

October 2, 1964

To the Graduate Council:

I am submitting herewith a thesis written by Arnold Ray Skelton entitled "Analysis of Efficiency of Cattle and Calf Movements in the Tennessee Livestock Industry." 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.

Irving Dubow
Major Professor

We have read this thesis and
recommend its acceptance:

Stanton P. Perry

Luther H. Keller

Accepted for the Council:

Stanton P. Smith
Dean of the Graduate School

ANALYSIS OF EFFICIENCY OF CATTLE AND CALF MOVEMENTS
IN THE TENNESSEE LIVESTOCK INDUSTRY

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
Arnold Ray Skelton
December 1964

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation to those who helped to make this study possible.

He is deeply grateful for the instruction, counseling, and constructive criticisms that have been offered by Dr. Irving Dubov. Without his assistance the study would not have been possible. This brief expression of gratitude is wholly inadequate for the help and guidance given by Dr. Dubov.

The author is also appreciative of the suggestions and constructive criticisms offered by Dr. Stanton P. Parry and Professor Luther H. Keller.

Appreciation is expressed to the secretaries and statistical clerks in the Department of Agricultural Economics for their assistance in preparing this manuscript. The author is also indebted to Mrs. Georgia Troglen for her patience and cooperation while typing the manuscript.

Last, but not least, the author wishes to express his gratitude and indebtedness to his wife, Lucy, for her hard work, patience, and encouragement during the preparation of this study.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION.	1
Purpose of the Study	2
Method and Procedure of Study.	5
Sampling procedure.	6
Method of analysis.	11
Review of Related Studies.	12
II. THEORETICAL FRAMEWORK	14
Assumptions of the Model	16
Transportations Cost Functions	17
Areas Used in the Analysis	19
III. ESTIMATED ACTUAL MOVEMENTS OF SLAUGHTER CATTLE AND CALVES . .	24
Cattle Movements	26
Good and above, first quarter	26
Standard and below, first quarter	26
Good and above, second quarter.	28
Standard and below, second quarter.	28
Good and above, third quarter	30
Standard and below, third quarter	30
Good and above, fourth quarter.	32
Standard and below, fourth quarter.	32

CHAPTER

PAGE

III. (CONTINUED)

Calf Movements	34
Prime and choice, first quarter	34
Good and standard, first quarter.	34
Prime and choice, second quarter.	35
Good and standard, second quarter	35
Prime and choice, third quarter	37
Good and standard, third quarter.	39
Prime and choice, fourth quarter.	39
Good and standard, fourth quarter	41
IV. OPTIMUM MOVEMENTS OF SLAUGHTER CATTLE AND CALVES.	43
Optimum Cattle Movements	44
Good and above, first quarter	44
Standard and below, first quarter	45
Good and above, second quarter.	45
Standard and below, second quarter.	47
Good and above, third quarter	49
Standard and below, third quarter	49
Good and above, fourth quarter.	51
Standard and below, fourth quarter.	52
Optimum Calf Movements	52
Prime and choice, first quarter	52
Good and standard, first quarter.	54

CHAPTER

PAGE

IV. (CONTINUED)

Prime and choice, second quarter	54
Good and standard, second quarter	56
Prime and choice, third quarter	56
Good and standard, third quarter	58
Prime and choice, fourth quarter	58
Good and standard, fourth quarter	60
V. COMPARISON OF ACTUAL AND OPTIMAL MOVEMENTS	62
Significant Non-Optimum Movements	62
The most significant inefficiencies	62
Efficiencies of calf movements	64
Efficiencies of cattle movements	65
Differences in efficiency of movements of cattle and calves	65
Significant Non-Optimum Routes of Cattle Movements	67
Good and above	67
Standard and below	69
Significant Non-Optimum Routes of Calf Movements	69
Prime and choice	69
Good and standard	71
Non-optimum routes of various grades	71
Causes of Inefficiencies	72
VI. CONCLUSIONS	74

CHAPTER	PAGE
BIBLIOGRAPHY.	78
APPENDIXES	
A.	82
B.	84



LIST OF TABLES

TABLE	PAGE
I. Numbers of Cattle Marketed, Slaughtered, and Consumed, by Substate Area in Tennessee in 1958	3
II. Areas Used in the Study by State and Substate Area. . . .	21
III. Estimated Optimum Movements of Slaughter Calves as Percentage of Actual Movements Within, Into, and Out of Tennessee During 1962, by Grade and by Quarter of the Year	63
IV. Estimated Optimum Movements of Slaughter Cattle as Percentage of Actual Movements Within, Into, and Out of Tennessee During 1962, by Grade and by Quarter of the Year	66
V. Non-Optimal Movements of Cattle by Routes Used and Quarter of the Year for 1962	68
VI. Non-Optimal Movements of Calves by Routes Used and Quarter of the Year for 1962	70
VII. Estimated Actual Movements of Cattle Into and Out of Tennessee During the First Quarter, 1962, for Cattle Graded Good and Above.	84
VIII. Estimated Actual Movements of Cattle Into and Out of Tennessee During the Second Quarter, 1962, for Cattle Graded Good and Above.	85

TABLE

PAGE

IX.	Estimated Actual Movements of Cattle Into and Out of Tennessee During the Third Quarter, 1962, for Cattle Graded Good and Above	86
X.	Estimated Actual Movements of Cattle Into and Out of Tennessee During the Fourth Quarter, 1962, for Cattle Graded Good and Above	87
XI.	Estimated Actual Movements of Cattle Into and Out of Tennessee During the First Quarter, 1962, for Cattle Graded Standard and Below	88
XII.	Estimated Actual Movements of Cattle Into and Out of Tennessee During the Second Quarter, 1962, for Cattle Graded Standard and Below	89
XIII.	Estimated Actual Movements of Cattle Into and Out of Tennessee During the Third Quarter, 1962, for Cattle Graded Standard and Below	90
XIV.	Estimated Actual Movements of Cattle Into and Out of Tennessee During the Fourth Quarter, 1962, for Cattle Graded Standard and Below	91
XV.	Estimated Actual Movements of Calves Into and Out of Tennessee During the First Quarter, 1962, for Calves Graded Prime and Choice	92
XVI.	Estimated Actual Movements of Calves Into and Out of Tennessee During the Second Quarter, 1962, for Calves Graded Prime and Choice	93

TABLE

PAGE

XVII.	Estimated Actual Movements of Calves Into and Out of Tennessee During the Third Quarter, 1962, for Calves Graded Prime and Choice	94
XVIII.	Estimated Actual Movements of Calves Into and Out of Tennessee During the Fourth Quarter, 1962, for Calves Graded Prime and Choice	95
XIX.	Estimated Actual Movements of Calves Into and Out of Tennessee During the First Quarter, 1962, for Calves Graded Good and Standard.	96
XX.	Estimated Actual Movements of Calves Into and Out of Tennessee During the Second Quarter, 1962, for Calves Graded Good and Standard.	97
XXI.	Estimated Actual Movements of Calves Into and Out of Tennessee During the Third Quarter, 1962, for Calves Graded Good and Standard.	98
XXII.	Estimated Actual Movements of Calves Into and Out of Tennessee During the Fourth Quarter, 1962, for Calves Graded Good and Standard.	99
XXIII.	Movements of Cattle in an Optimal System for Tennessee During the First Quarter, 1962, for Cattle Graded Good and Above	100
XXIV.	Movements of Cattle in an Optimal System for Tennessee During the Second Quarter, 1962, for Cattle Graded Good and Above	101

TABLE

PAGE

XXV. Movements of Cattle in an Optimal System for Tennessee	
During the Third Quarter, 1962, for Cattle Graded	
Good and Above	102
XXVI. Movements of Cattle in an Optimal System for Tennessee	
During the Fourth Quarter, 1962, for Cattle Graded	
Good and Above	103
XXVII. Movements of Cattle in an Optimal System for Tennessee	
During the First Quarter, 1962, for Cattle Graded	
Standard and Below	104
XXVIII. Movements of Cattle in an Optimal System for Tennessee	
During the Second Quarter, 1962, for Cattle Graded	
Standard and Below	105
XXIX. Movements of Cattle in an Optimal System for Tennessee	
During the Third Quarter, 1962, for Cattle Graded	
Standard and Below	106
XXX. Movements of Cattle in an Optimal System for Tennessee	
During the Fourth Quarter, 1962, for Cattle Graded	
Standard and Below	107
XXXI. Movements of Calves in an Optimal System for Tennessee	
During the First Quarter, 1962, for Calves Graded	
Prime and Choice	108
XXXII. Movements of Calves in an Optimal System for Tennessee	
During the Second Quarter, 1962, for Calves Graded	
Prime and Choice	109

TABLE

PAGE

XXXIII.	Movements of Calves in an Optimal System for Tennessee	
	During the Third Quarter, 1962, for Calves Graded	
	Prime and Choice	110
XXXIV.	Movements of Calves in an Optimal System for Tennessee	
	During the Fourth Quarter, 1962, for Calves Graded	
	Prime and Choice	111
XXXV.	Movements of Calves in an Optimal System for Tennessee	
	During the First Quarter, 1962, for Calves Graded	
	Good and Standard.	112
XXXVI.	Movements of Calves in an Optimal System for Tennessee	
	During the Second Quarter, 1962, for Calves Graded	
	Good and Standard.	113
XXXVII.	Movements of Calves in an Optimal System for Tennessee	
	During the Third Quarter, 1962, for Calves Graded	
	Good and Standard.	114
XXXVIII.	Movements of Calves in an Optimal System for Tennessee	
	During the Fourth Quarter, 1962, for Calves Graded	
	Good and Standard.	115

LIST OF FIGURES

FIGURE	PAGE
1. Geographic Dispersion of Sample Plants, by Size and Sub- state Areas	8
2. Geographic Dispersion of Sample Auctions, by Size and Sub- state Areas	9
3. Substate Areas Used for Determination of Cattle and Calf Movement Patterns	20
4. Actual Shipments of Slaughter Cattle During the First Quarter, 1962, Graded (a) Good and Above, and (b) Standard and Below	27
5. Actual Shipments of Slaughter Cattle During the Second Quarter, 1962, Graded (a) Good and Above, and (b) Standard and Below	29
6. Actual Shipments of Slaughter Cattle During the Third Quarter, 1962, Graded (a) Good and Above, and (b) Standard and Below	31
7. Actual Shipments of Slaughter Cattle During the Fourth Quarter, 1962, Graded (a) Good and Above, and (b) Standard and Below	33
8. Actual Shipments of Slaughter Calves During the First Quarter, 1962, Graded (a) Prime and Choice, and (b) Good and Standard.	36

FIGURE

PAGE

9.	Actual Shipments of Slaughter Calves During the Second Quarter, 1962, Graded (a) Prime and Choice, and (b) Good and Standard.	38
10.	Actual Shipments of Slaughter Calves During the Third Quarter, 1962, Graded (a) Prime and Choice, and (b) Good and Standard.	40
11.	Actual Shipments of Slaughter Calves During the Fourth Quarter, 1962, Graded (a) Prime and Choice, and (b) Good and Standard.	42
12.	Optimum Shipments of Slaughter Cattle During the First Quarter, 1962, Graded (a) Good and Above, and (b) Standard and Below	46
13.	Optimum Shipments of Slaughter Cattle During the Second Quarter, 1962, Graded (a) Good and Above, and (b) Standard and Below	48
14.	Optimum Shipments of Slaughter Cattle During the Third Quarter, 1962, Graded (a) Good and Above, and (b) Standard and Below	50
15.	Optimum Shipments of Slaughter Cattle During the Fourth Quarter, 1962, Graded (a) Good and Above, and (b) Standard and Below	53
16.	Optimum Shipments of Slaughter Calves During the First Quarter, 1962, Graded (a) Prime and Choice, and (b) Good and Standard.	55

FIGURE

PAGE

17. Optimum Shipments of Slaughter Calves During the Second Quarter, 1962, Graded (a) Prime and Choice, and (b) Good and Standard.	57
18. Optimum Shipments of Slaughter Calves During the Third Quarter, 1962, Graded (a) Prime and Choice, and (b) Good and Standard.	59
19. Optimum Shipments of Slaughter Calves During the Fourth Quarter, 1962, Graded (a) Prime and Choice, and (b) Good and Standard.	61

CHAPTER I

INTRODUCTION

Sales of beef cattle and calves have been especially important sources of cash income to farmers in Tennessee.¹ In 1962, income from sales of cattle and calves for beef amounted to \$99,804,000, which was the largest single source of income for farmers in Tennessee that year. This dollar value represented the live-weight equivalent of 505,085,000 pounds of beef.²

Estimates made in 1964 indicate that on the average 37 cents of each dollar the consumer spends for beef go for marketing charges.³ According to these figures the retail value of the beef marketed in Tennessee was \$158,419,047 which would result in a marketing margin of approximately \$58,615,047 in 1962. Therefore any inefficiencies in the marketing system could cost the people of Tennessee many millions of dollars.

The cost of transportation and moving cattle through the marketing channel to slaughterers is estimated to represent about 2 per cent of

¹Farm Income, 1949-62, A Supplement to Farm Income Situation, July 1963, Economic Research Service, (Washington: United States Department of Agriculture, August 1963), p. 99.

²Livestock and Meat Statistics, 1962, Statistical Bulletin No. 333 (Washington: United States Department of Agriculture, July 1963), p. 38.

³Marketing and Transportation Situation, Economic Research Service, (Washington: United States Department of Agriculture, February 1964), p. 18.

⁴Livestock and Meats, Marketing Research Report No. 418, (Washington: United States Department of Agriculture, 1960), p. 4.

the retail value of beef. On the basis of the figures previously cited, this 2 per cent amounts to about \$3,168,380 for beef produced in Tennessee. If inefficiencies exist in the marketing channels for cattle and calves, a considerable waste of money would result.

I. PURPOSE OF THE STUDY

There are apparent* inefficiencies in the marketing system in Tennessee. In 1958, farmers in East Tennessee marketed 138,300 head of cattle (Table I). Only 98,600 head were slaughtered, yet 154,400 head were consumed in East Tennessee. This shows 39,700 head being shipped out and the meat equivalent of 55,800 being shipped back in for consumption. In 1958 in West Tennessee, 66,800 head were shipped in for slaughter and the meat equivalent of 51,300 animals shipped out again.⁵ Such shipping patterns of a like commodity in opposite directions, unless otherwise explained, could suggest inefficiency in the movement patterns.

If the animals shipped in and out are non-comparable, then an inefficiency might not exist. Instead there may be an insufficient supply of some types of animals in certain areas. For example, the animals shipped out of an area could be feeder animals, and the animals shipped

*Some apparent inefficiencies may reflect market adjustments due to abnormal prices or other processes and can be explained as such.

⁵Roy G. Stout, J. C. Purcell, and W. L. Fishel, Marketing, Slaughter and Consumption of Livestock and Meats in the South, Bulletin No. 66, Southern Cooperative Series, August 1961, pp. 58-68.

TABLE I
NUMBERS OF CATTLE MARKETED, SLAUGHTERED, AND CONSUMED
BY SUBSTATE AREAS IN TENNESSEE IN 1958

	Marketings	Total slaughter	Consumption	Marketing less total slaughter	Consumption less total slaughter
	- - - - - thousands of head - - - - -				
West	98.9	165.7	114.4	-66.8	-51.3
Middle	207.7	200.2	112.5	7.5	-87.7
East	138.3	98.6	154.4	39.7	55.8
Total	444.9	464.5	381.3	-19.6	-83.2

Source: Roy G. Stout, J. C. Purcell, and W. L. Fishel, Marketing, Slaughter and Consumption of Livestock and Meats in the South, Bulletin No. 66, Southern Cooperative Series, August 1961, pp. 58, 68.

into the same area could be finished slaughter cattle. One criterion of inefficiency could be that the movement of the same type, grade, and weight of animals in opposite directions represents a type of inefficiency. This eliminates the question of comparative advantage, and the above criterion of efficiency will be used in this study.

Total transportation costs have been used to define and measure the degree of such inefficiencies.⁶ By determining the least cost routes of movement, the most efficient system of moving animals from surplus areas to deficit areas can be defined. This approach has been used in the Southern Regional Livestock Marketing Project, SM-23, of which the present study is a part.⁷

The specific objectives of the present analysis are:

1. To determine the movement patterns for different grades of cattle and calves shipped within, into, and out of Tennessee during the four quarters in 1962.
2. To determine the optimum (least cost) shipment patterns for these movements.

⁶See for example, R. J. Amick, "A Review of Research in Inter-regional Competition," (Paper given at Southern Farm Management Research Committee Workshop, New Orleans, Louisiana, March 23, 1964); C. C. Dennis and L. L. Sammet, "Interregional Competition in the Frozen Strawberry Industry," Hilgardia, Vol. 31, No. 15, (Berkeley, California: California Agricultural Experiment Station, December 1961); Donald E. Farris and R. A. King, Interregional Competition in Marketing Slicing Cucumbers (A. E. Information Series No. 78, Raleigh, North Carolina: North Carolina State College, September 1960); Richard A. King and William R. Henry, "Transportation Models in Studies of Interregional Competition," Journal of Farm Economics.

⁷W. L. Fishel, Irving Dubov, D. D. Rohdy, and R. G. Stout, Hog and Pork Movements in the Southeast, Bulletin No. 83, Southern Cooperative Series, January 1963.

3. To compare the actual movement patterns with the estimated optimum patterns to determine the degree of departure between the actual and optimum shipment patterns.
4. To suggest ways in which actual shipments of cattle and calves could be changed to minimize total transportation costs.

II. METHOD AND PROCEDURE OF STUDY

The area covered by the overall SM-23 study was the southeastern portion of the United States. Each state was divided into substate regions. Since attention of the present report focuses on the movement patterns that have specific reference to Tennessee, data pertaining to movement of cattle and calves in this state will be analyzed. Wherever applicable, data from other areas in the region that related to movements of animals into and out of Tennessee were used.

Tennessee was subdivided into the three areas of West, Middle, and East. The agencies from which data were gathered in each substate area were: packing plants, auction markets, and commission firms at terminal markets. A sample of firms was taken from each group of agencies.

Provision was made to eliminate double counting of animals that went through auctions to packers. For example, the origin and destination of each lot of animals was determined, and whether the animals were for slaughter or nonslaughter purposes was also recorded.

Sampling Procedure

The sampling procedure was drawn up by the Southern Regional Marketing Committee for use in the SM-23 project. Since most of the data used in this report were gathered for the SM-23 project, the sampling and data collection were governed by the procedures set up by the committee.

Packing plants. The population from which the sample was drawn consisted of all the packers in the state. This population was then classified into the following strata:

1. Federally inspected plants.*
2. Large non-federally inspected plants;** plants that handled more than 2,000,000 pounds annual volume but were not federally inspected.
3. Medium non-federally inspected plants; plants that handled an annual volume of more than 300,000 pounds but less than 2,000,000 pounds of meat.
4. Small non-federally inspected plants; all plants that handled less than 300,000 pounds annual volume were put into this stratum.

Data were obtained from all the FIS plants that cooperated; from a 50 per cent random sample drawn from the "Large Non-FIS" stratum and a

*Hereafter FIS shall mean Federally inspected.

**Hereafter non-FIS shall mean non-federally inspected.

20 per cent random sample in the "Medium Non-FIS" stratum. No sample of the "Small Non-FIS" plants was taken. The samples that were drawn from the three strata contained eight FIS plants, eleven large Non-FIS and six medium Non-FIS plants. Figure 1 shows the location of plants sampled.

Auctions. The auction markets within each substate area were listed. Volume data for each auctions were obtained which enabled a rank ordering of the auctions within each substate area according to volume. The group of largest auctions that collectively handled 50 per cent of auction volume in that substate area were classified as the "large" auctions. The smaller auctions that handled the remainder of the volume in that substate area were classified as "small" auctions. The group of auctions were sampled as follows:

For the "large" auctions a simple random sample of four auctions was drawn for each substate area. In cases where there were four auctions or less in the "large" category, all in that stratum in that substate area were selected.

A 10 per cent random sample was taken of the "small" auctions in each substate area. There were thirteen firms drawn for the "large" auction sample, and five firms drawn for the "small" auction sample.

Data obtained from commission firms operating at terminal markets were included in the auction data, and all terminal markets were covered. Figure 2 shows the location of auctions drawn and used for the sample.

Data were obtained from the firms in the samples for six selected one-week periods in 1962:

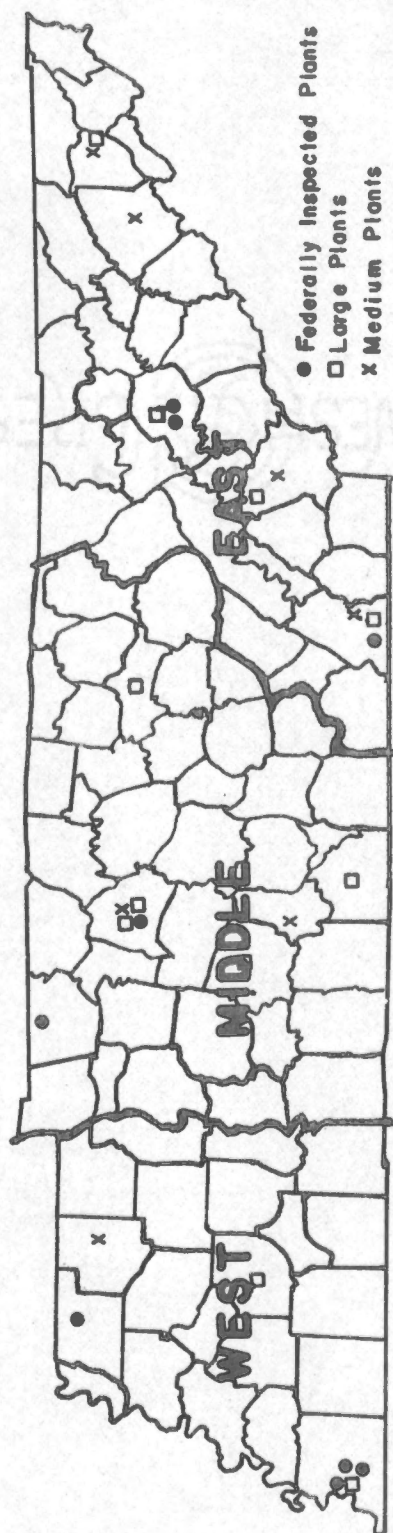


Figure 1. Geographic dispersion of sample plants, by size and substate areas.

