ECONOMIC INTERACTION BETWEEN WHEAT AND BEEF IN THE SOUTHERN GREAT PLAINS

By

RICHARD LYNN HARWELL

Bachelor of Business Administration
University of Texas-Austin
Austin, Texas
1951

Master of Science
Texas A & M University
College Station, Texas
1970

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
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Thesis Approved:

Thesis Adviser

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Goals of U. S. Agricultural policy have been directed toward satisfying different sectors of society. Producers are interested in bolstering and stabilizing their income, consumers want food expenditures kept low and taxpayers prefer an inexpensive farm program. Other special interest groups also have preferences. These goals are in conflict; this has augmented the elusive character of economic equilibrium in agricultural product markets (74). Commodity imbalances distort orderly production and marketing processes, not only for crops (notably cotton, feed grains, and wheat), but also for livestock (beef, dairy, and hogs), and closely parallel substantial year-to-year variation in price.

Producer response to production incentives has tended to outstrip domestic demand, a disparity magnified by continued technological improvement. Further, the needs of foreign customers tend to be difficult to predict, modified as they are by crop conditions as well as political and monetary considerations.

From the close of World War II until the early 1970's, farm policy has generally been directed toward restricting supply and at supporting prices at levels higher than would clear the market. Recent important shifts in both domestic and foreign demand and variable weather factors have deflated our stocks, thus creating a need for a re-examination of our productive capacity as well as our adjustment capability. Of particular concern are the beef and wheat subsectors.

Most agricultural producers in the United States are involved in producing more than a single farm commodity; such products are then competing with each other for resources and, as such, are part of an interdependent system. There are complementary or supplemental aspects to this basically competitive relationship. At certain times during the growing period, grazing has little or no effect on grain yields. Under certain circumstances, yields may be benefited. Improved analyses of supply-demand factors for many single commodities depend on a better understanding of how such products relate to others against which they must compete for the factors of production.

The nature of product competition can best be visualized at the firm level. However, the implications for economic equlibrium and, consequently, for policy considerations must be viewed in an aggregate framework. In-depth aggregate studies of specifically related commodities and how they interact over time in response to external stimuli are lacking.

Beef and wheat dominate farm production activity in a substantial portion of the Southern Great Plains. In a typical year, stocker cattle are placed on the region's wheat fields, where they spend some portion of the October to March grazing season before being moved onto feedlots. On occasion, rather than being harvested conventionally, wheat is entirely consumed by cattle in grazing activity that extends on into April and May. Small grain forage also supports a number of brood cows and replacement heifers.

The interrelated nature of wheat-beef production makes producers of either commodity sensitive to factors affecting both. For joint producers, there is the opportunity for some product substitution when price ratios are favorable.

