Optimal Locations of Beef Production and Processing Enterprises

Bulletin B-707
July 1973

Agricultural Experiment Station
OKLAHOMA STATE UNIVERSITY

Content

Optimal Regional Locations of Beef Production and Processing Enterprises

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Since World War II, the beef industry has been characterized by dynamic patterns of growth in all phases of production and processing. A primary "drawing force" for this dynamic growth has been a rapidly expanding demand for beef—composed largely of the combined forces of rapidly increasing population and even more rapidly increasing average consumer income. While the changes in the demand for beef have been dramatic, there have nevertheless been changes in still other variables that have affected the willingness and ability of producers to provide beef.

Acreage allotment programs have altered patterns of land use. Low crop prices have made the livestock enterprises relatively more attractive. Declining farm numbers, the resulting consolidation of agricultural lands, and the decline in rural labor availability have all worked in favor of enlarging the various beef enterprises. Finally, technological advance in areas such as nutrition, disease and parasite control, slaughter and processing, and the introduction of improved management and financing in the cattle business have further enhanced the profit potential in the beef industry.

The factors that have underlain the changes observed in the beef industry have not been equally important in all geographic regions. As a result, there have been some substantial changes in the relative importance of the various regions so far as the different phases of beef production, processing, and consumption are concerned. The Southeast has replaced the Intermountain West as the region of secondary importance in basic cow-calf production. The Desert Southwest (California and Arizona) and the Great Plains have emerged as major cattle feeding regions. The continuing rural-to-urban population migrations have further concen-

Research reported herein was conducted under Oklahoma Station Project No. 1449.

trated the beef consumption activity. And regional shifts in beef production coupled with improved beef slaughter and processing technology have generated not only regional shifts in beef slaughter, but also increased capacity in an industry that already had more than enough capacity to slaughter and process the available livestock.

The changes already observed in the beef industry raise questions concerning the sorts of further changes that might be expected. It is the purpose of this study first to analyze the optimal[1] regional locations of economic activity in the beef industry, based upon the current (1970) levels of population and income, assuming that all feeding and processing facilities must be constructed anew in any given region. A second analysis will define the optimal locations based upon current population and income estimates, given estimates of currently existing production, feeding, and slaughter facilities.

It is expected that the first analysis would suggest the adjustment that would be expected to ultimately prevail in the beef industry if full adjustment could be achieved instantaneously. That is, the first analysis will show the "target" toward which the beef industry would be expected to adjust. The second analysis is expected to give an indication of the path along which the industry would move toward that ultimate adjustment, since the life of investments in production, feeding and slaughter facilities is of sufficient length to preclude total adjustment in the beef industry over short or intermediate periods of time.

Method of Analysis

The analytical model used in this study was an adaptation of the transhipment model developed by Leath and Martin [1], whereby the total cost of serving the various regional demands for beef was minimized. The flow diagram of Figure 1, showing the movement of a beef animal through the transhipment model, indicates the various costs considered.

The beginning point for the entire system is the beef brood cow herd, limited in any given region by the acreage of native range available and the most of pasture improvement. Available forage may be used either for the production of 450-pound stocker calves or for growing these calves out to 600-pound feeder cattle, depending upon which activity minimizes the total cost of providing carcass beef. Stocker calves may be grown out either in the region of origin or may be transferred to an alternative region.

As in the case of stocker calves, feeder cattle may either be retained in a region for purposes of feeding, or they may be transferred to an

[1] For purposes of this study, "optimal" locations are defined to be those locations which minimize the total cost of producing, processing, transporting, and marketing all live and carcass beef products in the various consumer market areas.

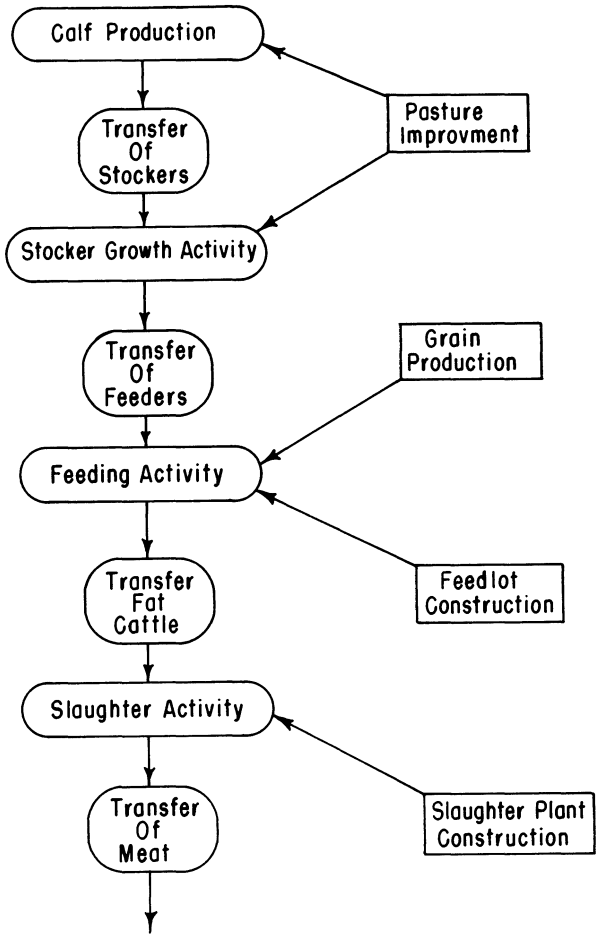

Figure 1. Flow Diagram Showing the Movement of a Beef Animal Through the Transhipment Model

alternative region to be fed to average liveweights of 1100 pounds, depending upon which region will minimize the total cost of providing carcass beef. The feeding activity in any region is limited by the availability and cost of feed grains and by the cost of cattle feeding facilities in the case of the first analysis, and by the combined effects of currently available regional feeding facilities and the cost of new facilities in the case of the second analysis.

Fat cattle may either be slaughtered in the region in which they are fed, or they may be moved to some other region, depending upon

the cost of constructing slaughter facilities in the case of the first analysis, and upon the combined effect of currently available slaughter facilities and new facility construction costs in the second analysis.

The interregional movements of feed grains are similar to the interregional movements of cattle. Each region enjoys the alternatives of using its own grain, of exporting that grain to an alternative region or of purchasing grain from another region. Wheat is treated as a feed grain for purposes of this study.[2]

Regional Demarcation

This study encompasses the forty-eight contiguous states. Regional demarcations were made on the basis of similarity of operations for different segments of the industry. States are generally the smallest entity for which data are available. However, through the use of state reporting services, some states have information available on a crop-reporting district or county basis. Because of the structural differences in the beef industry between the eastern and western limits of the states of Kansas and Nebraska, these two states have been internally divided.

Fourteen separate regions were defined as shown in Figure 2. The same regional demarcations were used for cow-calf production, feeding, slaughter, and consumption activities. Regional production and consumption were assumed to center around particular points within each region. Major population centers within the regions were used as consumption points. Production points were designated largely on the basis of proximity to livestock and feed grain production concentrations within the regions. Production points (origins) and consumption points (destinations) for the various regions are shown in Table 1.

The Data

Cow Herds

Cow herds were taken as given in the regions. An average number of beef cows reported for the years 1968, 1969, and 1970 was used to soften the impact of an unusual condition that might exist within any given region at any one point in time. Half the dairy cows for this time period were treated as beef cows, their calves being assumed to be available for feeding use. As an indication of the calving rates, calves born as a percent of cows and heifers two years and older were used. The percentage of calves born were used to ascertain the number of cows required to produce a living calf. Only those animals which competed for

[2] The mathematical definition of the production-transhipment model used in this study and a sample two-regional tableau of the problem are shown in Appendix A and Appendix B.

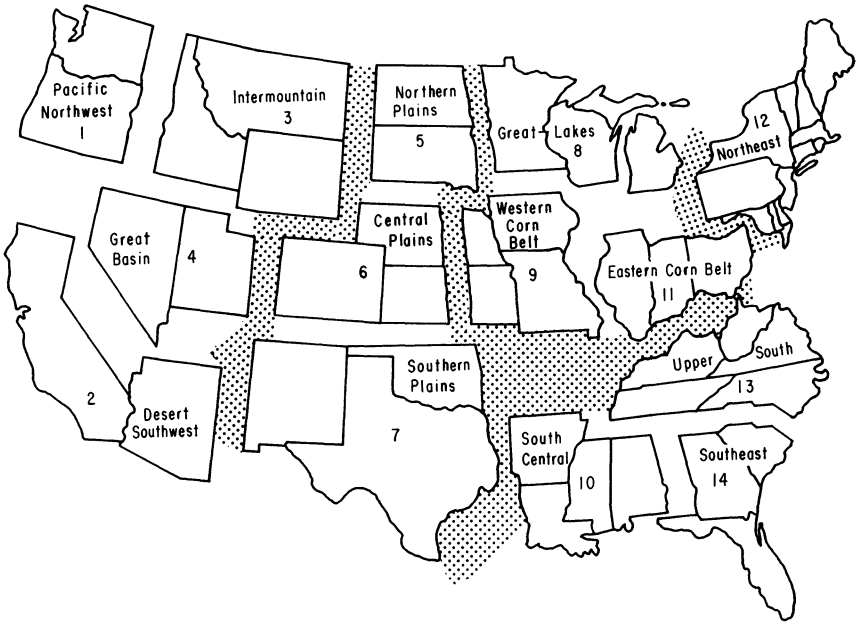

Figure 2. Regional Demarcation of the United States

Table 1. Regional Basing Points for Beef Production and Consumption

Region	States Included	Origin	Consumption
1 Pacific Northwest	Washington, Oregon	Portland	Portland
2 Desert Southwest	California, Arizona	Brawley	Los Angeles
3 Intermountains	Montana, Wyoming, Idaho	Helena, Montana	Helena, Montana
4 Great Basin	Utah, Nevada	Wells, Nevada	Salt Lake City
5 Northern Plains	No. Dakota, So. Dakota	Aberdeen, S. Dakota	Sioux Falls, S.D.
6 Central Plains	Colorado, W. Nebraska, W. Kansas	Holyoke, Colorado	Denver
7 Southern Plains	Oklahoma, Texas, New Mexico	Guymon, Oklahoma	Dallas
8 Lake States	Wisconsin, Michigan, Minnesota	St. Paul	St. Paul
9 Western Corn Belt	Iowa, Missouri, East Nebraska, East Kansas	Omaha	Omaha
10 South Central	Arkansas, Louisiana, Mississippi, Alabama	Jackson, Mississippi	New Orleans
11 Eastern Corn Belt	Illinois, Indiana, Ohio	Fort Wayne, Indiana	Chicago
12 Northeast	New England, New York, Pennsylvania, Maryland, New Jersey, Delaware	Albany	New York City
13 Upper South	West Virginia, Virginia, Kentucky, Tennessee, North Carolina	Knoxville	Richmond, Va.
14 Southeast	South Carolina, Georgia, Florida	Thomasville, Georgia	Atlanta

the available resources were allowed to move through the model. Calves were assumed to be homogenous in quality and weight.

While the quality of animals may vary both within and among areas, the data are not available to quantify this quality differential. Therefore, the model was designed under the assumption that every region could potentially supply calves to any other region. The number of cows regionally available are shown in Table 2.

Feedlot Capacity

There are no published data giving the feeding capacities of individual states. Regional feeding capacity was estimated by adding the largest quarterly totals for each of the four quarters during the 1968-1970 period. That is, the largest of the first quarter placements during this period was added to the largest of the second quarter placements, etc. This procedure gave an indication of the annual feeding capacity available in each region. The procedure does, perhaps, underestimate the feeding capacity in areas that do not typically feed cattle the year around. However, the structure of the feeding industry in these regions is such that any other method of estimation based on available data would most likely overstate the feeding potential.

Quarterly placement data were not available for states in the South Central, Northeastern, Upper South and Southeastern regions (Regions 10, 12, 13 and 14). Feedlot capacity was estimated for these regions by using the numbers of cattle on feed January 1 and July 1. This procedure most likely tends to underestimate the total feeding capacity since cattle are not likely to be on feed for a full 180 days. However, these regions have not historically put many resources into feeding and are unlikely to do so unless substantial increases in grain production occur. Therefore, any errors that result from this assumption are likely to be small. The estimated annual feeding capacity by regions is shown in Table 2.

Slaughter Capacity

Even though the total numbers of cattle slaughtered (including both cow slaughter and steer and heifer slaughter) are reported monthly by states, the slaughter capacity for individual states is not reported as such. To estimate the total cattle slaughter capacity, the largest total monthly slaughter of cattle, both federally inspected and non-federally inspected for the years of 1968, 1969, and 1970, was multiplied by twelve. Although this may underestimate the total United States potential slaughter capacity since numerous plants that were closed during the 1968-1970 period might potentially be reopened, the procedure does yield an estimate of the maximum capacity effectively available in any given locale.

Table 2. Estimated Number of Cows, Feedlot Capacity and Slaughter Capacity for Steers and Heifers by Regions, 1968-70

Region		Number of Cows	Feedlot Capacity	Slaughter Capacity
		(000 head)	(000 head)	(000 head)
1	Pacific Northwest	1217	548	952
2	Desert Southwest	1613	3064	3774
3	Intermountains	3032	720	277
4	Great Basin	647	157	226
5	Northern Plains	2865	776	549
6	Central Plains	3772	4247	4224
7	Southern Plains	8910	3964	3289
8	Lake States	2737	1540	3766
9	Western Corn Belt	5640	8675	8402
10	South Central	4383	191	441
11	Eastern Corn Belt	2104	2332	3043
12	Northeast	1616	149	1608
13	Upper South	3745	195	876
14	Southeast	2218	212	539
	Total	44449	26770	

The slaughter capacity estimate for any given region includes the capacity available for processing both fed cattle and cull cows. A method separating the two forms of slaughter was devised since cow beef and fed beef are really differnt products. Cows were assumed to be slaughtered within the region in which they originate. The regional estimates of cow slaughter were based on the proportion of total cows two years old and older that were present in each region. For example, if a region had 12 percent of the total cow population of the United States, that region was assumed to slaughter 12 percent of the cows which were slaughtered during the base period.

The estimate of regional cow slaughter was deducted from the original estimate of regional slaughter capacity. The resulting difference was defined to be the regional capacity for steer and heifer slaughter or for the slaughter of cattle coming from feedlots. The estimated total slaughter capacity for each region is shown in Table 2.

Regional Demand for Beef

Goodwin and Andorn have shown that the demand for beef tends to be an irreversible function.[2] This concept suggests that consumers exhibit one pattern of behavior under a given set of conditions which prevails for some period of time, and then change their behavior when circumstances change. When the consumers are again confronted with conditions approximating those they originally faced, their behavior dif-

fers from that exhibited during the initial period. This suggests that beef consumption depends not only upon the price of beef, income, and prices for substitute goods, but also upon the level of beef consumption to which consumers are accustomed.

Based on the hypothesis of an irreversible demand, a model was developed to measure the effects of not only prices and income but also the lagged effects during periods of increasing and decreasing consumption. The estimated income and price elasticities from this model were used in calculating the regional consumption estimates. [3].

To estimate the regional consumption, the following equation was used.

$$(1)\ C_i = Z_K + Z_K\,(I_E)\,(\Delta\ I_i) + Z_K\,(P_E)\,(\Delta\ P_Bi) + Z_K\,(P_X)\,(\Delta\ P_Xi)$$

where

C_i = consumption in region i.

Z_K = national average per capita consumption.

I_E = elasticity of demand for beef with respect to income.

ΔI_i = the percentage difference in per capita disposable income in region i and the national average per capita disposable income.

P_E = elasticity of demand for beef with respect to beef price.