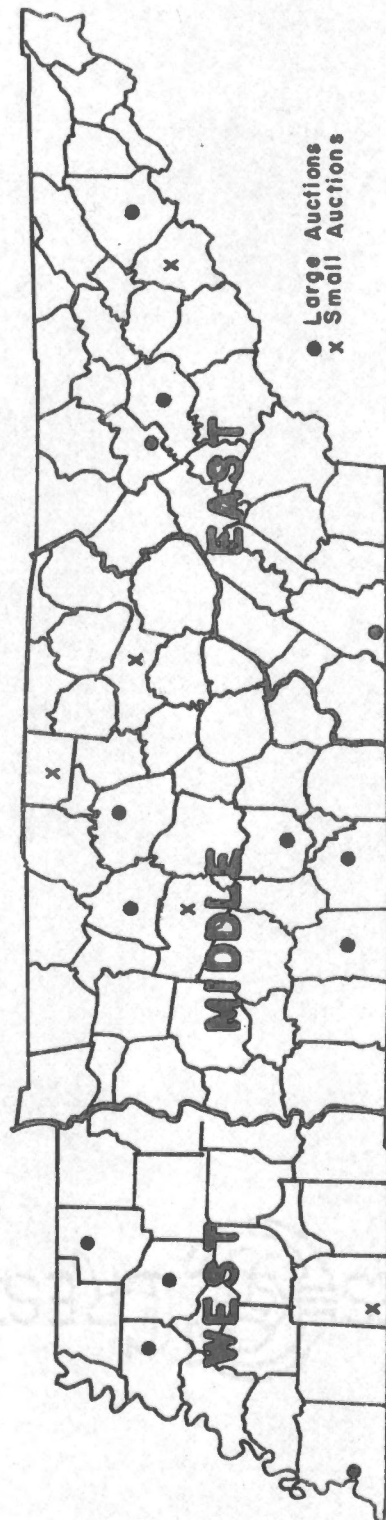


Figure 2. Geographic dispersion of sample auctions, by size and substate areas.

Week 1 -- February 4-10

Week 2 -- April 15-21

Week 3 -- June 10-16

Week 4 -- August 19-25

Week 5 -- October 7-13

Week 6 -- November 25 to December 1

Data were collected for all the animals handled by the auction (or commission firm) or packing plant in the selected one-week periods.

These weeks were chosen as representative of certain periods of the year. Week one, February 4-10, 1962, was considered representative of the first quarter of 1962. Only one week was used because of the relatively small volume of marketings in this quarter.

Two weeks, April 15-21 and June 10-16, were chosen in the second quarter due to the fluctuations in marketings in these spring months. The fourth week, August 19-25, in the third quarter was chosen to represent the marketings in the summer months. This week is in the middle of the third quarter which had a steady increase in marketings.

The two weeks, October 7-13 and November 25-December 1, were chosen as representative of the fourth quarter. Cattle and calf marketings usually reach their peak in this quarter and two weeks were used in order to avoid underestimating marketings.⁸

The data obtained were expanded to give estimates of total movements of animals into and out of Tennessee for the four quarters of 1962.

⁸Jack D. Johnson, Livestock Marketing in the Southern Region, Bulletin No. 26, Southern Cooperative Series, July 1952, p. 53.

As shown in Appendix A, the data were expanded by "time" factors to give quarterly estimates. Since the weeks used in the sample are considered to be representative of the corresponding quarters, the expansion for time was a multiplication of data for the week by the proportion that the week was of the quarter. The figures covered the transactions of a sample of packers and auctions, therefore, the data were then expanded to yield estimates of the volume handled by all marketing agencies in the "population" of packers and auctions in each substate area of Tennessee. The data from the firms in the various strata were expanded on the basis of relative importance to the total volume with respect to volume handled by firms in each stratum. The procedures used to expand the sample data are shown in greater detail in Appendix A. Finally, the movement patterns shown in Chapter III are based on the expanded data for each Tennessee substate area.

Method of Analysis

The transportation model is a form of linear programming in which the value of some variable may be maximized or minimized subject to given restrictions (or constraints). In this case the variable in question will be the total cost of moving animals from surplus* areas of

*Surplus areas are substate areas in which more livestock of specified grade is marketed than is slaughtered. These areas are considered as origins in the transportation model.

production to deficit* areas of production, subject to several conditions. The transportation model assumes that by minimizing the total transportation cost while allocating all surplus animals and filling all the deficits, the movements are made in an optimum manner.

The transportation model was used because it is the most convenient method of determining a pattern of movements that would result in the minimum total transportation cost. This is the minimum cost when all the surplus animals are allocated and all the deficits are filled.

III. REVIEW OF RELATED STUDIES

One study that closely paralleled the present one was the hog and pork movements phase of the Southern Regional Marketing Committee Project SM-23. This study estimated the apparent inefficiencies in the movement of hogs and pork. A transportation model was used to determine the optimum system of movements. The optimal patterns were compared to the actual movements. It was found that during certain parts of the year the animals moved over routes other than the least cost transportation routes. The departure of the actual movement patterns from optimal patterns indicated an inefficiency by that amount of departure.⁹ Other studies have been conducted to determine the optimum system of movements

*Deficit areas are defined as areas in which less livestock of specified grade is marketed than is slaughtered. They are considered destinations.

⁹W. L. Fishel, op. cit., pp. 26, 27.

for such products as eggs, cucumbers, milk and others.¹⁰

Many other studies have been reported that make use of the basic transportation model and the more sophisticated variations.¹¹ Many of these are interregional competition analyses that deal with commodities that are produced in more than one region of the United States.

¹⁰See Amick, op. cit., for review of relevant studies.

¹¹For further reference see bibliographical entries, Judge, Dennis, Jullierat, Koopmans, Heady, and King. See also Amick, op. cit.

CHAPTER II

THEORETICAL FRAMEWORK

The transportation model indicates a method of allocation in which a surplus of products in certain regions can be moved to remove the deficit of products in other regions in the least costly manner. The model as used in this study is the basic transportation model with stated assumptions and restrictions. The costs to be minimized are the sum of the costs of moving beef animals from surplus regions to deficit regions. This is the objective function to be minimized. Algebraically, the function to minimize is:

$$C = \sum_{i=1}^n \sum_{j=1}^m C_{ij} X_{ij}$$

where

C = total cost of transportation for all shipments.

C_{ij} = cost of transporting one head of cattle or calves from surplus area i to deficit area j .

X_{ij} = number of animals shipped from area i to area j .

The transportation model has constraints that specify the numbers of animals in the surplus and deficit areas. These constraints are not limits on total numbers in the areas but on numbers in surplus areas relative to numbers in deficit areas. These constraints are:

$$\sum_{i=1}^n X_{ij} = d_j \quad (j = 1 \dots m)$$

$$\sum_{j=1}^m X_{ij} = s_i \quad (i = 1 \dots n)$$

which result in

$$\sum_{j=1}^m d_j = \sum_{i=1}^n s_i$$

and the non-negativity requirement that

$$X_{ij} \geq 0$$

where

d_j = total deficit slaughter requirements in area j , and

s_i = total shipments of cattle available from area i .

These constraints require that the total surplus must be equal to the total deficit. That is, the sum of the numbers of animals available in the surplus areas must equal the sum of the deficit area slaughter requirements. These two constraints actually define the third constraint that the total surplus in the supply areas equals the total deficit in the slaughter areas.

These equality constraints are necessary to insure that all surplus will be shipped and that all deficits will be filled. In most actual situations, this equality of surplus and deficit will not occur. In the analyses "dummy areas" are set up to overcome this problem. In the event that surplus is greater than deficit, then dummy deficit areas are set up to receive the surplus. In an actual situation the dummy areas could very well be receiving points outside the aggregate of regions under study. The reverse would apply if the deficit was larger than the surplus. Dummy areas would supply the difference.

The requirement that the number of cattle shipped from surplus areas to deficit areas be equal to or greater than zero insures that there can be no negative shipments.

I. ASSUMPTIONS OF THE MODEL

To facilitate using the transportation model certain assumptions must be made concerning the situation of the beef cattle industry and specifying the homogeneity of the animals being marketed.

1. Animals in the same market class and grade are considered to be no different in the various areas in the study.
2. The markets for slaughter cattle and calves are assumed to be perfectly competitive.
3. Transportation costs between areas are considered to be the same throughout the year.
4. Each area must fill its own requirements from its own production before a surplus or deficit is indicated.
5. Areas shipping animals into Tennessee are surplus areas and the amount of surplus is the amount shipped in. Areas receiving shipments from Tennessee are deficit areas by the amount of shipments.*

It should be noted that to satisfy the last assumption, only animals shipped into Tennessee areas or animals shipped out of Tennessee

*This transportation model is designed to consider the optimum routes and allocations, and not to consider better sources of animals. An adequate model to consider the best sources and routes would have to be national in scope.

areas to other areas are included in the study. This assumption obviously excludes animals that are shipped between two areas which are outside of Tennessee because complete data on these shipments were unavailable at the time this analysis was made. With the restriction that only data concerning animals shipped to or from Tennessee were available, only the areas that were the origins or destinations of these animals could be used in the determination of the actual and optimal movement patterns.

These assumptions may not depict the real world situation in every sense but slight deviation from these assumptions will not affect the general nature of the analysis and results.

II. TRANSPORTATIONS COST FUNCTIONS

In order to derive costs for moving animals between regions or areas, shipping distances between all areas had to be established. To do this, one point in each area was selected as the shipping or receiving center for the area. Since much of the data used in this study came from the Southern Regional Livestock Marketing Project SM-23, the points of origin or destination in the various areas were the same as those used in the regional study.

Certain assumptions were necessary to arrive at realistic costs that could be used in the transportation problem, as solved by a digital computer:

1. Costs of transportation per mile per 100 lbs. live animal weight are constant for all routes between areas in each major region but costs between major regions may vary.

2. The variable costs increase directly with distance. That is, the variable cost per mile is constant.

The first assumption requires the use of four cost functions to derive costs for shipping animals between the areas in all regions used in the study. The second assumption allowed a linear cost function in the form:

$$C_t = C_f + C_v X$$

where

C_t = total transportation cost in dollars per 100 lbs. between any two areas.

C_f = fixed cost per 100 lbs.

C_v = cost per 100 lbs. per mile, and

X = highway miles between any set of origin and destination points.

The cost function as used here was developed by members of the Southern Regional Marketing Committee and was derived from data supplied by firms and packers in the southeast.¹

The cost function represents cost of transportation by trucks. This is the primary method of hauling livestock in the southeast. Nearly all livestock sold in the south is hauled from farm to market in trucks or trailers.²

¹Functions and coefficients used for this study were obtained from L. D. Malphrus, Clemson College. A full discussion of procedures used in obtaining these functions will be presented in a forthcoming Southern Cooperative Series Bulletin.

²Jack D. Johnson, Livestock Marketing in the Southern Region, Bulletin No. 26, Southern Cooperative Series, July 1952, p. 93.

Since the C_v coefficient represents the cost per 100 lbs., the equation had to be converted to a per head cost per mile because movements will be analyzed on a per head basis. Since the average weight of animals shipped between Tennessee areas and other areas in the Southeast differed from the average weight of animals shipped between Tennessee areas and areas outside the Southeast, two different average weights were used. The respective average weights were applied to the appropriate cost function which changed the formula to mean:

C_t = total transportation cost in dollars per head between
any two areas.

III. AREAS USED IN THE ANALYSIS

The transportation model used in this study allocates the surplus animals in various areas to fill the deficits in various other areas. These areas must be determined and a center for each area picked. As indicated previously the same areas will be used as in the SM-23 project.

Figure 3 shows the various states and the areas within each state. Table II shows in tabular form the states, areas, and cities used as the shipping or receiving point for each area. Road distances between each set of points was determined. This by definition, gives the distances in miles between any two areas so that the transportation cost per head can then be determined using the transportation cost function.

There exists the possibility for animals to be shipped from or to any of the areas shown in Figure 3, or even outside the Southeast. As

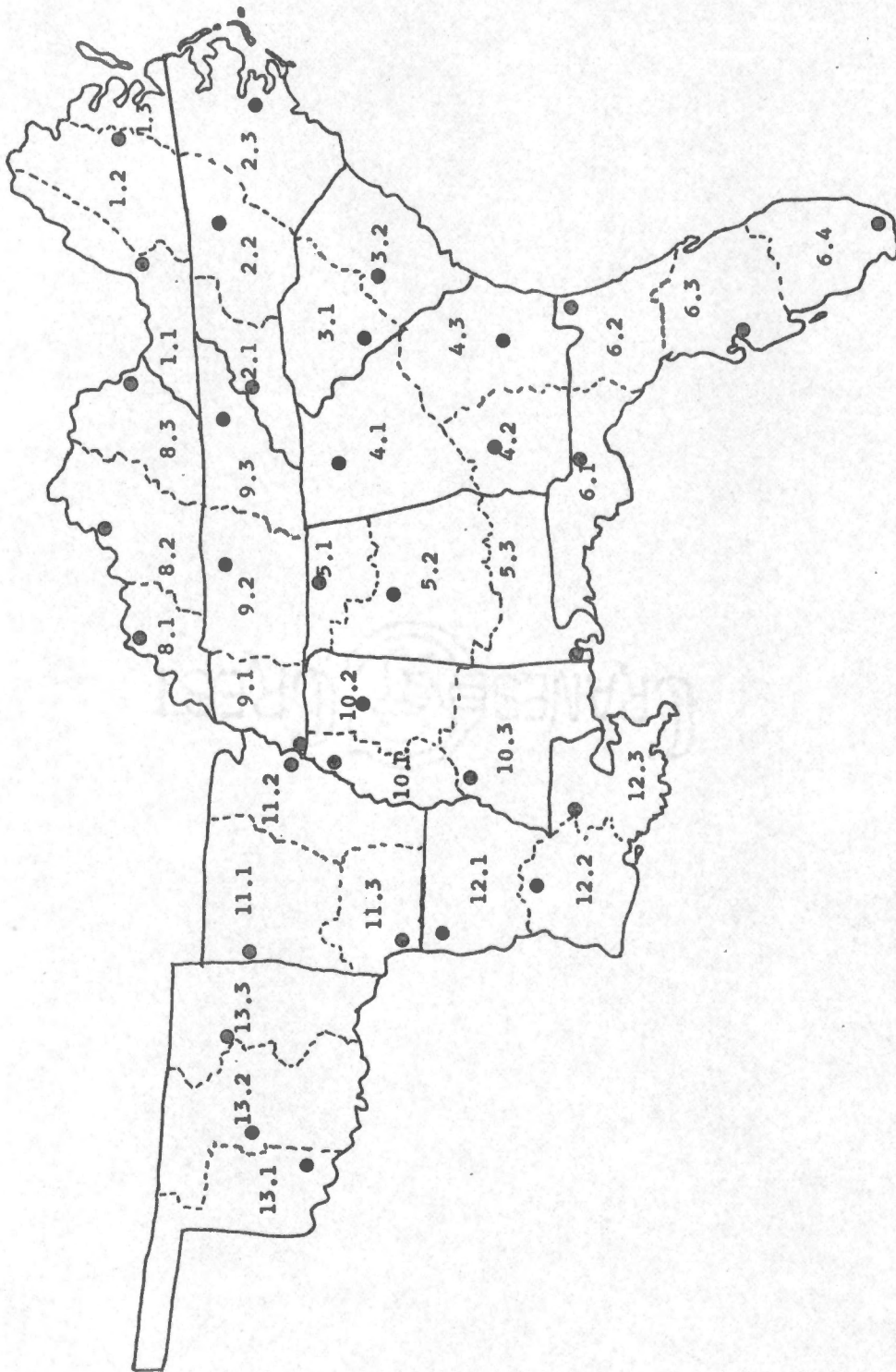


Figure 3. Substate areas used for determination of cattle and calf movement patterns.

TABLE II

AREAS USED IN THE STUDY BY STATE AND SUBSTATE AREA

State	Area	Center
Virginia	1.1	Roanoke
	1.2	Richmond
	1.3	Smithfield
North Carolina	2.1	Asheville
	2.2	Greensboro
	2.3	Kinston
South Carolina	3.1	Greenwood
	3.2	Orangeburg
Georgia	4.1	Atlanta
	4.2	Albany
	4.3	Dublin
Alabama	5.1	Huntsville
	5.2	Birmingham
	5.3	Dothan
Florida	6.1	Quincy
	6.2	Jacksonville
	6.3	Tampa
	6.4	Miami
Kentucky	8.1	Owensboro
	8.2	Louisville
	8.3	Ashland
Tennessee	9.1	Memphis
	9.2	Nashville
	9.3	Knoxville
Mississippi	10.1	Clarksdale
	10.2	West Point
	10.3	Jackson

TABLE II (CONTINUED)

State	Area	Center
Arkansas	11.1	Fort Smith
	11.2	West Memphis
	11.3	Texarkana
Louisiana	12.1	Shreveport
	12.2	Alexandria
	12.3	Baton Rouge
Oklahoma	13.1	Lawton
	13.2	Oklahoma City
	13.3	Tulsa
Areas Outside the Southeast		
Pennsylvania-New York	22	Philadelphia
Ohio	23	Columbus
Indiana	25	Indianapolis
Illinois	27	Chicago
Iowa	29	Des Moines
Missouri	30	Columbia
Nebraska	32	Omaha
Kansas	33	Kansas City
Arizona-New Mexico	36	Phoenix
California	39	San Francisco

pointed out earlier only the areas with animals shipped from and/or to Tennessee will be used as surplus or deficit areas. Many of the areas shown in Figure 3 are not included as destinations or origins since no shipments with these regions were reported during the period covered.

CHAPTER III

ESTIMATED ACTUAL MOVEMENTS OF SLAUGHTER

CATTLE AND CALVES

The expanded data were used to determine the actual movements of cattle and calves during the four quarters of 1962. Cattle and calf movements were analyzed separately. Cattle were classified as cows, bulls, heifers and steers weighing 500 pounds and over and calves as animals weighing less than 500 pounds. The cattle were divided into two grade groups. The good and above group consisted of slaughter grades prime, choice, and good. The other group, standard and below, included the remainder of the slaughter grades of cattle. Calves were grouped as follows: (1) prime and choice, (2) good and standard, and (3) below standard. Since there was very little inter-area shipment of animals grading below standard, the first group, prime and choice, and the second group, good and standard were the only grade-groups of calves analyzed.

The data gathered by weeks were expanded to provide quarterly estimates for 1962. The movements for each grade group for cattle and calves were examined for each quarter of the year.

The movements of cattle and calves that were pertinent to this study were the inter-area movements of animals that were shipped to and/or from the three areas in Tennessee. For brevity and exposition, "movements" is synonymous to "shipments" and both are defined as inter-

area transfer of animals. Since the total volumes of movements varied from quarter to quarter and among grade groups the analysis was made showing each movement as a percentage of total movements for that grade group for that quarter. In most cases the use of numbers of animals in depicting movement patterns would have been confusing due to the variation in total movements among quarters and for different grade groups. For example, an outshipment of 1,000 animals from an area in one time period could have accounted for 60 per cent of total movements, but in another period it might account for only 5 per cent of total movements. For this reason only percentages were used in many cases.

In calculating percentages of total shipments to be shown, total movements for a grade group of animals for a quarter were defined as numbers of animals moving from any one area used in the study to any other area. Only animals moving across area boundaries, as delineated in Table II were used as total movements.

The figures that follow show the movements of animals into and out of the three substate areas in Tennessee and the approximate volumes of movements. These figures include more than 97 per cent of the volume of movements. The remaining three per cent were not shown since in most cases they consisted of small shipments of only a very few animals over each route. Their inclusion would have tended to complicate the diagrams with relatively insignificant movements.

I. CATTLE MOVEMENTS

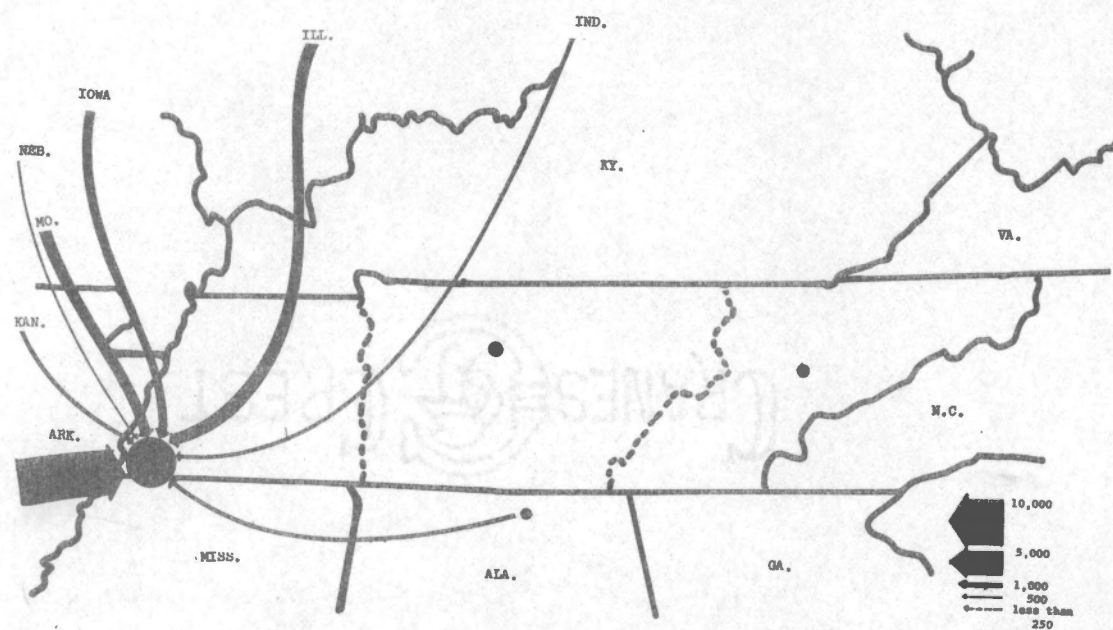
Good and Above, First Quarter

In the group graded good and above, Figure 4a shows that only the West Tennessee area had any inter-area movements during the first quarter. The animals were moved into this area with no outshipments or cross hauls. There seemed to be no apparent inefficiencies here.