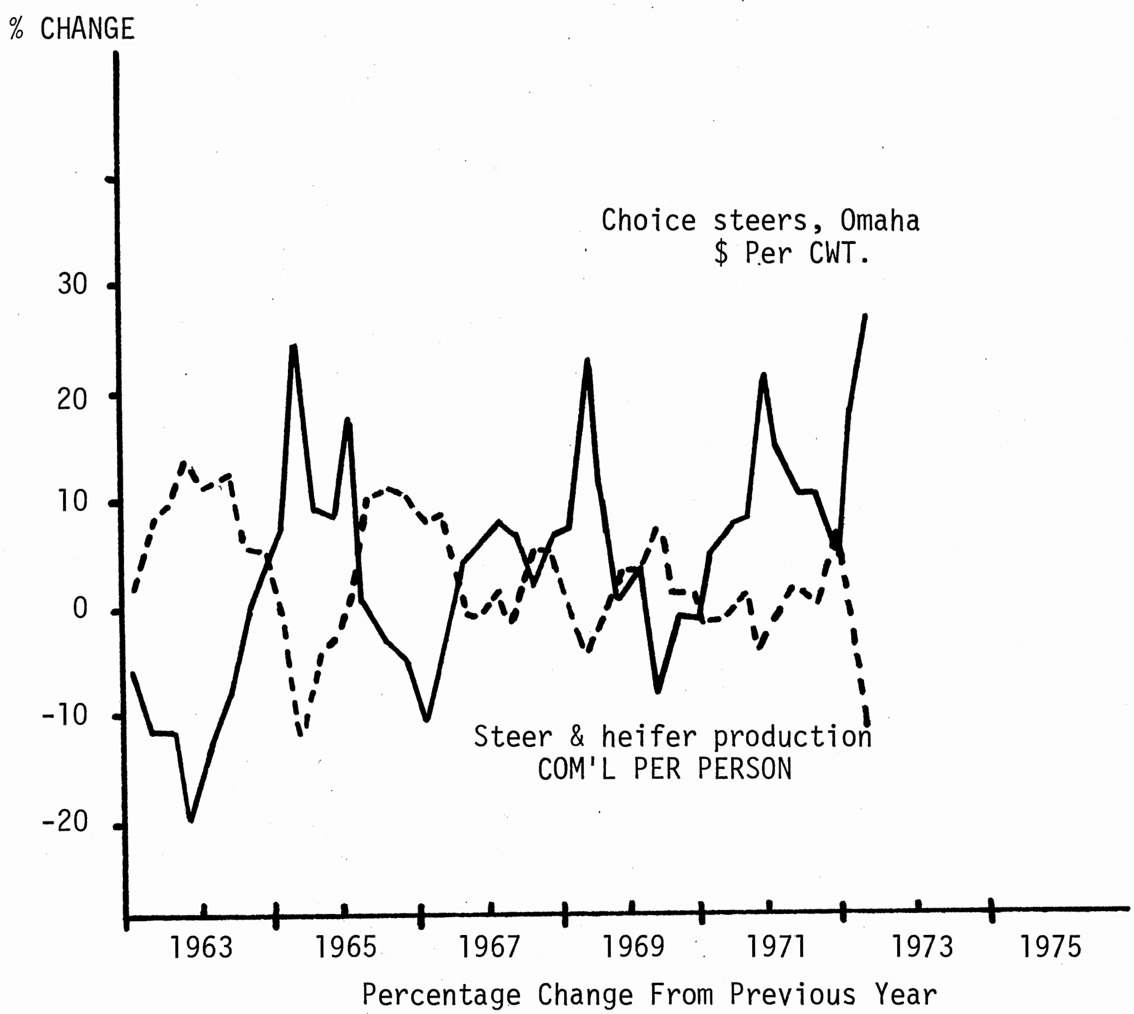
The Problem of Wheat-Beef Relations

Generally improving domestic demand for beef, coupled with highly spasmodic foreign demand for wheat, has placed stresses on producers of farm products in the Southern Great Plains. Resulting production patterns and policy regulations have not been sufficiently sensitive to changing needs; the consequence has been an unstable price pattern.

Domestic demand for beef has increased steadily for over two decades. Per capita consumption has risen from less than 65 pounds in 1950 to about 115 pounds in 1974 (101). During 1972, over one million feeder cattle were imported from Mexico and Canada; and import quotas on processed beef were dropped for the first time since their inception in 1964. Prices on all classes of cattle were higher than a year earlier, despite a two percent increase in beef output (101). Such an atmosphere encouraged continued expansion of beef supplies.

Production of cattle and calves was at a record high in 1973. Calf prices averaged $56.60 per 100 pounds liveweight, compared with $44.70 in 1972. Another production record was set in 1974, but prices fell 20 percent. The price declines were augmented by the sale of cows and forage-fed cattle, since herd liquidation had begun, and feed grain prices discouraged fattening in feedlots (101). Figure 1 illustrates the effect of beef supplies on prices paid since 1963.