ΔP_Bi = the percentage difference in the retail price of beef in region i and the national average price.

P_X = cross-price elasticity of demand for beef with respect to the price of pork.

ΔP_Xi = percentage difference in average price of pork in region i and the national average pork prices.

The equation estimates regional beef consumption in pounds per capita. Since the resulting value contains both cow beef and steer and heifer beef, adjustments were necessary to get an estimate of the beef consumption which actually comes from grain finished cattle.

To adjust the total beef consumption for non-fed beef, the *1965 Household Consumption Report* [4] estimates were adjusted, based upon the increased consumption of "lesser meats" between 1965 and 1970. Since the lesser meats can come from both cows and fed beef, it was calculated that 64 percent of all lesser meats come from cows and imports.[3] This percentage was applied to the adjusted consumption estimates derived from the *1965 Household Consumption Report* to obtain

an estimation of cow and import beef consumption for the four regions reported. Final results were that the West consumed 35.38 pounds, South 33.03 pounds, North Central 41.45 pounds, and the Northeast 25.23 pounds of cow and import meats per capita.

These values were distributed to the fourteen regions of this study depending upon which of the four regions reported in the *1965 Household Consumption Report* included the region in question. Subtracting the per capita consumption of lesser beef from the per capita consumption of total beef consumption as estimated by Equation (1) yielded an estimate of grain finished steer and heifer beef. These regional consumption estimates are shown in Figure 3.

[3] Through information provided in *Livestock and Meat Statistics*, the portions of beef consumption made up of cows, imports, fed beef and calves were calculated. Considering cows, imports, fed beef and calves were calculated. Considering cows, imports and hamburger meat from steers as lesser meats, it was calculated that 64 percent of this meat was from cows and imports.

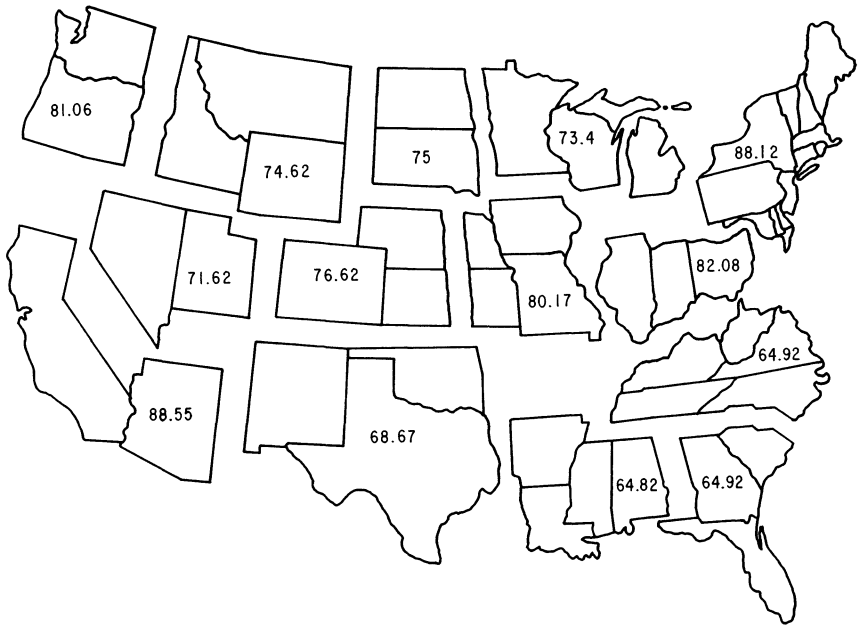

Figure 3. Estimated Annual Per Capita Consumption of Fed Beef by Regions, 1968-70

Grazing Capacity

The proximity of grazing to the other resources necessary for cycling beef through the system plays an important part in determining the size of the beef industry in a state or region. Grass may be utilized by either the cow herds or by stockers depending on the other conditions in the system.

A 1955 U.S.D.A. study reporting the available AUM's[4] of grazing on permanent pasture for each state provided the basis for defining the regional grazing potential. [5] Data from the 1955 study were increased for permanent pasture improvement brought about through the cooperative efforts of the Soil Conservation Service. [6] Published research results suggest that pasture improvement increases carrying capacity by about half. Further information from the *1964 Census of Agriculture* was used to determine the acreage of cropland converted to pasture, and temporary pasture from small grain and feed grain stubble was included in the estimates of pasture availability.[5] The total regional availability of grazing was generated, converting acreages to AUM's, through the use of estimated pasture carrying capacity for various types of pasture. [7] For the different operations a cow-calf operation was defined to require thirteen AUM's of grazing per cow unit, while a stocker animal required six AUM's.

Feed Grain Availability

Feed grains are defined to be corn, grain sorghum, barley and oats. The net-energy values of livestock feeds in therms from these grains were assumed to be perfect substitutes for each other.

All states produce some combination of these four grains. Some feed grains are used in manufacturing and some are exported. The manufactured and exported feed grains as well as those used for seed were withheld from the feed grain supply, with the residual feed grains defined to be available for livestock feed.

Total feed grain availability was estimated by averaging the production of each grain for the 1968, 1969, and 1970 crop years in each state, and then aggregating these estimates for the various regions. [8] The quantities of feed grains used in industrial manufacturing were not available from published sources. However, Leath estimated industrial

[4] An AUM (animal unit month) is defined to be roughly equivalent to 450 pounds of total digestible nutrients, i.e., the grazing necessary to maintain a 1,000 pound cow and her calf for a period of one month.

[5] The wheat pasture AUM's pertained only to the Southern Plains and Central Plains. The values were obtained by linking the number of acres of wheat planted in these states and multiplying by .7 which is the average AUM's of grazing provided by an acre of wheat. For stubble, the number of acres of corn and milo planted in a region was multiplied by .6.

use of feed grains for 1967. [9] Since the per capita consumption of these products did not change significantly between 1967 and 1970, [10] Leath's estimate of feed grains required for manufacturing was used in this study.

The grain exported from the separate regions to foreign destinations was also taken into account. Using the U.S.D.A. estimates of total value of feed grains exported by states in 1968, [11] bushels of grain exported could be ascertained. By incorporating the optimal exporting flows for feed grain from Leath's work and the actual grain cleared for export through the various ports, [12] estimates of grain exported to foreign markets from different regions were obtained. Seed use was determined by multiplying the acreage planted by the seeding rates. [13]

For purposes of this study, it was assumed that cattle would use only residual feed grains. Grain required for other livestock was estimated and withheld. [14] The feed grains available for beef feeding were converted to therms using 48 therms per bushel of wheat, 44.868 therms per bushel of corn, 43.568 threms per bushel of milo, 22.024 therms per bushel of oats and 33.84 therms per bushel of barley. [15] Regional availability of feed grains is found in Table 3.

Availability of Wheat

Wheat has become a major source of feed for livestock, especially in the High Plains. With the decline in wheat prices, livestock feeders have found it profitable to substitute wheat for feed grains, particularly

Table 3. Estimated Therms of Feed Grains Available in Each Region, 1968-70

Region		Therms Available Before Removed Other Livestock Feed Is	Therms Available After Is Removed Other Livestock Feed
		(000 therms)	(000 therms)
1	Pacific Northwest	1,041,719	—0—
2	Desert Southwest	3,799,917	—0—
3	Intermountains	3,366,052	1,233,282
4	Great Basin	280,236	11,820
5	Northern Plains	11,940,612	5,583,110
6	Central Plains	13,483,698	8,595,874
7	Southern Plains	13,030,881	5,399,631
8	Lake States	31,119,417	7,756,365
9	Western Corn Belt	53,823,424	25,012,296
10	South Central	1,694,512	—0—
11	Eastern Corn Belt	47,767,437	22,052,828
12	Northeast	6,467,121	—0—
13	Upper South	6,136,578	—0—
14	Southeast	2,571,087	—0—

during the summer and early fall. Research has shown that cattle perform well so long as wheat constitutes no more than half the concentrates in the ration. [16] The feeding activities in this model permit wheat to be used for meeting up to half of the concentrate requirements in any feeding enterprise.

The availability of feed wheat was calculated in a fashion similar to that used for feed grains. The exceptions were (1) no allowance was made for exports, and (2) no allowance was made for use in feeding other livestock. Industrial and human consumption use were withheld.[7] The volume of wheat which can be profitably used in cattle feeding is a question of prime concern in the high-risk farming areas of the Plains. Wheat exports were not reserved in order to permit each region to use its wheat for cattle feeding if wheat feeding was profitable, since the trend of wheat exports has been consistently downward since 1965. [18] The therms available from wheat for each region are shown in Table 4.

Availability of Roughage

It was determined that roughage would not play a major role in determining the competitive position of any regions. If other necessary resources were regionally available for cattle feeding, the acquisition of roughage was no real problem. Therefore, for the purpose of this study, roughage for *feeding* was assumed to be unlimited.

Table 4. Estimated Therms of Wheat Available for Livestock Feed by Regions, 1968-70

Region		Therms
		(000 therms)
1	Pacific Northwest	5,674,656
2	Desert Southwest	35,472
3	Intermountains	6,459,696
4	Great Basin	80,400
5	Northern Plains	10,900,896
6	Central Plains	15,556,224
7	Southern Plains	8,241,072
8	Lake States	1,009,392
9	Western Corn Belt	47,760
10	South Central	2,896,176
11	Eastern Corn Belt	—0—
12	Northeast	445,056
13	Upper South	—0—
14	Southeast	—0—

Regional Production and Processing Activities

The costs involved in the production and processing activities in the beef industry are those costs associated with stocker growth, cattle feeding activities, and cattle slaughter. These costs vary between regions due to technology, labor costs, the size of operation, and climatic conditions.

Cow-Calf

Beef cow herds are found throughout the United States. In recent years, the cow herds have made the greatest growth in the South and in the Southern Plains. Since calf production is the basis for the whole beef industry, the location of cow herds potentially plays a large role in the beef system. For this reason, a cow-calf production activity was used in this study. The data for this activity were obtained from work completed at Oklahoma State University by Bowser and Goodwin. [19] Their work contained cash cost data for cow enterprises located throughout the United States. These cash cost values were inflated by the index of prices paid by farmers and used in this work. The regional cost estimates for the cow-calf enterprises are shown in Table 7.

Stocker Growth

The stocker growth activity involves growing an animal from 400 to 600 pounds. As with the cow-calf activity, cash costs were the only costs calculated for the stocker growing activity. Among these costs were protein supplement, veterinary expenses, roughage expenses, taxes on cattle, interests on cattle, grain, mineral-salt, miscellaneous costs and death losses. Land cost was not included since the livestock enterprises cannot be charged for the externalities which are typically included in land values. For example, land in California or Florida has speculative value due to the limited land and a large demand for urban and recreational uses. Land in the Southern Plains and Central Plains frequently has an undeveloped mineral potential that increases its cost. Incorporating these values into a land charge for livestock production burdens the enterprise with a much greater liability than that enterprise could fairly be expected to pay. Since the return to land is normally a residual after all other costs have been paid, the exclusion of a land charge in this analysis should create no problems in the validity of the results. The regional costs for growing stocker cattle were derived from the most recent State Experiment station publications available. [20] For these studies published prior to 1970, the cost estimates were inflated by the

Index of Prices Paid by Farmers. The regional cost estimates for growing stockers are shofn in Table 5.

Cattle Feeding Activity

For the feeding activities, three major costs are involved. These costs include (1) non-feed costs, (2) feed grain costs, and (3) roughage costs. Roughage costs are not considered in this study. Each region is assumed to be feeding a homogeneous feeder from the weight of 600 to 1,100 pounds. That is, each animal is expected to gain 500 pounds in the feedlot.

Non-feed costs include costs for depreciation, labor, management, office expense, veterinary expenses, interest on cattle, interest on working capital, taxes on cattle and miscellaneous costs. Each region must pay this expense for the full 500 pounds of gain if they feed. No provisions were made for feeding to weights other than 1,100 pounds. The data with regard to feeding costs were obtained from State Experiment Station publications listed in the Bibliography. Data were inflated to 1970 standards by the Index of Prices Paid by Farmers. Regional non-feed costs are shown in Table 5.

Feed costs per pound of gain depend upon the level of efficiency and the cost for feed grains in each region. Four levels of efficiency were

Table 5. Estimated Costs of Cow-Calf Operations, Growing Stocker Calves from 400 to 600 Pounds and Non-Feed Costs for Feeding Activity by Regions, 1968-70

Region		Non-Land Cost of Cow-Calf Opn.	Stocker Calves 400 to 600 Pounds	Non-Feed Costs for Feeding Activity
		Cost/Cow	Cash Cost/Head Excludes Cost of Calf	($ for 500 lb. gain)
1	Pacific Northwest	$28.13	$30.00	$26.75
2	Desert Southwest	21.36	30.00	21.94
3	Intermountains	11.58	23.20	26.75
4	Great Basin	18.45	23.20	26.75
5	Northern Plains	14.34	17.80	27.29
6	Central Plains	16.17	22.00	21.40
7	Southern Plains	13.41	16.20	21.40
8	Lake States	20.12	26.00	48.15
9	Western Corn Belt	22.54	25.60	32.10
10	South Central	21.28	16.80	27.29
11	Eastern Corn Belt	2508	36.00	37.45
12	Northeast	25.08	26.00	37.45*
13	Upper South	22.65	21.80	26.75
14	Southeast	21.28	16.32	26.75*

[1] Values of nearest region of same general characteristic were used because no actual costs were located.

considered in this study. Gains of 2, 2.5, 3, and 3.4 pounds of gain per day were used. The therm requirement for each rate of gain was obtained from nutritional research conducted at Oklahoma State University.[21] For the rations, concentrates were assumed to make up 70 percent, 75 percent, 80 percent, and 85 percent of the rations yielding daily gains of 2, 2.5, 3, and 3.4 pounds per day.

Every region was allowed to purchase its feed concentrates from any other region. These concentrates could be made up of either feed grains or wheat. Feed concentrates were priced in cents per therm, f.o.b. point of origin, using the weighted average price received by farmers for the 1968, 1969, and 1970 crop years.[22] If grain was moved from one region to another for feeding, the cost of using that grain included the price at the point of origin plus the cost of transportation and handling. Prices for feed grains and wheat, free of transportation costs, are shown in Table 6.

Slaughter Activity

Cost information for the beef slaughter activity was taken from a forthcoming Southern Cooperative Series publication. [23] Slaughter costs include (1) wages and salaries, (2) annual investment allowances, (3) utilities. From the regions defined in the Southern Cooperative study, the points nearest the production origins used in this study were used. The regional costs specified in Table 7 are the costs associated with slaughtering an eleven hundred pound animal.

Table 6. Costs of Feed Grains and Wheat, Free of Transportation Costs by Region in Cents per Therm, 1968-70

Region		Cost per Therm of Feed Grain	Cost per Therm of Wheat
1	Pacific Northwest	.029	.0282
2	Desert Southwest	.0325	.0294
3	Intermountains	.0243	.0257
4	Great Basin	.0315	.0275
5	Northern Plains	.024	.0294
6	Central Plains	.0245	.0253
7	Southern Plains	.0249	.0263
8	Lake States	.0257	.0279
9	Western Corn Belt	.0256	.0253
10	South Central	.0316	.0247
11	Eastern Corn Belt	.0267	.0256
12	Northeast	.031	.0259
13	Upper South	.029	.0264
14	Southeast	.03	.0262

Table 7. Estimated Costs for Slaughtering an 1100 Pound Beef Animal, 1968-70

Region		Cost/Head
1	Pacific Northwest	$11.66
2	Desert Southwest	12.43
3	Intermountains	10.89
4	Great Basin	11.99
5	Northern Plains	11.77
6	Central Plains	12.21
7	Southern Plains	10.67
8	Lake States	13.20
9	Western Corn Belt	12.76
10	South Central	10.34
11	Eastern Corn Belt	11.77
12	Northeast	9.46
13	Upper South	9.68
14	Southeast	10.34

Source: Irving Dubov, University of Tennessee, Knoxville, Tennessee, Southern Cooperative Publication in process.

