RESEARCH BULLETIN 981 FEBRUARY 1966

Suggested Location of Ohio Livestock Markets to Reduce Total Marketing Costs

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AGDEX 400/842

2-66-2.5M

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INTRODUCTION

The most important function of a livestock market is to bring the seller and buyer of livestock together and satisfy the needs of each more efficiently than either can do separately. The buyer wants an adequate supply of livestock, with the desired weight, grade, and quality required by his trade, from a few sources relatively close to his base of operations. The seller wants a strong, conveniently located market with enough buying competition to insure a good market price and reasonably low marketing costs.

The number of markets in operation affects the efficiency of the marketing system. When too many markets exist, many are apt to be weak financially and lack the resources to efficiently carry on the necessary marketing functions.

During 1964, there were 60 auction markets, 3 terminal markets, 77 packer buying stations with scales, and 143 concentration yards in operation in Ohio.[1] This total of 283 markets appeared to be a considerably larger number than desirable for an efficient marketing system in the state.

One method to determine a more efficient marketing system is to apply the general principles involved in location analysis. These are that business activities tend to locate where procurement, processing, and distribution costs are at a minimum.

When terminal markets began operation, these markets were compelled to build facilities at the large railroad centers. The nature of railroad transportation would not allow the markets much flexibility in location. However, development of motor truck transportation since the 1920's has presented a much different situation. The flexibility of this kind of transportation aided the development of auction and local markets and enabled them to locate facilities close to the livestock. With the

[1]More than 340 dealers were operating in Ohio in 1964. Many were associated with above markets and some were operating independently.
Source: Ohio Dept. of Agr.

growth and expansion of auction and local markets, location has become more important in insuring successful operation.

The objective of this study is to determine the number and approximate location of livestock markets which will minimize average total costs of marketing (the sum of the average unit cost of market operation and the average unit cost of transportation). To do this, the volume of livestock marketed by county, cost of livestock market operation, and transportation cost must be determined. This information is combined into an expression representing the total average unit cost of marketing livestock. Then the number and location of markets which will minimize total marketing costs can be suggested.

It is realized that all operating markets have made their decisions on location, buildings have been erected, concrete has been laid, and the operators have little choice except to compete from their present locations. However, with information from this study, market operators should be in a better position to plan for future operations, changes, expansions, or consolidations.

VOLUME OF LIVESTOCK MARKETED

A method has been developed to estimate the number of cattle, calves, hogs, sheep and lambs sold in each county. The Crop Reporting Board of the Statistical Reporting Service, U. S. Department of Agriculture, publishes annually the inventory of livestock on farms, by counties, on January 1 and the number of livestock marketed in the state each year by species. To estimate the number of cattle marketed per county, the percentage of all cattle on farms January 1 in each county was multiplied by the total number of cattle marketed within the state in 1961. This process was then repeated for each species in all Ohio counties. To have a uniform measure of livestock volume, total numbers of livestock marketed were changed to a new unit, a *marketing unit.* A marketing unit is a measure of service revenue (income) to the market or a measure of cost to market livestock for the seller.

In the interior markets of Ohio for 1962, a marketing unit was approximately equal to $2.50 or the average cost of marketing one cow or steer, or two calves, or five hogs, or five sheep and lambs. If a group of farmers sold 100 cattle, 200 calves, 500 hogs, and 500 sheep and lambs, they sold 100 marketing units each of cattle, calves, hogs, and sheep and lambs, or a total of 400 marketing units.

For the Cleveland and Cincinnati areas, a slightly different basis was used for 100 marketing units. In Cleveland, 100 marketing units consisted of 100 cattle, or 200 calves, or 312 hogs, or 555 sheep and lambs; in Cincinnati, 100 cattle, or 192 calves, or 357 hogs, or 357

TABLE 1.—Total Marketing Units by County and Sub-area for 1950, 1955, 1960, 1961, and 1962, Ohio.

County and Sub-area	Total Marketing Units				
	1950	1955	1960	1961	1962
Allen	25,200	24,600	23,600	21,700	21,500
Defiance	12,400	13,300	13,100	12,900	13,000
Fulton	25,900	31,100	36,900	37,200	38,000
Hancock	34,500	37,000	37,700	35,100	35,000
Henry	13,500	15,900	15,900	15,800	15,700
Lucas	6,200	7,600	6,000	5,400	5,300
Paulding	7,300	6,900	6,600	6,300	6,300
Putnam	31,900	34,000	33,500	31,200	31,000
Van Wert	13,300	12,900	12,100	11,600	11,500
Williams	23,600	24,400	25,900	25,200	25,200
Wood	19,300	22,600	21,600	21,500	21,400
Northwestern or Sub-area 1	213,100	230,300	232,900	223,900	223,200
Ashland	17,000	22,200	20,000	20,700	20,800
Crawford	29,800	34,800	32,600	30,600	30,900
Erie	7,100	7,700	6,900	6,700	6,700
Huron	16,300	17,900	18,500	17,900	18,100
Lorain	13,900	15,800	13,600	14,500	14,700
Ottawa	4,700	5,300	5,000	4,800	4,900
Richland	19,900	22,000	18,200	18,000	18,000
Sandusky	16,500	19,800	19,000	19,100	19,600
Seneca	28,600	33,600	30,500	29,000	29,200
Wyandot	26,300	28,900	27,200	24,900	25,100
Northern or Sub-area 2	180,100	208,000	191,500	186,200	188,200
Ashtabula	14,500	18,700	14,000	15,700	16,100
Columbiana	13,100	15,800	14,100	15,500	15,900
Cuyahoga	2,500	1,800	1,100	800	800
Geauga	8,700	9,600	7,200	7,600	7,600
Lake	2,100	2,200	1,400	1,300	1,300
Mahoning	10,600	12,500	8,700	9,200	9,200
Medina	15,700	18,400	15,600	16,300	16,800
Portage	12,900	14,200	11,600	12,200	12,500
Stark	18,700	21,800	19,800	20,600	21,000
Summit	6,000	6,300	3,200	3,200	3,100
Trumbull	12,300	15,600	11,200	12,200	12,400
Wayne	29,800	37,900	38,700	39,700	40,500
Northeastern or Sub-area 3	146,900	174,800	146,000	154,300	157,200

TABLE 1. (Continued)—Total Marketing Units by County and Sub-area for 1950, 1955, 1960, 1961, and 1962, Ohio.