Changes in wheat relationships have been no less dramatic. World grain supplies have been influenced strongly by the Soviet Union's massive grain purchases during 1973. U. S. wheat supplies fell to the



Source: Meat Animals (101)

Figure 1. Choice Steer Prices, Omaha, and Per Capita Commercial Steer and Heifer Production, 1963-73

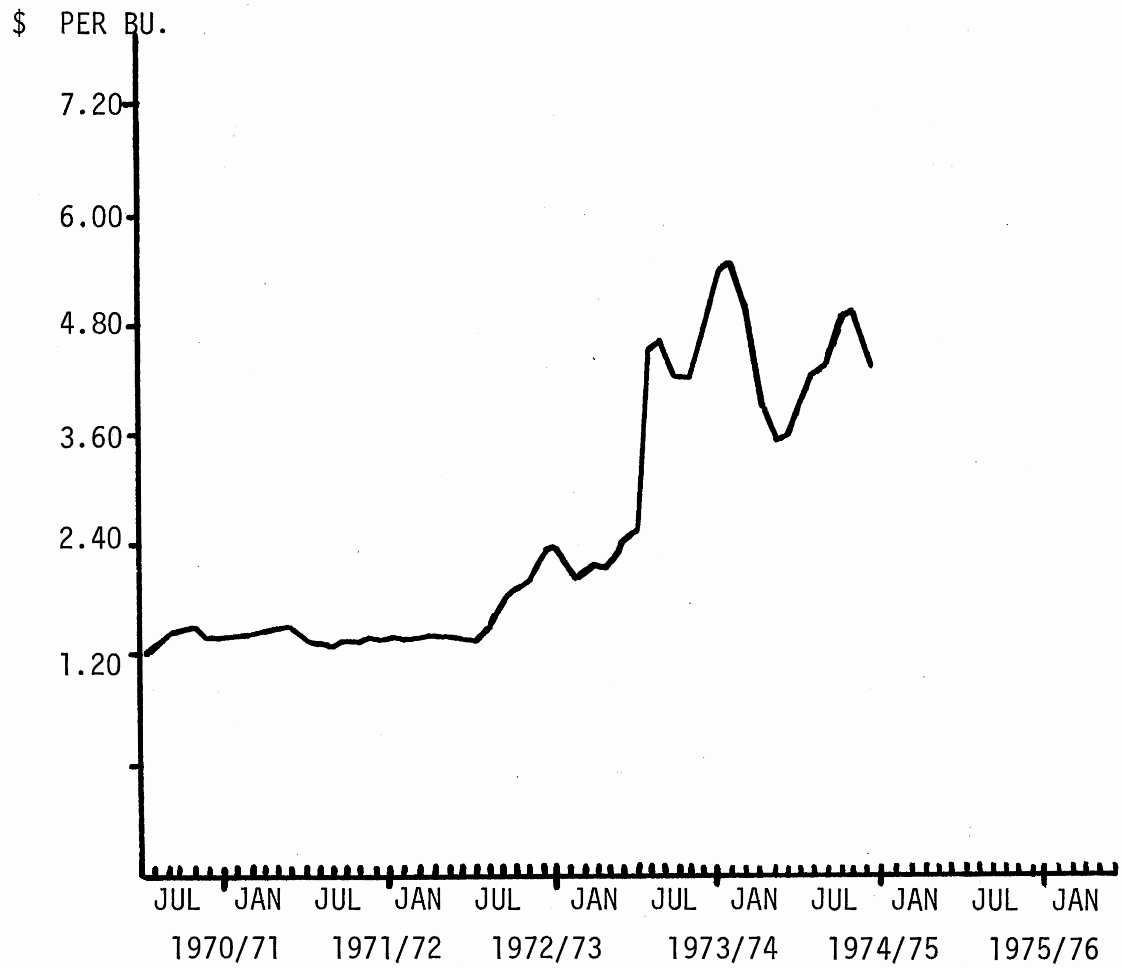
lowest point since 1962, while grain exports set new records. Production in both 1973 and 1974, though well above national norms, was insufficient in increase carryovers. This was in spite of acreage control removals and price increases of 200 percent and more (98). Recent price levels are pictured in Figure 2.