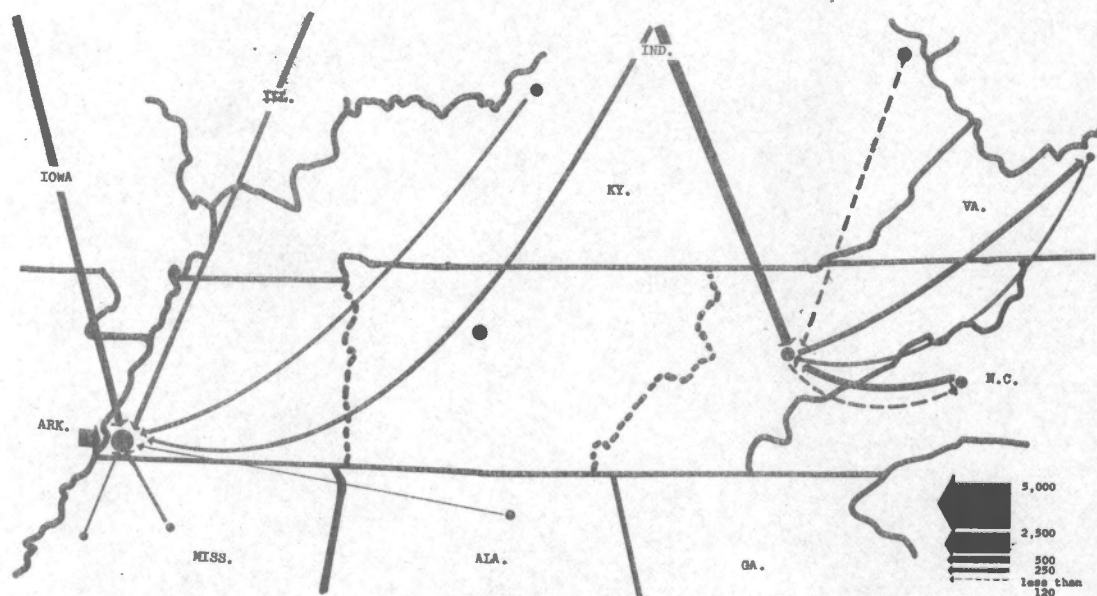
Standard and Below, First Quarter

Most of the animals graded standard and below were shipped into West Tennessee during the first quarter. Of the total number moving into and out of Tennessee areas, 65 per cent were shipped into West Tennessee. More than half of this group came from Arkansas and the rest came from seven other origins (Figure 4b). The remainder of the movements indicated that, of the total movements, 23 per cent were shipped into East Tennessee and 10 per cent were shipped out of this area.* In two instances, shipments were moving in opposite directions. One instance was the shipment of 170 animals into East Tennessee from Virginia and the shipment of 585 animals of the same grade from East Tennessee to the same area in Virginia. The other instance was the

*The percentages in some cases may add up to be larger than 100. These percentages were calculated by dividing the number moving into or out of a substate area by the total volume moved. In the cases where the animals are moving between areas in Tennessee, the per cents would be calculated for both areas and the sum for all per cents would be greater than 100.



a.



b

Figure 4. Actual shipments of slaughter cattle during the first quarter, 1962, graded (a) good and above, and (b) standard and below.

shipping of 533 animals into East Tennessee from North Carolina and the shipment of 39 animals from East Tennessee to the same area in North Carolina.

Good and Above, Second Quarter

The movements of good and above (Figure 5a) from April through June show a marked difference from first quarter movements. There were approximately 14,654 animals shipped into West Tennessee, which represented 62 per cent of the movements of animals between all points considered. Middle Tennessee showed some cross shipments. About 23 per cent were shipped into this area and about one per cent shipped out. Shipments in East Tennessee showed more of a tendency toward unnecessary cross hauls. In this area almost 13 per cent were shipped in and about one per cent were shipped out.

Standard and Below, Second Quarter

There was a relatively low volume of shipments of standard and below grades of cattle from April through June (Figure 5b). A total of 8,562 animals were shipped on an inter-area* basis. Of this total, 49 per cent were shipped into West Tennessee while only 2 per cent were shipped out of the same area. There were relatively light movements in Middle Tennessee. Only 2 per cent of the total moved into this area and 19 per cent moved out. Forty-seven per cent of the total moved into

*Inter-area was defined as between any of the areas designated in Table II.

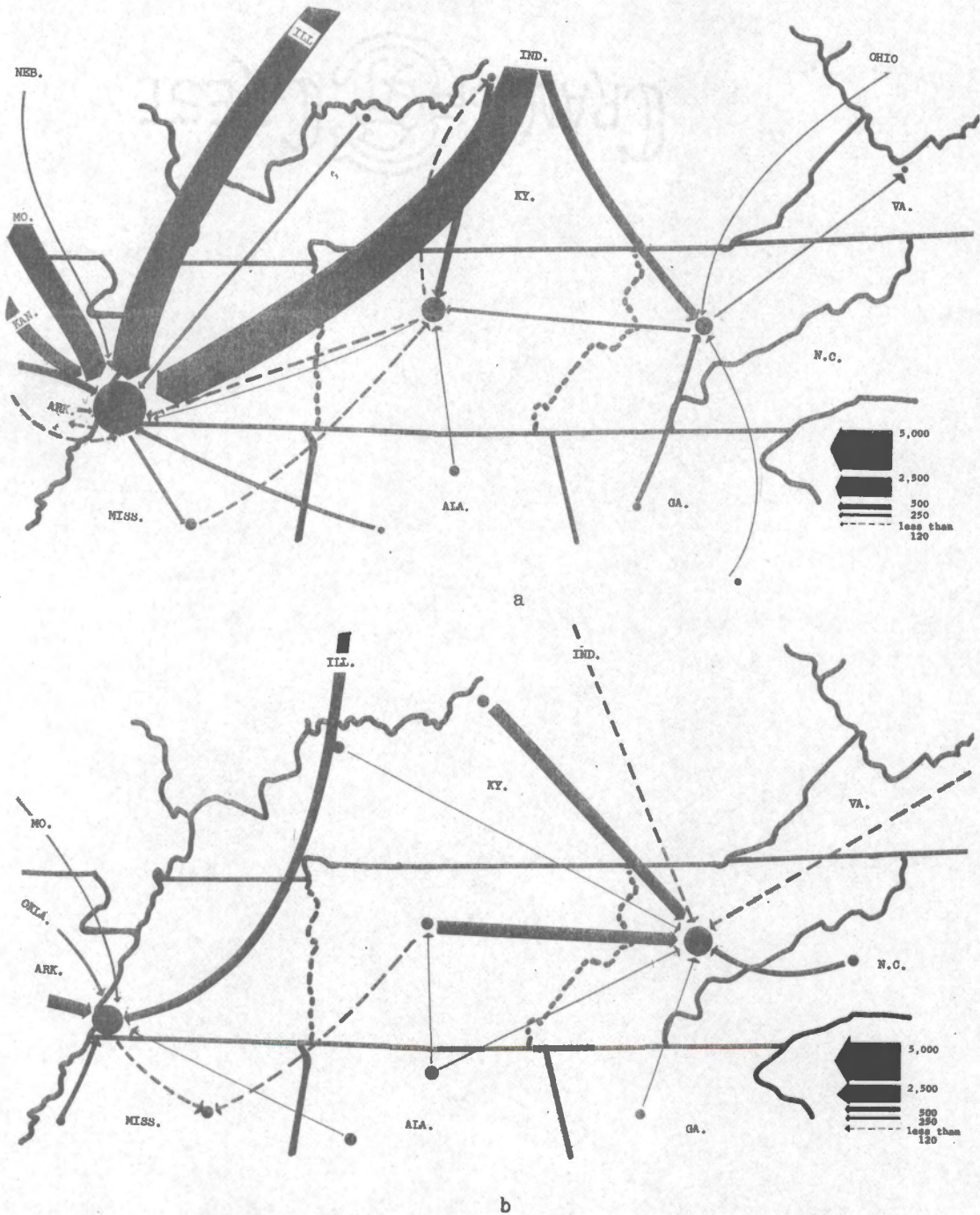


Figure 5. Actual shipments of slaughter cattle during the second quarter, 1962, graded (a) good and above, and (b) standard and below.

East Tennessee while there were no outshipments.

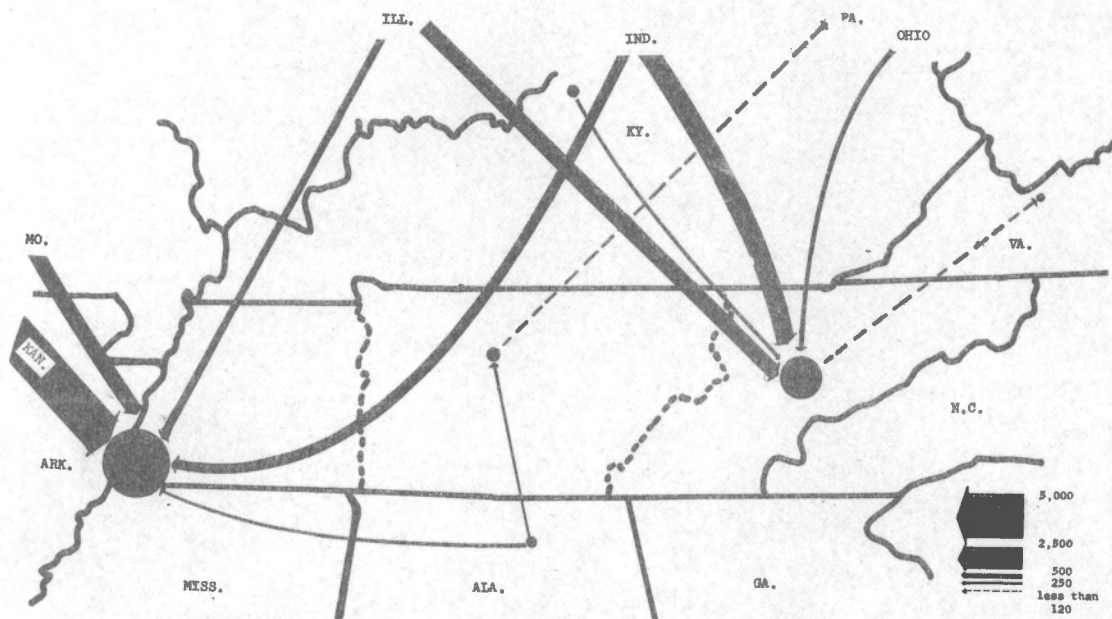
Good and Above, Third Quarter

All three regions of the state were deficit areas with respect to animals graded good and above from July through September. Figure 6a shows that only one area, East Tennessee, had outshipments of animals and this was overshadowed by inshipments of 6,331 animals, which represented 35 per cent of the 18,265 animals moved. Inshipment into West Tennessee represented 64 per cent of the movements, or approximately 11,650 animals. The Middle Tennessee area had inshipments of only 250 animals which was only 1 per cent of total movements. West and East Tennessee had the largest deficits in this case.

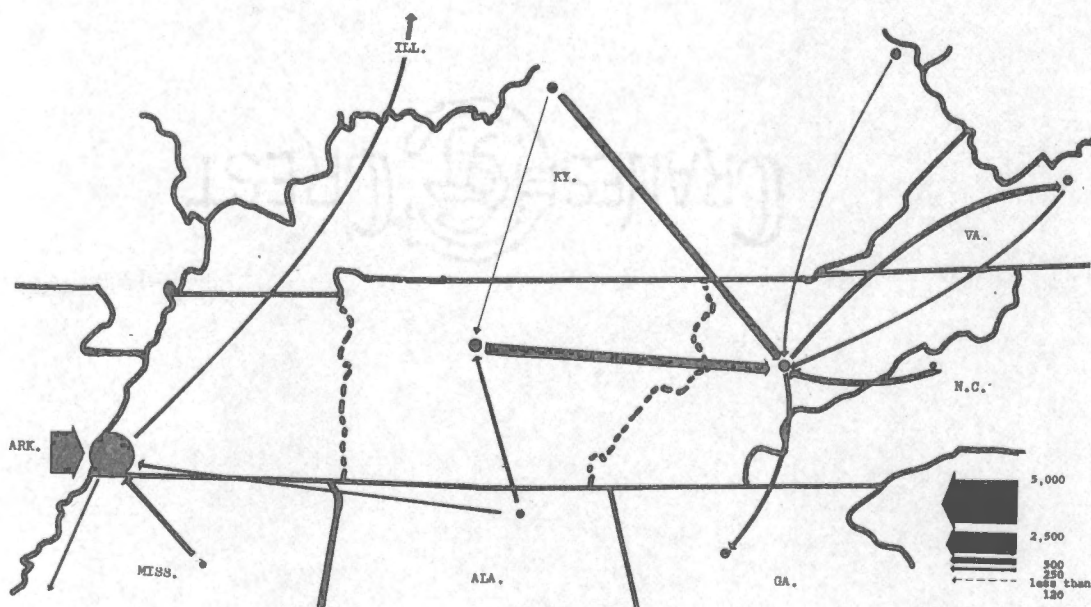
Standard and Below, Third Quarter

Movements of standard and below animals in the third quarter were varied and inconsistent (Figure 6b). There were an estimated 14,001 animals moved, with both inshipments and outshipments in all three areas of the state. In West Tennessee animals representing 46 per cent of the total movements were shipped into this area with 6 per cent being shipped out. In Middle Tennessee the opposite occurred: 3 per cent were shipped in and 18 per cent were shipped out. The pattern in East Tennessee resembled the West Tennessee situation: 38 per cent of total movements were shipped in and 4 per cent were shipped out.

During this quarter animals were shipped into Middle Tennessee from areas outside the state and animals were shipped from Middle to



a



b

Figure 6. Actual shipments of slaughter cattle during the third quarter, 1962, graded (a) good and above, and (b) standard and below.

East Tennessee. Also in this quarter 598 animals were shipped to Roanoke from East Tennessee and 416 animals shipped from Roanoke to the same Tennessee area.

Good and Above, Fourth Quarter

Most of the movements of good and above animals in the fourth quarter were inshipments into West Tennessee (Figure 7a). Of the total movements, 77 per cent of the animals were shipped into this area. Less than one per cent of the total were shipped out. The Middle Tennessee area had movements of animals in opposite directions but these movements were relatively small. Two hundred twenty-eight animals were shipped to East Tennessee from Middle Tennessee and 254 were shipped in the opposite direction into Middle Tennessee from East Tennessee. East Tennessee had inshipments amounting to 19 per cent of total movements and outshipments of approximately two per cent. The large deficit in West Tennessee was the overshadowing factor in this quarter.

Standard and Below, Fourth Quarter

As shown in Figure 7b, both West and East Tennessee were deficit areas while Middle Tennessee was a surplus area of standard and below animals in the fourth quarter. The 9,694 animals shipped into West Tennessee were the largest movements of any of the three areas. This number represented 57 per cent of total shipments. East Tennessee had inshipments of 6,530 animals or 38 per cent, but outshipments accounted for 2 per cent of total movements. The Middle Tennessee area had out-

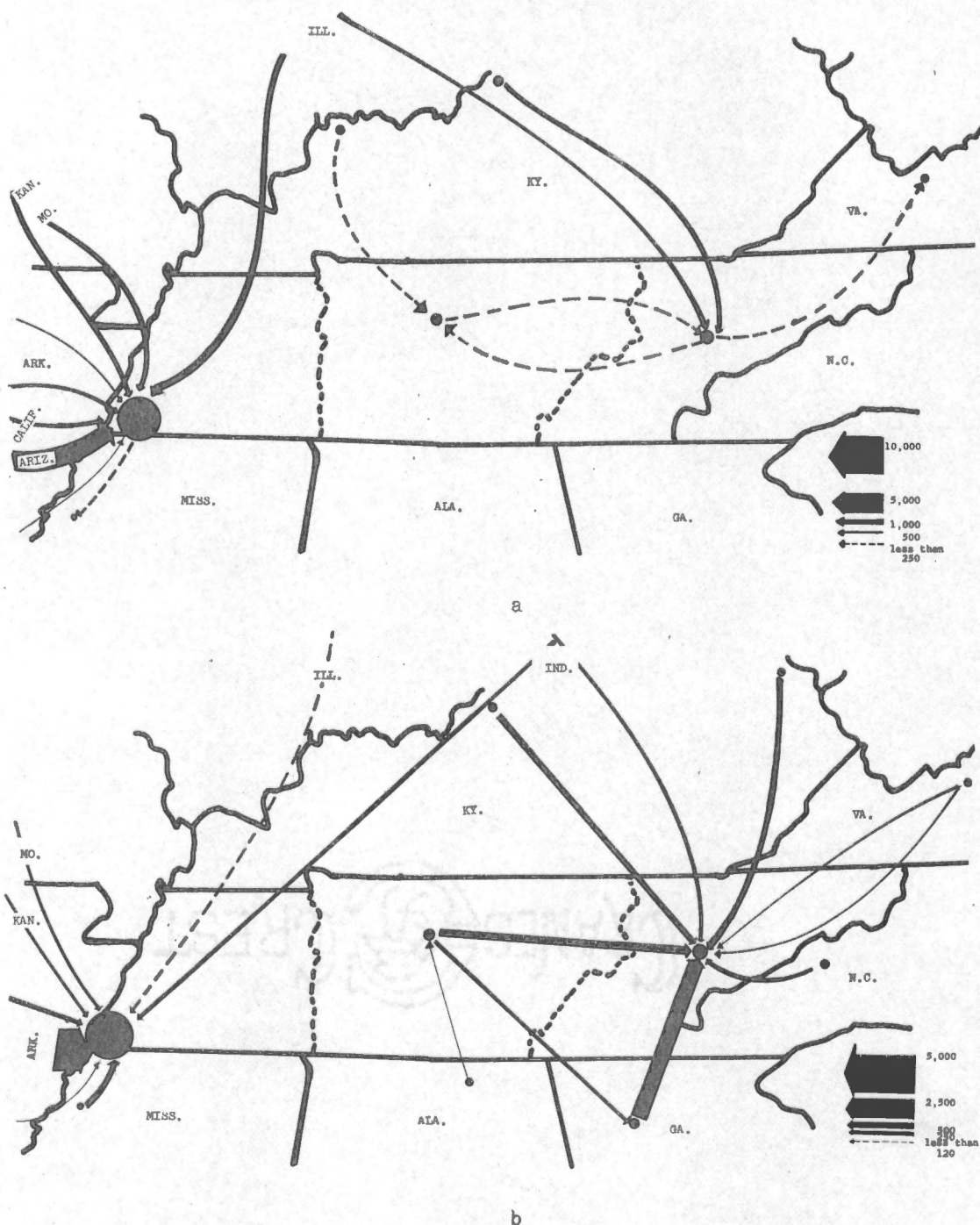


Figure 7. Actual shipments of slaughter cattle during the fourth quarter, 1962, graded (a) good and above, and (b) standard and below.

shipments of 2,477 animals which was 15 per cent of total movements, and inshipments of one per cent of the total shipments. In one instance animals were shipped in opposite directions, presumably over the same routes. The East Tennessee area had 248 animals shipped from Roanoke, Virginia, and 299 animals were shipped to that same area from East Tennessee.

II. CALF MOVEMENTS

Prime and Choice, First Quarter

Most of the movements of calves graded prime and choice are outshipments from Middle and East Tennessee (Figure 8a). Middle Tennessee had outshipments amounting to 52 per cent of total movements and 35 per cent of total movements were shipped out of East Tennessee. West Tennessee had no inshipments, and outshipments of one per cent of total shipments. Almost 13 per cent of total movements were shipped into Middle Tennessee, compared to the 52 per cent outshipments. One inconsistency might exist in this area. Approximately 2,820 animals were shipped into Middle Tennessee from Louisville and 1,105 were shipped from Middle Tennessee to Indiana. These shipments represented 11 per cent and 4 per cent of total shipments, respectively. As shown in the figure all three Tennessee areas are surplus areas.

Good and Standard, First Quarter

Relatively small total movements of good and standard calves occurred in January, February, and March. Total movements amounted to

approximately 1,768 animals. West Tennessee had inshipments of 338 animals and outshipments of 221 animals. These shipments amounted to 19 per cent and 12 per cent of total movements, respectively. Eighty animals were shipped from Middle Tennessee to West Tennessee and 220 animals were shipped from West back to Middle Tennessee (Figure 8b). The sum of these shipments represented almost 19 per cent of total calf movements for the quarter. This shipment in opposite directions could represent an inefficiency. East Tennessee had inshipments amounting to 60 per cent and outshipments of 7 per cent of total movements.

Prime and Choice, Second Quarter

During the second quarter, West Tennessee had similar movements to those occurring the first quarter. No movements of prime and choice calves occurred in this area (Figure 9a) during the second quarter. Inshipments in East Tennessee were almost equal during this quarter. There were 21 per cent of total movements shipped in and 24 per cent shipped out. There was a larger difference between inshipments and outshipments in Middle Tennessee but still a large number was shipped in. There were approximately 10,056 animals shipped in and 18,559 animals shipped out. These numbers were 24 and 43 per cent of total shipments, respectively. Further analysis will be made of shipments in this quarter.