County and Sub-area	Total Marketing Units				
	1950	1955	1960	1961	1962
Auglaize	29,000	30,800	29,400	28,400	29,000
Champaign	35,500	38,200	36,300	35,100	35,700
Clark	33,200	37,200	36,700	34,800	35,400
Darke	41,500	44,500	45,700	42,500	43,500
Hardin	33,600	34,100	30,900	28,700	29,000
Logan	26,900	29,200	25,600	25,100	25,600
Mercer	36,000	38,700	38,000	35,500	36,200
Miami	21,900	23,000	22,500	22,400	22,800
Shelby	24,100	27,600	24,900	23,800	24,300
Western or Sub-area 4	249,300	303,300	290,000	276,300	281,500
Delaware	25,700	28,400	24,500	23,800	24,100
Fairfield	35,100	40,400	39,100	37,100	38,000
Fayette	51,400	61,900	56,400	48,800	49,700
Franklin	26,000	27,300	22,300	20,800	20,500
Knox	28,800	31,000	30,000	29,200	29,700
Licking	35,300	40,000	34,100	33,300	33,300
Madison	44,900	52,400	53,000	47,300	48,400
Marion	31,200	33,300	34,100	30,900	31,000
Morrow	23,300	26,200	22,700	21,600	21,500
Pickaway	48,900	51,200	50,700	46,200	47,000
Ross	34,200	35,500	36,800	33,700	34,400
Union	32,600	33,900	32,700	31,200	31,300
Central or Sub-area 5	417,400	461,500	436,400	403,900	408,900
Belmont	13,600	14,300	13,300	14,500	14,300
Carroll	10,000	11,600	11,200	11,700	11,900
Coshocton	20,400	21,400	21,800	21,700	21,700
Harrison	9,800	9,800	9,800	10,500	10,600
Holmes	22,000	26,800	26,100	25,700	25,600
Jefferson	6,600	7,600	5,900	6,200	6,200
Tuscarawas	15,200	17,700	16,200	16,900	16,900
Eastern or Sub-area 6	97,600	109,200	104,300	107,200	107,200
Butler	43,800	47,600	40,600	38,200	38,700
Clermont	19,200	18,200	15,200	15,300	15.400
Clinton	57,000	59,900	63,600	55,900	56,300
Greene	48,500	54,600	57,000	50,300	51,100
Hamilton	11,100	9,300	6,100	5,800	8,500
Montgomery	25,500	25,300	21,100	20,600	20,500
Preble	44,200	48,500	38,600	43,500	44,100
Warren	38,300	37,600	32,500	30,900	25,400
Southwestern or Sub-area 7	287,600	301,000	284,700	260,500	260,000

TABLE 1. (Continued)—Total Marketing Units by County and Sub-area for 1950, 1955, 1960, 1961, and 1962, Ohio.

County and Sub-area	Total Marketing Units				
	1950	1955	1960	1961	1962
Adams	15,100	16,800	16,800	16,900	17,000
Brown	26,300	28,000	28,000	27,500	25,500
Gallia	100,400	11,500	9,800	10,500	10,400
Highland	44,600	48,300	47,200	43,300	43,200
Jackson	6,500	7,700	6,300	6,600	6,500
Lawrence	6,100	6,700	4,500	4,800	4,800
Pike	8,500	7,200	7,500	7,300	7,400
Scioto	7,700	7,400	7,300	7,400	7,500
Southern or Sub-area 8	125,200	133,600	127,400	124,300	122,300
Athens	9,300	11,200	8,300	9,000	9,000
Guernsey	13,200	14,800	13,200	14,400	14,900
Hocking	6,900	6,700	6,100	6,300	6,300
Meigs	8,600	9,600	7,900	8,500	8,600
Monroe	10,000	10,600	8,000	8,900	8,900
Morgan	11,900	13,800	11,400	12,400	12,500
Muskingum	20,000	23,600	20,600	21,500	21,800
Noble	11,700	12,100	10,000	11,000	13,200
Perry	12,700	14,200	12,100	12,300	12,400
Vinton	4,800	5,100	4,600	4,500	4,500
Washington	13,500	15,400	12,600	13,600	13,800
Southeastern or Sub-area 9	122,600	137,100	114,800	122,400	125,900
Ohio	1,872,200	2,058,800	1,928,600	1,859,000	1,874,400

sheep and lambs. A more complete discussion of the method of estimating marketing units is given in the Appendix.

Total marketing units sold in each county are shown in Table 1.

COST OF LIVESTOCK MARKET OPERATIONS

A representative sample of Ohio auction and auction-dealer combination markets was the basis for cost of market operation curves, Figures 1 and 2. The sample included more than half of all auction and combination markets in the state. A combination market is one that holds an auction one day a week and buys hogs the remainder of the week.

Average cost curves for the markets in the sample were developed for the total cost of market operation from the following seven cost categories:

(1) Salaries: All wages, auctioneers' salaries and expenses, and owners' salaries.

(2) Transportation: Autos and trucks, gas, oil, maintenance, and depreciation; and travel.

(3) Advertising, Utilities, and Supplies: Advertising, telephone, telegraph, heat, light, water, office supplies, postage, yard expense, feed, and yardage.

(4) Miscellaneous and Losses: Directors' expenses, local committee, professional, bad debts, dead and crippled livestock, and miscellaneous.

(5) Taxes: Retirement, Social Security, unemployment insurance, and real estate taxes.

(6) Interest, Rent, and Insurance: Interest on borrowed funds, rent, and insurance.

(7) Depreciation and Maintenance: Depreciation of yard facilities, restaurant, furniture, fixtures, and buildings; repairs to yard, furniture, and buildings.

The process used to calculate these average cost curves[2] is discussed in the Appendix.

The total cost of market operation is represented by the upper curve in Figure 1. This shows the average total cost of market operation in relation to market size. The average cost of market operation, as read on the vertical scale, decreases rapidly as size of market increases from 5,000 marketing units (MU's) until a volume of 30,000 MU's is reached. After 30,000 MU's, average cost decreases less as volume increases.

The lower curve in Figure 1 represents the average salary and wage costs of markets included in the sample. The general form of this curve is the same as the total cost of market operation curve, with large decreases in average cost up to about 30,000 marketing units. After 30,000 MU's, the added savings with increasing volume become smaller and smaller. Salary and wage costs averaged about 62 to 64 percent of the total cost, depending on size of market operation. Changes in market operations that increase labor efficiency reduce the total cost of market operations more than any other cost category.

The upper curve of Figure 2 is the average cost of advertising, utilities, and supplies. It is the same type of curve as those in Figure 1 and has a similar relationship, with savings in average cost as size increases.

The five cost categories of interest-rent-insurance, transportation, depreciation-maintenance, miscellaneous-loss, and taxes do not

[2]Dr. Francis E. Walker, Department of Agricultural Economics and Rural Sociology, gave valuable help and assistance in research methodology and mathematical procedures used in this publication.