Transportation Charges

The largest data class for this problem was transportation costs. Transportation costs required were (1) transportation costs for shipment of feed grains, (2) transportation costs for shipment of wheat, (3) transportation costs for shipment of stocker cattle, (4) transportation costs for shipment of feeder cattle, (5) transportation coss for shipment of fat cattle, and (6) transportation costs for shipment of carcass beef. In each case both rail and truck rates were considered. Where applicable, barge rates were also considered in moving grain. [27] Point-to-point rates were obtained for all modes of transportation except the truck movement of grain. A functional relationship based on distance of haul was utilized in the case of truck movement. [25]

Shipment of Cattle

In each case, the rates used for transporting cattle included the total cost of moving one complete animal. Shrinkage costs were incorporated into the movement of animals by charging the cost for bringing the animal back to the original weight. [26]

For the movement of stocker calves, point-to-point movement was assumed except in the case of the Southern Plains region. McAlester, Oklahoma, was used as the origin of stocker calves while Vernon, Texas, was used as the receiving point. This was done for two reasons: (1) the geographically disparate distributions of different types of cattle operations in the region, and (2) the very large disances potentially involved

in moving cattle within this region.

The transportation charges for the movement of each class of cattle are found in Tables 8, 9, and 10. These costs represent the minimum costs of shipping cattle by truck or railroad modes.

Transfer of Grain

Truck rates, rail rates, and barge rates were all considered in this study. Actual rates between points were collected for rail and barge movement. These were furnished by railroad and barge companies and contain the most recent rail rate increases of January, 1971.

Truck rates used were estimated through regression analysis by the Texas Transportation Institute and Marketing Economics Division of ERS. Truck shipments were not permitted for distances greater than 700 miles for wheat nor greater than 600 miles for other grains since greater distances were beyond the levels to which the regression equations presented above were applicable. The Texas Transportation Institute recommended that the rates calculated from the regression equations be increased by six percent for all grains except corn, and that rates for corn be increased by ten percent to reflect 1970 conditions. Since the various feed grains were combined in this study, the rates for the feed grain predominant within any region were applied to all feed grain shipments from that region.

Included in the cost of transferring grain are the handling costs associated with receiving and shipping grain by the difference modes. Handling costs are shown in Table 11. Transportation costs for feed grain and wheat, handling costs included, are shown in Tables 12 and 13.

Transfer of Carcass Beef

Carcass beef may be moved either by rail or truck. Each is under government regulation and published tariffs are available. Packing companies furnished much of the data for motor carriers on a point-to-point basis. Rail companies furnished the rail rates. Separate destinations were used for the shipment of carcasses. Large population centers were designated as delivery points for the meat. The origin and destinations are presented in Table 14 with the least cost mode for shipping 682 pounds of carcass beef—that is, the carcass weight of an 1,100 pound live animal to these destinations in Table 15.

Table 8. Minimum Cost in Shipping 400 Pound Stocker Calves in Dollars Per Head by Mode of Transportation, 1970

FROM REGION \ TO REGION	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	–	7.62	5.86	3.98	8.52[1]	8.68[1]	10.24	9.12[1]	9.76[1]	13.92[1]	14.00[1]	18.64[1]	16.00[1]	16.16[1]
2	7.62	–	10.43	4.65	9.80	8.28	5.91	10.16	8.84	None[2]	None	None	None	None
3	5.86	10.43	–	4.01	4.27	4.08	7.08	5.04	5.33	None[2]	None	None	None	None
4	3.98	4.65	4.01	–	7.59	5.65	7.60	8.24[1]	7.40[1]	None[2]	11.06	None	None	None
5	8.52[1]	9.80	4.27	7.59	–	3.12	5.68	1.44	2.19	None[2]	4.91	9.10	None	None
6	8.68[1]	8.28	4.09	5.65	3.12	–	5.04[1]	4.12	2.16	None[2]	6.05	10.28	None	None
7	10.63	7.69	7.48[1]	8.52[1]	5.57	5.04[1]	1.54	5.20	3.63	3.04	5.51	10.27	5.70	6.76
8	9.12[1]	10.16[1]	5.04	8.24[1]	1.44	4.12	4.54	–	2.28	6.69	3.69	7.88	5.39	8.24
9	9.76[1]	8.84[1]	5.33	7.40[1]	2.19	2.16	2.70	2.28	–	5.52	3.86	8.34	6.02	7.82
10	14.00[1]	9.11	11.00[1]	11.74	7.80	7.60	4.14	6.69	5.52	–	4.86	8.20	3.81	2.68
11	14.00[1]	13.40[1]	11.00[1]	11.06	4.91	6.05	6.87	3.69	3.86	4.86	–	4.49	1.30	5.22
12	18.64[1]	18.00[1]	12.99	15.55	9.10	10.28	11.66	7.88	8.34	8.20[1]	4.49	–	4.76[1]	6.97
13	16.00[1]	12.75	11.59	12.98	8.38	8.62	7.00	5.39	6.02	3.81	1.30	4.76[1]	–	3.00
14	16.16[1]	13.32[1]	12.68[1]	13.92[1]	10.16	9.96[1]	6.74	8.24	7.82	2.68	5.22	6.97	3.00	–

[1] Denotes rail rates; others are truck rates.
[2] None designates that these shipments were assumed not to exist.

Table 9. Minimum Cost for Transporting 600 Pound Feeder Cattle in Dollars Per Head by Mode of Transportation, 1970

FROM REGION \ TO REGION	1	2	3	4	5	6	7[2]	8	9	10	11	12	13	14
1	[3]	11.48	8.83	6.00	12.78[1]	13.02[1]	15.36[1]	13.68[1]	14.64[1]	20.88[1]	21.00[1]	27.96[1]	24.00[1]	24.24[1]
2		8.90				7.56	80[1]	15.24[1]	13.26[1]	15.60[1]	10.10[1]	27.00[1]	19.22[1]	19.98[1]
3				6.04	6.43	6.16	8.94	7.59	8.03	15.36[1]	12.25	19.57	17.47	19.02[1]
4					11.44	8.51	10.14	12.36[1]	11.10	17.04[1]	16.67	23.43	19.55	20.88[1,4]
5						7.14[1]	8.40	2.17	3.30	12.06	7.39	13.71	12.62	15.30
6					4.70		3.69	6.20	3.26	11.34	9.11	15.49	13.0	14.94
7[2]			15.72	7.01	16.70[1]	12.42[1]	16. 0	6.85	4.07	6.23	13.0	17.57	10.65	10.15
8							7.33		3.44	10.08	5.56	11.88	8.12	12.42
9							4.51			8.32	5.81	12.57	9.07	11.78
10		13.72	14.94[1]	16.74[1]			7.76				7.32	12.30	5.73	4.04
11	19.86[1]	19.20[1]					10.52					6.76	1.97	7.86
12	25.82[1]	23.88[1]	19.38[1]	22.44[1]			17.66						7.96	10.51
13	23.58[1]			19.44[1]			10.81							4.57
14			18.66[1]	20.52[1,4]			12.61							

[1] Denotes rail rates; others are truck rates.
[2] Costs from region 7 were from Vernon, Texas, while costs "in" were to Guymon, Oklahoma.
[3] Blank spots mean that the costs are the same as the above diagonal.
[4] Some costs differ to and from regions because of rail rate structures.

Table 10. Minimum Cost for Transporting 1100 Pound Slaughter Cattle in Dollars Per Head by Mode of Transportation, 1970

FROM REGION \ TO REGION	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	_	20.95	16.12	10.96	26.92	25.97	29.23	29.37[1]	29.72	43.19	40.30	None	None	None
2	20.95	_	28.68	12.79	30.15	23.73	22.44[1]	32.78[1]	28.49[1]	None[2]	None	None	None	None
3	16.12	28.68	_	11.03	11.74	11.24	16.31	13.86	14.65	None[2]	24.19	None	None	None
4	10.96	12.79	11.03	_	20.88	15.52	18.50	24.71	23.76[1]	None[2]	30.43	None	None	None
5	26.93	30.15	11.74	20.88	_	8.58	15.33	3.96	6.02	None[2]	13.49	25.03	None	None
6	25.97	23.73	11.24	15.52	8.58	_	6.74	11.32	5.95	20.91	16.63	28.26	None	None
7	29.33	23.43	16.31	18.50	15.33	6.74	_	14.30	8.23	14.16	19.20	32.17	19.72	23.01
8	29.75	32.78[1]	13.86	24.71	3.96	11.32	14.30	_	6.28	18.39	10.15	21.68	14.82	22.66
9	29.75	29.21	14.65	26.39	6.02	5.95	8.23	6.28	_	15:19	10.61	22.94	16.56	21.51
10	43.19	19.47[1]	30.40	32.29	22.02	20.91	14.16	18.39	15.19	_	13.35	24.65	10.47	7.37
11	40.30	None[2]	24.19	30.42	13.49	16.63	19.20	10.15	10.61	13.35	_	12.34	3.59	14.35
12	51.81[1]	48.07[1]	35.72	42.75	25.03	28.26	32.17	21.68	22.94	22.55[1]	12.34	_	14.53	19.18
13	45.64	35.07	31.89	35.68	23.03	23.71	19.72	14.82	16.56	10.47	3.59	14.53	_	8.26
14	50.70	38.36	36.07	40.62	27.93	28.46	23.01	22.66	21.51	7.37	14.35	19.18	8.26	_

[1] Denotes rail movement; others are truck rates.
[2] None designates that these shipments were assumed not to exist.

Table 11. Estimated Costs of Handling Grain in Commercial Elevators by Geographic Area, Type of Facility and Mode of Transportation, 1967-1968

Area and Facility	Received by			Shipped by		
	Truck	Rail	Water	Truck	Rail	Water
			Cents Per Bushel			
Northern Plains[1]						
Inland elevators	1.95	4.81	---	3.50	2.71	1.00
Port elevators	---	---	---	---	---	---
Mid-Plains[2]						
Inland elevators	2.28	2.87	---	2.36	3.56	---
Port elevators	---	---	---	---	---	1.00
Southern Plains[3]						
Inland elevators	3.07	10.50	---	3.38	4.19	---
Port elevators	1.60	1.20	1.20	2.30	3.10	0.80
West[4]						
Inland elevators	2.64	7.55	---	3.45	3.15	---
Port elevators	2.00	2.30	1.20	2.00	4.20	1.50
Great Lakes[5]						
Inland elevators	2.47	6.75	---	2.49	3.08	---
Port elevators	1.30	3.00	1.10	4.30	2.60	1.40
South and East[6]						
Inland elevators	1.95	3.86	2.00	3.20	2.18	---
Port elevators	1.30	1.80	4.00	3.90	2.40	1.00

[1] North Dakota, South Dakota, and Minn. (excluding port facilities).
[2] Nebr., Kansas, Colorado, Wyoming, Iowa, and Missouri.
[3] Oklahoma, New Mexico, and Texas, plus all gulf port facilities.
[4] Wash., Oregon, Idaho, Montana, Calif., Ariz., Nevada, and Utah.
[5] Wis., Illinois, Indiana, Ohio, Mich., and Minn. port facilities.
[6] Arkansas, Mississippi, S. C., Tenn., Kentucky, New York, Va., Pa., New Jersey, Maryland, Del., La., Alabama Georgia, West Virginia, North Carolina, and New England (excluding port facilities).

Source: Mack Leath, "An Interregional Analysis of the United States Grain Marketing Industry" (unpub. Ph.D. dissertation, Oklahoma State University, Stillwater, Oklahoma, May, 1970).

Table 12. Minimum Costs of Shipping Feed Grain in Cents Per Therm by Mode of Transportation, 1970

FROM REGION \ TO REGION	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1														
2														
3	.0103	.0136		.0082	.0081	.0082	.0105	.0094	.0097					
4	.0090	.0112	.0090		.0196[1]	.0129[1]	.0145[1]	.0219[1]	.0129[1]					
5	.0717	.10202	.0098	.0337		.0069	.0138	.0044	.0054	.0124	.0390	.0570	.0143[1]	.0161[1]
6	.0215[1]	.0215[1]	.0091	.0160	.0068		.0057	.0091	.0051	.0139	.0341	.0827	.0153[1]	.0165[1]
7	.0216[1]	.0216[1]	.0162	.0214	.0143[1]	.0057		.0129	.0065	.0135	.0127	.0298	.0236[1]	.0165[1]
8	.0213[1]	.0213[1]	.0138	.0213[1]	.0041	.0091	.0134		.0053	.0042†	.0237	.0371	.0050†	.0065†
9	.0215[1]	.0215[1]	.0141	.0214[1]	.0053	.0051	.0056	.0054		.0037†	.0151	.0438	.0057†	.0077†
10														
11					.0388	.0335	.0133	.0237	.0151	.0032†		.0543	.0042†	.0055†
12														
13														
14														

[1] Denotes rail movement; † denotes barge movement; others are truck movement.
[2] Costs above and below the diagonal may differ because of handling costs difference between the regions.
[3] No transportation costs were charged for intraregional movements. The other blanks indicate that the activities were assumed not to exist prior to programming.

Table 13. Minimum Cost for Shipping Wheat in Cents per Therm by Mode of Transportation, 1970

FROM REGION \ TO REGION	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		.0088	.006[2]	.0077[2]	.0714	.0233[1]	.0249[1]	.0255[1]	.0233[1]					
2	.088		.0137	.0079	.1017	.0233[1]	.0249[1]	.0268[1]	.0233[1]					
3	.0067[2]	.0135		.0076	.0075	.0075	.0071	.0077	.0075					
4	.0075[2]	.0078	.0076		.0196	.0233[1]	.0249[1]	.0268[1]	.0233[1]					
5	.0716	.1019	.0077	.0335		.0068	.0248[1]	.0268[1]	.023[1]	.0140	.0388	.057	.0143	.0162[1]
6	.0215[1]	.0205[1]	.0075	.0215[1]	.0067		.0057	.0053	.0051	.0139	.0341	.0827	.0154	.0165
7	.0216[1]	.0216[1]	.0216[1]	.0216[1]	.0185	.0059		.0128	.0066	.0135	.0127	.029	.0236	.0165
8	.021[1]	.021[1]	.021[1]	.021[1]	.0059[1]	.0053	.0133		.0053	.0041†	.0236	.037	.0049†	.0049†
9	.0215	.0215	.0215	.0215	.0054	.0053	.0056	.0055		.0037†	.0151	.0437	.0056†	.0076†
10								.0071	.0072		.0076†	.0074†	.0039	
11					.0387	.0335	.0132	.0236	.015	.0031		.0054	.0044	.0059
12														
13										.0039	.0074			.0065
14														

[1] Denotes rail movement; † denotes barge movement; others are truck movement.
[2] Costs above and below the diagonal may differ because of handling costs difference between the regions.
[3] No transportation costs were charged for intraregional movements. The other blanks indicate that the activities were assumed not to exist prior to programming.