Good and Standard, Second Quarter

Approximately the same number of good and standard calves were shipped inter-area in the second quarter as in the first quarter. A

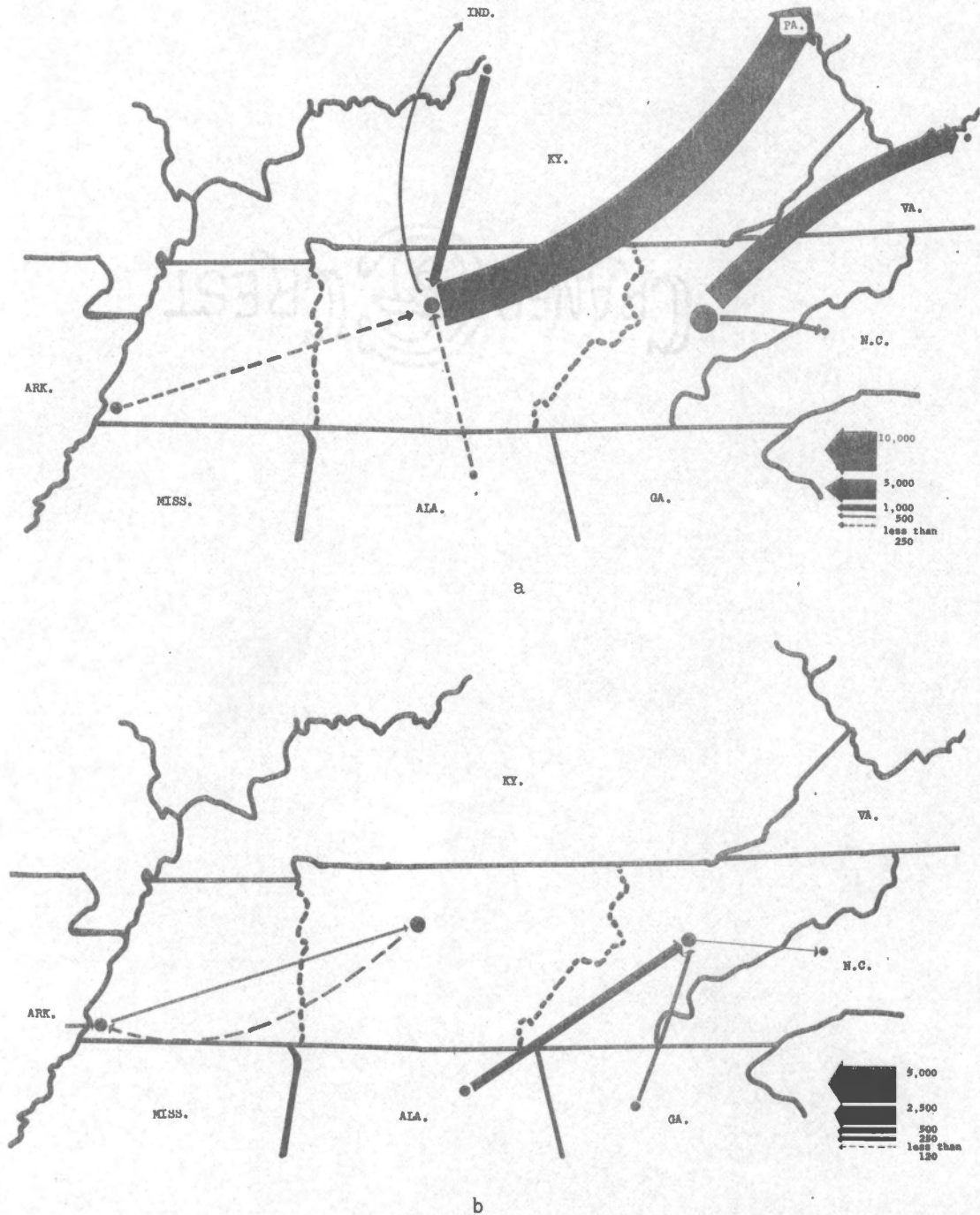


Figure 8. Actual shipments of slaughter calves during the first quarter, 1962, graded (a) prime and choice, and (b) good and standard.

total of 1,912 calves were shipped and about 95 per cent of the shipments were in Middle and West Tennessee (Figure 9b). Inshipments and outshipments from East Tennessee accounted for only about 5 per cent of the total movements. Movements of calves into Middle Tennessee accounted for 66 per cent of movements while outshipments amounted to only 5 per cent. West Tennessee had almost equal inshipments and outshipments, which composed 17 and 16 per cent of total shipments, respectively. There seems to be little inconsistency here since the pattern of movements is in a northeasterly direction, with the exception of the movements from Kentucky to Middle Tennessee.

Prime and Choice, Third Quarter

Here again, as in previous quarters, there were no movements of prime and choice animals into or out of West Tennessee (Figure 10a). Even with no shipments in West Tennessee, there was a relatively large total shipment of calves, amounting to 36,062 animals. Inshipments and outshipments were fairly close, percentage wise, in both Middle and East Tennessee. Middle Tennessee had inshipments of 34 per cent of total and outshipments of 25 per cent. Inshipments into East Tennessee amounted to 30 per cent and outshipments were 32 per cent of total movements. An inefficiency here, if it exists, could be of consequence because of the large volume of calves moved.

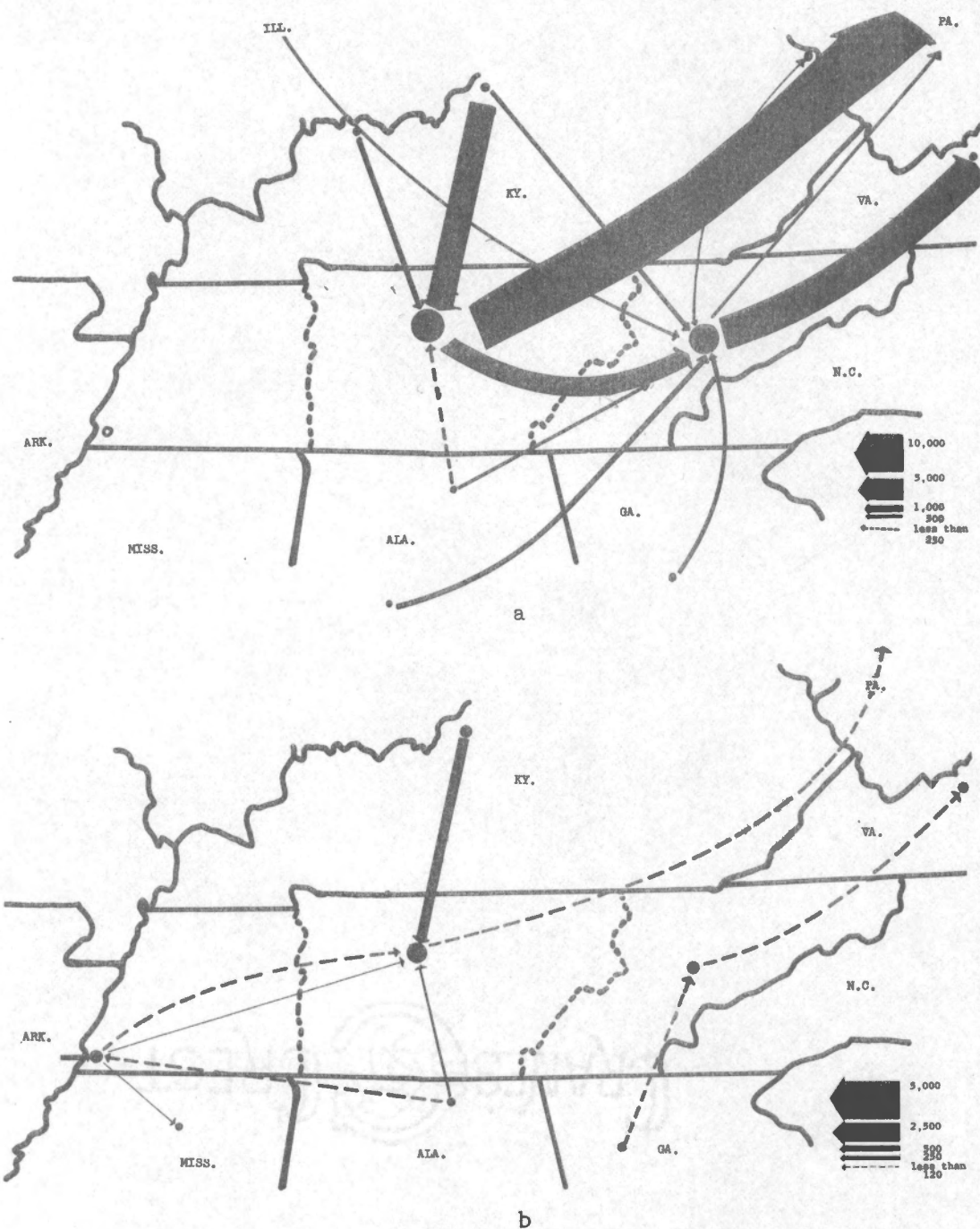


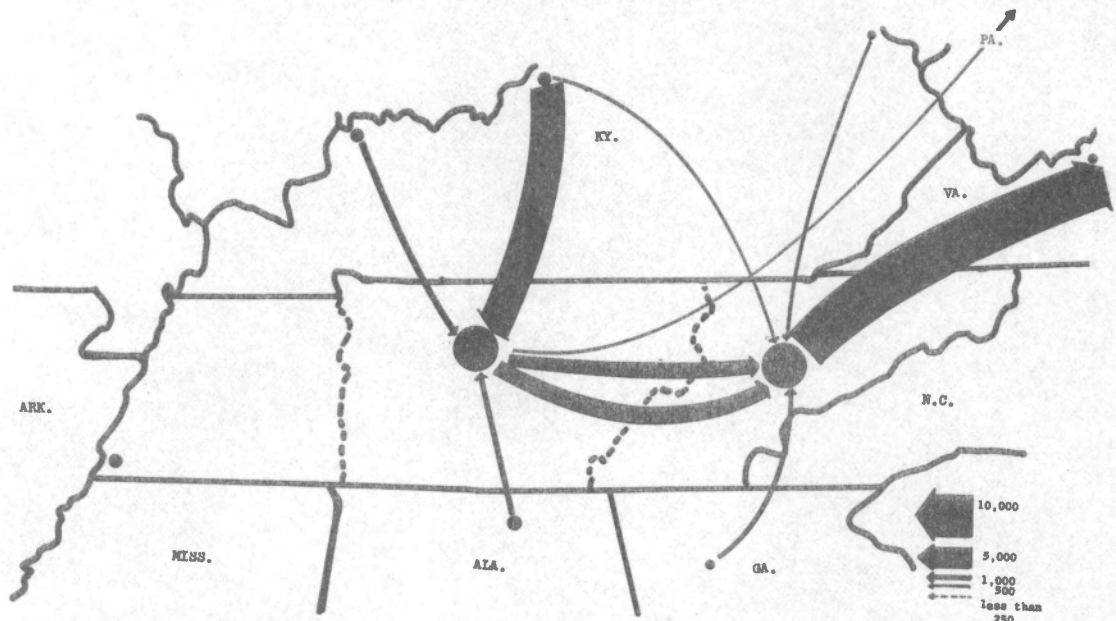
Figure 9. Actual shipments of slaughter calves during the second quarter, 1962, graded (a) prime and choice, and (b) good and standard.

Good and Standard, Third Quarter

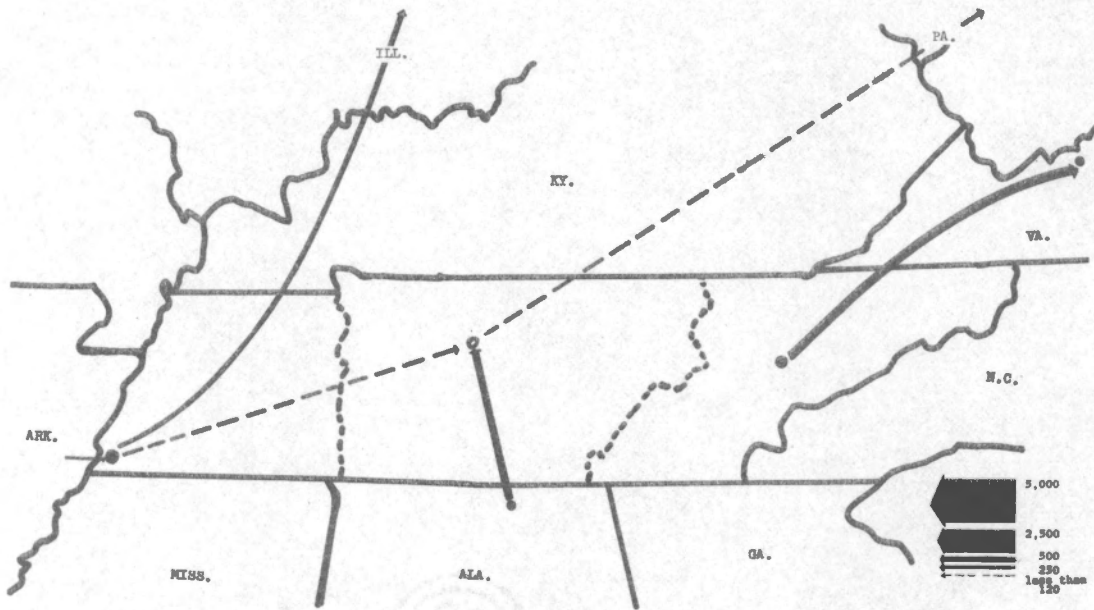
Movements of good and standard calves were small in total volume in the third quarter, 4,017 animals, but there was still a considerable increase over the previous two quarters. West Tennessee had similar volumes of inshipments and outshipments (see Figure 10b), which amounted to 6 per cent and 11 per cent of total movements, respectively. Inshipments into Middle Tennessee comprised 41 per cent but most of these animals came from one source, Huntsville, Alabama. East Tennessee had outshipments of 43 per cent and all of those went to Roanoke, Virginia. There seemed to be little cross shipment.

Prime and Choice, Fourth Quarter

During the fourth quarter total shipments of prime and choice calves were lower than the previous two quarters. The total number of calves shipped across area boundaries was estimated at 26,460 animals. Most of the shipments were into and out of East Tennessee (Figure 11a). Outshipments were 45 per cent of the total shipments and inshipments were 24 per cent. Inshipments came from several sources but all outshipments from East Tennessee were to Roanoke, Virginia. As in previous quarters, there were inshipments from Middle to East Tennessee but this was the first instance that prime and choice calves were shipped from West Tennessee to the Eastern substate area. Middle Tennessee had inshipments and outshipments of 29 per cent and 11 per cent, respectively. Both West and East Tennessee were surplus areas and Middle Tennessee



a



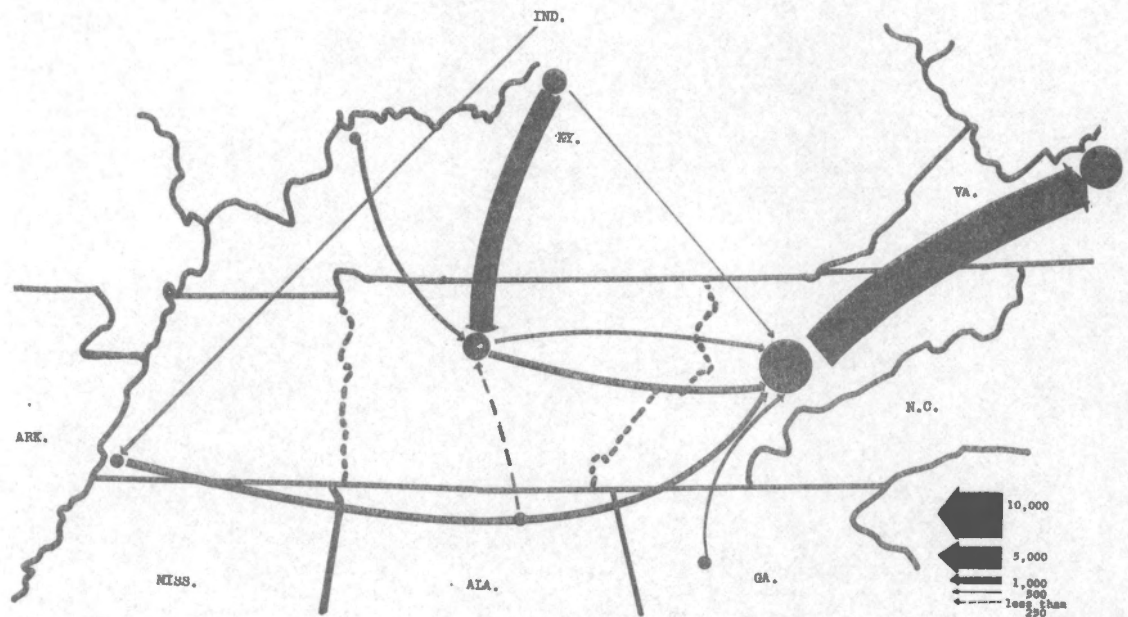
b

Figure 10. Actual shipments of slaughter calves during the third quarter, 1962, graded (a) prime and choice, and (b) good and standard.

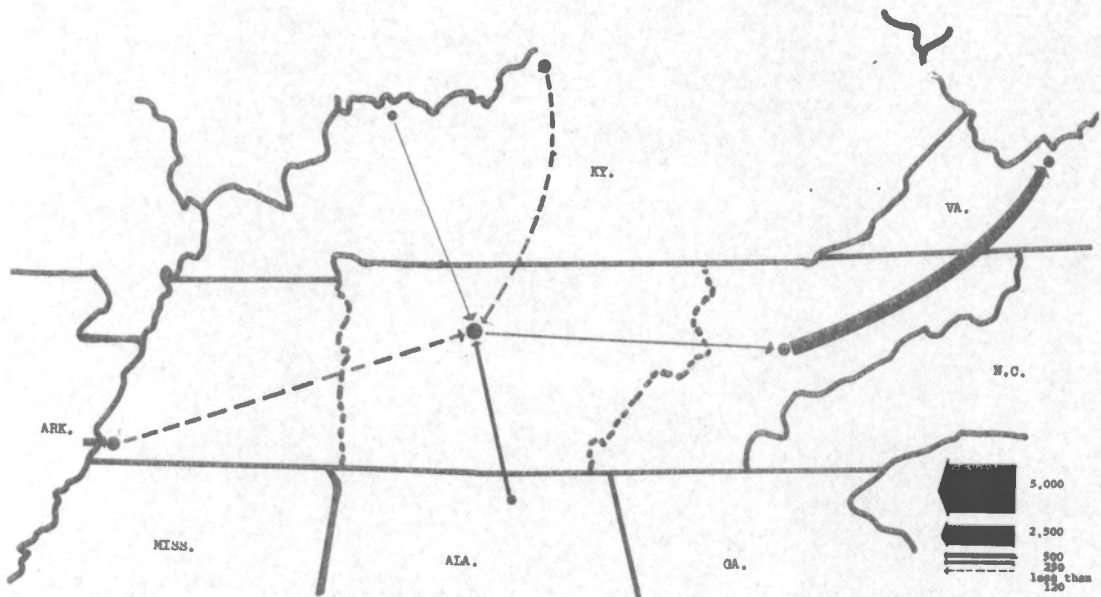
was a deficit area. This would suggest that shipments were going in the wrong direction from Middle to East Tennessee.

Good and Standard, Fourth Quarter

Total shipment of good and standard calves during the fourth quarter was 5,463 animals, which was higher than any of the three previous quarters. West Tennessee had inshipments from Arkansas which were 12 per cent of total shipments. Outshipments from West Tennessee amounted to only one per cent. Middle Tennessee had more evidence of cross hauls with 13 per cent inshipments and 3 per cent outshipments. Both of these areas had net inshipments which made them deficit areas. East Tennessee was a surplus area with 72 per cent outshipments and 3 per cent of total inshipments. With Middle Tennessee as a deficit area and East Tennessee as a surplus area, the shipment of 150 animals from Middle to East is probably in the wrong direction (Figure 11b).



a



b

Figure 11. Actual shipments of slaughter calves during the fourth quarter, 1962, graded (a) prime and choice, and (b) good and standard.

CHAPTER IV

OPTIMUM MOVEMENTS OF SLAUGHTER CATTLE AND CALVES

The optimum system of movements was determined by use of the transportation model described in Chapter II. The movements were "optimum" in the sense that they would minimize the total transportation cost of moving the specified numbers of animals from the surplus areas to fill the requirements of specified deficit areas. The analysis designates areas that shipped animals into Tennessee as "surplus areas" and designates areas that received shipments of animals from Tennessee as "deficit areas." For this reason the number of "surplus" animals shipped equaled the number of "deficit" animals received for each grade group for each quarter and the activation of dummy areas was not necessary.

In many cases there were actual movements in opposite directions between an area in Tennessee and another area.* The net outshipment or inshipment along with other shipments for the Tennessee area determined whether that area was designated as surplus or deficit. The assumptions of the transportation model used required that each area fill its own requirements before any outshipment or inshipment occurred. Then the net outshipment or net inshipment was used to measure the quantity of "surplus" or "deficit" animals.

*See Figures 4b, 6b, 7a, 7b, and 8b in Chapter III.

It should be noted that shipments between areas outside of Tennessee occurred in the optimum solution. Shipments between areas outside of Tennessee were not included in the actual movement patterns but since some of these areas were surplus areas and others were deficit areas, shipments between these areas were allowed in the optimal solution. These shipments between areas outside of Tennessee are shipments of animals determined in the "actual patterns" but are least cost allocation of surplus animals to fill deficits in other areas. These shipments do not include shipments that may have occurred that were not shown as "actual movements." These shipments between areas outside of Tennessee indicate that actual movements were not optimal by at least the volume contained in these shipments.

The system as described below is optimal in accordance with the assumptions stated previously. This ideal system will be discussed below as if it had actually existed in order to develop a comparison between this system and actual movements.

I. OPTIMUM CATTLE MOVEMENTS

Good and Above, First Quarter

During January through March there were no outshipments from Tennessee of cattle graded good and above (Figure 12a). Of the total movements* of 14,547 animals into Tennessee, only 1.3 per cent, or 182

*In the optimal system the total surplus equals the total deficit and the total number of animals moved. Hereafter, the terms total surplus, total deficit, and total movements will refer to the same number of animals of a particular grade in a specified quarter of the year.

animals moved into East Tennessee. The remaining 98.7 per cent (14,365) were shipped into West Tennessee. Two areas, Illinois and Missouri, supplied more than half the animals to West Tennessee while eight other areas supplied the remainder. Two areas supplied the small number to East Tennessee. There were no movements recorded to or from Middle Tennessee.

Standard and Below, First Quarter

In the first quarter all three Tennessee areas were deficit areas, in the production of standard-and-below cattle, as shown in Figure 12b. The West Tennessee area had the largest deficit--3,978 animals, or 75 per cent of the 5,304 animals moved. East Tennessee's deficit amounted to only 15 per cent (819 animals) of total movements. This deficit in East Tennessee was filled primarily by shipments from Western North Carolina and Indiana. Middle Tennessee had a negligible deficit of 91 animals, or only 2 per cent of total movements.