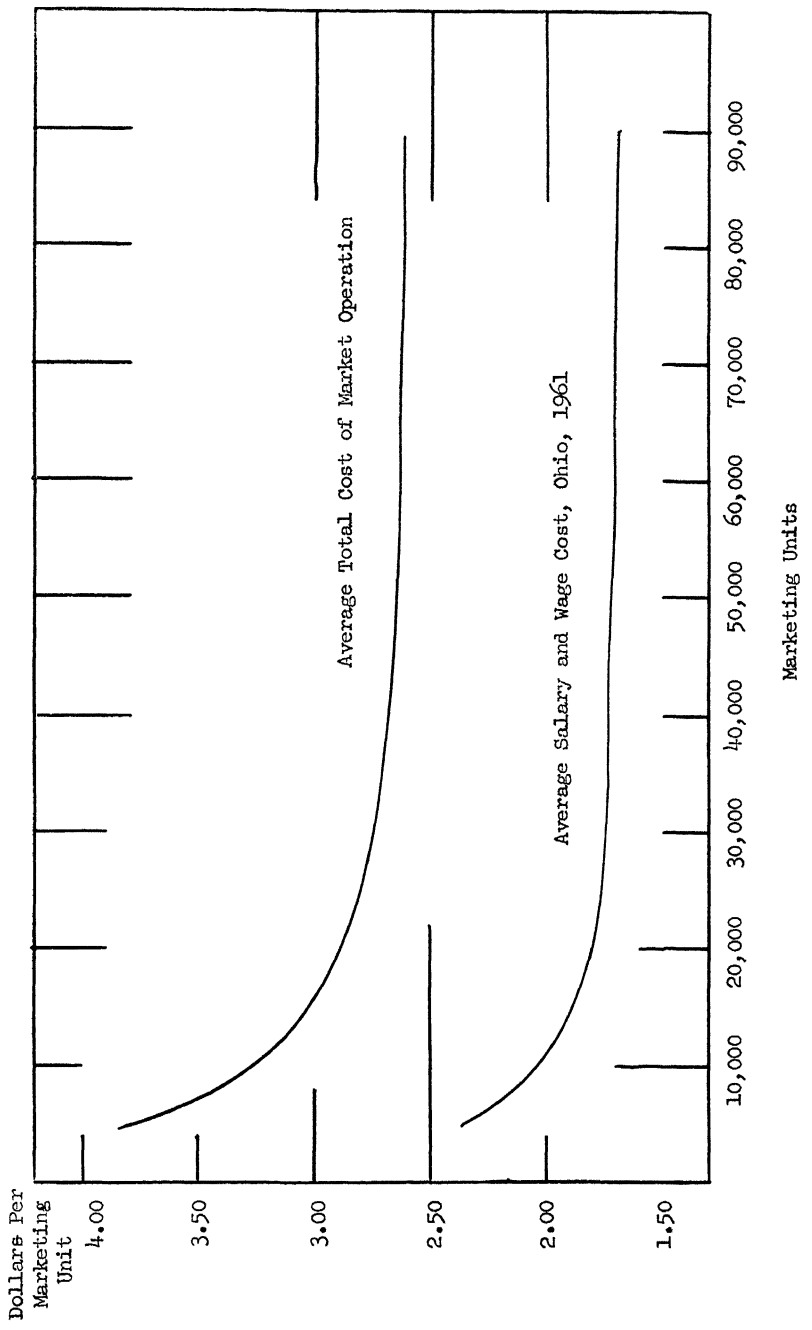

Fig. 1.—Average total cost of market operation and average salary and wage cost, Ohio, 1961.

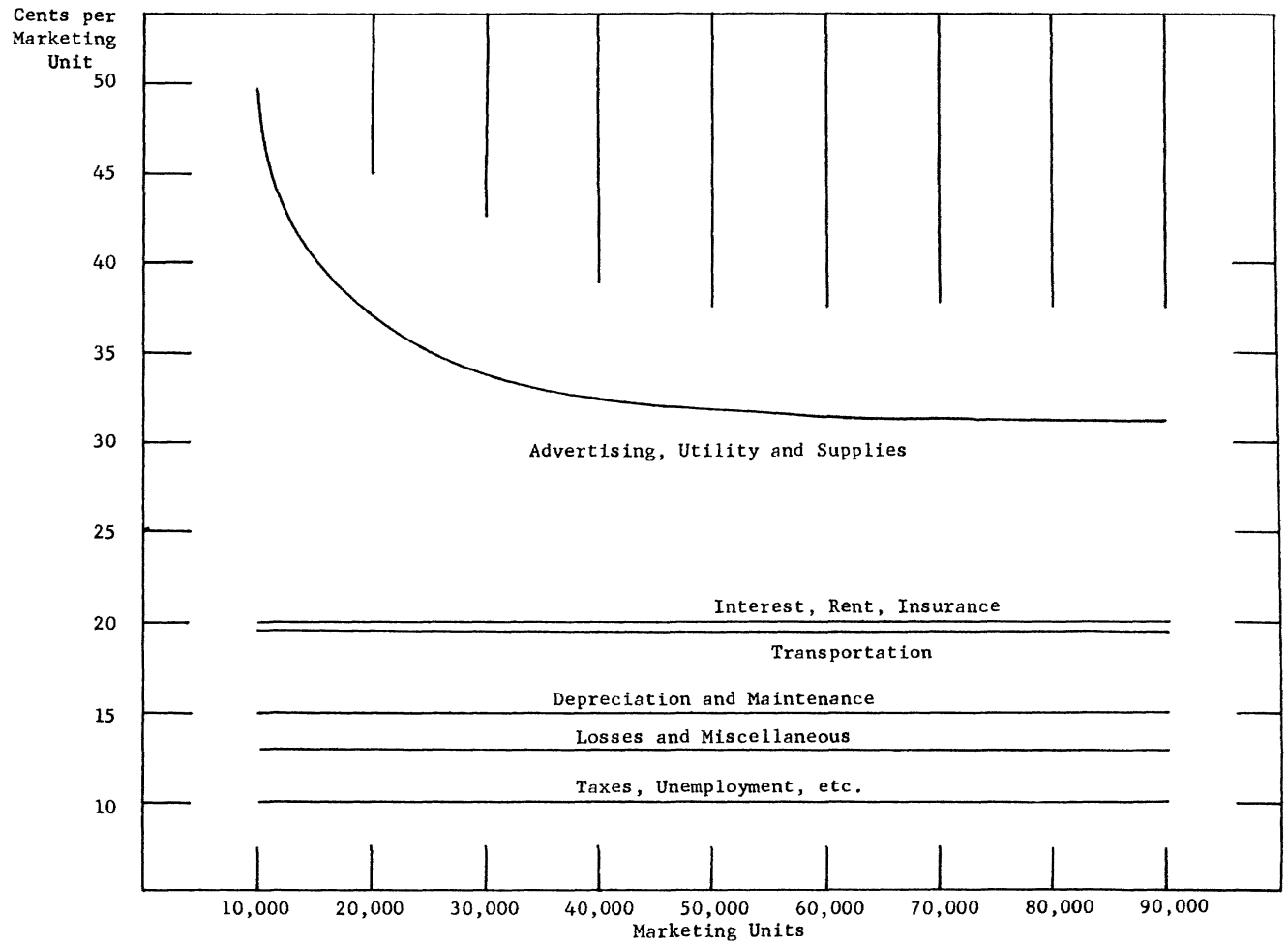

Fig. 2—Other costs of market operation by six cost groups, Ohio, 1961.

change on the average as size of market increases. This indicates that the larger markets do not operate at lower average cost than the small markets in relation to these latter cost categories, which make up approximately 25 percent of all costs.