Table 14. Regional Basing Points for Carcass Meat Origins and Designations

Regions		Origin	Destination
1	Pacific Northwest	Portland, Oregon	Portland, Oregon
2	Desert Southwest	Brawlay, California	Los Angeles, California
3	Intermountains	Helena, Montana	Billings, Montana
4	Great Basin	Wells, Nevada	Salt Lake City, Utah
5	Northern Plains	Aberdeen, South Dakota	Sioux Falls, S. Dakota
6	Central Plains	Holyoke, Colorado	Denver, Colorado
7	Southern Plains	Guymon, Oklahoma	Dallas, Texas
8	Lake States	St. Paul, Minnesota	St. Paul, Minnesota
9	Western Corn Belt	Omaha, Nebraska	Omaha, Nebraska
10	South Central	Jackson, Mississippi	New Orleans, Louisiana
11	Eastern Corn Belt	Fort Wayne, Indiana	Chicago, Illinois
12	Northeast	Albany, New York	New York City, New York
13	Upper South	Knoxville, Tennessee	Richmond, Virginia
14	Southeast	Thomasville, Georgia	Atlanta, Georgia

The Results

The first analysis was designed to define the optimum locations for various beef enterprises, assuming that there were no "fixed" resources in slaughter and feeding facilities. In other words, the first analysis examined the question of where and in what magnitudes would the various beef enterprises be expected to develop if the beef industry were an entirely new industry with no existing long term investments in production facilities and no traditional sources of product?

The results of this analysis should provide information with regard to the ultimate adjustment toward which the industry would be expected to move as the fixed facilities in processing and feeding are amortized. Since these fixed production and processing assets do currently exist, and since the life of these assets is of a length sufficient for retarding the adjustment process, a second analysis taking the existence of these assets into consideration has been made. The second analysis is expected to indicate the means by which the ultimate adjustment is achieved (or the path along which the industry would initially move toward the adjustment "target.")

The optimal locations for calf production, stocker growing, cattle feeding, and livestock slaughter will be discussed for each analysis, and the optimal patterns of movement defined. The regional volumes of production and the product flows should be interpreted as the manner in which the marketing system would be expected to function—given supply, demand, and competitive conditions approximating those of 1970—in order to minimize the cost for meeting the estimated regional consumption requirements for beef. Given the basic data, no other pat-

Table 15. Minimum Cost for Transporting Carcass Beef in Cents Per Pound by Mode of Transportation, 1970

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	[2]	1.82		2.06	3.32	2.23	3.32[1]	3.32	3.32	3.32[1]	3.62	5.55	5.51	5.06
2	1.98	.79	2.25	1.45	3.32[1]	1.81	3.15	3.32[1]	3.17	3.32[1]	3.29	5.14	3.39	3.16
3		1.88	[2]	1.84	1.79	1.87	3.46	1.50	2.28	3.68	2.08	4.73	3.97	3.52
4	1.24	2.02	1.35	[2]	3.32[1]	1.65	3.24	3.32	2.58	2.39	3.46	4.35	5.08	3.85
5	2.71	2.53	2.53	2.67	[2]	1,375[1]	2.96[1]	.935[1]	1.10[1]	1.92	1.12	2.338[1]	2.48[1]	1.98
6	1.38[1]	1.35[1]	1.34[1]	1.38[1]	1.42	.35	1.50	1.00	.90	1.82	1.39	2.61[1]	2.96	2.31
7	1.76[1]	1.54[1]	1.76[1]	1.54[1]	1.35	.94	1.08	1.54	.98	1.55	1.65	2.76	2.65	2.01
8	2.67	2.85	2.67	2.85	.76	2.03[1]	1.31	[2]	.70	1.84	.74	2.26[1]	2.095[1]	1.74
9	2.67	2.63	2.67	2.63	.56	1.03	1.45[1]	.82	[2]	1.67	.85	2.26[1]	2.095[1]	1.69
10					2.55[1]	2.425[1]	2.005[1]	2.232[1]	1.97[1]	0[2]	1.15[1]	1.76[1]	.43[1]	.49[1]
11	2.04[1]	3.10	3.14	3.10	1.78	1.74	2.25	1.222[1]	1.519[1]	1.27[1]	.50	1.72	1.77	1.34
12							2.51[1]			1.76[1]		[2]	1.25[1]	1.55[1]
13					2.48[1]	2.68[1]	2.48[1]	2.095[1]	2.095[1]	.49[1]	.79[1]	1.25[1]	[2]	.49[1]
14					2.99[1]	2.917[1]	2.63[1]	2.63[1]	2.483[1]	.43[1]	.76[1]	1.55[1]	.49[1]	[2]

[1] Denotes rail transportation.
[2] No transportation costs were charged for intraregional movements. The other blanks indicate that the activities were assumed not to exist prior to programming.

tern of production and marketing would result in a lower total cost for the system as a whole.

Each analysis is discussed in terms of the operation of the beef industry within five major aggregated regions:

(1) The West (including the Pacific Northwest, the Desert Southwest, the Intermountain area, and the Great Basin),
(2) The Great Plains (including the Northern, Central, and Southern Plains regions),
(3) The Corn Belt (including the Eastern and Western Corn Belt regions and the Lake States),
(4) The Northeast, and
(5) The South (including the Upper South, the Southeast, and the South Central regions).

Following this, beef industry sectors (i.e., cow-calf, stocker growing, feeding, etc.) are discussed across all regions. Finally, the degree of resource utilization and the efficiency of the beef industry are defined.

The Results Assuming Total Adjustment

The West

The beef industry in the four Western regions would be expected to shift almost entirely to calf production (Figure 4). Except for the Great Basin, stocker calves produced in the West would be moved to the Central and Southern Plains to be grown to feeder weights.

The Great Basin was the only Western region to hold calves beyond weaning. Limited numbers of great Basin feeder cattle were fed in local feedlots, with the remainder being fed in the adjacent Intermountain area. The Great Basin and Intermountain regions were the only Western regions which had feed grain available for cattle feeding.

The Great Plains

The Great Plains dominated the cattle feeding industry under full adjustment conditions (Figure 5).[6] Some of the grass in the Plains was used to grow stocker calves produced in other regions to feeding weights. By substituting stocker growing enterprises for cow-calf operations, the Great Plains beef industry was able to reduce the total cost of producing beef. This saving was due to the different levels of costs involved in transporting stocker cattle versus feeder cattle.

The Great Plains regions are characterized by relatively low calf production costs, the lowest non-feed cost for feeding, and relatively low

[6] For all maps, the solid lines represent the movements of stocker cattle while the dashed lines represent the movements of feeder cattle.

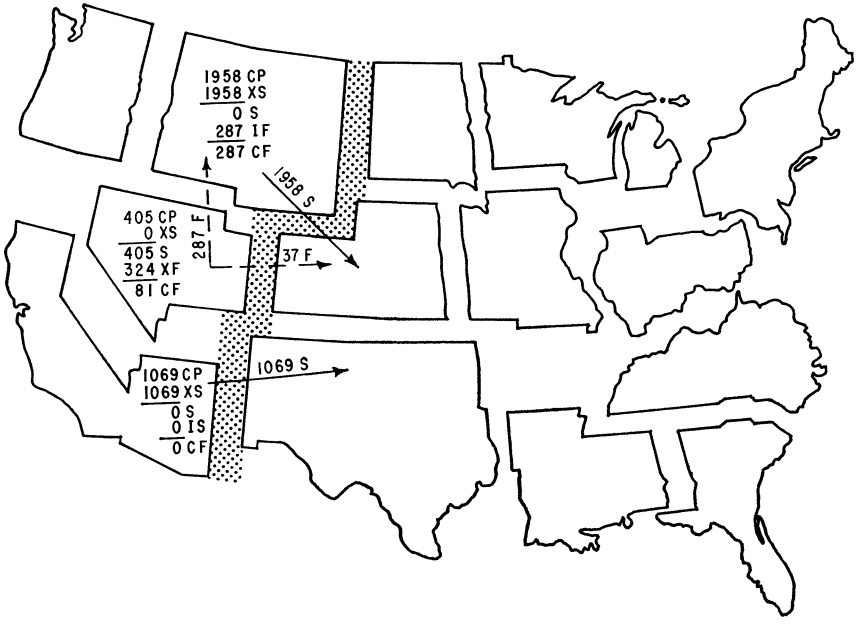

Figure 4. Calf, Stocker and Feeding Operations in the Western Regions, Under Conditions of Full Adjustment

CP Calf Production
IS Import Stockers
XS Export Stockers
IF Import Feeders
XF Export Feeders
CF Cattle Fed
S Stockers
(figures in 000's)

costs of slaughtering. Of the calves produced in the three Plains regions under conditions of full adjustment, all are grown out to feeder weights within the region of origin. The Central Plains receives additional stocker calves from the Intermountain area, and the Southern Plains imports additional stockers from the Desert Southwest.

Additional feeder cattle are drawn into the Southern and Central Plains from the South Central area. The Central Plains acquires feeder cattle from the Western Corn Belt, the Lake States, and the Great Basin areas, as well as from the South Central region. Vast quantities of feed grain were drawn from the Western Corn Belt to the Southern Plains in order to supplement the large surplus of Southern Plains wheat. Both the Southern and Central Plains utilized equal proportions of wheat and feed grains as concentrates in their rations. Cattle fed in the Northern Plains utilized a ration composed exclusively of feed grain concentrate.

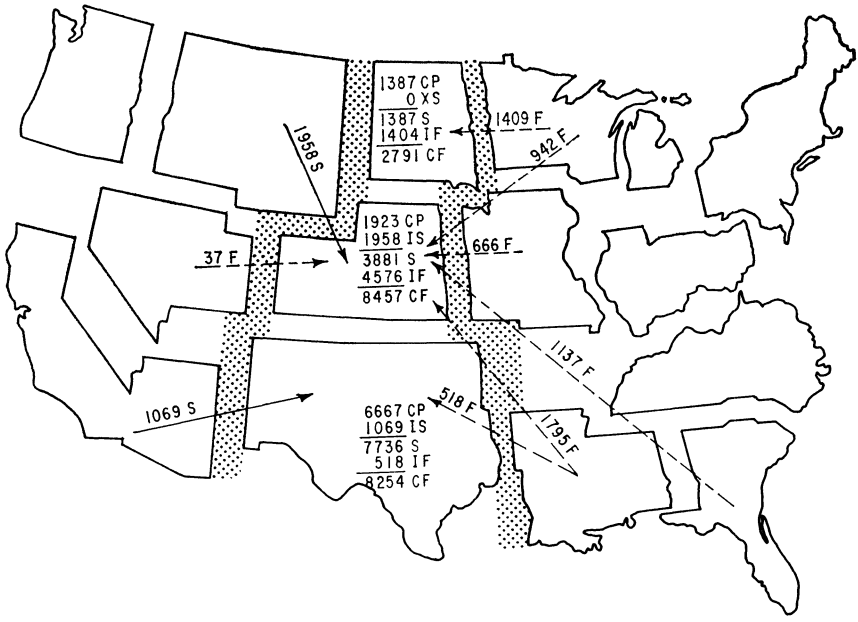

Figure 5. Calf, Stocker and Feeding Operations in the Great Plains Regions, Under Conditions of Full Adjustment

CP Calf Production
IS Import Stockers
XS Export Stockers
IF Import Feeders
XF Export Feeders
CF Cattle Fed
S Stockers
(figures in 000's)

Corn Belt

Even though the three Corn Belt regions are located near large consumer markets, these regions experienced a major disadvantage as a result of their inability to supply large quantities of feeder cattle and their relatively high non-feed costs. Two of the Corn Belt regions became suppliers of feeders for the Plains region under conditions of full adjustment (Figure 6). Feeding in the Corn Belt was carried out only in the Eastern Corn Belt. This region received feeder calves from the Upper South for their feeding operations. All beef produced from Eastern Corn Belt lots was marketed internally to the region. The cost structure was such that Eastern Corn Belt beef could not carry any additional cost in the form of transportation and still compete effectively in any other region.

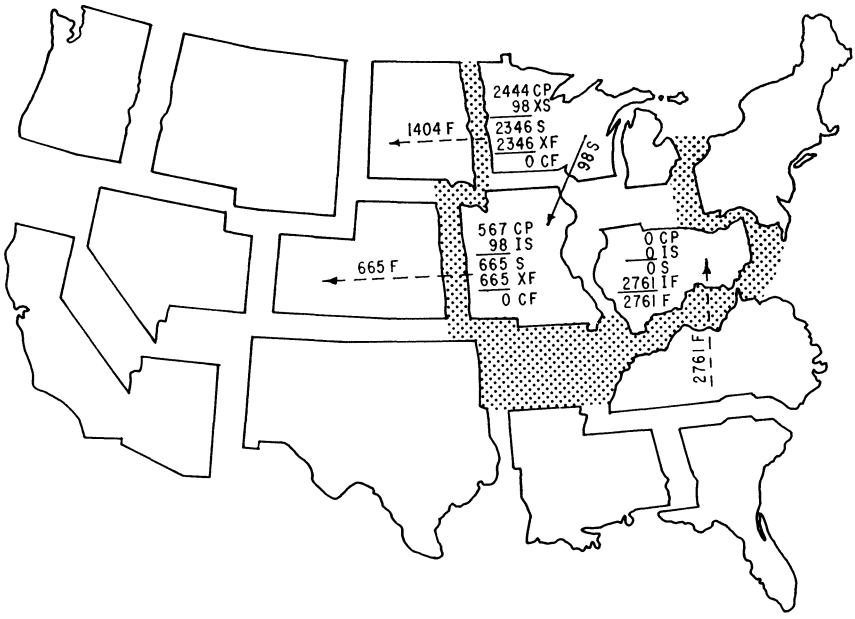

Figure 6. Calf, Stocker and Feeding Operations in the Corn-Belt Regions, Under Conditions of Full Adjustment

CP Calf Production
IS Import Stockers
XS Export Stockers
IF Import Feeders
XF Export Feeders
CF Cattle Fed
S Stockers
(figures in 000's)

Northeast

Under conditions of full adjustment, the Northeast was strictly a beef consuming region and did not figure in the beef production patterns of the United States.

The South

Under conditions of full adjustment, the Southern beef industry centered largely on calf and feeder cattle production (Figure 7). Only the Upper South was involved in cattle feeding. Feeder cattle from the South Central and Southeast areas were shipped to the South and Central Plains. These two Southern regions found themselves facing the same limitations as did the Corn Belt plus the added disadvantage that the regions were both heavily deficit in feed grains.

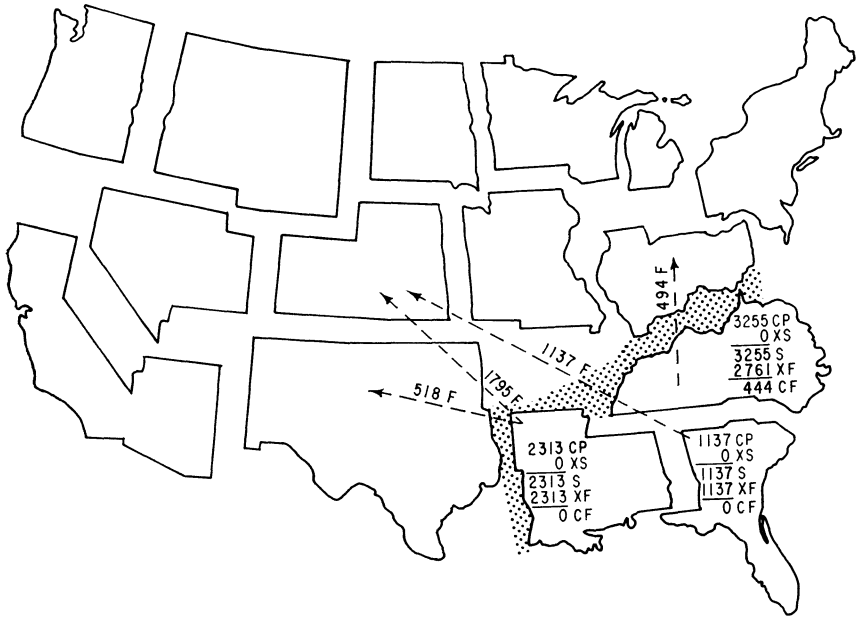

Figure 7. Calf, Stocker and Feeding Operations in the Southern Regions, Under Conditions of Full Adjustment

CP Calf Production
IS Import Stockers
XS Export Stockers
IF Import Feeders
XF Export Feeders
CF Cattle Fed
S Stockers
(figures in 000's)

Beef Industry Sectors Under Conditions of Full Adjustment

Calf Production

Optimal calf production for each individual region is shown in Table 16. The majority of the calves were produced in the Plains. The major market for the calves produced outside of the Plains was in the Plains region since this is where the lion's share of feeding eventually occurred.