Good and Above, Second Quarter

During the second quarter all three sections of Tennessee showed deficits of good-and-above animals (Figure 13a). Although the deficit in Middle Tennessee was comparatively small, 6 per cent of a total of 22,528 animals, the deficit was 1,428 animals. East Tennessee had a much larger deficit this quarter than during the first quarter. The deficit was 12 per cent of total shipments, or 2,799 animals. More than half the animals allocated to fill this deficit came from Indiana and the remainder

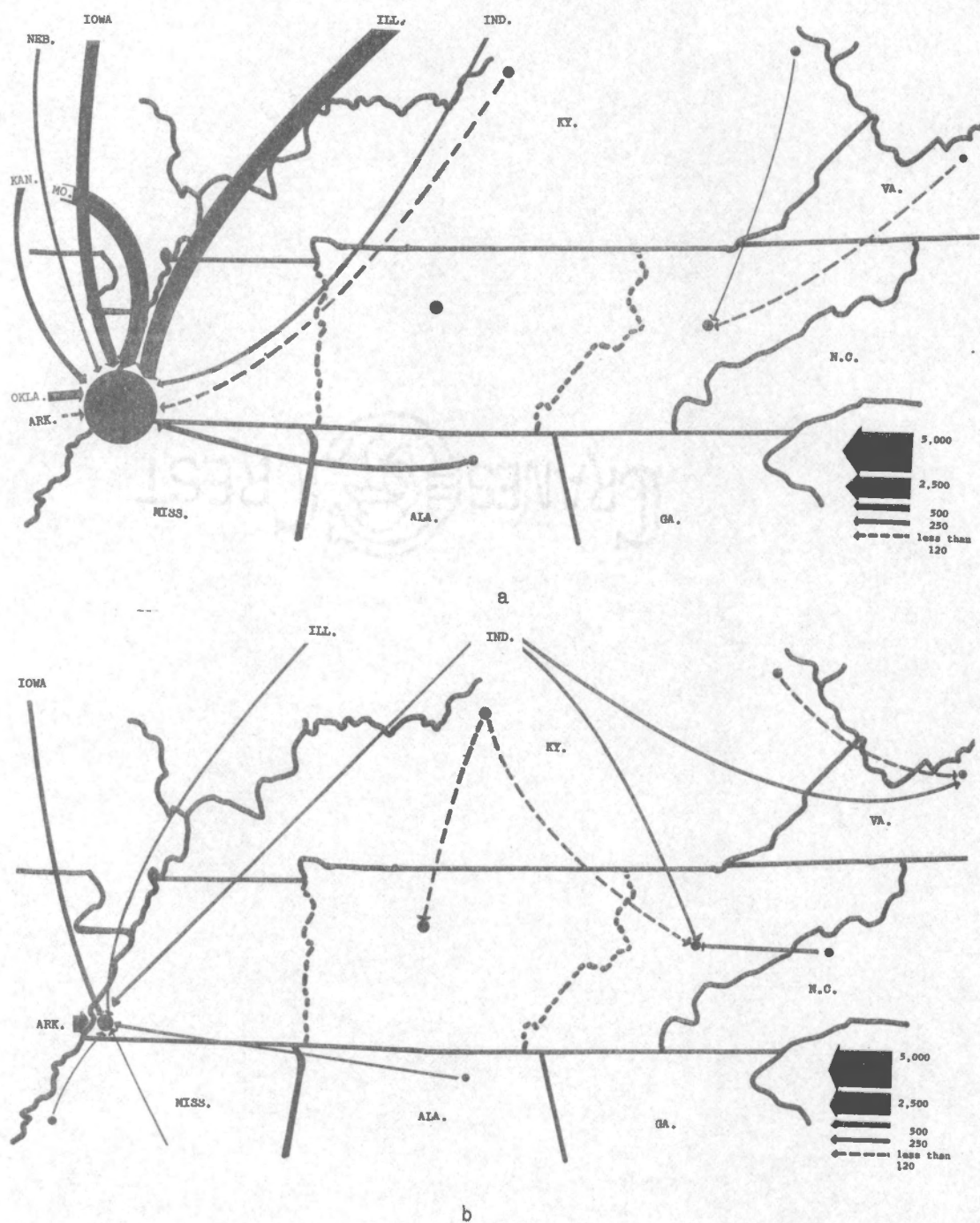


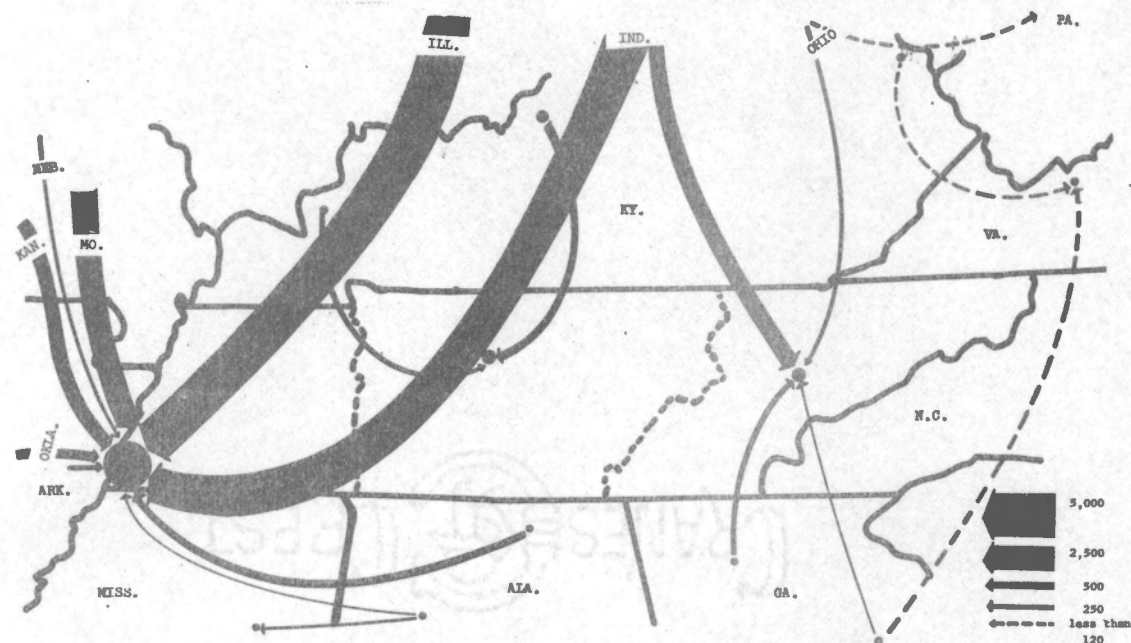
Figure 12. Optimum shipments of slaughter cattle during the first quarter, 1962, graded (a) good and above, and (b) standard and below.

came from Atlanta and Dublin, Georgia, and Ohio. West Tennessee had a smaller percentage of total inshipments, compared to those in the first quarter, but the absolute number of animals was larger. There were 17,956 animals shipped into West Tennessee which was 80 per cent of the 22,528 total animals allocated in the shipments.

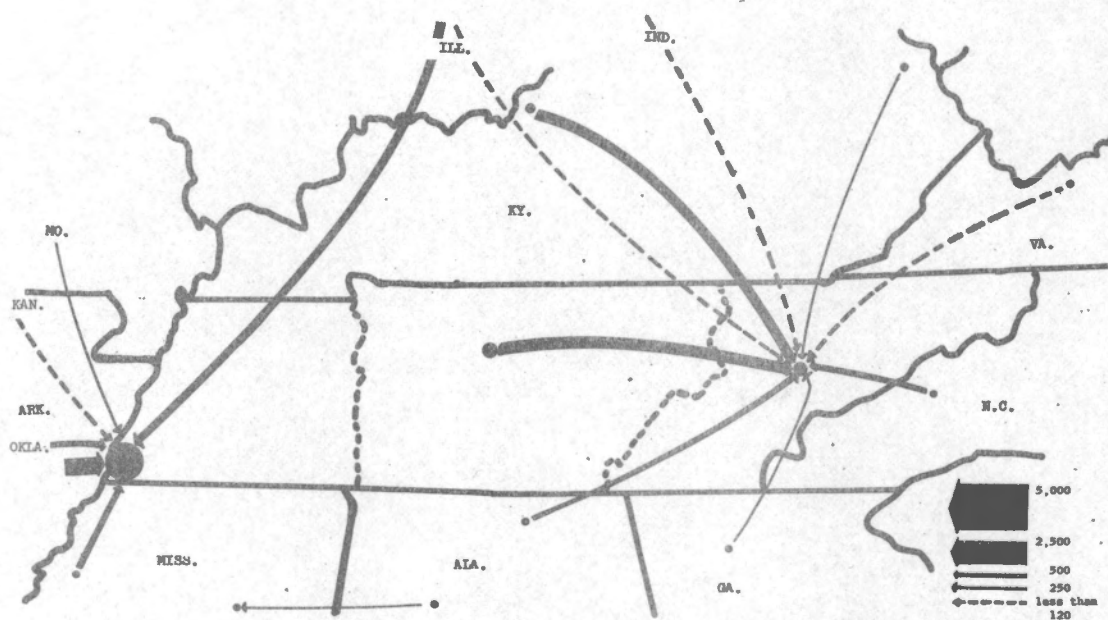
There were 345 animals, or almost 2 per cent, shipped from areas outside of Tennessee to other areas outside of Tennessee. These were small shipments to Pennsylvania, Roanoke, and West Point, Mississippi.

Standard and Below, Second Quarter

Figure 13b shows East and West Tennessee as deficit areas and Middle Tennessee as a surplus area in the production of standard-and-below cattle for second quarter. The surplus during this quarter was 17 per cent of total movements and all of these 1,399 animals were allocated to East Tennessee. The deficit in East Tennessee (49 per cent or 4,022 animals) was much larger in the second quarter than in the first. Over half of this deficit was filled by shipments from Louisville and Middle Tennessee. West Tennessee had a deficit of 49 per cent of total deficit or 4,039 animals. About half the animals in these shipments came from West Memphis, Arkansas, and the remainder from various other areas. Only 2 per cent, or 124 animals were shipped between areas outside of Tennessee. There was a total of 8,185 animals shipped during this quarter as compared to 5,304 animals shipped during the first quarter.



a



b

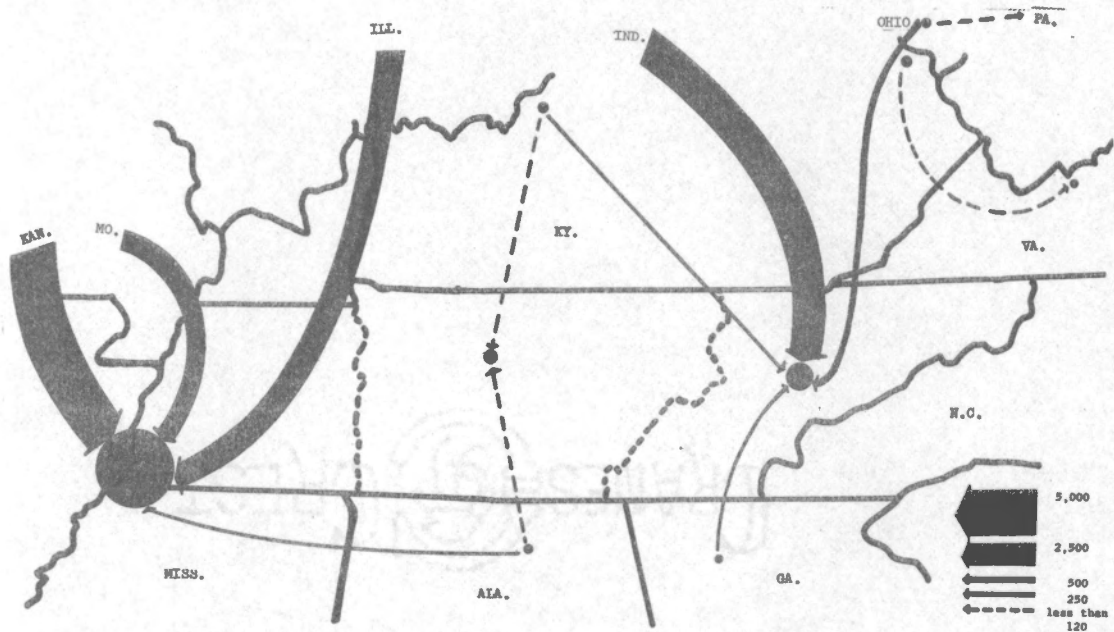
Figure 13. Optimum shipments of slaughter cattle during the second quarter, 1962, graded (a) good and above, and (b) standard and below.

Good and Above, Third Quarter

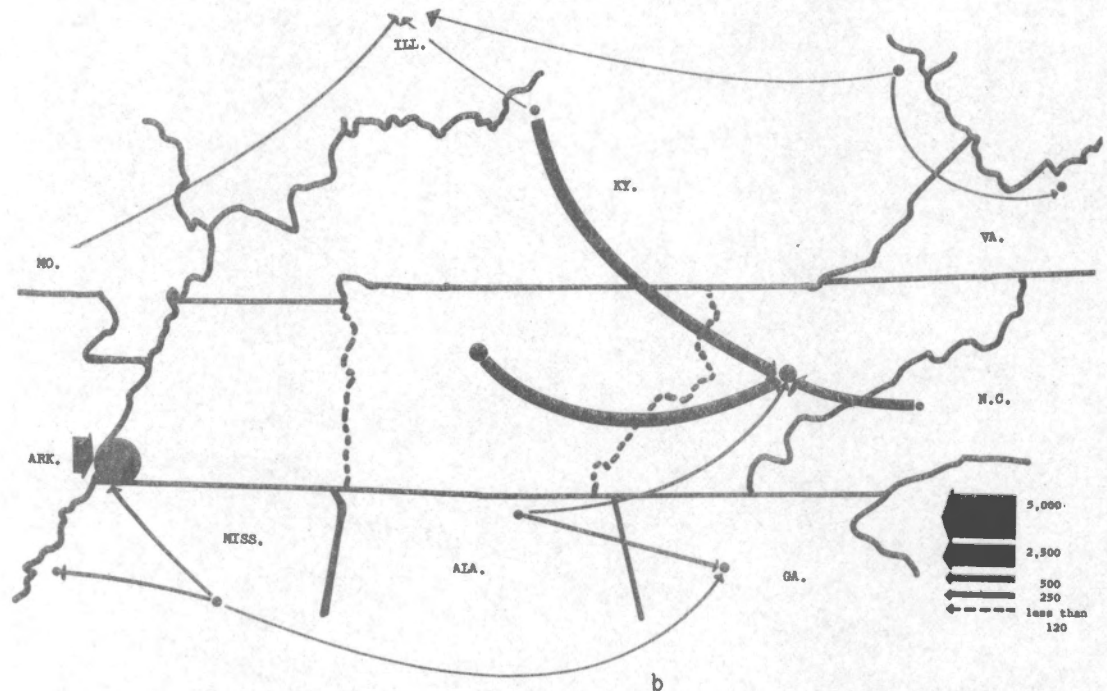
Analysis of the third quarter's movements shows a decrease of good-and-above animals shipped as compared to the second quarter. A total of 18,226 animals were shipped from surplus to deficit areas. All three Tennessee areas were shown as deficit (Figure 14a). West Tennessee again had the largest deficit, which was 11,973 animals or 66 per cent of total deficit for the system for this grade group for this quarter. This area has had a steady decrease in the size of its deficit with each succeeding quarter. The shipments into West Tennessee were large in volume from only four out-of-state areas. East Tennessee has had an increasing deficit, both in numbers and as per cent of the total number shipped to deficit areas. During the third quarter, the deficit was 33 per cent of the total--5,980 animals. Middle Tennessee had a relatively insignificant deficit of 1.3 per cent or 234 animals. Small shipments between areas outside of Tennessee of 13 animals from Ohio to Pennsylvania and 26 animals from Ashland to Roanoke comprised less than 2 per cent of total shipments.

Standard and Below, Third Quarter

During the third quarter, 11,969 standard-and-below animals were shipped from surplus areas to deficit areas. Shipments of 1,365 animals between areas outside Tennessee accounted for 11 per cent of total shipments. The Chicago and Atlanta areas received 442 animals and 507 animals respectively from sources outside Tennessee. The remainder were shipments from Ashland to Roanoke and West Point to Clarksdale, Mississippi.



a



b

Figure 14. Optimum shipments of slaughter cattle during the third quarter, 1962, graded (a) good and above, and (b) standard and below.

The remaining 89 per cent were shipped to West and East Tennessee, which received 50 and 39 per cent, respectively. The 5,937 animals shipped to West Tennessee came primarily from West Memphis. Of the 4,667 animals allocated to East Tennessee, about 40 per cent of them or 1,989 animals came from Middle Tennessee. The remainder came from Huntsville, Asheville, and Louisville (Figure 14b).

Good and Above, Fourth Quarter

There were some shipments of good-and-above cattle between areas outside of Tennessee, but these were limited in the fourth quarter. They comprised only one per cent of total shipments for a total of 169 animals. These were shipments between areas outside of Tennessee and were from Chicago to Roanoke and Arizona to Clarksdale, Mississippi. The rest of the shipments went into West Tennessee to fill the 13,608 animal deficit and East Tennessee to fill a 3,525 animal deficit. Arizona and California (see Figure 15a) supplied 40 per cent of the 17,302 animals shipped. This was probably a "forced" supply since, as was pointed out earlier, the surplus areas used in actual shipments were also used as surplus areas in the transportation model. Since total surplus must equal total deficit and all surplus must be shipped to exactly fill the deficits, then these animals from Arizona and California had to be shipped to deficit areas.* The possibility exists that animals to fill the West Tennessee deficit could be shipped from closer areas, but that is beyond the scope of the present study.

*See page 14.

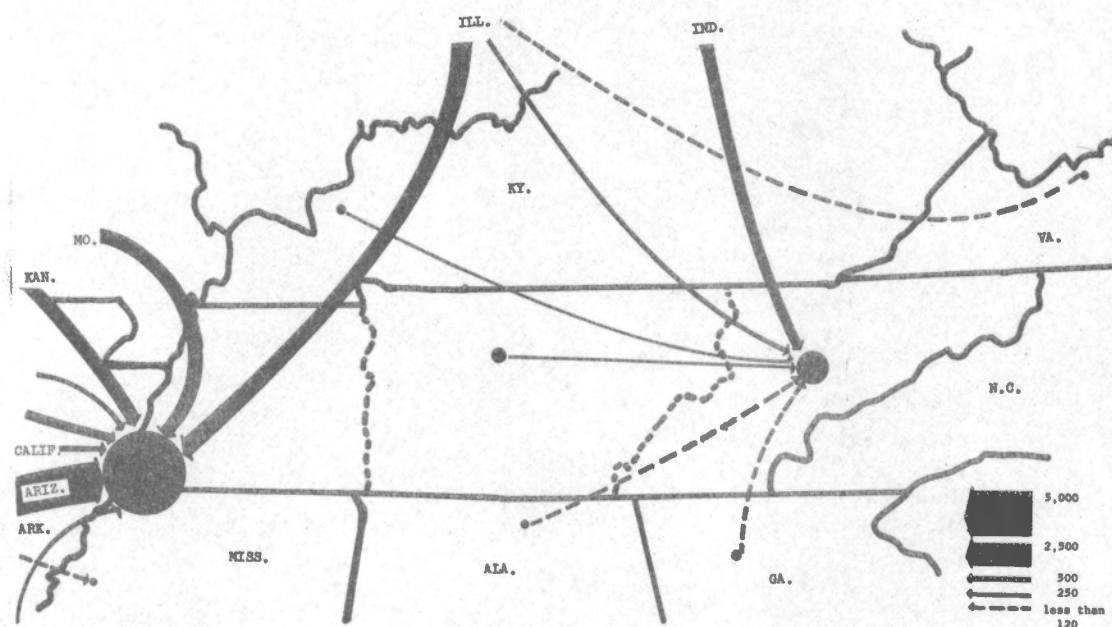
Standard and Below, Fourth Quarter

During the fourth quarter, East and West Tennessee were deficit areas and Middle Tennessee was a surplus area in production of cattle graded standard-and-below. West Tennessee received 59 per cent and East Tennessee received 36 per cent of total shipments. These percentages represent 9,589 animals and 5,828 animals, respectively. Outshipments from Middle Tennessee represented 18 per cent (2,919 animals) of total shipments. Shipments between areas outside of Tennessee amounted to 961 animals, or 6 per cent of the total of 16,387 animals that were shipped during the quarter. Figure 15b shows that the majority of animals shipped to West Tennessee came from surplus areas west of that area. Animals shipped into East Tennessee came from Middle Tennessee, Louisville, Indiana, and North Carolina.

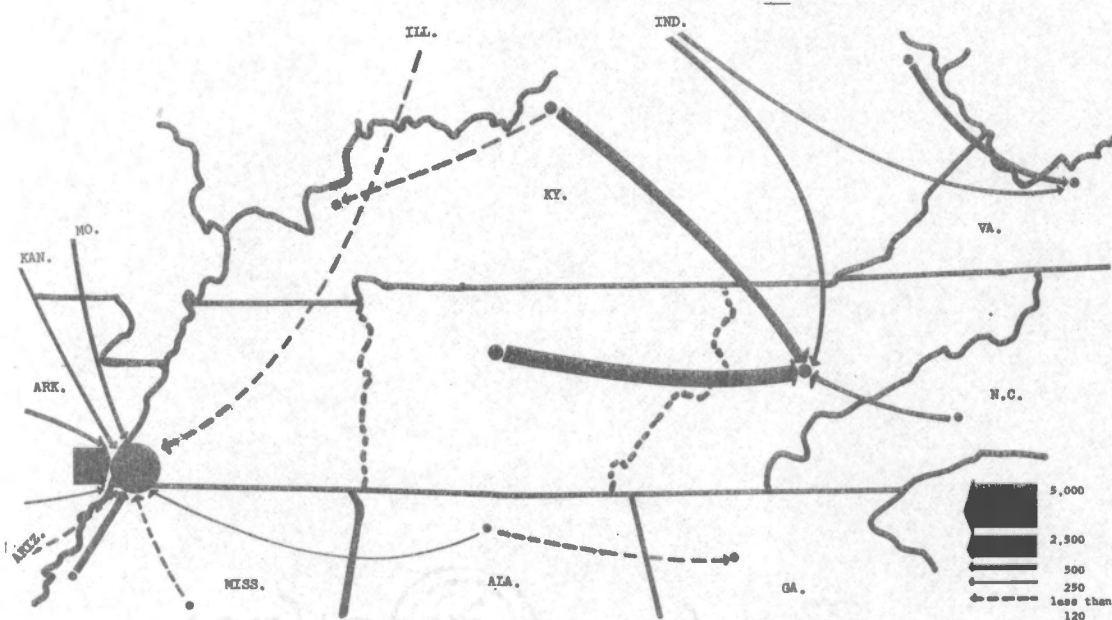
II. OPTIMUM CALF MOVEMENTS

Prime and Choice, First Quarter

For calves graded prime and choice, all three areas of Tennessee were surplus areas (Figure 16a) during the first quarter. A total of 21,918 animals were moved within the system during the period with 18,915 animals being shipped out of Tennessee. The 18,915 animals accounted for 86 per cent of total shipments. The remaining 14 per cent, or 3,003 animals moved to areas outside of Tennessee. The West Tennessee surplus of 273 animals was small compared to the surpluses in Middle and East Tennessee. The surplus in Middle Tennessee was 45 per cent of total movements, or 9,854 animals. East Tennessee had a slightly smaller surplus,



a



b

Figure 15. Optimum shipments of slaughter cattle during the fourth quarter, 1962, graded (a) good and above, and (b) standard and below.