This study showed that costs for all markets studied remained about the same after markets reached an annual volume of approximately 40,000 marketing units. This might indicate that there is no reason for markets larger than 40,000 marketing units. However, large concentrations of livestock at an auction give buyers more choice and selection of grades and weights. This could mean more buyers, stronger competition, and more satisfactory prices at markets with an annual volume of more than 40,000 marketing units. This phase of volume influence was not a part of this research.

TRANSPORTATION COST

Data were collected in 1959 and 1960, as part of a regional livestock marketing project, on transportation costs paid by farmers for moving their livestock to market in the Corn Belt States.

An analysis of these data is shown in the Appendix. The results indicate that the average transportation cost per cwt. was:

10 miles	$.126 per cwt.
20 miles	$.146 per cwt.
30 miles	$.166 per cwt.
40 miles	$.187 per cwt.

Transportation costs increase an average of 2 cents per cwt. for every 10-mile increase in shipping distance.

Recently there have been indications that transportation costs may be the same over an area 30 or more miles in diameter. If this pattern develops, the transportation factor will have a different effect on market location. It will permit larger markets to operate and still minimize the cost of transportation and market operation.

OPTIMUM LIVESTOCK MARKET LOCATION

The optimum point of market location is where the average total cost of marketing is lowest for a given density of livestock.

Before developing the average total cost curve, two adjustments must be made in the average transportation cost curve.[3] One involves density of marketing units and the other concerns a change in units of measure.

[3]Computation details are covered in the appendix.

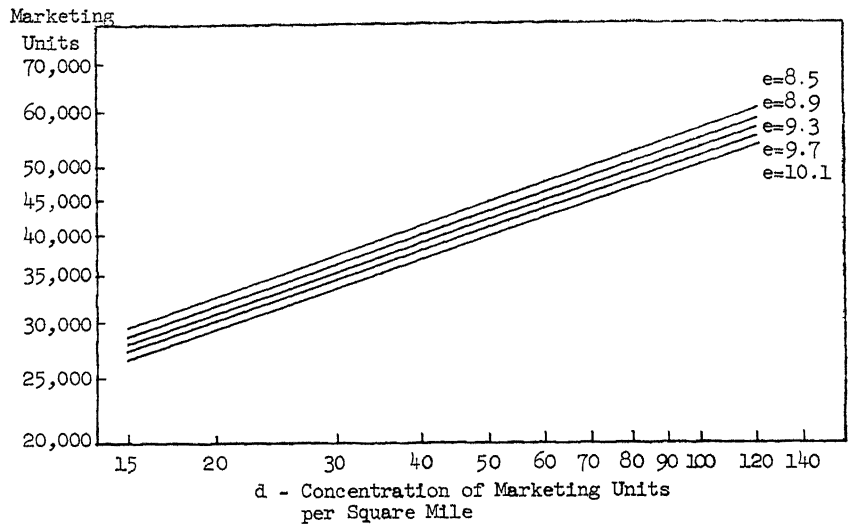

Fig. 3.—Optimum size livestock market for given "d" and "e" values.

The density of marketing units per square mile is computed for each county and called the "d" value. This factor can be introduced in the transportation equation to adjust the cost of transportation for different densities of livestock.

The cost of market operation curve is measured in dollars per marketing unit but the transportation curve is measured in dollars per hundredweight of livestock. A value "e" is computed for each county to change from cost per hundreweight to cost per marketing unit.

By adding the adjusted transportation function and market operation function, an expression of average total cost of marketing livestock is obtained.

Figure 3 enables the reader to determine the approximate number of marketing units to minimize the average total cost curve for given "d" and "e" values. For example, in Allen county (Fig. 4) d = 53.0 and e = 9.7. On Figure 3 where d = 53.0 intersects the curve with e= 9.7, the optimum size market is shown at about 41,200 marketing units.

When the "e" value is between curves, the point representing the "e" value must be estimated. If the market serves more than one county, the "d" and "e" values are determined by averaging those values for the counties represented. Figure 4 gives the number of marketing units and "d" and "e" values for counties in 1961.

AN OHIO MARKETING SYSTEM TO MINIMIZE AVERAGE TOTAL COSTS

The state was divided into 21 relatively homogeneous density areas and average "d" and "e" values were computed for each area. From these "d" and "e" values, the market size minimizing average total costs was calculated. In each density area, the total number of marketing units was divided by the optimum market size to determine the number of markets necessary to minimize average total costs of marketing. This process was completed for each of the 21 density areas.

The next step was to recommend the location and size of markets which will produce a more efficient marketing system than currently

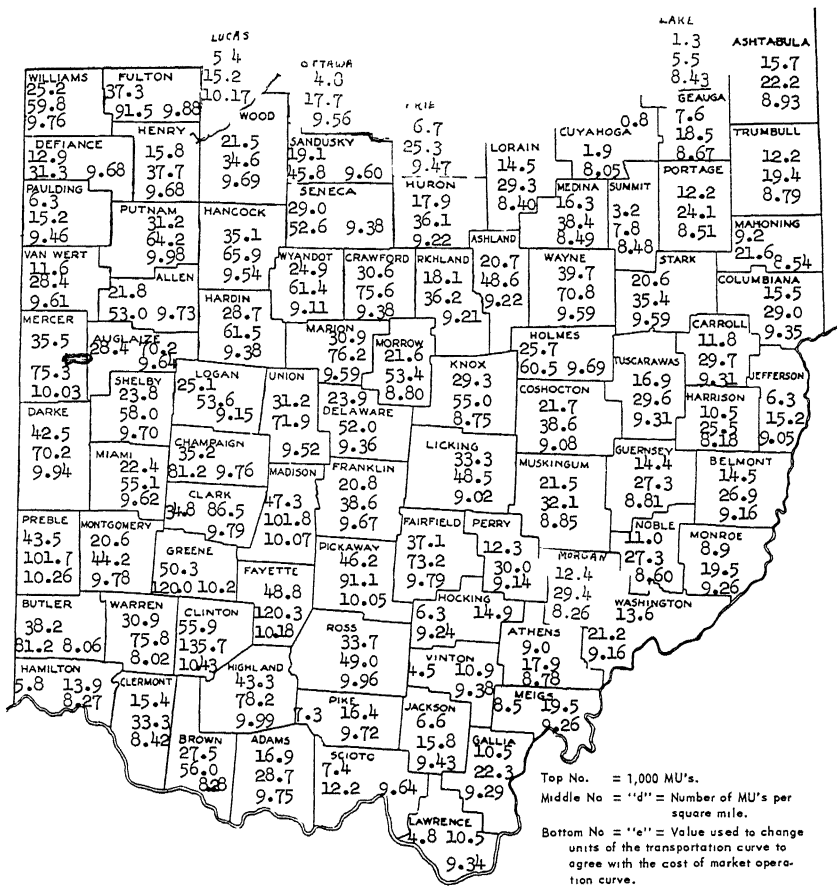

Fig. 4—Marketing units, "d" and "e" values necessary to determine optimum market size, 1961.