Stocker Growing

Stocker calves were grown out primarily in the regions in which they originated. Some stocker calves were shipped out of the Western region and some interregional movement took place from the Lake States. Other than these isolated movements, feeder cattle were the ones which were eventually transported.

Table 16. Optimal Production Levels of Calves Produced and Optimal Feeding Levels Under Conditions of Full Adjustment

Region		Production Level	Feeding Level
		(000 head)	(000 head)
1	Pacific Northwest	—0—	—0—
2	Desert Southwest	1069	—0—
3	Intermountains	1958	287
4	Great Basin	405	81
5	Northern Plains	1387	2791
6	Central Plains	1923	8457
7	Southern Plains	6667	8254
8	Lake States	2444	—0—
9	Western Corn Belt	567	—0—
10	South Central	2313	—0—
11	Eastern Corn Belt	—0—	2761
12	Northeast	—0—	—0—
13	Upper South	3255	494
14	Southeast	1137	—0—
	Total	23,125	23,125

Feeding Activity

The location of the major inputs played a large role in locating the feeding activities under conditions of full adjustment in the beef industry. Also, the levels of non-feed costs, slaughtering costs, and costs of carcass beef transportation help to determine the location of feeding activities. If all feeding and slaughter facilities were to be built anew, cattle feeding would be expected to concentrate in the South and Central Plains (Table 16). The balance of the feeding would be centered in the Northern Plains, and the Eastern Corn Belt with minor areas in the Intermountain region and the Upper South. Surprisingly, cattle feeding did not optimally occur in the Western Corn Belt under conditions of full adjustment. This region is the largest single feeding region under current conditions. This suggests that the locational inertia resulting from fixed investments in feeding and for slaughter facilities is substantial.

The Plains regions, with large commercial lots, enjoy low per head costs of non-feed items used in the feeding activity. Costs for feed grains were as low in these regions as in any region except for the Intermountain area. Also, abundant numbers of feeder cattle produced in the immediate vicinity of the large feed supplies further reduced total production costs for cattle fed in the Great Plains. The Central and Northern Plains had enough local grains to feed their cattle. The Central Plains used equal amounts of wheat and feed grains, while the Northern Plains

used only feed grains. Cattle feeding rations in the Southern Plains consisted of home-grown wheat mixed with locally produced feed grains and with feed grains transported into the region from the Western Corn Belt.

The relative advantage of low costs in both non-feed and feed items coupled with slaughter costs that are lower than in the Northern, Western and Eastern states allowed the Southern Plains to produce a chilled beef carcass at lower costs than any alternative region.

While the Intermountain area enjoyed the lowest feed grain price of any region in the United States, non-feed costs for this area were about average for the country. The Intermountain proximity to the Portland and Seattle markets and the distance of these markets from alternative supply areas permitted the Intermountain area to be competitive in feeding to a limited degree.

The Eastern Corn Belt's feeding advantage results from their proximity to the large consuming areas within this region. The short distance to the consumer offset the disadvantages of relatively high non-feed costs and higher slaughter costs.

The Desert Southwest is currently an area of large commercial lots, but their inability to secure grain at competitive cost places them in a poor competitive position so far as cattle feeding is concerned under conditions of full adjustment.

Non-feed costs were the item that prevented the Western Corn Belt from feeding cattle. A reduction in non-feed cost of $5.81 per head would have been necessary to bring the Western Corn Belt into cattle feeding. (Total non-feed costs per head reported in the Experiment Station Research Bulletins used in this study were $29.25.) At the lower non-feed costs, feeder cattle would be shipped into the region for feeding.

Movement of Beef

Slaughtering facilities were built in conjunction with the feeding facilities under the conditions of full adjustment in the beef industry. All slaughter occurred at the point of production. With the major portion of the feeding and slaughtering occurring in the Plains regions, these areas were the major suppliers of dressed meat. The Central Plains shipped largely to the Western regions and to the lush markets of the Northeast, while the Southern Plains concentrated their shipments into the three Southern regions as well as the Northeast. Northern Plains beef was transported to the Lake States and the Northeastern markets. The Intermountain area still provided its own needs of 25,000 carcasses, shipping the remainder of the Intermountain beef to the Pacific Northwest. The optimal meat flows are shown in Figure 8.

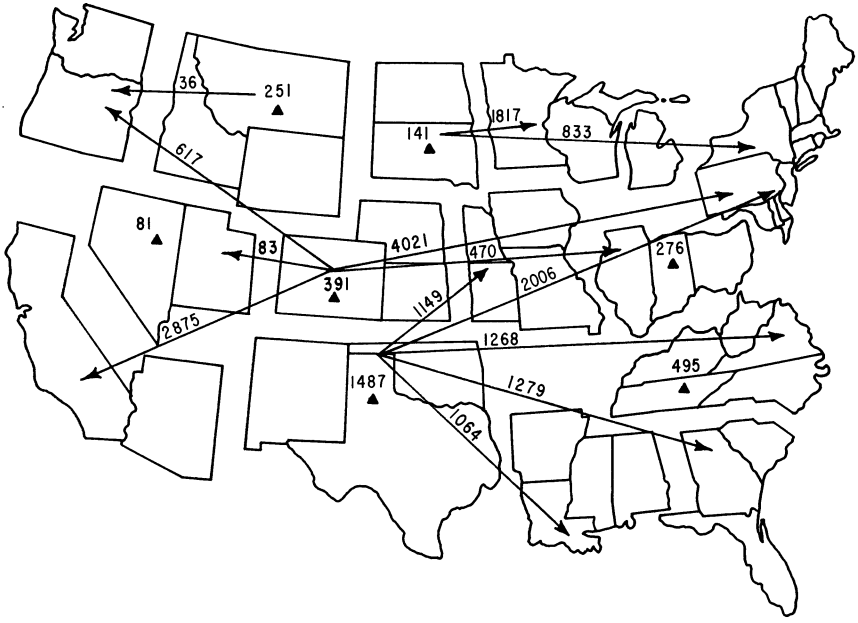

Figure 8. Optimal Flow Pattern of Carcass Meat Under Conditions of Full Adjustment

Industry Efficiency

The average cost of supplying a 682-pound beef carcass under conditions of full adjustment was $232.58. This cost includes the transportation costs involved in serving the markets and the costs of purchasing all new feeding and slaughtering facilities. Since 83 percent of all cattle were fed in the Plains regions, the distance that the cattle traveled, both live and in the carcass, was substantial.

The Results Considering Currently Existing Feeding and Slaughter Facilities

As has already been suggested, the locational inertia in the beef industry resulting from currently existing fixed investments in feeding and slaughtering facilities appears to be substantial. The second analysis, considering the existence of these facilities, provides some quantification of this locational inertia. Also, this analysis should provide information as to which adjustments are most likely to be immediately forthcoming,

and as to which regions are most likely to make those adjustments.

As with the first analysis, the regional industries will be discussed first with the optimal patterns of movement defined. Following this, the industry sectors will be discussed across regions, and the degree of resource utilization and industry efficiency defined.

The West

When currently existing feeding and slaughter facilities are considered, the beef industry in the four Western regions appears to be largely independent of the industry in other areas, at least through the feeding stage. The major movements of cattle occur among the four Western regions. Limited numbers of stocker calves do leave the Intermountain area to move into the Central Plains and Western Corn Belt (Figure 9). Within the West, the Desert Southwest exports excess calves

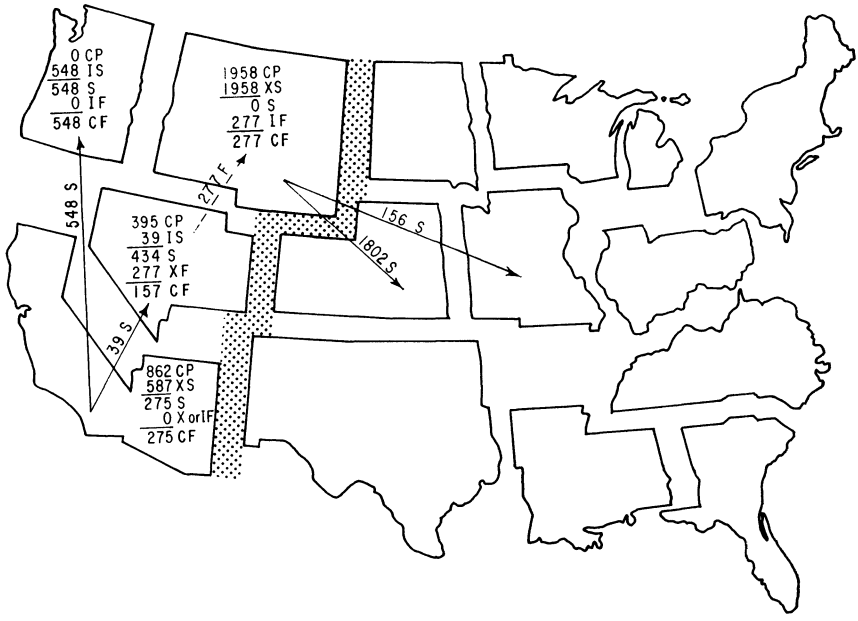

Figure 9. Calf, Stocker and Feeding Operations in the Western Regions, Considering Currently Existing Feeding and Slaughter Facilities

CP Calf Production
IS Import Stockers
XS Export Stockers
IF Import Feeders
XF Export Feeders
CF Cattle Fed
S Stockers
(figures in 000's)

to the Pacific Northwest and the Great Basin. Calf production is nonexistent (under optimum conditions) in the Pacific Northwest because of the high costs involved in maintaining cow herds. Cattle operations in the West were constrained because of the lack of available facilities, lack of grass, and a market for finished products limited to the West because of distances and transfer cost involved.

The Pacific Northwest completely utilized its feeding facilities and received additional beef supplies from its Eastern neighbor. Feeding in the Intermountain area was limited because of the lack of extra-regional market outlets other than the Pacific Northwest

The Great Basin region of Utah and Nevada served as a "balancing center" for the other three Western regions. All available Great Basin grass was utilized in cow-calf and stocker operations. Small numbers of calves were imported for growing out to feeder weights. The Great Basin retained only those feeder cattle necessary for filling local feedlots and shipped the remaining production to the Intermountain area for feeding.

The Desert Southwest contains 73 percent of the ultimate demand for beef in the four Western regions. Because of the lack of locally available feed concentrates, beef operations were limited to those numbers which could be fed using locally available wheat and imported feed grains. Feeding beyond this magnitude is not feasible because of the great cost involved in transporting grain and the close competitive position of the three regions in the Great Plains.

The lack of feed concentrates in any region limits all phases of beef production in the West. Calf production in the Desert Southwest is limited to the numbers of calves which can be feasibly grown out in the West, since the costs are prohibitive for moving grains in or calves out to grain producing regions.

The Great Plains

The three Great Plains regions would be expected to produce about 15 percent more calves under conditions imposed by currently existing feeding and slaughter facilities than under conditions of full adjustment. Unlike the West, the Plains regions also rely on other regions for substantial volumes of stockers and/or feeders in addition to the major supplies produced locally. The market outlets for all classifications of cattle are readily available within the Plains and adjacent regions. Each of the Plains regions is located such that it can potentially supply deficit regions with stocker calves and feeder cattle in addition to meeting its own demands for each class of cattle.

The Plains states are the predominant calf producing regions as shown in Figure 10. Each of these regions ranks among the lowest cost

regions for calf production. Consequently, vast proportions of the pasture capability in these regions are allocated to cow-calf enterprises. The Northern Plains is a major supplier of stockers for the Western Corn Belt because of proximity to the area. Surprisingly, when considering current investments in feeding and slaughter facilities, the Southern Plains should optimally export stockers to the South Central area. This situation arises from the fact that the Southern Plains would optimally produce more calves than could be grown out locally to feeding weights, on the available grass.

The Central Plains region is the only Plains region which imports stocker calves, receiving them from the Intermountain area. This balance of calf production and stocker growing for the Central Plains occurred since grass is not available in sufficient quantities for carrying all calves required by the region through to feed weight. Further, the Intermountain area is the only area from which the Central Plains can feasibly im-

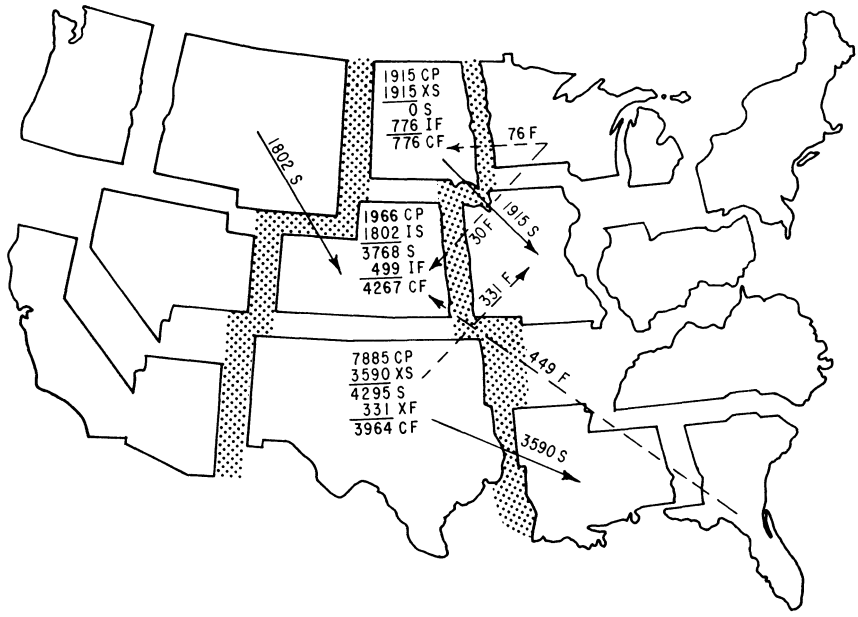

Figure 10. Calf, Stocker and Feeding Operations in the Plains Regions, Considering Currently Existing Feeding and Slaughter Facilities

CP Calf Production
IS Import Stockers
XS Export Stockers
IF Import Feeders
XF Export Feeders
CF Cattle Fed
S Stockers
(figures in 000's)

port calves. The Intermountain area utilized all available grass in the cow-calf enterprise. Grass in the Central Plains is divided between local calf production and stocker growing operations that utilize the Intermountain calves.

Stocker growing operations are important in both the Southern and Central Plains areas. Since the Northern Plains utilized available pasture solely for calf production, Northern Plains calves were grown to feeding weight in the Western Corn Belt. Feeder calves were imported for feeding in the Northern Plains from the Lake States. The Central Plains received additional feeders from the Lake States and from the Southeast.

The Great Plains regions utilized their own feed grains and wheat for fattening cattle. Both the Central and Northern Plains areas utilized only feed grains for feeding cattle. The Southern Plains used large amounts of wheat in their rations, although feed grains were the predominant concentrate. In the absence of "feed" wheat, the Southern Plains would have been forced either to import feed grains or to reduce feeding by 1.2 million head.