8,788 animals, which was 40 per cent of total shipments. Shipments of 2,821 animals from Louisville to Pennsylvania accounted for most of the 3,003 animals shipped between outside areas. Shipments from Huntsville to Asheville accounted for the remaining 182 animals, which was less than one per cent of total shipments.

Good and Standard, First Quarter

A comparatively small number, 1,391 animals, was shipped during the first quarter. East and Middle Tennessee had deficits of good and standard animals, while West Tennessee was a surplus area (Figure 16b). Only three areas shipped into Tennessee and these were on the Tennessee borders. The deficit in East Tennessee accounted for 67 per cent of the total. Due to the small total number, this represented only 936 animals. The 338 animal deficit in Middle Tennessee accounted for 24 per cent of the total. Shipments between areas outside of Tennessee were of 117 animals but this accounted for 8 per cent of total shipments.

Prime and Choice, Second Quarter

The largest percentage of shipments between areas outside of Tennessee occurred in the movements of prime-and-choice calves during the second quarter. Of the 23,680 calves that were shipped, 14,451 were shipped between the outside areas. This number represented 61 per cent of the total. As shown in Figure 17a, most of these animals went to the Pennsylvania area. Other shipments between these areas outside of Tennessee were from Huntsville to Roanoke, Owensboro to Ashland, and West Memphis to West Point, Mississippi. Middle Tennessee had the largest

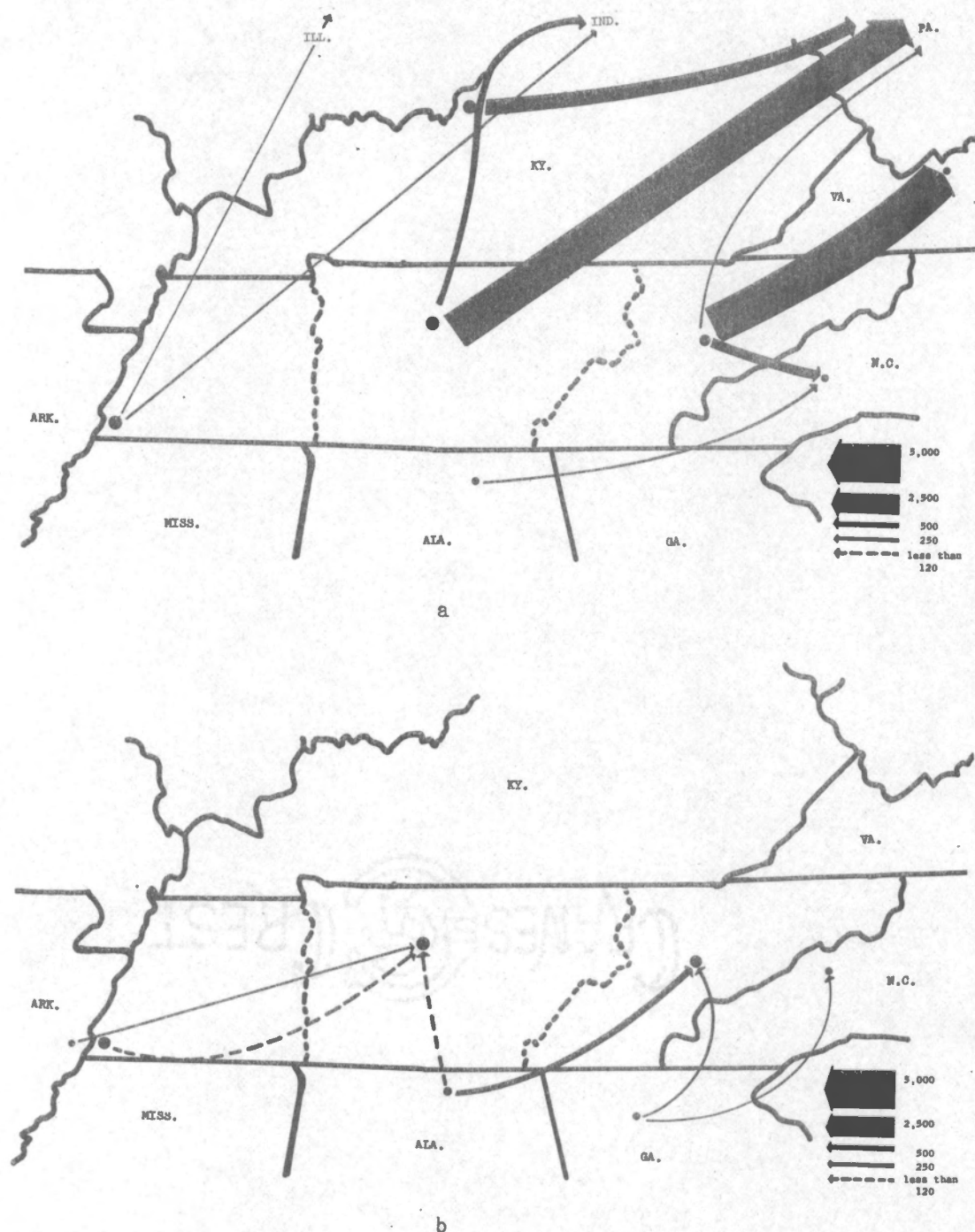


Figure 16. Optimum shipments of slaughter calves during the first quarter, 1962, graded (a) prime and choice, and (b) good and standard.

surplus of three Tennessee areas, with 7,833 animals which was 33 per cent of the total. West and East Tennessee had one per cent and 5 per cent of the total surplus, respectively. One characteristic of this grade group during this quarter is that almost all shipments were in a northeasterly direction.

Good and Standard, Second Quarter

Total movement of calves graded good and standard during the second quarter were slightly larger than in the first quarter. A total of 1,457 animals were moved from five surplus areas to fill the deficits in six areas (Figure 17b). Included in the deficit areas were West and Middle Tennessee, which accounted for one per cent (20 animals) and 79 per cent (1,151 animals) of total movements, respectively. The remaining 20 per cent of total movements (286 animals) were between areas outside of Tennessee. These movements were from West Memphis, Atlanta, and Louisville surplus areas.

Prime and Choice, Third Quarter

Movements of prime-and-choice calves during the third quarter were not as heavy as in the second quarter (Figure 18a). The total this quarter was 16,146 animals. A total of 16,146 animals were moved during this quarter and, of these, 11,365 were moved between areas outside of Tennessee. This indicates at most only 27 per cent were moving over the optimum route during this quarter and there is the possibility that less than this were optimum movements. Further analysis on this point will be made in Chapter V of this report.

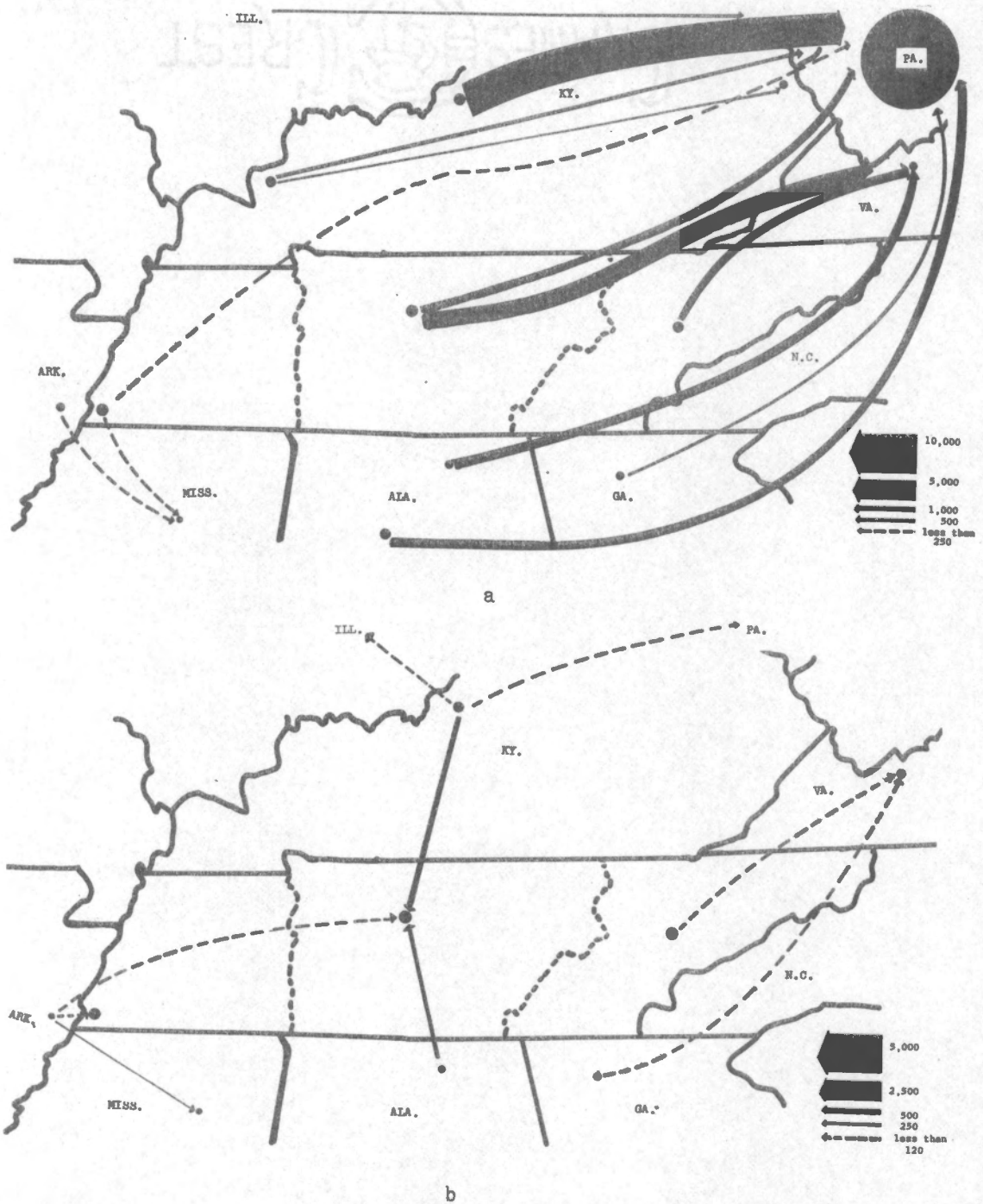


Figure 17. Optimum shipments of slaughter calves during the second quarter, 1962, graded (a) prime and choice, and (b) good and standard.

Good and Standard, Third Quarter

Shipments of calves during the third quarter graded good and standard were 3,705 animals. During this quarter Middle Tennessee was a deficit area. West and East Tennessee were surplus areas with a combined total of 1960 surplus animals, as shown in Figure 18b. East Tennessee had the largest outshipment (Figure 18b), which totaled 1,729 animals, or 47 per cent of all surplus animals. West Tennessee had 6 per cent of the total and more than half of these went to Middle Tennessee. Shipments of animals between areas outside of Tennessee accounted for 8 per cent of total movements, or 312 animals.

Prime and Choice, Fourth Quarter

Calves graded prime and choice that were shipped during the fourth quarter totaled 17,011. Almost 70 per cent of these went to Roanoke which had a deficit of 11,732 animals. Many of the animals shipped to Roanoke were from areas outside of Tennessee (Figure 19a). The numbers of animals constituting shipments between areas outside of Tennessee represented 26 per cent of total shipments. Animals to fill the deficit in the Roanoke area came from Atlanta, Louisville, and Indiana. West and Middle Tennessee were deficit areas having deficits of 3 and 29 per cent, respectively, of the total deficit in the system. East Tennessee was a surplus area with 43 per cent of the total surplus. All the surplus animals, 7,344, in East Tennessee were shipped to Roanoke which left the deficit in Middle Tennessee to be filled with calves from Owensboro and Louisville, Kentucky.

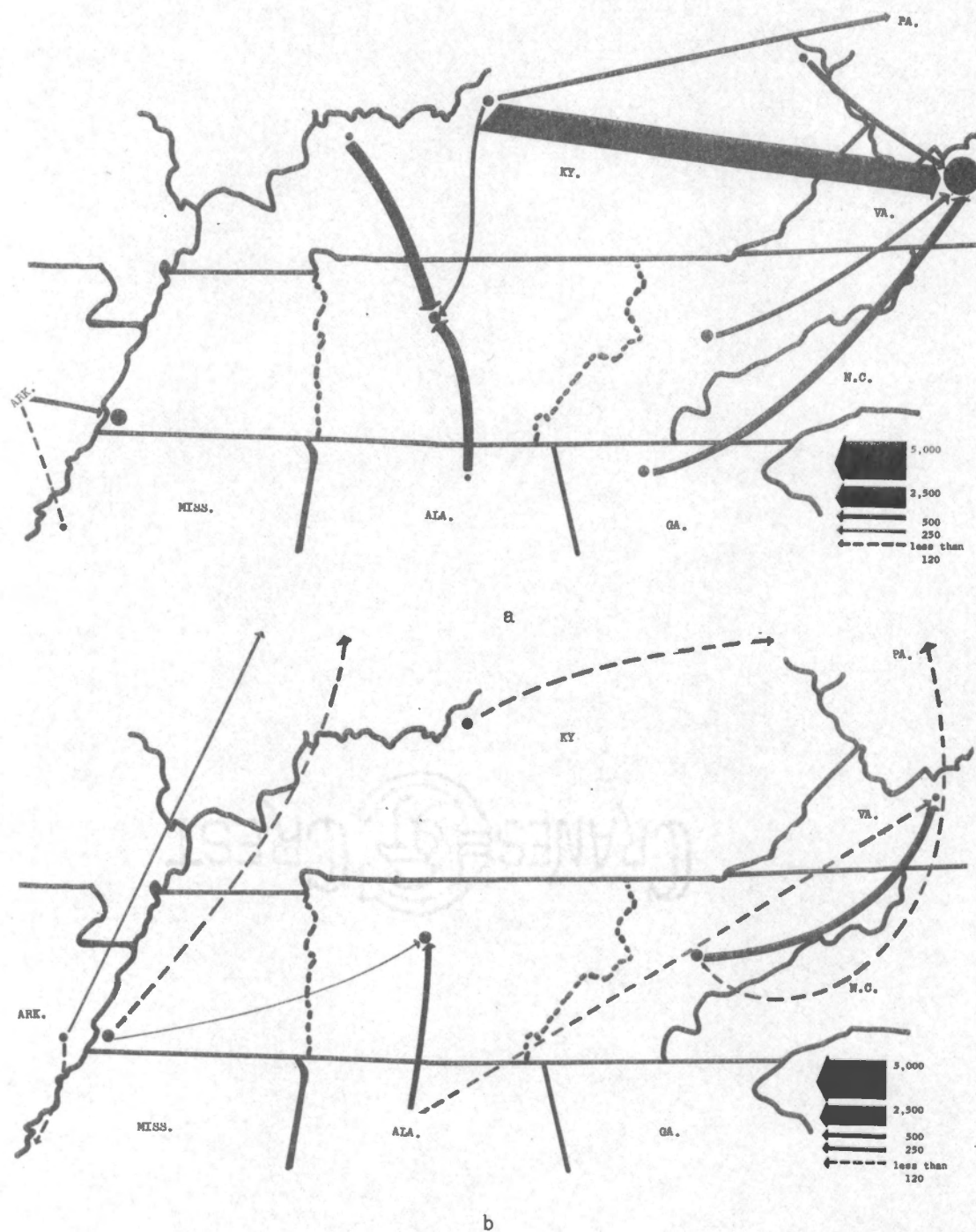
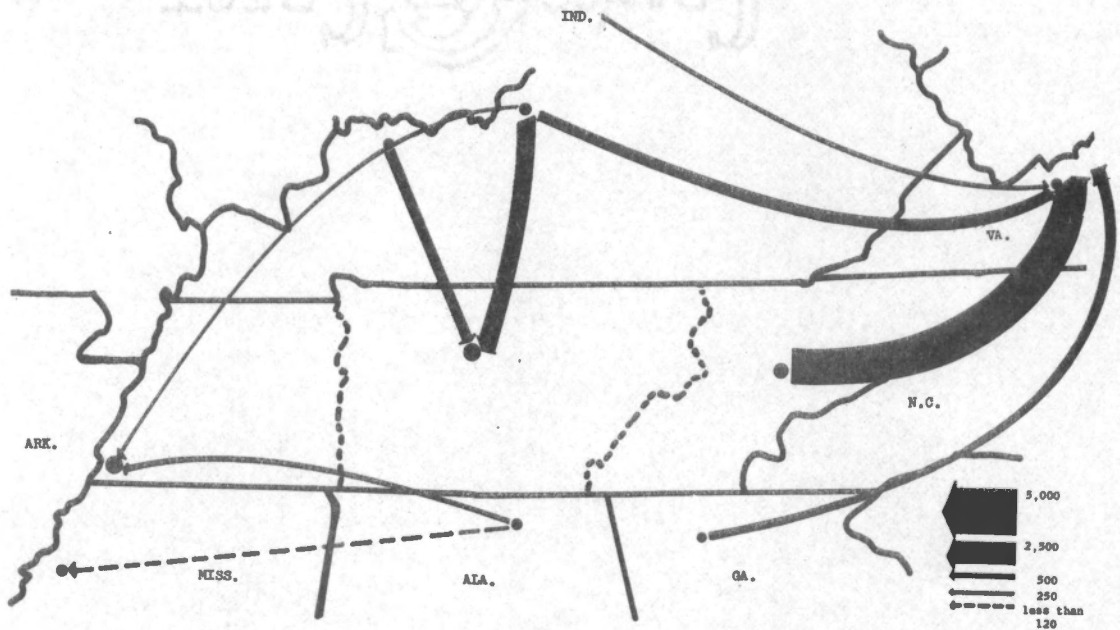


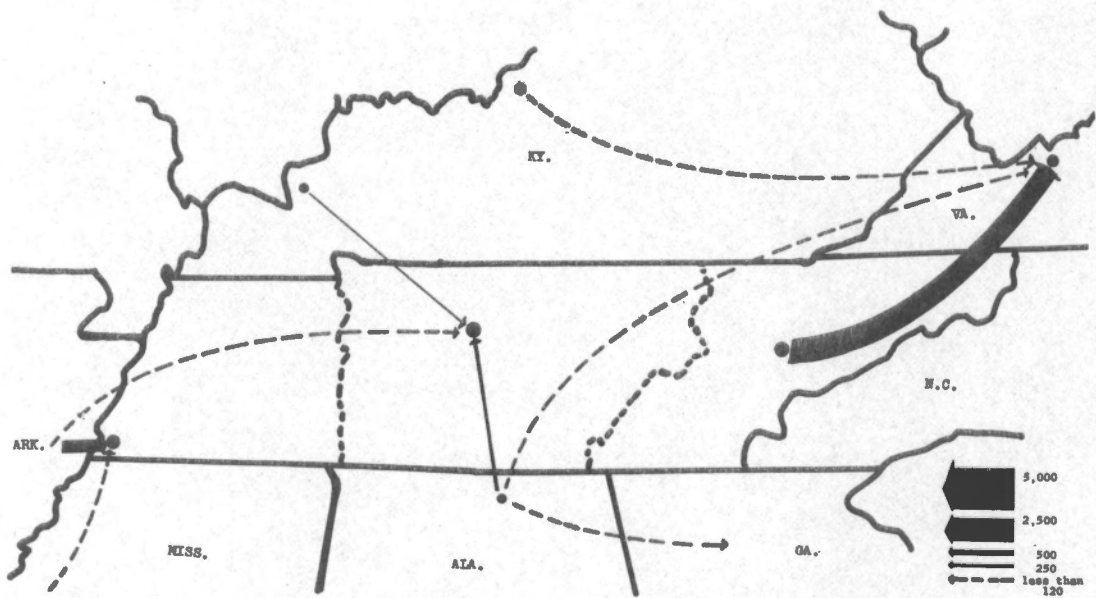
Figure 18. Optimum shipments of slaughter calves during the third quarter, 1962, graded (a) prime and choice, and (b) good and standard.

Good and Standard, Fourth Quarter

There were 5,097 animals shipped during the fourth quarter that were graded good and standard. Shipments between areas outside of Tennessee accounted for 3 per cent of the total. These shipments were from Huntsville and Louisville to Roanoke, which were almost one per cent and two per cent, respectively, and from Huntsville to Atlanta, which were only seven animals. Roanoke had a deficit of 3,952 animals, or 78 per cent of total deficit. East Tennessee supplied most of the animals to the area, as shown in Figure 19b. The 3,802 animals shipped from East Tennessee were 75 per cent of the total surplus. West and Middle Tennessee were both deficit areas. Owensboro and Huntsville supplied most of the animals to Middle Tennessee while West Memphis was the major supplier to West Tennessee.



a



b

Figure 19. Optimum shipments of slaughter calves during the fourth quarter, 1962, graded (a) prime and choice, and (b) good and standard.

CHAPTER V

COMPARISON OF ACTUAL AND OPTIMAL MOVEMENTS

In comparing the actual and optimal movement patterns the optimal pattern was assumed to be the most efficient (least-cost) method of moving the animals from surplus to deficit areas. Therefore the relative efficiency of actual movements was determined by the conformity to the optimal system. Actual movements were evaluated in terms of percentages of animals that moved over the same routes as in the optimal solution.