exists. In making the final recommendations on market size and location, results of the mathematical formulations and a group of other factors relating to current marketing systems were considered. These factors were:

1. Current location of larger marketing facilities in the state.
2. Large urban areas and relatively low densities of marketing units surrounding urban areas.
3. Location of state forest areas and consequent lack of livestock production.
4. Location of present markets. Generally, it is not advantageous to locate two markets in the same community since this tends to divide

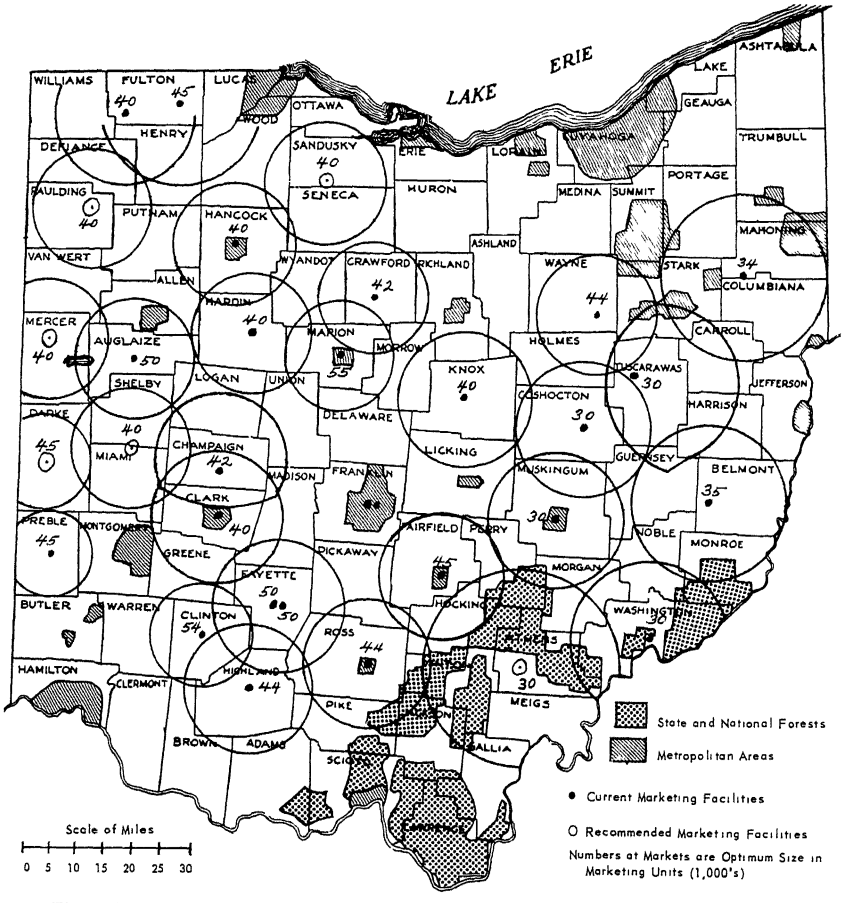

Fig. 5.—Recommended location of livestock markets in Ohio which will tend to minimize total marketing costs.

volume of marketing units and increase transportation costs. However, in areas of heavy density such as the Clinton-Fayette-Madison-Greene area, two markets can be located in one city without appreciably increasing costs.

5. Location of terminal markets. Careful thought was given to current flow of livestock movement and the current and future importance of the terminal markets and packer buying stations.

6. Flexibility of markets. This is an important consideration so adjustment forces can take place more easily. If the number of markets were reduced to the recommended size, most remaining markets could easily increase total volume with the same physical plant by holding more than one auction per week.

Figure 5 shows the approximate location and size of livestock markets in Ohio which would minimize the average total costs of marketing. The large circles indicate the approximate area needed to obtain the required number of marketing units for each market. The dots are the markets currently in operation which could fit into this new pattern of market structure. The numbers beside the dots and the circles indicate the optimum number of marketing units (in thousands) for the market and related density area.

Large cities should be avoided for market location. It is better for slaughterers located in large cities to move the livestock direct to the slaughter plant from markets or the point of original purchase.

COMPARISON OF CURRENT AND RECOMMENDED MARKET STRUCTURES

Under the recommended marketing structure, there would be 29 markets, plus Cleveland, Columbus, Dayton and Cincinnati, handling annually at least 30,000 or more marketing units. During 1964 there were 60 auctions, 3 terminal markets, 77 slaughtering establishments with scales, and 143 concentration yards operating in Ohio. This makes a total of 283 markets providing the services of bringing buyers and sellers of livestock together, compared to the recommended number of 33.

Since Ohio has more than eight times as many marketing locations as recommended in this study, this seriously complicates livestock buyers' problems of obtaining the quantity and quality of livestock wanted and increases considerably the average total costs of marketing.

From information available in this investigation, it appeared that more than 50 percent of Ohio livestock markets were operating at less than 10,000 marketing units annually. These low volume markets were

adding from $200,000 to $500,000 to annual marketing costs. No estimate has been made of extra costs to packers for procurement from so many small markets. However, this would be an important added cost.

In the recommended marketing structure, the optimum size market in the highest density area was calculated at 52,000 marketing units per year. It should be noted that marketing costs do not change much per 10,000 marketing units on either side of the optimum. However, at small markets of 5,000 to 10,000 marketing units, costs increase very rapidly with changes in volume. In addition, costs increase less rapidly with volumes higher than optimum than with volumes less than optimum.

Larger markets with a greater selection of livestock grades, weight, and quality should attract more buyers. With more buyers, the farmer should be assured of receiving a fair market price for his livestock. With 30 to 40 markets in Ohio instead of the present number (283), more buyers could attend an individual market or sale.

It should be noted that future changes in costs of operation or transportation could change the optimum number and size of markets. This research should be continued for 5 or more years to see if important changes in costs develop or if other factors enter the marketing situation which would alter the conclusions.