Since beef cattle production is dependent on wheat forage in the Southern Great Plains, agricultural planners and policy makers require macro tools and information which will allow an improved view of the interlocking nature of the two commodities. Needed primary knowledge covers the quantity and quality of wheat grazing, the classes of cattle which utilize it, how frequently it is available, and how frequently changes in usage are occurring. Also, impediments to grazing and the extent to which they will respond to economic and institutional stimuli should be examined.

Investigation of more technical economic relationships awaits development of the primary information. The effects of drought in wheat pasture regions on winter forage production, stocker cattle flows, and feedlot placements is subject to considerable speculation. Knowledge of price dependencies between wheat pasture and beef cattle are needed. In addition, the U. S. contribution to world food supplies is assuming increased importance. Improved projections of forage, beef cattle, and wheat production is becoming a necessity.

A Working Hypothesis

An investigation designed to expose macro economic relationships that exist between wheat and beef cattle production can (1) yield a better understanding of these phenomena and (2) aid in the development



Source: Agricultural Prices (97)

Figure 2. Wheat Prices Received by Farmers

of a tool of analysis designed to provide estimates of regional crop and beef cattle production over time, in accordance with price, policy, and weather signals.

Objectives

The specific objectives of this study are:

(1) To characterize the winter wheat grazing area within the Southern Great Plains and describe parameters pertinent to the interlocking nature of wheat and beef cattle production.

(2) To construct an analytical model designed to predict aggregate crop and beef cattle production over time, in response to induced price, weather, and policy variables.

(3) To utilize the model in the analysis to temporal interaction between wheat and beef cattle in the Southern Great Plains, in response to selected external price, weather, and policy stimuli.

Aggregate Wheat Grazing Activity

To initiate the study, a general overview of Southern Plains winter grazing activity was developed. More than 100 extension specialists in Colorado, Kansas, Oklahoma, and Texas cooperated in providing much of the needed information. Their responses to mail questionnaires[1] was displayed in the form of iso-activity lines on maps of the region. In a variation of the Delphi technique (11), these maps were then submitted to the respondents with the request that they adjust the contour lines

[1]A copy of the mail questionnaire is presented in Appendix E.

where they felt it was justified.

Availability

Spasmodic weather patterns in the Great Plains alter the quantity and quality of winter pasture. Irrigation offsets some of the effect of drought but does little to combat excessive cold or heavy snow cover. Still, available moisture does increase as one moves eastward; and warmer temperatures are a function of both lower latitude and lower elevation. On the other hand, excessive moisture can be detrimental to pasture usage, causing trampled fields and poor weight gains.

Figure 3 shows the frequency of occurrence of winter wheat pasture, expressed as the number of years in five in which wheat grazing will constitute a substantial proportion of available winter forage. The illustration emphasizes that pasture frequency declines rapidly as one moves away from the central area, suggesting that a rather unique combination of soil and climate are required for the consistent production of usable green pastures during the winter months.

Most beef cows in the Southern Great Plains are bred so that their offspring can be made available for sale as weaners calves during the fall months. When wheat pasture is available, it serves as an efficient allocation system, allowing lumpy receipts of weaner calves to be systematically fed into feedlots of the Southern Great Plains during the fall and winter months. January 1 inventory numbers confirm that a higher proportion of lighter-weight animals are maintained in wheat pasture states at midwinter.