I. SIGNIFICANT NON-OPTIMUM MOVEMENTS

The Most Significant Inefficiencies

The most significant departures of actual shipments from the optimum were the inter-area movements of calves graded prime and choice during the second, third and fourth quarters of 1962. As shown in Table III, movements were less than 50 per cent efficient for all three quarters. The smallest percentage of animals moving over optimum routes occurred during the third quarter; only 11 per cent. Conversely 89 per cent of the movements were inefficient. The second quarter had only 24 per cent of the movements that were optimal which left an inefficiency of 76 per cent. Further analysis of these movements is made below. Movements during the first and second quarters of grades good and standard were the next lowest in efficiency with movements that were 57 and

TABLE III

ESTIMATED OPTIMUM MOVEMENTS OF SLAUGHTER CALVES AS PERCENTAGE
OF ACTUAL MOVEMENTS WITHIN, INTO, AND OUT OF TENNESSEE
DURING 1962, BY GRADE AND BY QUARTER OF THE YEAR

Grade	Quarter	Total movements - - - number of animals	Number moving over optimal routes	Per cent moving over optimal routes
Prime and choice	1	25,285	18,551	73.4
Prime and choice	2	42,787	10,407	24.3
Prime and choice	3	36,062	4,056	11.2
Prime and choice	4	26,406	12,025	45.4
Total		130,594	45,039	34.5*
Good and standard	1	1,768	1,014	57.4
Good and standard	2	1,912	1,041	54.4
Good and standard	3	4,017	3,328	82.8
Good and standard	4	5,463	4,881	89.3
Total		13,160	10,264	78.0*

*These percentages are the total number moving over optimal routes divided by total number of actual shipments and is the weighted average of the above four percentage figures.

54 per cent efficient, respectively. The above movements were the least efficient but further analysis of the selected grades of both cattle and calves is presented below.

Efficiencies of Calf Movements

As shown in Table III, efficiency of movements of calves varied by quarters. The efficiency of prime and choice decreased steadily from the first through the third quarter, and then increased again; from 73 per cent down to 11 per cent then up to 45 per cent. The differences in efficiency among quarters is greater in this group than in any other. The per cent efficiency for this grade group for the year (34.5) is less than half the comparable figure for good and standard.

For calves graded good and standard the efficiency of movements for the year is 78 per cent. Variation of efficiency among quarters exists in this grade group, but is not as pronounced as the variation of efficiency of movements of prime and choice animals. Differences in efficiency of good and standard seem to fall into two groups: the first and second quarters in the first group (lower percentage of efficiency) and the third and fourth quarters in the second group (higher percentage efficiency). One characteristic to be noted is that the volume of movements varies among the quarters also. During the first two quarters, which had the smaller percentage of efficient movements, the volume of calves moved is much smaller than the volume moved during the last two quarters, which had the larger percentage of efficient movements.

Efficiencies of Cattle Movements

The differences in relative efficiencies of cattle movements are not too great. In movements of cattle graded good and above, the per cent efficiencies range from 74 per cent to 100 per cent (Table IV). The total volume of cattle graded good and above was 74,272 animals of which 62,640 head moved over optimal routes. This resulted in 84.3 per cent of cattle graded good and above moving over optimal routes, or movements that were 84 per cent efficient.

Efficiency of movements of cattle graded standard and below showed even less variation than cattle graded good and above. Efficiencies of movements of standard and below ranged from 71 per cent to 92 per cent, with a weighted average of 80 per cent efficiency.

There seemed to be little difference between the per cent efficiency for the year of the two grade groups of cattle.

Differences in Efficiency of Movements of Cattle and Calves

There was a considerable difference between the efficiency of cattle movements and of calf movements. The efficiency of movements of cattle graded good and above (good, prime, and choice) was 84.3 per cent for the year. This figure is more than twice as large as the proportion of calves graded prime and choice that moved over optimal routes, which was 34.5 per cent. The variation of efficiency among the various quarters between cattle and calves was similar. For both classes of animals, the highest efficiency of movements for the year occurred during the first quarter. Movements of both cattle and calves were the least efficient

TABLE IV

ESTIMATED OPTIMUM MOVEMENTS OF SLAUGHTER CATTLE AS PERCENTAGE
OF ACTUAL MOVEMENTS WITHIN, INTO, AND OUT OF TENNESSEE
DURING 1962, BY GRADE AND BY QUARTER OF THE YEAR

Grade	Quarter	Total movements	Number moving over optimal routes	Per cent moving over optimal routes
- - - Number of animals- - -				
Good and above	1	14,547	14,547	100.0
Good and above	2	23,637	17,506	74.1
Good and above	3	18,265	13,754	75.3
Good and above	4	17,823	16,833	94.4
Total		74,272	62,640	84.3*
Standard and below	1	6,136	4,524	73.7
Standard and below	2	8,562	7,899	92.3
Standard and below	3	14,001	9,984	71.3
Standard and below	4	16,991	14,111	83.0
Total		45,690	36,518	79.9*

*These percentages are the total number moving over optimal routes divided by total number of actual shipments and is the weighted average of the preceding four percentage figures.

during the second and third quarters, and efficiency increased during the last quarter.

The level of efficiencies of cattle graded standard and below and calves graded good and standard is very near the same for the year's movements. The percentages of efficiency are 80 and 78, respectively. For these two grade groups the association between efficiencies in comparable quarters is not as evident as in the case above. For cattle the peak efficiency of movements occurred during the second quarter and the lowest percentage of optimum movements occurred during the third quarter. The largest percentage of optimum movement for this grade group of calves occurred the fourth quarter and the lowest during the second quarter.

II. SIGNIFICANT NON-OPTIMUM ROUTES OF CATTLE MOVEMENTS

Good and Above

For cattle graded good and above, there were three major non-optimum routes over which 8,106 head were shipped, accounting for 70 per cent of the total 11,632 head in the non-optimum movements. Missouri to Middle Tennessee was the route over which the largest volume of non-optimum shipments (3,790 head) occurred for this grade group (see Table V). Indiana to West Tennessee and Illinois to East Tennessee (with volumes of 2,028 head and 2,288, respectively) were the other two routes.

Shipments from area 5.1 (Huntsville, Alabama) to Middle Tennessee and from East Tennessee to area 1.1 (Roanoke, Virginia) were non-optimum

TABLE V

NON-OPTIMAL MOVEMENTS OF CATTLE BY ROUTES USED AND
QUARTER OF THE YEAR FOR 1962

Routes Used		Quarter				Total
From	To	1	2	3	4	
----- Number of head-----						
Good and above						
5.2	9.1		215			215
25	9.1			2,028		2,028
5.1	9.2		377	65	98	540
8.1	9.2				202	202
9.3	9.2				254	254
30	9.2		3,790			3,790
27	9.3			2,288		2,288
9.1	10.2		319			319
9.3	1.1		156	26	104	286
Standard and below						
5.1	9.1			195		195
5.2	9.1		117			117
8.2	9.1	182				182
10.2	9.1			416		416
9.1	10.2		104			104
25	9.1				499	499
30	9.1			169		169
5.1	9.2		117	299	156	572
8.2	9.2			169		169
1.1	9.3			416	248	664
9.3	1.1	585		598	299	1,482
8.3	9.3	104		325	624	1,053
9.2	9.3		155			155
10.1	9.3			117		117
25	9.3	403				403
30	9.3				254	254
9.1	10.1			357		357
9.1	27			442		442
9.2	4.1			507	247	754

for three of the four quarters. The volume of animals shipped over these routes was low, however, compared to the three large volume routes.

Standard and Below

Non-optimal shipments of cattle graded standard and below were made over many routes. The 9,172 head involved in non-optimal shipments were well dispersed over 19 different routes. Three routes, however, had recurring shipments for three of the four quarters. These routes were East Tennessee to Roanoke (which carried non-optimal shipments of good and above, also), Ashland to East Tennessee, and Huntsville to Middle Tennessee (which also carried non-optimal shipments of good and above).

III. SIGNIFICANT NON-OPTIMUM ROUTES OF CALF MOVEMENTS

Prime and Choice

Most of the non-optimum movements of prime-and-choice calves were made over four routes. The routes were used for 80 per cent of the 85,184 animals involved in the non-optimal shipments. Movements over these routes occurred during two or more quarters. The route carrying the largest volume of non-optimal shipments was from Louisville to Middle Tennessee. Other "non-optimal" routes in descending order of volume carried were Middle to East Tennessee, East Tennessee to Pennsylvania. Several other routes were used for shipments during two or three quarters of the year (see Table VI).

TABLE VI

NON-OPTIMAL MOVEMENTS OF CALVES BY ROUTES
USED AND QUARTER OF THE YEAR FOR 1962

Prime and choice		Quarter				Total
Routes used						
From	To	1	2	3	4	
- - - - - Number of head - - - - -						
25	9.1				650	650
5.1	9.2	182	312			352
8.1	9.2		1,151			1,151
8.2	9.2	2,821	8,379	8,853	2,600	22,653
9.1	9.2	273	214			487
4.1	9.3		520	1,196	1,053	2,769
5.1	9.3		995			995
5.2	9.3		1,339			1,339
8.2	9.3		728	676	390	1,794
9.1	9.3				1,827	1,827
9.2	9.3		4,953	8,125	2,945	16,023
27	9.3		371			371
9.2	22	2,913	10,103	715		13,730
9.2	25	156				156
9.2	27	117				117
9.3	1.1			10,972	4,435	15,407
9.3	2.1	182				182
9.3	8.3		364			364
9.3	22		748			748
Good and standard						
9.2	9.1	78				78
11.2	9.1	260				260
5.1	9.2			78	53	131
8.2	9.2		104		104	208
9.1	9.2	181	156		59	396
4.1	9.3	117				117
9.1	10.2		130			130
9.1	27			182		182
9.2	9.3				150	150
9.2	22		91	78		169
9.3	1.1			78	150	228
9.3	2.1	117				117

Good and Standard

One route was used consistently for shipment of good-and-standard calves during all four quarters, and also had the largest volume of "non-optimal" shipments of this category of animals. This route was from the West Memphis, Arkansas area to West Tennessee. Even though West Memphis is only five miles from West Tennessee, the shipments from West Memphis were usually allocated to other areas in the optimum solution. Even though the West Memphis area is adjacent to the West Tennessee area, there were many cases in which both West Memphis and West Tennessee were surplus areas. Because both were surplus areas shipments between the two areas were not allowed. Five other routes were used during two or more quarters and these six (the five and the West Memphis shipments) were responsible for 67 per cent of the total 2,896 head of non-optimum shipments.

Non-Optimum Routes of Various Grades

Two routes were used consistently for non-optimum shipments for both grade groups for both cattle and calves. These routes were from East Tennessee to the Roanoke area, and from the Huntsville area to the Middle Tennessee area. Three other seemingly non-optimum routes were used for shipments of three of the four grade groups of cattle and calves. These routes were: the Louisville, Kentucky area to Middle Tennessee, Middle to East Tennessee, and West Tennessee to the West Point, Mississippi area.

This indicates that five routes were used consistently for non-optimum movements of most grades of cattle considered. These five

routes did not necessarily carry all of the shipments, but roughly 55 per cent of the volume of total non-optimal shipments were shipped over these routes.

IV. CAUSES OF INEFFICIENCIES

One of the basic assumptions of the transportation model is that each area fills its own needs before showing any surplus or deficit. This assumption has been the indicator of much of the inefficiency found in the system actual of movements. In several cases the Tennessee areas had both inshipments and outshipments. Under the above assumption, the area is specified as a surplus or deficit area and under an optimal system would have only outshipments or inshipments. Of the 28 non-optimum routes of cattle shipment indicated in Table V, ten of these routes had shipments either into a Tennessee area that was already a surplus area, or shipments out of a Tennessee area that was a deficit area during one or more quarters. There are 31 non-optimum routes indicated for calf shipments and the inshipment to surplus areas or outshipment from deficit areas was indicated for 19 of the routes. Non-optimum shipments of this type further compound the inefficiency. For example, if an area was a deficit area and had outshipments, then an additional number of animals equal to the volume of outshipments would have to be obtained from some other area. This additional number would be non-optimal shipments in the least-cost solution. This leads to the observation that the volume of outshipments from a deficit area, or inshipments to a surplus area

causes an inefficiency in movements that is twice as large as the non-optimum outshipments or inshipments. In the optimal solution, situations of this example occurred in both grades of cattle and of calves. In most cases the shipments were to relatively close areas, and in some cases would have been moved over a least-cost route if distance alone was considered.

CHAPTER VI

CONCLUSIONS

The proportion of animals moving over least-cost routes varied by grade group and by quarter of the year. The proportion was highest for cattle graded good and above and lowest for calves graded prime and choice. The least efficient and most efficient movements occurred during different quarters for different grade groups. There was no one particular quarter in which efficiency was highest or lowest for all grade groups.

The least efficient movements were those of prime and choice calves. For the whole year, 34.5 per cent of calves graded prime and choice moved over optimal routes. During the third quarter, only 11 per cent of the movements of calves graded prime and choice were shipped over optimum routes. The third quarter was the only one during which the efficiency of prime-and-choice calf movements was at all comparable to efficiency of other grade groups.

The comparison of actual and optimum patterns indicated that movements of cattle graded good and above were the most efficient of all grade groups considered. Although efficiency of movements of good and above was the highest, there were only small differences in efficiency among the three grade groups: cattle graded good and above, cattle graded standard and below, and calves graded good and standard. The

efficiency of movements on a yearly basis for the above three grade groups were 84, 80, and 78 per cent, respectively.

There are two possible explanations of the inefficiencies of movements: (1) Shipments of animals into surplus areas and/or shipments of animals out of deficit areas, (2) Random shipments to areas that could have been supplied by surplus areas that were closer to the deficit areas than were the areas that actually shipped the animals.

The shipments of animals into surplus areas and/or out of deficit areas resulted in inefficiencies that were equal to the volume of the shipments. One of the assumptions of the model was that each substate area must fill its own requirements before showing a surplus or deficit. According to this assumption there could be only a surplus or a deficit and not both in the optimal pattern of movements. Substate areas that had both inshipments and outshipments of one grade group in one quarter showed an inefficiency.

The inshipments into surplus areas and outshipments out of deficit areas caused another inefficiency of movements. In many instances additional shipments had to be made out of a surplus area to counteract the shipments into the surplus area. These additional shipments were inefficient and did not show up when inshipments into surplus areas were discontinued (that is, in the optimal solution).

Conclusions can be enumerated as follows:

1. Movements of calves graded prime and choice were least efficient with an efficiency of 34.5 per cent.

2. Movements of cattle graded good and above were most efficient although there were little differences with regard to efficiency among the grades of good and above, standard and below, and calves graded good and standard.
3. Many inefficiencies were caused by movements of animals into surplus areas and out of deficit areas.
4. Movements of animals as described in 3 (above) caused additional inefficiencies because other animals had to be moved out of or into these areas to counteract these movements.

Having more complete market information would be one way of reducing inefficiencies. That is, more complete market information would help both the sellers and buyers of cattle and calves. Knowledge of supply and demand of animals in a Tennessee area could reduce the inshipment and outshipment of comparable animals in an area. For example, if a packer knew of surplus animals in his substate area he would not need to import animals from some other area. Buying animals located in his own area would save transportation costs to him.

As a caution, the apparent inefficiency of some of the movements may result from arbitrary decisions made in the analysis with regard to delineation of grade groups, market areas, and time periods. The transportation model used permitted no substitution among grade groups, weight classes, or time periods. Some movements of animals of one grade group in one time period that were inefficient in this analysis could possibly have been eliminated if substitution had been allowed.

If these inefficiencies indicated above were reduced or eliminated, there could be savings of transportation charges and loss from shrinkage due to hauling. These savings could accrue to the producers of these animals and/or to the buyers. In any event, the marketing margin for beef produced and marketed in Tennessee could be reduced.



BIBLIOGRAPHY

CRANES & CREST

BIBLIOGRAPHY

- Amick, R. J. "A Review of Research in Interregional Competition." Paper read at the Southern Farm Management Research Committee Meeting, New Orleans, Louisiana, March 23, 1964.
- Dennis, C. C., and L. L. Sammet. "Interregional Competition in the Frozen Strawberry Industry," Hilgardia. Vol. 31, No. 15. Berkeley: University of California, December 1961.
- Farm Income, 1949-62, A Supplement to Farm Income Situation, July 1963. Economic Research Service. Washington: Government Printing Office, August 1963.
- Farris, D. E., and R. A. King. Interregional Competition in Marketing Slicing Cucumbers. A. E. Information Series No. 78. Raleigh: North Carolina State College, September 1960.
- Fishel, W. L., Irving Dubov, D. D. Rohdy, and R. G. Stout. Hog and Pork Movements in the Southeast. Bulletin No. 83, Southern Cooperative Series, January 1963.
- Heady, Earl O., and Wilfred Candler. Linear Programming Methods. Ames: The Iowa State College Press, 1958.
- Johnson, Jack D. Livestock Marketing in the Southern Region. Bulletin No. 26, Southern Cooperative Series, July 1952.
- Judge, George G. Competitive Position of the Connecticut Poultry Industry. Storrs Agricultural Experiment Station Bulletin 318. Storrs: University of Connecticut, January 1956.
- Juillerat, Monte and Roy Stout. Marketings, Slaughter, and Consumption of Hogs and Pork Products in Virginia. Bulletin 550. Blacksburg: Virginia Polytechnic Institute, November 1963.
- King, G. A., and L. F. Schrader. "Regional Location of Cattle Feeding--A Spatial Equilibrium Analysis," Hilgardia. Vol. 34, No. 10. Berkeley: University of California, July 1963.
- King, R. A., and W. R. Henry. "Transportation Models in Studies of Interregional Competition," Journal of Farm Economics, Vol. 41, pp. 997-1011, 1959.

Koopmans, T. C. (ed.). Activity Analysis of Production and Allocation. Cowles Commission for Research in Economics Monograph No. 13. New York: John Wiley and Sons, Inc., 1951.

Linton, D. A., and M. J. Danner. Hog and Pork Movements in Alabama. Agricultural Experiment Station Bulletin 351. Auburn: Auburn University, November 1963.

Livestock and Meat Statistics, 1962. Statistical Bulletin No. 333. Washington: United States Department of Agriculture, July 1963.

Livestock and Meats. Agricultural Marketing Service, Marketing Research Report No. 418. Washington: United States Department of Agriculture, November 1960.

Marketing and Transportation Situation. Economic Research Service. Washington: United States Department of Agriculture, February 1964.

Stout, Roy G., J. C. Purcell, and W. L. Fishel. Marketing, Slaughter and Consumption of Livestock and Meats in the South, Bulletin No. 66, Southern Cooperative Series, 1961.

APPENDICES

CRANES & CREST

APPENDIX A

EXPANSION PROCEDURES

The following shows the weeks, the quarter that it (or they in two cases) represents, and the expansion factor by which the data gathered were expanded to determine the total yearly volume for that packing plant or auction.

<u>Week No.</u>	<u>Date</u>	<u>Quarter</u>	<u>Expansion factor</u>
1	February 4-10	1st	13.0
2	April 15-21	2nd	6.5
3	June 10-16	2nd	6.5
4	August 19-25	3rd	13.0
5	October 7-13	4th	6.5
6	November 25-December 1	4th	6.5

The volume data for the sample plants and sample auctions was expanded to determine the total volume for the packers and auctions for the state in 1962. The expansion factors are defined as follows:

$$EF = \frac{\text{Monthly marketings of cattle and calves for all plants in a given stratum of a substate area}}{\text{Monthly marketings of cattle and calves for sample plants in a given stratum of a substate area}}$$

This can be expressed symbolically as:

$$EF_{jkl} = \frac{TS_{jkl}}{\sum_{i=1}^n SPS_{jkl}}$$

and

i = sample plants of one stratum of a substate area

j = strata (FIS, large non-FIS, and medium non-FIS, large and small)

k = substate area (9.1 to 9.3)

l = sample month (February, April, June, October, November)

where

EF_{jkl} = expansion factor for j^{th} stratum, k^{th} substate area and l^{st} month.

TS_{jkl} = total marketings of cattle and calves (head) for j^{th} stratum, k^{th} substate area, and l^{st} month.

$\sum_{i=1}^n SPS_{jkl}$ = summation of sample marketings of cattle and calves (head) for j^{th} stratum, k^{th} substate area and l^{st} month.¹

¹See Don Rhody Memo, November 9, 1961, of Southern Region Marketing Committee Research Project SM-23.