CONCLUSIONS

The large number of small markets is the chief complicating factor in the current Ohio livestock marketing system. These smaller firms generally do not have the resources to do an efficient job for either the buyer or seller of livestock. A marketing agency should handle annually at least 30,000 marketing units to minimize the average total costs of marketing.

Based on this study, Ohio should have approximately 33 livestock markets under an optimum marketing structure. The optimum size market would vary between 30,000 and 55,000 marketing units, depending on the density of marketing units in the market area.

Most of the economies of large market operations based on Ohio 1961-62 costs were realized at a volume of 30,000 to 40,000 marketing units. As the size of market declined to 10,000 marketing units, the average unit cost of operation rose about 50 cents per marketing unit.

Average unit cost of market operation and salary and advertising costs of market operation appear to have a hyperbolic relationship (Fig. 1)with size of market. Average unit costs were much higher at low volumes and declined sharply as volume increased. As volume ap-

proached 30,000 marketing units, the average cost of operation remained about the same. There was little additional decrease in average costs as volume continued to increase. The cost categories of interest, transportation, depreciation and maintenance, taxes, and miscellaneous items appeared to have linear (straight line) cost relationships.

Average total costs of transportation and market operation did not change much when markets were operating within 10,000 marketing units above or below optimum volume. Optimum volume was the volume that minimized average total cost. The optimum volume within a given area was affected by density of marketing units.

If the market system in Ohio adjusted to the optimum number indicated in this study, advantages to both buyers and sellers should develop.

Advantages to Livestock Sellers

Fewer and larger markets would offer greater selection in both quantity and quality of slaughter livestock. This should attract more buyers and help sellers obtain more uniformly competitive market prices.

A strong market is more capable of supplying other necessary marketing functions. These include grading and sorting livestock, obtaining and financing feeder livestock, and doing a better job of urging producers to supply the weight, grade (or quality), and quantity of livestock meeting the demands of packers and consumers.

Advantages to Livestock Buyers

Fewer and larger markets would reduce the sources required and simplify buyers' problems of obtaining the required number of slaughter livestock.

Buyers should be in a better position to obtain livestock within the state producing the meat carcass quality demanded by consumers.

Overall procurement costs should be reduced.

RECOMMENDATIONS

The problems involved in moving from the current Ohio livestock marketing system to a more efficient one are not easy to solve. Many individual changes would have to be made.

Perhaps the quickest and easiest way would be for four or five of the smaller markets to combine their selling activities into one unit offering at least 30,000 marketing units of livestock for sale. Each market would then be a sub-assembly point for the larger organization but each could continue to operate its own physical facilities. The larger organization, with enough livestock for sale, could do a more efficient job of sorting and grading livestock and thus attract more buyers.

Changes in the business relationships between individual markets would present difficulties. The solution of these problems should be the subject of future research.

Another possibility in reducing the total number of facilities is through the merger and consolidation of current markets into new corporations. However, the resolution of organizational and financial problems would make this a time-consuming approach to the overall problem.

Two developments taking place in the livestock industry may be of great concern to Ohio livestock markets. In the western and southwestern areas of the United States, rapid growth of large cattle feedlots[4] is taking place. Many feed out more than 20,000 head of cattle a year which are sold directly to large supermarket organizations or slaughterers. In Ohio, two intermediate size food chains are operating feedlots and the cattle are not marketed through any Ohio livestock market.

Developments such as these can seriously affect the Ohio livestock market structure. The Ohio livestock marketing system must be flexible and make the changes required to keep pace with these and other developments in the future.

APPENDIX

The mathematical relationships of this study are covered in this appendix. The entire analysis is covered in detail by Edgar A. Miller.[5] Standard statistical steps are not discussed in detail due to space limitations and the reader is referred to the dissertation or standard statistical textbooks.

Number of Livestock Marketed Per County

The process used to estimate the number of livestock marketed per county by species consists of two parts.

The first step is to obtain the total number of livestock marketed by species for a given year in the state as a whole. This information is published by the U. S. Department of Agriculture in April for the preceding year.[6]

The second step is to distribute the total state marketings by counties. The information used for this distribution is the January 1 inventory of livestock on farms by county. This estimate is published by the Ohio Crop Reporting Service and is available each April for the preced-

[4]On October 1, 1963, the California crop and livestock marketing service reported that 69.5% of the cattle on feed were in feedlots with a capacity of 10,000 or more head.

[5]Miller, Edgar A. 1962. A Mathematical Method of Locating Livestock Markets in Ohio to Minimize Average Total Cost of Transportation and Market Operation. Unpublished Ph. D. dissertation, The Ohio State University.

[6]Meat Animals 1-1, Farm Production, Disposition, and Income by States. Statistical Reporting Service, U. S. Dept. of Agriculture.

ing year.[7] The percentage of cattle and calves on Ohio farms January 1, 1961 is calculated for each county. This percentage is then multiplied by the total number of cattle marketed in Ohio during 1961.

$$\text{Example} \quad \frac{\text{Allen County Jan. 1 Inventory, Cattle and Calves}}{\text{Jan. 1 Inventory, Cattle and Calves All 88 Counties in Ohio}} \times \text{Ohio Cattle Marketings 1961}$$

A slight adjustment can be made to make the calculation process easier and more accurate. The ratio of cattle marketings to total number of cattle and calves in inventory can be multiplied by each county January 1 inventory. The expression looks like this:

$$\frac{\text{Ohio Cattle Marketings, 1961}}{\text{Jan. 1 Inventory, Cattle and Calves, All 88 Counties in Ohio}} \times \text{Allen County Jan. 1 Inventory Cattle and Calves}$$

Tables showing this information for each species for 1950, 1955, 1960, and 1961 are printed in Research Bulletin 963, Livestock Marketing in Ohio, by George F. Henning and Edgar A. Miller, Ohio Agricultural Research and Development Center.

Changing County Marketings into Marketing Units

A marketing unit (MU) is a measure of the service charge revenue available to marketing agencies from livestock marketed within a county. Each MU is equal to $2.50, which is the average revenue obtained by auction markets in the state for services rendered in selling one steer or cow. It takes about two calves, five hogs, and five sheep and lambs to equal $2.50 revenue or one MU. However, the relationship between species of livestock differs in areas where most of the livestock move to the Cleveland and Cincinnati terminal markets.

Table 2 shows the number of each species of livestock required to equal one MU. To determine the number of marketing units, the number of each species marketed is multiplied by the transformation factor in Table 2.

Average Cost of Market Operation Curve

Details of the calculation of this curve are discussed by Miller.[8] The curve is hyperbolic in form, indicating that most of the decrease in average cost occurs with rather small volume (25,000 to 30,000 MU's). As the size of the market expands, the average cost of operation decreases less. There is no indication that the average cost of operation increases with the largest operation.[9]

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[7]Ohio Agricultural Statistics. Ohio Crop Reporting Service, USDA Crop Reporting Board, 217 Old Federal Building, Columbus, Ohio.