Corn Belt

Calf production in the Corn Belt occurs only in the Lake States when the currently existing facilities for feeding and slaughter are considered (Figure 11). Efficient utilization of the available grass was the major factor controlling calf production in these regions. Because of the large acreage of grass required per beef cow, the Western Corn Belt gets its required levels of feeder cattle at lower cost by utilizing grass for stocker growing. The cost of shipping the heavier feeder animals into the region would increase the total cost of fed beef production. Stocker calves for the Western Corn Belt were imported from the Northern tier of states between Michigan and Idaho. Since the quantity of grass produced in the Western Corn Belt is insufficient for meeting the total needs for feeder cattle, additional feeder cattle were imported from the Southern regions and the Southern Plains.

The Eastern Corn Belt utilized no grass in the production of calves nor in stocker growing. Feeder cattle could be supplied from the Upper South at a lower total cost than these cattle could be produced in the Eastern Corn Belt.

Feed grains were the primary feed concentrate in all Corn Belt regions. Less than one percent of the concentrate was made up of wheat in any Corn Belt region.

Northeast

The Northeast did not produce calves, feeders or fat cattle.

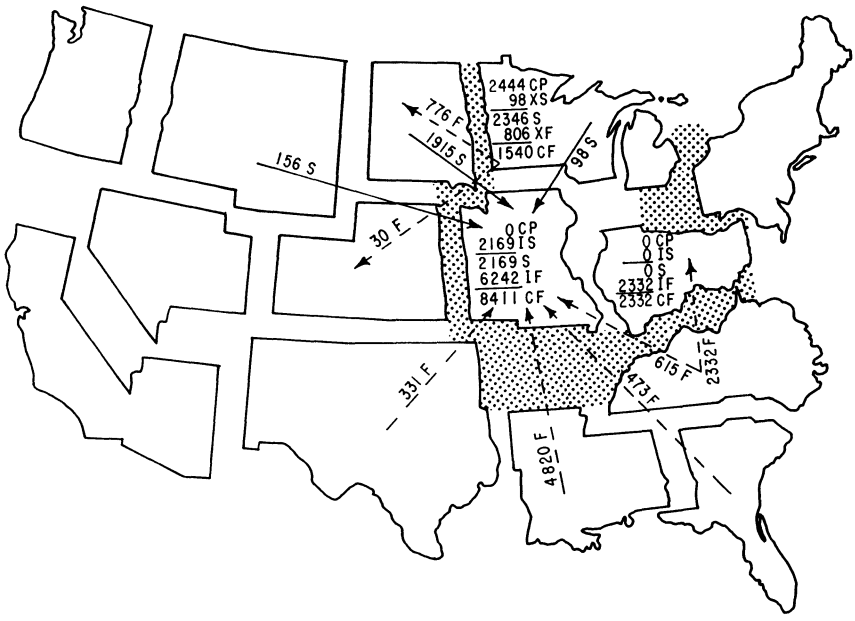

Figure 11. Calf, Stocker and Feeding Operations in the Corn-Belt Regions, Considering Currently Existing Feeding and Slaughter Facilities

CP Calf Production
IS Import Stockers
XS Export Stockers
IF Import Feeders
XF Export Feeders
CF Cattle Fed
S Stockers
(figures in 000's)

The South

The second largest general calf producing area under conditions considering current feedlot and packing house investments was composed of the three Southern regions. Figure 12 shows that the Southern regions should be major suppliers of feeder cattle for both the Corn Belt and the Central Plains. The South Central area was the only region importing cattle of any kind. While calf production was an important sector in this region, most of the grass was utilized in stocker activities and growing calves originating in the South Plains. The South Central region was the growing area for 21 percent of all stocker cattle in the nation with South Central feeder cattle making up the lion's share of the cattle fed in the Western Corn Belt.

Cattle exported from the other two Southern regions originated locally and were grown to feeding weights on locally available grass. The proximity of Corn Belt feedlots was a major factor encouraging large

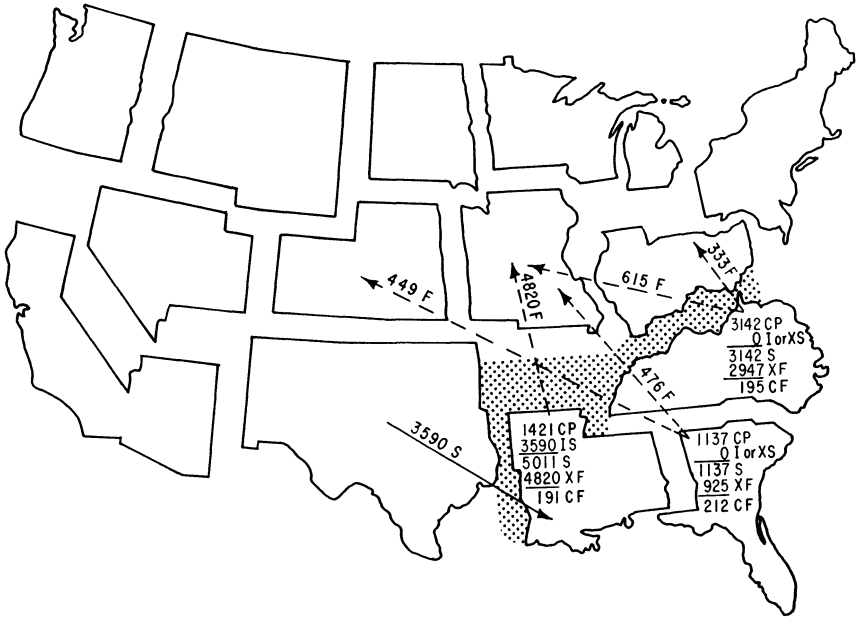

Figure 12. Calf, Stocker and Feeding Operations in the Southern Regions, Considering Currently Existing Feeding and Slaughter Facilities

CP Calf Production
IS Import Stockers
XS Export Stockers
IF Import Feeders
XF Export Feeders
CF Cattle Fed
S Stockers
(figures in 000's)

volumes of calf production and stocker growing activities in these regions.

Feeding in the South was limited to the facilities which were already present. Cattle resources were readily available but feed grains were lacking. Although low-cost barge transportation could be used to move feed concentrates into the South, the combined costs of feeding and grain transportation placed the South at a disadvantage compared with the Southern Plains.

Beef Industry Sectors

Calf Production

When current levels of feeding and slaughter facilities are considered, calf production exhibits a higher degree of regional concentration

than was evident in the full adjustment analysis. Optimal calf production for each individual region is shown in Table 17. The vast majority of these calves originated in the three Southern regions and the Plains regions. These regions were favorably located with respect to large feeding areas and abundant feed grains. Consequently, large markets existed for their calves.

Feeding

Feeding hinges upon the regional capability to assemble feeder cattle and feed concentrates at minimum cost, and upon low cost access to beef consuming markets. In the analytical model, each region had the option of purchasing additional feeding facilities. However, this option was not utilized under the assumptions approximating current conditions. All cattle were fed in existing facilities. Optimal feeding for each region is shown in Table 17.

Feeding centered around the abundant feed grain suppliers of the Plains and Corn Belt. These regions were located such that the beef could be readily distributed to large consumer markets. The West and South did feed cattle but on very limited scale, since these regions lacked the feed grains to compete with the Plains and Corn Belt areas except within their own local markets.

Table 17. Optimal Regional Distribution of Calf Production and Optimal Feeding Numbers, Considering Currently Existing Feeding and Slaughter Facilities

Region		Calf Production	Feeding Number
		(000 head)	(000 head)
1	Pacific Northwest	—0—	548
2	Desert Southwest	862	275
3	Intermountains	1958	277
4	Great Basin	395	157
5	Northern Plains	1915	776
6	Central Plains	1966	4247
7	Southern Plains	7885	3964
8	Lake States	2444	1540
9	Western Corn Belt	—0—	8411
10	South Central	1421	191
11	Eastern Corn Belt	—0—	2332
12	Northeast	—0—	—0—
13	Upper South	3142	195
14	Southeast	1137	212
	Total	23125	23125

Stocker Operations

Stocker cattle were grown to feeding weights in the same general geographic pattern as were calves (Table 18). The areas adjacent to large feeding concentrations and those regions which enjoyed abundant grass capacity were major suppliers of feeders. The West produced only for the relatively small Western feeding industry.

Movement of Fat Cattle and Slaughtering

When currently existing feeding and slaughtering facilities were considered, cattle slaughter was heavily production orientated since carcasses could be moved at much lower cost than could fat cattle. The only movement of fat cattle that occurred was a very limited movement from the Northern Plains into the Lake States. Currently existing Northern Plains slaughter capacity was insufficient for slaughtering the cattle optimally produced in Northern Plains feedlots, but it was cheaper to move the surplus cattle to surplus slaughter capacity in the nearby Lake States than to build new local slaughter capacity.

Of the Western regions, only the Intermountain area used all available slaughtering capacity. Excess capacity for about four million animals was unused in the other Western regions.

Table 18. Optimal Receiving of Stockers and Stocker Growing, Considering Currently Existing Feeding and Slaughter Activities

Region		Received Stockers From	Quantity Received	Total Number Grown
			(000 head)	
1	Pacific Northwest	2	548	548
2	Desert Southwest	2	275	275
3	Intermountains	None	None	None
4	Great Basin	2	39	
		4	395	434
5	Northern Plains	None	None	None
6	Central Plains	3	1802	
		6	1966	3768
7	Southern Plains	7	4295	4295
8	Lake States	8	2346	2346
9	Western Corn Belt	3	156	
		5	1915	
		8	98	2169
10	South Central	7	3590	
		10	1421	5011
11	Eastern Corn Belt	None	None	None
12	Northeast	None	None	None
13	Upper South	13	3142	3142
14	Southeast	14	1137	1137

The Plains regions utilized all of their available slaughter. Two of these regions—the Central Plains and the Southern Plains—bought additional capacity. The Southern Plains bought capacity to slaughter 675,000 additional cattle annually. This would be equivalent to about three new plants, each having the annual capacity of 225,000 head of cattle. The Central Plains built 23,000 head of additional capacity.

The Corn Belt regions had ample slaughtering facilities. Only the Western Corn Belt fully utilized its existing capacity, and built 9,000 head of additional capacity in order to kill the animals fed locally. The other Corn Belt regions had 2.7 million head of unused capacity. Slaughter in the Southern regions was limited to locally fed animals, leaving 1.2 million head of unused capacity in the South.

Of the 23,125,000 head of cattle fed, less than one percent of the fat cattle were transported live. All regions (except for the Northern Plains) with insufficient slaughter capacity for the cattle fed built new facilities.

Distribution of Beef

The optimal flows of beef shown in Figure 13 illustrate the optimal concentration of feeding in the central part of the United States with shipments from the heartland to outlying coastal areas. Almost three-fourths of all cattle optimally should be fed and slaughtered in the major feeding regions of the Southern and Central Plains and the Corn Belt regions. Beef produced in the Western regions is consumed in the West. The Plains are located near the geographic center of the United States. Consequently, these areas are able to move either direction with great efficiency as shown in Figure 13. A cost change of a fraction of a cent on east-bound shipments would pull large volumes of Central Plains beef to the East. The resulting slack in the West Coast market would be picked up by the Southern Plains and the Intermountain area.

For the Southern Plains, the major market was the Southern part of the United States. The rapidly growing population in the Gulf Coast and Atlantic seaboard areas encourages a rapidly growing beef industry in the Southern Plains. These Southern markets were not sensitive to any reasonable transportation cost changes. That is, Gulf Coast and South Atlantic markets are likely to be dominated by the Southern Plains regardless of transportation rate structure.

Beef in the Corn Belt flows to the heavy beef-consuming areas of the East. A strong market advantage is enjoyed by these regions for selling beef in the Northeast market due to the favorable transportation cost structure.

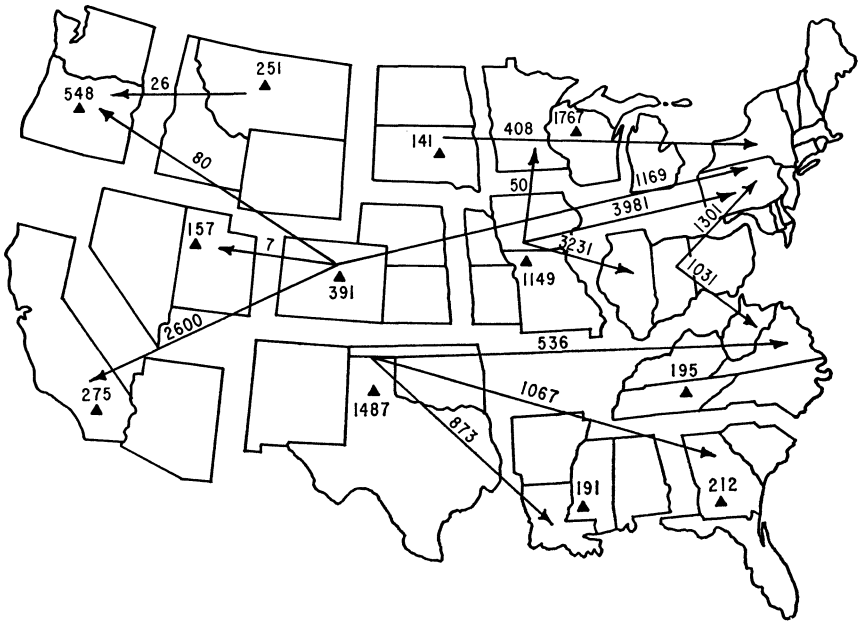

Figure 13. Optimal Flows of Dressed Beef, Considering Currently Existing Feeding and Slaughter Facilities

Feed Grains and Wheat

Feed grains and wheat movements were limited mainly to intraregional moves within the five general aggregate regions, as shown in Tables 19 and 20. Feeding in the West was totally dependent on feed grains produced in the Intermountain area. The Intermountain area supplied each of the Western regions with the feed grains necessary to balance the locally available wheat used in their concentrate ration.

The only other interregional movement of feed grains or wheat occurs by barge transportation from various points in the Corn Belt to the Southern regions.

Transporting the Products

In the movements of the different beef animals, all of the movements of the live animals were handled by truck. This was true of stocker cattle and feeder cattle as well as of the fat cattle that were shipped. Rail movements were not competitive unless cattle were moved for very long distances. In the optimal flow patterns, movements of this type did not occur.

Table 19. Optimal Shipment of Feed Grains Considering Currently Existing Feeding and Slaughter Facilities

Origin		Destination		Quantity
				(000,000 therms)
3	Intermountains	1	Pacific Northwest	546
		2	Desert Southwest	274
		3	Intermountains	269
		4	Great Basin	145
4	Great Basin	4	Great Basin	12
5	Northern Plains	5	Northern Plains	1558
6	Central Plains	6	Central Plains	8502
7	Southern Plains	7	Southern Plains	5400
8	Lake States	8	Lake States	3069
		13	Upper South	194
		14	Southeast	211
9	Western Corn Belt	9	Western Corn Belt	16167
		10	South Central	190
11	Eastern Corn Belt	11	Eastern Corn Belt	2397

Table 20. Optimal Shipment of Wheat Considering Currently Existing Feeding and Slaughter Facilities

Origin		Destination		Quantity
				(000,000 therms)
1	Pacific Northwest	1	Pacific Northwest	546
		2	Desert Southwest	239
2	Desert Southwest	2	Desert Southwest	35
3	Intermountains	3	Intermountains	269
		4	Great Basin	76
4	Great Basin	4	Great Basin	80
7	Southern Plains	7	Southern Plains	2500
9	Western Corn Belt	9	Western Corn Belt	1009
10	South Central	10	South Central	48
11	Eastern Corn Belt	10	South Central	143
		11	Eastern Corn Belt	2397
		14	Southeast	211
13	Upper South	13	Upper South	194

In the transportation of meat, trucks tended to dominate the shorter interregional moves as well as the moves within regions. Railroads handled the longer hauls except for the meat movements to the Southern regions from the South Plains.

