- | 1.4 | 6.7 | -- | -- | -- |
| Sell oats | - | bu. | 1,888.3 | 1,527.1 | 1,136.7 | 1,888.3 | 1,565.6 | 1,314.1 |
| Sell alfalfa hay | - | ton | 28.0 | 20.5 | 13.0 | 28.0 | 20.5 | 13.0 |
| Sell lespedeza hay | - | ton | 25.7 | 20.7 | 15.2 | 25.7 | 17.6 | 1.2 |
| Buy straw | - | ton | 19.1 | 24.8 | 31.1 | 19.1 | 24.2 | 28.3 |
| Net Returns to Land, Labor, Invest. Cap. & Mgt. = | | | $12,292 | $14,603 | $17,621 | $12,292 | $14,594 | $17,579 |