[8]Miller, Edgar A. op. cit.

[9]Similar results were obtained by Gibb and Riley, An Analysis of Operating Cost at Michigan Livestock Auctions, Tech. Bull. 283, Michigan State University, East Lansing, Mich.; and Lindberg and Judge, Estimated Cost Functions for Oklahoma Livestock Auctions, Bull. B-502, Oklahoma State University, Stillwater, Okla.

TABLE 2.—Transformation Factor to Change Number of Livestock Marketed into Marketing Units for 1961 Charges.

Species	Interior Markets	Cleveland*	Cincinnati†
Cattle	1.00	.98	1.00
Calves	.50	50	.52
Hogs	.20	.32	.28
Sheep and Lambs	.20	.18	28

*Used for Lorain, Mahoning, Lake, Medina, Cuyahoga, Ashtabula, Summit, Geauga, Portage, and Trumbull Counties.

†Used for Butler, Hamilton, Brown, Warren, and Clermont Counties.

The formula for the average cost of market operation and the seven cost categories is shown below. Y is measured in dollars per MU and X equals the number of MU's. These functions show the relationship of average cost as volume changes for total cost of market operation and seven cost categories.

Average Total Cost $= Yc = 2.56275 + \frac{6473}{X}$

Average Salaries Cost $= Yc = 1.65325 + \frac{3566}{X}$

Average Advertising, Utility and Supply Cost $= Yc = .29615 + \frac{1041.8}{X}$

Average Interest, Rent, and Insurance Cost $= Yc = \overline{Y} = .18797$

Average Transportation Cost $= Yc = \overline{Y} = .18297$

Average Depreciation and Maintenance Cost $= Yc = \overline{Y} = .15016$

Average Tax Cost $= Yc = \overline{Y} = .11124$

Average Misc. Cost and Losses $= Yc = \overline{Y} = .13182$

Transportation Curve

The average transportation curve is obtained from standard regression procedures and has the form:

Transportation Cost $= a + bX$
$= .105393 + .0020278X$

Transportation Cost = dollars per hundredweight (cwt.) per mile
X = miles

The units of the original transportation function are dollars per cwt. per mile. These units must be changed into dollars per MU per mile

so they are the same as those in the cost curve of market operation. Therefore, the original curve ($/cwt.) is multiplied by cwt./MU:

$$\frac{\$}{\text{cwt.}} \times \frac{\text{cwt.}}{\text{MU}} = \frac{\$}{\text{MU}}$$

With the number of MU's available per county and the average weight of slaughter livestock, the transformation value "e" can be calculated:

Transportation cost $TC = a_2 + b_2 X$ measured in dollars per cwt.

1. $TC = ae + beX$ $\quad e =$ cwt. per marketing unit

The transformation factor (e) for each county is calculated as follows. It is assumed that the average weight of each species of livestock in the county is the same as the state average.

W_1 = average slaughter weight of cattle = 990 lb.
W_2 = average slaughter weight of calves = 190 lb.
W_3 = average slaughter weight of hogs = 220 lb.
W_4 = average slaughter weight of sheep and lambs = 85 lb.
N_1 = number of cattle marketed
N_2 = number of calves marketed
N_3 = number of hogs marketed
N_4 = number of sheep and lambs marketed

$$2.\ \frac{\text{Total Weight in cwt.}}{\text{Marketing Units}} = \frac{\sum_{i=1}^{N} N_i W_i}{\text{MU}} = \frac{\sum_{i=1}^{N} \text{cwt.}}{\text{MU}} = e$$

For example in Clinton County:

Species	Head Marketed		Average cwt. per Animal	=	cwt. Marketed
Cattle	9,100	X	9.90		90,090
Calves	2,300	X	1.90		4,370
Hogs	218,300	X	2.20		480,260
Sheep	10,000	X	.85		8,500
				Total	583,220

"e" for Clinton County $= \frac{583{,}220 \text{ cwt.}}{55{,}910 \text{ MU for Clinton County}} = 10.4314$ cwt. per marketing unit

The average transportation function varies with changing density. The number of MU's available in any given density area is:

3. $MU = \pi dX^2$ $\quad d =$ density of MU's per square mile
$\pi = 3.1416$
$X =$ radius in number of miles

Now the transformed transportation function is:

4. $TC = a_2\ e + b_2\ e\ X$ $\quad X =$ miles

Distance is equal to:

$$5.\ X^2 = \frac{MU}{d\pi} \qquad X = \sqrt{\frac{MU}{d\pi}}$$

So the final transformed average transportation function is:

$$6.\ TC = a_2\ e + b_2\ e \sqrt{\frac{MU}{d\pi}} \quad \text{or}$$

$$7.\ TC = a_2\ e + \frac{b_2 e}{\sqrt{d\pi}} \sqrt{MU}$$

The cost of market operation function is:

$$8.\ MC = a_1 + b_1 \frac{1}{MU}$$

The total average cost of marketing is the sum of the average transportation and cost of market operation function.

$$9.\ \text{Average Total Cost} = \begin{matrix}\text{Transportation} \\ \text{Average Cost}\end{matrix} + \begin{matrix}\text{Market Operation} \\ \text{Average Cost}\end{matrix}$$

$$ATC = a_2\ e + \frac{b_2\ e}{\sqrt{d\pi}} \sqrt{MU} + a_1 + b_1 \frac{1}{MU}$$

Total average costs are minimized at the point where the slope of the transportation function is equal to the negative of the slope of the market cost function. This can be determined easily by taking the first derivative of the average total cost function.

$$\frac{d\ ATC}{d\ MU} = \frac{1}{2} \frac{b_2\ e}{\sqrt{d\pi}} \frac{1}{\sqrt{MU}} - \frac{b_1}{MU^2}$$

If the above expression is set equal to zero and solved for MU, the result is the optimum number of MU's needed per market to minimize total average costs.

$$\frac{1}{2} \frac{b_2\ e}{\sqrt{d\pi}} \frac{1}{\sqrt{MU}} - \frac{b_1}{MU^2} = 0$$

$$\frac{MU^2\ b_2\ e}{2\sqrt{d\pi}\sqrt{MU}} = b_1$$

$$MU^{3/2}\ b_2\ e = 2b_1 \sqrt{d\pi}$$

$$MU^{3/2} = \frac{2b_1 \sqrt{d\pi}}{b_2\ e}$$

The final expression to find how many MU's are required to minimize average total costs is:

$$10.\quad MU^{3/2} = \frac{2b_1\sqrt{d\pi}}{b_2\ e}$$

After the optimum size market is determined, the expression

$$11.\quad D = \sqrt{\frac{MU}{d\pi}}$$

can be used to determine how large a radius is required to produce the optimum number of marketing units.