Capacity Constraints

The production constraints were placed in the analytical model in order to describe current conditions as realistically as possible. For

the most part, the beef industry utilized the facilities which were currently available rather than constructing new facilities. Grass capacity was completely utilized in all regions except for the Pacific Northwest, Desert Southwest, Eastern Corn Belt, Northeast, and Upper South. Any additional growth in the beef industry in other regions will require substantial grassland improvements.

Slaughter capacity was completely utilized in the Intermountain region in the Northern Central and Southern Plains and in the Western Corn Belt. Of these, only the Northern Plains and Intermountain areas purchased no additional capacity.

Feedlot capacity was exhausted in all regions except for the Desert Southwest, Intermountain, and Western Corn Belt regions. Feed grain supplies were depleted in the Intermountain, Great Basin and Southern Plains regions. All other regions have substantial volumes of surplus feed grains. Wheat supplies were completely consumed in the Desert Southwest, Great Basin, Western Corn Belt and South Central regions. Ample wheat remained available in other regions.

Efficiency of the Industry

Economic efficiency is often discussed as the law by which managers must live. For the beef industry, economic efficiency may be defined to be getting the carcass animal to the consumer at the lowest possible cost. When currently existing investments in feeding and slaughter are considered, the lowest cost for supplying one additional beef carcass was that of providing an additional carcass to the Intermountain region. This minimum non-land marginal cost was $234.75 (21 cents per pound, liveweight). Additional beef moved to the Richmond, Virginia, area would be the most expensive at $252.98 (23 cents per pound, liveweight) above the cost for land. The rank of the regions from lowest to highest marginal cost is shown in Table 21. These marginal costs suggest just how costly it may become to provide beef to population growth areas as population continues to shift.

Following the optimal flow and production patterns, the average cost of supplying a carcass animal was $199.19 (18 cents per pound, liveweight). If the animal is converted to the 1969 average price, the carcass would be valued at $334.00. This leaves $114.81 as a return to land, management, roughages and profits for all the different segments of the beef industry.

Table 21. Non-Land[1] Costs for Supplying One Additional Beef Carcass to Each Region, Considering Currently Existing Feeding and Slaughter Facilities

Region		Cost
3	Intermountains	$ 234.75
9	Western Corn Belt	237.24
6	Central Plains	237.24
5	Northern Plains	238.20
7	Southern Plains	242.20
8	Lake States	242.83
11	Eastern Corn Belt	243.03
2	Desert Southwest	244.05
4	Great Basin	244.26
1	Pacific Northwest	244.26
10	South Central	245.49
14	Southeast	248.63
12	Northeast	252.65
13	Upper South	252.99

[1] Roughage costs in feeding rations are excluded from these figures.

Summary and Implications

The purpose of this study was to examine the interregional adjustments in beef production, slaughter, and marketing that could be expected to occur as a result of the economic incentives present during the 1968-1970 period—assuming that those conditions persist for a period of time long enough for the adjustment process to be completed. A secondary purpose was to suggest the route by which the appropriate adjustment could be achieved, considering the constraints imposed by existing investments in feeding and slaughter facilities.

The principal conclusions to be drawn from this analysis relate to the applicability of the findings in indicating probable directions of change in the location of beef production and in product flows. Interpretation of the magnitudes of regional production and of geographic flows of products must be conditioned by the nature of the available data. The various series of published livestock data are often inconsistent, not only between series but also occasionally within series. Because of this data limitation, the magnitudes of the estimates in this study should be interpreted as relative rather than absolute figures in anticipating the relative changes among regions.

The regional balance sheet for beef production during the 1968-1970 period is shown in Table 22. It will be noted that only 62 percent of the calves actually produced were actually available for feeding, once needs for beef replacement heifers, calf slaughter, and death loss had

Table 22. Balance Sheet of Calf Production and Disposition, by Region Forty-Eight Contiguous States, 1968-70 Average

Region	Potential Feeder Calf Prod.[1]	Less: Beef Replmt. Heifer Needs[2]	Less: Comm. Calf Sltr.	Less: Death Loss[3]	Less: Farm Sltr.[4]	= No. of Calves Avail. for Feeding	± Regional Imports (+) or Exports (—)	= Actual No. of Fed Cattle Mktd.
			(Thousand Head)					
Pacific Northwest	1,107	110	26	111	38	822	— 306	516
Desert Southwest	1,387	144	196	205	19	823	+2,029	2,852
Intermountain	2,820	424	2	232	27	2,135	—1,534	601
Great Basin	576	114	6	62	8	386	— 386	[7]
Northern Plains	2,693	374	[5]	226	29	2,064	—1,354	710
Central Plains	3,546	564	4	366	21	2,591	+2,431	5,022
Southern Plains	7,841	1,326	330	550	46	5,589	—2,141	3,448
Lake States	2,463	146	681	514	76	1,046	+ 270	1,316
Western Corn Belt	5,302	746	301	506	50	3,699	+3,279	6,978
South Central	3,726	792	364	339	34	2,197	—2,197	[7]
Eastern Corn Belt	1,873	190	310	300	48	1,025	+1,137	2,162
North East	1,374	40	1,876	270	46	— 858	+ 991	133[8]
Upper South	3,296	527	308	361	41	2,059	—2,059	[7]
Southeast	1,819	299	354	149	15	1,002	—1,002	[7]
48-State Total	39,823	5,796	4,758	4,191	498	24,580	— 842[6]	23,738

[1] Total Beef Calf production plus half of Dairy Calf production.
[2] Includes .125 percent of average Beef Cowherd plus average of increase in Beef Cowherd.
[3] Death loss of cattle and calves.
[4] Farm Slaughter of cattle and calves.
[5] Less than 500 head.
[6] Should be interpreted as total of non-fed Steer and Heifer slaughter plus fed cattle marketings in non-reported states.
[7] Not available.
[8] Pennsylvania is the only state included in this figure. Other states not reported.
SOURCE: All data reported in *Livestock and Meat Statisitcs*, Statistical Bulletin No. 333 and Supplements, ERS, USDA, Washington, D.C., and in *Livestock Slaughter*, 1968, 1969, and 1970, CRB, SRS, USDA, Washington, D.C.

been met. The numbers of calves potentially available for feeding during this period exceeded the numbers actually fed by 842,000 head or by 3.5 percent. This 3.5 percent should be interpreted to include the non-fed steer and heifer slaughter and all fed cattle marketed in those states not reporting the number of cattle marketed from feed lots.

It is not possible to define the regional incidence of growing stocker calves from weaning weights to feeding weights, since the available data do not provide information as to the weights of cattle included in regional inshipments or outshipments. Further, regional inshipments of cattle can not be identified as to the region of origin, and regional outshipments cannot be identified as to destination. Therefore, any comparisons between the actual and optimal regional levels of beef production and marketing activities must necessarily exclude comparisons for the stocker growing activity.

Beef Production

The optimal regional allocations of beef production activities — not only as constrained by existing feeding and slaughter facilities, but also under conditions of full adjustment—are compared with the actual conditions prevailing during the 1968-1970 period in Table 23. The general implications of Table 23 are that the economic incentives were present during the 1968-1970 period to spur massive changes throughout the beef industry.

Because of existing feeding and slaughter facilities, and because of high calf production costs, forage in the Western Corn Belt could have been utilized more economically to grow stocker calves imported from the Intermountain, Northern Plains, and Lake States to feeding weights. These cattle, along with massive numbers of feeder cattle imported from the three Southern regions were then fed out in a substantially expanded feeding industry. Forage capacity in the Eastern Corn Belt was unused, even though the cattle feeding activity was continued at about the level actually observed during the base period.

When full adjustment conditions were considered, neither the Lake States, the Eastern nor Wastern Corn Belts could afford to feed cattle if the returns from the feeding enterprise were expected to cover the full costs of investment and operation. The Midwest is currently a major producer of fed cattle, but the economic pressures present in the 1968-1970 period were overwhelmingly in favor of transferring the lion's share of feeding activity to the three Plains regions. The presence of major long-term investments in Midwestern feeding and slaughter facilities can retain a substantial feeding industry in the Midwest for the moment. But the observed trend to transfer feeding to the Plains is most likely to

Table 23. Regional Location of Beef Production Enterprises: Actual 1968-1970 Location Compared with Optimum Locations Considering Existing Feeding and Slaughter Facilities, and with Optimum Locations under Full Economic Adjustment

Region	1968-70 Actual			"Constrained" Optimum, Considering Existing Feeding & Slaughter Facilities				Full Adjustment Optimum			
	Calves Avail. for Feeding[1]	Impts(+) or Expts(—) of Cattle	Fed Cattle Mktgs.	Calves Prod. for Feeding	Impts(+) or Expts(—) of Stkr. Calves	Impts(+) or Expts(—) of Feeder Calves	Fed Cattle Mktgs.	Calves Prod. for Feeding	Impts(+) or Expts(—) of Stkr. Calves	Impts(+) or Expts(—) of Feeder Calves	Fed Cattle Mktgs.
					(1000 hd)						
Pacific Northwest	822	— 306	516	0	+ 548	0	548	0	0	0	0
Desert Southwest	823	+2,029	2,852	862	— 587	0	275	1,069	—1,069	0	0
Intermountain	2,135	—1,534	601	1,958	—1,958	+ 277	277	1,958	—1,958	287	287
Great Basin	386	— 386	[2]	395	+ 39	— 277	157	405	0	— 324	81
Northern Plains	2,064	—1,354	710	1,915	—1,915	+ 776	776	1,387	0	+1,404	2,791
Central Plains	2,591	+2,431	5,022	1,966	+1,902	+ 499	4,267	1,923	+1,958	+4,576	8,457
Southern Plains	5,589	—2,141	3,448	7,885	—3,590	— 331	3,964	6,667	+1,069	+ 518	8,254
Lake States	1,046	+ 270	1,316	2,444	— 98	— 806	1,540	2,444	— 98	—2,346	0
Western Corn Belt	3,699	+3,279	6,918	0	+2,169	+6,242	8,411	567	+ 98	— 665	0
South Central	2,197	—2,197	[2]	1,421	+3,590	—4,820	191	2,313	0	—2,313	0
Eastern Corn Belt	1,025	+1,137	2,162	0	0	+2,332	2,332	0	0	+2,761	2,761
Northeast	— 858[4]	+ 991	133[5]	0	0	0	0	0	0	0	0
Upper South	2,059	—2,059	[2]	3,142	0	—2,947	195	3,225	0	—2,761	494
South East	1,002	—1,002	[2]	1,137	0	— 925	212	1,137	0	—1,137	0
48-State Total	24,580	— 842[3]	23,738	23,125	0	+ 20[6]	23,145[6]	23,125	0	0	23,125

[1] "Calves Available" includes beef calf crop plus half of dairy calf crop, less beef replacement heifer needs, commercial slaughter of calves, and death loss and farm slaughter of cattle and calves.
[2] Fed Cattle Marketings not reported for these regions.
[3] This 842,000 head "export" for the 48-states should be interpreted as the total of non-fed steer and heifer slaughter plus the fed cattle marketed in non-reporting states.
[4] Negative value results from large numbers of imported slaughter calves.
[5] Pennsylvania only. Other states do not report fed cattle marketings.
[6] Regional Imports exceed Regional Exports slightly due to rounding errors.

continue and accelerate as it becomes necessary to replace these facilities.

The presence of long-term fixed investments and geographic isolation from alternative sources of beef can be expected to maintain the feeding industry at about its present level in the Pacific Northwest, but not in the Desert areas of California-Arizona. Full adjustment conditions can be expected to eliminate cattle feeding in all areas along the Pacific Coast.

The Central Plains have already expanded cattle feeding beyond those levels which would be optimal considering existing investments in feeding and slaughter facilities, even though under full adjustment conditions the Central Plains could expect massive further feeding increases. Basic calf production in the Central Plains would optimally be replaced to a limited extent by an increase in stocker growing operations as Central Plains cowmen begin to replace feeder cattle imports with light stocker calves.

The Northern Plains are currently very near the constrained optimum in all phases of the beef industry. But as feeding and slaughter facilities are worn out in other regions, a substantial increase in Northern Plains feeding could be expected.

The heart of the beef industry is and will continue to be the Plains —specifically the Southern Plains. Major increases in all phases of beef production would be appropriate when considering the presence of fixed facility investments, although some of the increase in basic calf production is likely to be replaced by "backgrounding" imported stocker cattle as the deterioration of feeding facilities in other regions spurs the growth in Southern Plains feeding.

Fat Cattle Slaughter

The actual and optimum locations of beef slaughter activities are shown in Table 24. It is apparent from Table 24 that a large excess of capacity for cattle slaughter existed during the 1968-1970 base period (8.2 million head or 26 percent of total estimated capacity was unused). The major portion of this excess capacity is located in the Lake States, the Eastern and Western Corn Belts, in the Northeast, and along the Pacific Coast. Much of this excess capacity dates from the time when central markets dominated the livestock industry, when both the central markets and the livestock slaughter and processing facilities were located in major population and consuming centers. Since World War II, the slaughter industry has become "production oriented," locating new facilities in areas of concentrated livestock supplies. The expansion of slaughter capacity in supply areas has generated enormous excess slaughter capacity in some regions, even though there were still substantial local

Table 24. Regional Location of Fed Cattle Marketings, Fat Cattle Slaughter, and Interregional Movements of Fed Cattle; Actual for 1968-1970 Compared with Optimum Locations Considering Existing Feeding and Slaughter Facilities, and with Optimum Locations Under Full Economic Adjustment

Region	1968-70 Actual			"Constrained" Optimum, Considering Existing Feeding & Slaughter Facilities					Full Adjustment Optimum		
	Fed Cattle Mktgs.	Steer and Heifer Sltr.[1]	Impts(+) or Expts(—) of Sltr. Cattle	Fed Cattle Mktgs.	Fat Cattle Sltr.	Impts(+) or Expts(—) of Fat Cattle	Sltr. Capacity Est. Exist. Cpcty.	Sltr. Capacity New Cnstn(+) or Unused Capacity(—)	Fed Cattle Mktgs.	Fat Cattle Sltr.	Change from Actual 1968-70 Sltr. Capacity
					(1,000 Cattle)						
Pacific Northwest	516	780	+ 264	548	548	0	952	— 404	0	0	— 952
Desert Southwest	2,852	2,567	— 285	275	275	0	3,774	—3,499	0	0	—3,774
Intermountain	601	519	— 82	277	277	0	277	0	287	287	+ 10
Great Basin	[2]	253	+ 253[4]	157	157	0	226	— 69	81	81	— 145
Northern Plains	710	765	+ 55	776	549	—227	549	0	2,791	2,791	+2,242
Central Plains	5,022	3,210	—1,812	4,267	4,267	0	4,224	+ 43	8,457	8,457	+4,233
Southern Plains	3,448	2,270	—1,228	3,964	3,964	0	3,289	+ 675	8,254	8,254	+4,965
Lake States	1,316	2,899	+1,583	1,540	1,767	+227	3,766	—1,999	0	0	—3,766
Western Corn Belt	6,918	8,493	+1,575	8,411	8,411	0	8,402	+ 9	0	0	—8,402
South Central	[2]	592	+ 592[4]	191	191	0	441	— 250	0	0	— 441
Eastern Corn Belt	2,162	2,249	+ 87	2,332	2,332	0	3,043	— 711	2,761	2,761	—3,043
Northeast	133[3]	1,026	+ 893[4]	0	0	0	1,608	—1,608	0	0	—1,608
Upper South	[2]	782	+ 782[4]	195	195	0	876	— 681	494	494	— 876
Southeast	[2]	466	+ 466[4]	212	212	0	539	— 327	0	0	— 539
48-State Total	23,738	26,738	+3,133	23,145	23,145	0	31,966	--	23,125	23,125	--
								+ 727			—11,450
								—9,548			—23,546

[1] Estimated from Total Cattle Slaughter less Regional Cow Slaughter. Regional Cow Slaughter estimates derived from information provided by Western Livestock Information Project, Cooperative Extension Service, Western States and USDA, Denver, Colorado. Estimated Steer and Heifer Slaughter includes non-fed slaughter, and thus exceeds total of fed cattle marketings. Also, total steer and heifer slaughter exceeds the "potential number of calves available for feeding" estimated in Table 22. Total steer and heifer slaughter includes feeder cattle which originated in Canada and Mexico as well as culled dairy replacement heifers. Neither of these groups were considered in the potential feeder cattle estimate.