APPENDIX B

TABLE VII

ESTIMATED ACTUAL MOVEMENTS OF CATTLE INTO AND OUT OF
TENNESSEE DURING THE FIRST QUARTER, 1962,
FOR CATTLE GRADED GOOD AND ABOVE

Surplus areas	Deficit areas		Total surplus
	9.1	9.3	
	Number of animals		
1.1		52	52
5.1	780		780
8.2	65		65
8.3		130	130
11.2	39		39
13.3	1,820		1,820
25	403		403
27	3,601		3,601
29	2,392		2,392
30	3,757		3,757
32	390		390
33	1,118		1,118
Total deficit	14,365	182	14,547
Per cent of total deficit	98.7	1.3	

TABLE VIII

ESTIMATED ACTUAL MOVEMENTS OF CATTLE INTO AND OUT OF TENNESSEE DURING THE SECOND QUARTER, 1962,
FOR CATTLE GRADED GOOD AND ABOVE

Surplus areas	Deficit area					Total surplus	Per cent of total surplus
	1.1	9.1	9.2	9.3	10.2	11.2	
	Number of animals						
1.1				33		33	
2.1				124		124	
4.1				507		507	
4.3				202		202	
5.1			377	7		384	
5.2		351				351	
8.1		358	130			488	
8.2		20	995			1,015	
8.3				39		39	
9.1			156	319	7	495	2.1
9.2		7		13		223	.9
9.3	156					156	.7
10.2		117				117	
11.2		273				273	
13.3		956				956	
23				221		221	
25		5,142		1,691		6,833	
27		5,109				5,109	
30			3,790			3,790	
32		234				234	
33		2,087				2,087	
Total deficit	156	14,654	5,448	2,955	332	7	13
Per cent of total deficit		62.0	23.0	12.5			

TABLE IX

ESTIMATED ACTUAL MOVEMENTS OF CATTLE INTO AND OUT OF
TENNESSEE DURING THE THIRD QUARTER, 1962,
FOR CATTLE GRADED GOOD AND ABOVE

Surplus areas	Deficit areas					Total surplus	Per cent of total surplus
	1.1	9.1	9.3	9.3	22		
	- - - - - Number of animals - - - - -						
4.1					195	195	
5.1		221	234			455	
8.2			13	325		338	
8.3				26		26	
9.2					13	13	.1
9.3	26					26	.1
23					468	468	
25		2,028		3,029		5,057	
27		1,079		2,288		3,367	
30		2,873				2,873	
33		5,447				5,447	
Total deficit	26	11,648	247	6,331	13	18,265	
Per cent of total deficit		63.8	1.3	34.7			

TABLE X

ESTIMATED ACTUAL MOVEMENTS OF CATTLE INTO AND OUT OF
TENNESSEE DURING THE FOURTH QUARTER, 1962,
FOR CATTLE GRADED GOOD AND ABOVE

Surplus areas	Deficit areas					Total surplus	Per cent of total surplus
	1.1	West 9.1	Mid 9.2	East 9.3	10.1		
	----- Number of animals -----						
1.1				26		26	
4.1				111		111	
5.1			98			98	
8.1			202			202	
9.1					91	91	.5
9.2				228		228	1.3
9.3	104		254			358	2.0
12.1		273				273	
13.2		975				975	
13.3		644				644	
25				2,282		2,282	
27		2,373		728		3,101	
30		1,697				1,697	
33		1,769				1,769	
36		5,097				5,097	
39		871				871	
Total deficit	104	13,699	554	3,375	91	17,823	
Per cent of total deficit		76.9	3.1	18.9			

TABLE XI

ESTIMATED ACTUAL MOVEMENTS OF CATTLE INTO AND OUT OF
 TENNESSEE DURING THE FIRST QUARTER, 1962,
 FOR CATTLE GRADED STANDARD AND BELOW

Surplus areas	Deficit areas					Total surplus	Per cent of total surplus
	1.1	2.1	9.1	9.2	9.3		
	- - - - - Number of animals - - - - -						
1.1					169	169	
2.1					533	533	
5.1			130	91		221	
8.2			182			182	
8.3					104	104	
9.3	585	39				624	10.2
10.1			156			156	
10.2			143			143	
11.2			2,054			2,054	
25			338		637	975	
27			325			325	
29			650			650	
Total deficit	585	39	3,978	91	1,443	6,136	
Per cent of total deficit			64.9	1.5	23.5		

TABLE XII

ESTIMATED ACTUAL MOVEMENTS OF CATTLE INTO AND OUT OF
TENNESSEE DURING THE SECOND QUARTER, 1962,
FOR CATTLE GRADED STANDARD AND BELOW

Surplus areas	Deficit areas					Total surplus	Per cent of total surplus
	9.1	9.2	9.3	10.2	27		
	- - - - - Number of animals - - - - -						
1.1			105			105	
2.1			345			345	
4.1			131			131	
5.1		117	169			286	
5.2	124		7			131	
8.2			1,476			1,476	
8.3			124			124	
9.1		65		104	13	182	2.1
9.2	7		1,554	20		1,581	18.5
10.1	605					605	
11.2	2,041					2,041	
13.3	247					247	
25			111			111	
27	1,021					1,021	
30	163					163	
33	13					13	
Total deficit	4,221	182	4,022	124	13	8,562	
Per cent of total deficit	49.3	2.0	47.0				

TABLE XIII

ESTIMATED ACTUAL MOVEMENTS OF CATTLE INTO AND OUT OF TENNESSEE DURING THE THIRD QUARTER, 1962,
FOR CATTLE GRADED STANDARD AND BELOW

Surplus areas	Deficit areas					Total surplus	Per cent of total surplus
	1.1	4.1	9.1	9.2	9.3	10.1	27
	Number of animals						
1.1					416	416	
2.1					910	910	
5.1			195	299		494	
8.2				169	1,560	1,729	
8.3					325	325	
9.1						793	5.7
9.2		507	13		1,937	2,457	17.5
9.3	598					598	4.3
10.1					117	117	
10.2			728			728	
11.2			5,265			5,265	
30			169			169	
Total deficit	598	507	6,370	468	5,265	351	442
						14,001	
Per cent of total deficit			45.5	3.3	37.6		

TABLE XIV

ESTIMATED ACTUAL MOVEMENTS OF CATTLE INTO AND OUT OF TENNESSEE DURING THE FOURTH QUARTER, 1962,
FOR CATTLE GRADED STANDARD AND BELOW

Surplus areas	Deficit areas				Total surplus	Per cent of total surplus
	1.1	4.1	8.1	9.1 9.2 9.3		
	Number of animals					
1.1					248	
2.1					456	
4.1					377	
5.1				156	156	
8.2					1,892	
8.3					624	
9.1			13	26	65	.4
9.2		247			2,477	14.6
9.3	299				299	1.8
10.1					1,274	
10.2					85	
11.1					416	
11.2					6,663	
11.3					137	
25					499	
27					111	
30					111	
33					391	
36					98	
Total deficit	299	247	13	182	6,530	26
Per cent of total deficit				57.1	1.1	38.4

TABLE XV

ESTIMATED ACTUAL MOVEMENTS OF CALVES INTO AND OUT OF TENNESSEE DURING THE FIRST QUARTER,
1962, FOR CALVES GRADED PRIME AND CHOICE

Surplus areas	Deficit areas						Total surplus	Per cent of total surplus
	1.1	2.1	9.2	9.3	22	27		
	Number of animals							
5.1			182				182	
8.2			2,821				2,821	
9.1			273				273	1.1
9.2				91	11,817	1,105	13,130	51.9
9.3	7,280	1,521			78		8,879	35.1
Total deficit	7,280	1,521	3,276	91	11,895	1,105	25,285	
Per cent of total deficit			13.0	.4				

TABLE XVI
ESTIMATED ACTUAL MOVEMENTS OF CALVES INTO AND OUT OF TENNESSEE DURING THE SECOND QUARTER, 1962,
FOR CALVES GRADED PRIME AND CHOICE

Surplus areas	Deficit areas							Total surplus	Per cent of total surplus
	1.1	8.3	9.1	9.2	9.3	10.2	22		
	Number of animals								
4.1					520			520	
5.1				312	995			1,307	
5.2					1,339			1,339	
8.1				1,151				1,151	
8.2				8,379	728			9,107	
9.1				214		26		253	.6
9.2	13		91		4,953	46	13,436	18,559	43.4
9.3	9,048	364	20				748	10,160	23.7
11.2								20	
27					371			371	
Total deficit	9,061	364	111	10,056	8,906	72	14,184	42,787	
Per cent of total deficit			.3	23.5	20.8				

TABLE XVII

ESTIMATED ACTUAL MOVEMENTS OF CALVES INTO AND OUT OF TENNESSEE DURING THE THIRD QUARTER,
1962, FOR CALVES GRADED PRIME AND CHOICE

Surplus areas	Deficit areas						Total surplus	Per cent of total surplus
	1.1	West 9.1	Middle 9.2	East 9.3	10.1	22	4.1	
	Number of animals							
4.1								
5.1				1,196			1,196	
8.1			1,183				1,183	
8.2			1,599				1,599	
8.3			9,412	676			10,088	
9.1				975			975	
9.2					78		78	.2
9.3				8,125		715	8,853	24.6
11.2	11,687	403					11,687	32.4
							403	
Total deficit	11,687	403	12,194	10,972	78	715	13	36,062
Per cent of total deficit		1.1	33.8	30.4				

TABLE XVIII
ESTIMATED ACTUAL MOVEMENTS OF CALVES INTO AND OUT OF TENNESSEE DURING THE FOURTH QUARTER,
1962, FOR CALVES GRADED PRIME AND CHOICE

Surplus areas	Deficit areas					Total surplus	Per cent of total surplus
	1.1	4.1	West 9.1	Middle 9.2	East 9.3	10.1	
	----- Number of animals -----						
1.1					46	46	
4.1					1,053	1,053	
5.1				352		352	
8.1				1,008		1,008	
8.2				6,273	390	6,663	
9.1				52	1,827	1,905	7.2
9.2		59			2,945	3,004	11.4
9.3	11,779					11,779	44.5
25			650			650	
Total deficit	11,779	59	650	7,685	6,261	26	26,460
Per cent of total deficit			2.5	29.0	23.7		

TABLE XIX

ESTIMATED ACTUAL MOVEMENTS OF CALVES INTO AND OUT OF
TENNESSEE DURING THE FIRST QUARTER, 1962,
FOR CALVES GRADED GOOD AND STANDARD

Surplus areas	Deficit areas				Total surplus	Per cent of total surplus
	2.1	9.1	9.2	9.3		
	- - - - - Number of animals - - - -					
4.1				351	351	
5.1			39	702	741	
9.1			220		220	12.4
9.2		78			78	4.5
9.3	117				117	6.6
11.2		260			260	
Total deficit	117	338	259	1,053	1,767	
Per cent of total deficit		19.1	14.7	59.6		

TABLE XX

ESTIMATED ACTUAL MOVEMENTS OF CALVES INTO AND OUT OF TENNESSEE DURING THE SECOND QUARTER, 1962,
FOR CALVES GRADED GOOD AND STANDARD

Surplus areas	Deficit areas						Total surplus	Per cent of total surplus
	1.1	West 9.1	Middle 9.2	East 9.3	10.2	27		
	Number of animals							
4.1				39			39	
5.1		39	228				267	
8.2			884				884	
9.1			156		130	13	299	15.7
9.2		26				91	117	6.1
9.3	52						52	2.7
11.2		254					254	
Total deficit	52	319	1,268	39	130	13	1,912	
Per cent of total deficit		16.7	66.3	2.0				

TABLE XXI

ESTIMATED ACTUAL MOVEMENTS OF CALVES INTO AND OUT OF TENNESSEE DURING THE THIRD QUARTER, 1962,
FOR CALVES GRADED GOOD AND STANDARD

Surplus areas	Deficit areas					Total surplus	Per cent of total surplus
	1.1	9.1	9.2	9.3	10.1	22	27
	Number of animals						
5.1			1,521			1,521	
8.2				13		13	
9.1			130	39		442	11.0
9.2					78	78	1.9
9.3	1,742					1,742	43.4
11.2		221				221	
Total deficit	1,742	221	1,651	13	39	78	273
Per cent of total deficit		5.5	41.1	.3			

TABLE XXII

ESTIMATED ACTUAL MOVEMENTS OF CALVES INTO AND OUT OF TENNESSEE DURING THE FOURTH QUARTER, 1962,
FOR CALVES GRADED GOOD AND STANDARD

Surplus areas	Deficit areas			Total surplus	Per cent of total surplus
	1.1	4.1	9.1 9.2 9.3		
	Number of animals				
5.1			365	365	
8.1			156	156	
8.2			104	104	
9.1			59	59	1.1
9.2		7		157	2.9
9.3	3,952			3,952	72.3
10.1			13	13	
11.2			657	657	
Total deficit	3,952	7	670	5,463	
Per cent of total deficit			12.3	12.5	2.8

TABLE XXIII

MOVEMENTS OF CATTLE IN AN OPTIMAL SYSTEM FOR TENNESSEE
DURING THE FIRST QUARTER, 1962 FOR CATTLE GRADED
GOOD AND ABOVE

Surplus areas	Deficit areas		Total surplus
	9.1	9.3	
	Number of animals		
1.1		52	52
5.1	780		780
8.2	65		65
8.3		130	130
11.2	39		39
13.3	1,820		1,820
25	403		403
27	3,601		3,601
29	2,392		2,392
30	3,757		3,757
32	390		390
33	1,118		1,118
Total deficit	14,365	182	14,547
Per cent of total deficit	98.7	1.3	

TABLE XXIV

MOVEMENTS OF CATTLE IN AN OPTIMAL SYSTEM FOR TENNESSEE
DURING THE SECOND QUARTER, 1962, FOR CATTLE
GRADED GOOD AND ABOVE

Surplus areas	Deficit areas						Total surplus
	1.1	9.1	9.2	9.3	10.2	22	
	-----Number of animals-----						
2.1				124			124
4.1				507			507
4.3	84			118			202
5.1		384					384
5.2		136			215		351
8.1			488				488
8.2			940	3			943
8.3	39						39
11.2		260					260
13.3		956					956
23				214		7	221
25		5,000		1,833			6,833
27		5,109					5,109
30		3,790					3,790
32		234					234
33		2,087					2,087
Total deficit	123	17,956	1,428	2,799	215	7	22,528
Per cent of total deficit		79.7	6.3	12.4			

TABLE XXV

MOVEMENTS OF CATTLE IN AN OPTIMAL SYSTEM FOR TENNESSEE
DURING THE THIRD QUARTER, 1962, FOR CATTLE
GRADED GOOD AND ABOVE

Surplus areas	Deficit areas					Total surplus
	1.1	9.1	9.2	9.3	22	
	Number of animals					
4.1				195		195
5.1		286	169			455
8.2			65	273		338
8.3	26					26
23				455	13	468
25				5,057		5,057
27		3,367				3,367
30		2,873				2,873
33		5,447				5,447
Total deficit	26	11,973	234	5,980	13	18,226
Per cent of total deficit		65.7	1.3	32.8		

TABLE XXVI

MOVEMENTS OF CATTLE IN AN OPTIMAL SYSTEM FOR TENNESSEE
DURING THE FOURTH QUARTER, 1962, FOR CATTLE
GRADED GOOD AND ABOVE

Surplus areas	Deficit areas				Total surplus	Per cent of total surplus
	1.1	9.1	9.3	10.1		
	- - - - - Number of animals - - - - -					
4.1			111		111	
5.1			98		98	
8.1			202		202	
9.2			182		182	1.1
12.1		273			273	
13.2		975			975	
13.3		644			644	
25			2,282		2,282	
27	78	2,373	650		3,101	
30		1,697			1,697	
33		1,769			1,769	
36		5,006		91	5,097	
39		871			871	
Total deficit	78	13,608	3,525	91	17,302	
Per cent of total deficit		78.6	20.4			

TABLE XXVII

MOVEMENTS OF CATTLE IN AN OPTIMAL SYSTEM FOR TENNESSEE
DURING THE FIRST QUARTER, 1962, FOR CATTLE
GRADED STANDARD AND BELOW

Surplus areas	Deficit areas				Total surplus
	1.1	9.1	9.2	9.3	
	----- Number of animals -----				
2.1				494	494
5.1		221			221
8.2			91	91	182
8.3	104				104
10.1		156			156
10.2		143			143
11.2		2,054			2,054
25	312	429		234	975
27		325			325
29		650			650
Total deficit	416	3,978	91	819	5,304
Per cent of total deficit		75.0	1.7	15.4	

TABLE XXVIII

MOVEMENTS OF CATTLE IN AN OPTIMAL SYSTEM FOR TENNESSEE
DURING THE SECOND QUARTER, 1962, FOR CATTLE
GRADED STANDARD AND BELOW

Surplus areas	Deficit areas			Total surplus	Per cent of total surplus
	9.1	9.3	10.2		
	- - - - Number of animals - - - -				
1.1		105		105	
2.1		345		345	
4.1		131		131	
5.1		286		286	
5.2	7		124	131	
8.2		1,476		1,476	
8.3		124		124	
9.2		1,399		1,399	17.1
10.1	605			605	
11.2	2,041			2,041	
13.3	247			247	
25		111		111	
27	963	45		1,008	
30	163			163	
33	13			13	
Total deficit	4,039	4,022	124	8,185	
Per cent of total deficit	49.3	49.1			

TABLE XXIX

MOVEMENTS OF CATTLE IN AN OPTIMAL SYSTEM FOR TENNESSEE DURING THE THIRD QUARTER, 1962,
FOR CATTLE GRADED STANDARD AND BELOW

Surplus areas	Deficit areas					Total surplus	Per cent of total surplus
	1.1	4.1	9.1	9.3	10.1		
	Number of animals						
2.1				910		910	
5.1		325		169		494	
8.2			1,599		130	1,729	
8.3	182				143	325	
9.2			1,989			1,989	16.6
10.2		182	312		234	728	
11.2			5,625			5,625	
30					169	169	
Total deficit	182	507	5,937	4,667	234	11,969	
Per cent of total deficit			49.6	39.0			

TABLE XXX

MOVEMENTS OF CATTLE IN AN OPTIMAL SYSTEM FOR TENNESSEE DURING THE FOURTH QUARTER, 1962,
FOR CATTLE GRADED STANDARD AND BELOW

Surplus areas	Deficit areas				Total surplus	Per cent of total surplus
	1.1	4.1	8.1	9.1	9.3	
	Number of animals					
2.1						
5.1		39		117	456	456
8.2			13			156
8.3	624				1,879	1,892
9.2					2,919	624
10.1				1,222		2,919
10.2				85		1,222
11.1				416		85
11.2				6,663		416
11.3				137		6,663
25	278				574	137
27	7					852
30				104		111
33				365		365
36				391		391
				98		98
Total deficit	909	39	13	9,598	5,828	16,387
Per cent of total deficit				58.6	35.6	

TABLE XXXI

MOVEMENTS OF CALVES IN AN OPTIMAL SYSTEM FOR TENNESSEE DURING
THE FIRST QUARTER, 1962, FOR CALVES
GRADED PRIME AND CHOICE

Surplus areas	Deficit areas					Total surplus	Per cent of total surplus
	1.1	2.1	22	25	27		
	- - - - - Number of animals - - - - -						
5.1		182				182	
8.2			2,821			2,821	
9.1				156	117	273	1.2
9.2			8,905	949		9,854	45.0
9.3	7,280	1,339	169			8,788	40.0
Total deficit	7,280	1,521	11,895	1,105	117	21,918	

TABLE XXXII

MOVEMENTS OF CALVES IN AN OPTIMAL SYSTEM FOR TENNESSEE
DURING THE SECOND QUARTER, 1962, FOR CALVES
GRADED PRIME AND CHOICE

Surplus areas	Deficit areas				Total surplus	Per cent of total surplus
	1.1	8.3	10.2	22		
	- - - - - Number of animals - - - - -					
4.1				520	520	
5.1	1,307				1,307	
5.2				1,339	1,339	
8.1		364		1,457	1,821	
8.2				9,074	9,074	
9.1			52	90	142	.6
9.2	6,500			1,333	7,833	33.1
9.3	1,254				1,254	5.3
11.2			20		20	
27				370	370	
Total deficit	9,061	364	72	14,183	23,680	

TABLE XXXIII

MOVEMENTS OF CALVES IN AN OPTIMAL SYSTEM FOR TENNESSEE DURING THE THIRD QUARTER, 1962,
FOR CALVES GRADED PRIME AND CHOICE

Surplus areas	Deficit areas			Total surplus	Per cent of total surplus
	1.1	9.1	9.2	10.1	22
	Number of animals				
4.1	1,183				
5.1			1,183		
8.1			1,599		
8.2	8,814		559	715	
8.3	975				
9.3	715				4.4
11.1		325		78	
Total deficit	11,687	325	3,341	78	715
Per cent of total deficit		2.0	20.7		
					16,146

TABLE XXXIV

MOVEMENTS OF CALVES IN AN OPTIMAL SYSTEM FOR TENNESSEE
DURING THE FOURTH QUARTER, 1962, FOR CALVES
GRADED PRIME AND CHOICE

Surplus areas	Deficit areas				Total surplus	Per cent of total surplus
	1.1	9.1	9.2	10.1		
	- - - - - Number of animals - - - -					
4.1	994				994	
5.1		326		26	352	
8.1			1,008		1,008	
8.2	2,744	246	3,673		6,663	
9.3	7,344				7,344	43.2
25	650				650	
Total deficit	11,732	572	4,681	26	17,011	
Per cent of total deficit		3.4	27.5			

TABLE XXXV

MOVEMENTS OF CALVES IN AN OPTIMAL SYSTEM FOR TENNESSEE
DURING THE FIRST QUARTER, 1962, FOR CALVES
GRADED GOOD AND STANDARD

Surplus areas	Deficit areas			Total surplus	Per cent of total surplus
	2.1	9.2	9.3		
	- - - - Number of animals - - - -				
4.1	117		234	351	
5.1		39	702	741	
9.1		39		39	2.8
11.2		260		260	
Total deficit	117	338	936	1,391	
Per cent of total deficit		24.3	67.3		

TABLE XXXVI

MOVEMENTS OF CALVES IN AN OPTIMAL SYSTEM FOR TENNESSEE DURING THE SECOND QUARTER, 1962,
FOR CALVES GRADED GOOD AND STANDARD

Surplus areas	Deficit areas				Total surplus	Per cent of total surplus
	1.1	9.1	9.2	10.2	22	27
	Number of animals					
4.1	39				39	
5.1			267		267	
8.2			780		91	13
9.3	13				13	0.9
11.2		20	104	130	254	
Total deficit	52	20	1,151	130	91	13
Per cent of total deficit		1.4	79.0			
					1,457	

TABLE XXXVII

MOVEMENTS OF CALVES IN AN OPTIMAL SYSTEM FOR TENNESSEE DURING THE THIRD QUARTER, 1962,
FOR CALVES GRADED GOOD AND STANDARD

Surplus areas	Deficit areas			Total surplus	Per cent of total surplus
	1.1	9.2	10.1 22 27		
	Number of animals				
5.1	78	1,443		1,521	
8.2			13	13	
9.1		130		221	6.0
9.3	1,664		65	1,729	46.7
11.2			39	221	
Total deficit	1,742	1,573	78	3,705	
Per cent of total deficit		42.5			

TABLE XXXVIII

MOVEMENTS OF CALVES IN AN OPTIMAL SYSTEM FOR TENNESSEE
DURING THE FOURTH QUARTER, 1962, FOR CALVES
GRADED GOOD AND STANDARD

Surplus areas	Deficit areas				Total surplus	Per cent of total surplus
	1.1	4.1	9.1	9.2		
	- - - - Number of animals - - - - -					
5.1	46	7		312	365	
8.1				156	156	
8.2	104				104	
9.3	3,802				3,802	74.6
10.1			13		13	
11.2			598	59	657	
Total deficit	3,952	7	611	527	5,097	
Per cent of total deficit			12.0	10.3		