The density and "e" values are responsible for the changing optimum market size. Large density values increase the number of marketing units required for optimum market size and smaller densities have an opposite effect. The actual determination of marketing units is solved by application of logarithms, as shown in the following example.

To simplify the calculation and location process, the state was divided into relatively homogeneous density areas. Density contours included whole counties and parts of counties so that, with few exceptions, the maximum variation in density per county per contour was not more than 10 marketing units per square mile. Within these contours, a weighted average density value and "e" value were calculated. The weights used were the number of marketing units in each county.

In contour areas where counties were divided, estimates were based on approximate densities to determine the number of marketing units within the differing contours. Figure 6 shows the contour areas with the available marketing units, densities, and values.

The following sample calculations show details of the mathematics involved. In the Hancock-Hardin-Wyandot county area, there are 83,700 marketing units, a density of 62.5 marketing units per square mile, and an "e" value of 9.40. Formula 10 is used to determine optimum market size.

$$10.\quad MU^{3/2} = \frac{2\ b_1\sqrt{d\pi}}{b_2\ e} \qquad b_1 = 6473 \qquad b_2 = .0020278$$

$$MU^{3/2} = \frac{2\ (6473)\ \sqrt{d\pi}}{.0020278}$$

Substituting the actual density and "e" values of Hancock-Hardin-Wyandot counties, the result is:

$$MU^{3/2} = \frac{2\ (6473)\ \sqrt{(62.5)\ (3.14)}}{.0020278\qquad (9.40)} = \frac{175{,}769.46}{.0190613}$$

$$MU^{3/2} = 9{,}221{,}273 \text{ and } MU = 43{,}973 \text{ or } 44{,}000$$

The number of markets required equals:

$$\frac{\text{MU in density area}}{\text{optimum size market}} \quad \frac{83{,}700}{44{,}000} = 1.90 \text{ or } 2 \text{ markets}$$

The number of required markets was rounded to the nearest half market. The radius required around the market to obtain the necessary number of marketing units is calculated from formula 11:

$$D = \sqrt{\frac{MU}{d\pi}} = \sqrt{\frac{44{,}000}{(62.5)\ (3.14)}} = \sqrt{224.80} = 14.9$$

D = 15 miles

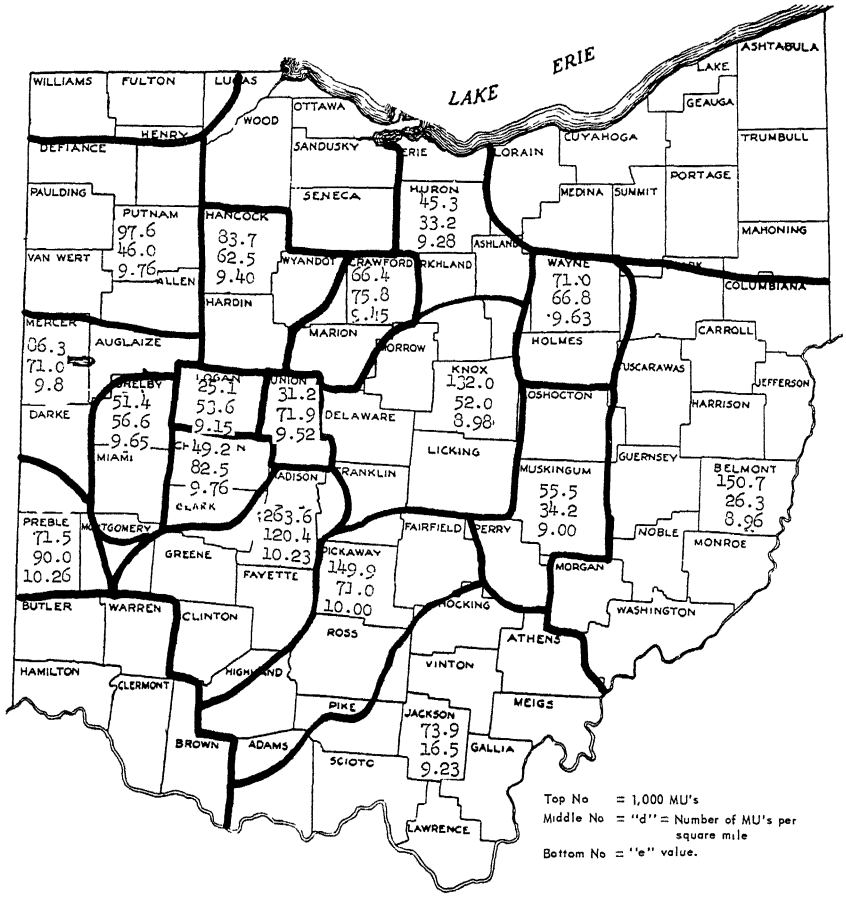

Fig. 6—Homogenous density areas used to calculate optimum market size, 1962.

The results of similar calculations for each density area are shown in Table 3.

TABLE 3.—Optimum Market Size and Related Data for Each Density Area.

County or Area	Average Density	"e" cwt. MU	Total MU's	Optimum Size Market (1,000 MU's)	Optimum Number of Markets	Distance
Columbiana-Washington	26.3	8.96	150,660	34.2	4 ½	20
Wayne-Holmes	66.8	9.63	70,950	44.2	1 ½	15
Knox-Delaware	52.0	8.98	132,040	42.6	3	16
Coshocton-Perry	34.2	9.00	55,510	37.0	1 ½	19
Hocking-Lawrence	16.5	9.23	73,880	28.6	2 ½	24
Fairfield-Highland	71.0	10.00	149,860	44.0	3 ½	14
Madison-Clinton	120.4	10.23	263,570	51.7	5	12
Preble	90.0	10.26	71,510	46.8	1 ½	13
Mercer-Auglaize-Darke	71.0	9.8	86,330	44.6	2	14
Shelby-Miami	56.6	9.65	51,350	41.8	1	15
Champaign-Clark	82.5	9.76	49,160	47.0	1	14
Logan	53.6	9.15	25,130	42.5	½	16
Union	71.9	9.52	31,220	45.7	½	14
Hancock-Hardin-Wyandot	62.5	9.40	83,700	44.0	2	15
Williams	59.8	9.76	25,180	42.3	½	15
Fulton	91.5	9.88	42,750	48.3	1	13
Wood	34.6	9.69	23,350	35.4	½	18
Sandusky-Seneca	49.9	9.47	48,070	40.6	1	16
Ottawa	17.7	9.56	4,750	28.6	½	23
Erie-Huron	33.2	9.28	45,340	35.5	1 ½	18
Crawford-Marion	75.8	9.45	66,410	46.7	1 ½	14
Defiance-Allen	46.0	9.76	97,600	39.5	2 ½	17