[2] Not reported.

[3] Pennsylvania only. Other States not reported.

[4] Imports likely overestimated since fed cattle marketings not reported for these regions.

[5] Total new construction of slaughter capacity in regions will project increase in cattle feeding.

[6] Total unused slaughter capacity in other regions.

capacity shortages in all three of the Plains regions as late as 1970.

The facts are that the optimal patterns of cattle slaughter—both for the constrained optimum and the full adjustment optimum—are very much at odds with the patterns that existed during the 1968-1970 base period. While the available data do not define points of origin and destination for fat cattle movement, the three Plains regions annually produced more than a million fat cattle in excess of the capacity they had for slaughtering and processing beef during the 1968-1970 period. The Intermountain region likewise was forced in the actual situation to move substantial numbers of cattle outside the region for slaughter.

The indications are that the production orientation of beef slaughter will continue and accelerate. Even considering the existence of excess capacity in other regions, the economic incentives are present for the Southern Plains to construct substantial additional slaughter capacity. The magnitude of the 675,000 head estimate of the new construction which would be optimal for the Southern Plains suggests three additional plants slaughtering 225,000 head of cattle per year. Very small slaughter capacity increases are also suggested under the constrained optimum in the Central Plains and the Western Cornbelt.

The only interregional movement of slaughter cattle observed under conditions in which the existence of current feeding and slaughter facilities are considered was a small movement from the Northern Plains into the Lake States. The lack of Northern Plains facilities, the proximity of large excesses in Lake State slaughter capacity, and low costs of fat cattle movement from the Northern Plains to the Lake States all combine to generate this transfer.

When full economic adjustment conditions under which all facilities must be replaced are considered, the production orientation of beef slaughter becomes total. No slaughter cattle are shipped between regions. The emergence of the three Plains regions as the dominant force in cattle feeding calls for large scale increases in Plains slaughter capacity. Lack of current slaughter capacity appears to be a major deterrent to growth in cattle feeding in the Northern Plains, and a mild limitation to the beef industry in the Intermountain area. Both the Southern Plains and the Central Plains are likely to be major beneficiaries of interregional shifts in both feeding and slaughter of beef as it becomes necessary to replace outmoded feeding and slaughter facilities in other areas.

Movements of Carcass Beef

There are no data to suggest the magnitudes of actual interregional movements of fed beef carcasses. Numerous beef marketing studies have suggested the probable directions and magnitudes, and discussions with

packers and food chains indicate that the results of these studies are generally correct. Nevertheless, the actual movements can be discussed only in generalities.

In general, during the 1968-1970 base period, South Central and Southeastern markets were served by beef produced in the Southern Plains. Beef markets in the Upper South were shared by the Southern Plains, Central Plains, and Eastern Corn Belt. The lush Northeastern market was served by the Eastern and Western Corn Belts, and by the Northern and Central Plains. Pacific Coast markets were shared by the Desert Southwest, the Central Plains, and occasionally by the Southern Plains. Markets in the Chicago-Detroit sector were served by the Eastern and Western Corn Belts and by the Lake States.

When the existence of current feeding and slaughter facilities is considered, the optimum movements of fed beef carcasses do not vary substantially from the general patterns that actually prevailed during the base period. While the Southern Plains could have profitably marketed carcass beef in the Pacific Coast and Northeastern markets, even greater profits were available from markets in the three Southern regions. Thus the Southern Plains dominated the South Central and Southeastern beef markets and shared the Upper South with the Eastern Corn Belt. The Central Plains dominated all four Western regions except for local production, and shipped the remaining carcasses to the Northeast. The Western Cornbelt dominated Midwestern markets except for local production in the Lake States, and shipped the remaining surplus into the Northeast.

Under conditions of full economic adjustment, the three Plains regions dominated virtually all phases of the beef industry. The Plains restricted the Eastern Corn Belt to its local markets as the Plains became the dominant supplier in the Upper South. In addition, the Western Corn Belt and the Northeast both became major outlets for Southern Plains beef. The Central Plains retained all of its Western markets, expanded its share of the Northeastern market, and penetrated the markets of the Upper Midwest. The Northern Plains dominated the Lake States beef markets and expanded its share of the Northeastern market.

General Implications

General implications that can be drawn from the results of this study include:

1. The three beef production regions of the Great Plains—especially the Southern and Central Plains areas—can be expected to be of increasing importance in *all* phases of the beef industry.

even considering the existence of substantial investments in feeding and slaughter facilities in the Midwest and in the Far West. As it becomes necessary to replace these facilities, the Southern and Central Plains can be expected to greatly increase their regional shares of both cattle feeding and slaughter.

2. The three Southern regions—particularly the South Central and Upper South—can be expected to be of increasing importance as a source of stocker calves, but even more significantly, as a source of cattle of feeding weights. Under conditions of full economic adjustment, the Upper South also has some limited cattle feeding potential.
3. The Western Corn Belt, the Lake States and the Desert Southwest are likely to be progressively less and less important as cattle feeding potential.
4. The vast acreages of the four Western regions are most likely to continue to be utilized as "nurseries" for the production of stocker calves. Because of geographic isolation, these regions can engage in a limited degree of cattle feeding so long as their current investments in feeding and slaughter facilities are in usable condition. It is unlikely, however, that these regions can generate the returns from the feeding enterprise to justify reinvestment and maintenance, once these existing facilities are depleted.

Appendix A

MATHEMATICAL DEFINITION OF THE PRODUCTION-TRANSHIPMENT MODEL

Summary and Implications

Minimize:

$$(1)\quad A = \sum_i B_{Ki}\, U_i + \sum_i \sum_j C_{Pij}\, S_{ij} + \sum_i I_i\, U'_j + \sum_i \sum_j C'_{ij}\, M_{ij} + \sum \sum C_{Tij}\, G_{ij} + \Sigma_i\, N_{Zi}\, Q_i$$

Subject to the constraints,

$$(2)\quad St_i \leqslant St_i + \Sigma\, St_{ji} - \Sigma\, St_{ij}$$

$$(3)\quad F_i \leqslant F_i + \Sigma F_{ij} - \Sigma\, F_{ij}$$

$$(4)\quad Fa_i \leqslant Fa_i + \Sigma\, Fa_{ji} - \Sigma\, Fa_{ij}$$

$$(5)\quad FG_i \leqslant FG_i + \Sigma\, FG_{ji} - \Sigma FG_{ij}$$

$$(6)\quad W_i \leqslant W_i + \Sigma\, W_{ji} - \Sigma\, W_{ij}$$

$$(7)\quad \sum_i FG_{ij} - \geqslant \sum_i W_{ij}$$

$$(8)\quad SC_i \geqslant \sum_i SA_i$$

$$(9)\quad FC_i \geqslant \sum_i FA_i$$

$$(10)\quad GC_i \geqslant \sum_i AUM_i$$

$$(11)\quad \sum_i DM_i = \sum_i SM_i$$

where

A is the total cost of providing the required volumes of carcass beef in all regions.
K is the kind of production activity.
P is the kind of animal transferred.
T is the kind of grain transferred.
Z is the kind of new facilities acquired.
B_{Ki} is the cost of producing K in region i.
C_{Pij} is the cost of transporting animal p from i^{th} region to j^{th} destination.
I_i is the cost of slaughtering in region i.
C'_{ij} is the cost of transporting carcass meat from region i to region j.
C_{Tij} is the cost of transporting grain T from region i to region j.
N_{Zi} is the cost of acquiring facility Z in region i.
U'_j is the number of animals slaughtered in region i.
M_{ij} is the number of carcasses shipped from region i to region j.
G_{ij} is the amount of therms of grain T shipped from region i to region j.
Q_i is the quantity of new facilities built in region i.
St_i is the number of stockers used in region i.
F_i is the number of feeders used in region i.
Fa_i is the number of fat animals used in region i.
FG_i is the quantity of feed grains used in region i.
W_i is the quantity of wheat used in region i.
SC_i is the slaughter capacity of region i.
SA_i is the number of animals slaughtered in region i.
FC_i is the feeding capacity in region i.
FA_i is the number of animals fed in region i.
GC_i is the grazing capacity utilized in region i.
AUM's is the quantity of grazing utilized in region i.
DM_i is the demand for beef in region i.
SM_i is the supply for beef in region i.

Equation 1 is a total beef industry cost function which is to be minimized within the constraints of the model. Equations 2, 3, 4, 5, and 6 are the quantities of factors used in any region and are equal to or less than the resource availability within that region, plus any inshipments and less any outshipments. Equation 7 limits the feeding of wheat to one-half the total energy of the ration fed in any region. The capacity restraints are shown in equations 8, 9, and 10. Equation 11 requires that the supply of beef in each region be equal to the final consumption.

The assumptions of the model were:

(1) Production and Consumption occur at particular points in each region.
(2) Quantities of resources available in each region and the quantity of beef demanded in each region are preassigned.
(3) Only that quantity of beef required for meeting total consumption needs is moved through the system.
(4) Resources available in any region can be used in any other region (except in the case of native and improved pasture). That is, resource homogeneity is assumed.
(5) Feed grains and wheat are measured in therms, and a therm of any grain is perfectly substitutable for a therm of any other grain.

Variations of the Model

The analysis of the optimal locations of beef enterprises from a complete systems approach is based on the model described above. Variations in the constraints imposed upon the model account for the variance in the two analyses reported in this study. These models may be described briefly as follows:

First Analysis: The supply of intermediate products of feed grain and wheat are given at average 1968-1970 levels. Constraints on the numbers of beef cows and grazing capacity which various regions face at the present (1970) time are used. Feeding efficiency for each region is assumed to be the same—i.e., feed required is the same per animal in all regions. Transfer functions are specified for the intermediate products and for dressed meat, using the least cost mode or combination of modes of truck, rail, or barge movement. Costs of the various activities differ among regions due to the differences in cash costs of operation. Prices of concentrates differ among regions depending upon the feed grain and wheat prices received by farmers. Each region must purchase all feeding and slaughter facilities as they are used. The demand for beef relates the quantity of fed beef demanded to price and income differentials among regions.

Second Analysis: Different from first analysis in that slaughter and feeding constraints were imposed at the levels of slaughter and feeding facilities available in 1970. Each region had the opportunity to purchase and operate additional slaughter and/or feeding facilities as needed.

Appendix B: Matrix Format of the Model for Two Regions.

Column		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
				T	T	T	T				T	T	T	T		T	T	T	T								T	T	T									
				S	S	S	S	S			T	T	T	T		F	F	F	F	K	K	T	T	T	T	F	F	F	F	T	T	T	T				
		C	C	T	T	T	T	S	S		F	F	F	F		C	C	C	C	I	I	M	M	M	M	G	G	G	G	W	W	W	W	A	A	F	F	H
		C	C	,	,	,	,	G	G	,	,	,	,	,	F	F	,	,	,	,	L	L	,	,	,	,	,	,	,	,	,	,	,	,	S	S	C	C	S
	Rows	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1
1	Cost	N	C	B	A	B	B	A	B	B	A	B	B	A	C	C	B	B	B	B	B	B	A	B	B	A	B	B	B	B	B	B	B	B	A	A	B	B
2	COW1	L	A																																			F
3	COW2	L		A																																		F
4	SSTOCK1	E	-1		1	1																																
5	SSTOCK2	E		-1			1	1																														
6	STCCKR1	E			-1		-1		1																													
7	STCCKR2	E				-1		-1		1																												
8	SFDER1	L					-1		1	1																												
9	SFDER2	L						-1			1	1																										
10	FDERR1	E							-1		-1		1																									
11	FDERR2	E								-1		-1		1																								
12	FLOTC1	L											1																							-1		G
13	FLOTC2	L												1																							-1	G
14	SFATC1	L											-1		1	1																						
15	SFATC2	L												-1			1	1																				
16	RFATC1	E													-1	-1		1																				
17	RFATC2	E														-1	-1		1																			
18	KILLC1	L																1																-1				G
19	KILLC2	L																	1															-1				G
20	SPEAT1	E																-T		1	1																
21	SMEAT2	E																	-T			1	1														
22	DMEAT1	G																		1		1																G
23	DMEAT2	G																			1		1															G
24	STOKC1	L	B					A																														G
25	STOKC2	L		B					A																													G
26	SFGRA1	L																								1	1											G
27	SFGRA2	L																										1	1									
28	RFGRA1	N																								1		1										
29	RFGRA2	N																									1		1									
30	SWHT1	L																												1	1							G
31	SWHT2	L																														1	1					
32	RWHT1	N																												1		1						
33	RWHT2	N																													1		1					
34	ENGT1	E						B		A		A		C												-1		-1		-1								
35	ENGT2	E							C		A		A		C												-1		-1		-1							
36	WHTC1	L																								-1		-1		1		1						
37	WHTC2	L																									-1		-1		1		1					
38	NKILL1	L																																1				F
39	NKILL2	L																																	1			F
40	NLOT1	L																																		1		F
41	NLOT2	L																																			1	F

Figure 14. Matrix Format of the Production-Transhipment Model

Where		
Columns		
CC	is	Calf Production
TST	is	Transfer Stockers
SG	is	Stocker Growth
TF	is	Transfer Feeders
F	is	Feeding Activity
TFC	is	Transfer Fat Cattle
KILL	is	Slaughter Activity
TM	is	Transfer Meat
TFG	is	Transfer Feed Grain
TFW	is	Transfer Wheat
AS	is	Acquire New Slaughter
AFC	is	Acquire New Feeding Facilities
Rows		
COW	is	Cow Constraint
SSTOCK	is	Supply of Stocker
STOCKER	is	Stockers Received
SFDER	is	Supply of Feeders
FDERR	is	Feeders Received
FLOTC	is	Feedlot Capacity
SFATC	is	Supply of Fat Cattle
RFATC	is	Receive Fat Cattle
KILLC	is	Slaughter Capacity
SMEAT	is	Supply of Meat
DMEAT	is	Demand of Meat
STOCK	is	Grass Capacity
SFGRA	is	Supply of Feed Grains
RFGRA	is	Receive Feed Grains
SWHT	is	Supply of Wheat
RWHT	is	Receive Wheat
ENGT	is	Energy Transfer
WHTC	is	Wheat Control
WKILL	is	New Slaughter Facilities
NLOT	is	New Feeding Facilities

Information Provided by the Model

(1) Optimum locations of cow herds, stocker operations, feeding, and slaughter, and the optimum combinations of feed grains and wheat used in fattening rations in the various regions.
(2) Optimum shipment patterns for stockers, feeders, fat cattle, and feed grains.
(3) Optimum shipment patterns for carcass beef.
(4) Costs associated with introducing "sub-optimal" activities.

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