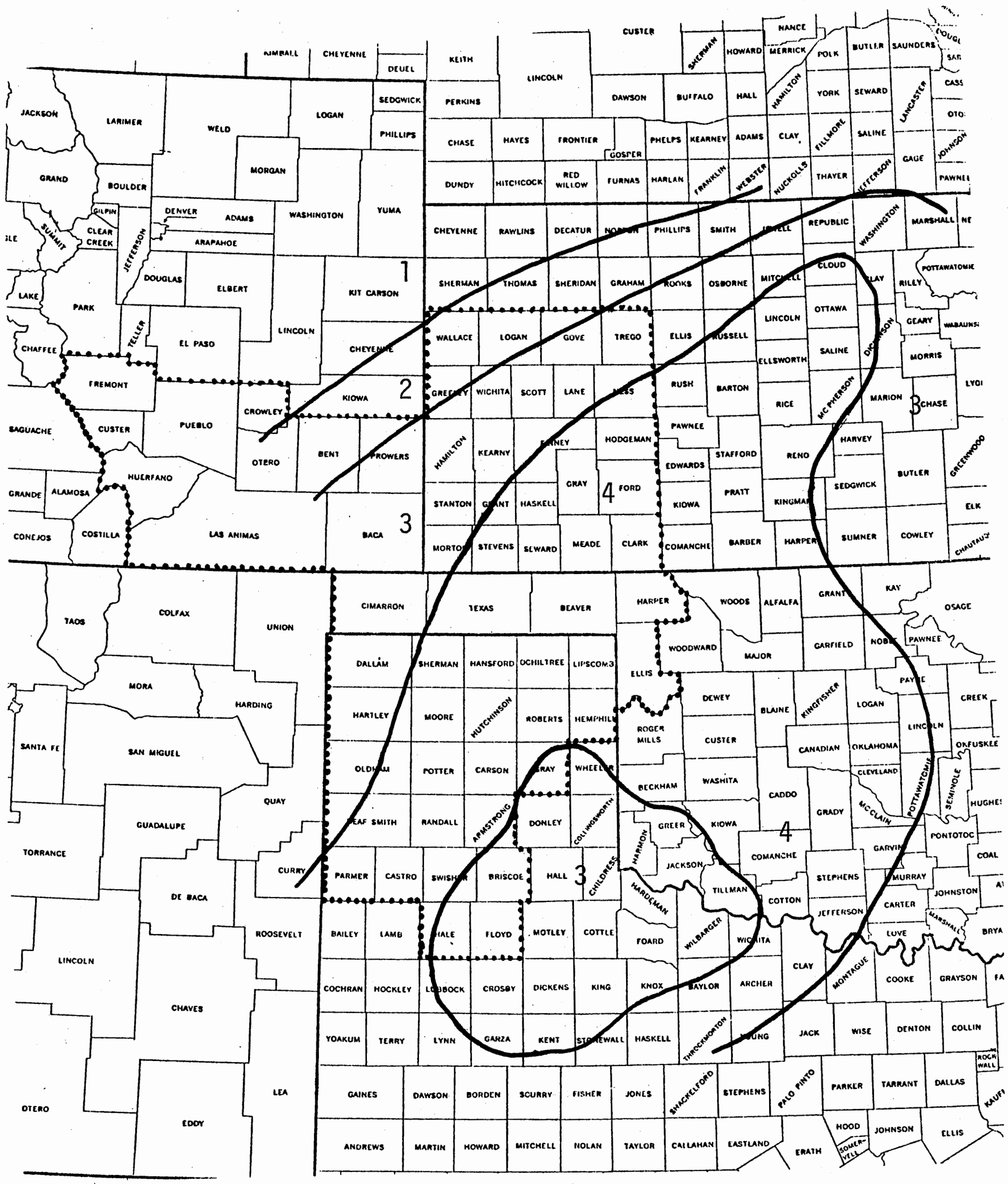


Figure 3. Number of Years in Five When Winter Wheat Pasture is Sufficient for Grazing

Utilization

Much of the pasturable wheat is not used. Some of the reasons cited for such action may not be economic. In localities where wheat pasturing is not common, queries will receive replies such as, "This isn't cattle country," or "I'm a grain farmer, not a livestock farmer."

Figure 4 portrays utilization patterns and gives visual suggestion to some of the reasoning behind them. Very high usage patterns in Texas prevail where grain yields are lower and less dependable. Such high-risk areas appear to be consistent with stocker cattle ventures, which serve as effective risk transfer implements. Original settlement patterns may also exert an influence. Farm size (and field size) is considerably larger in Texas than in Oklahoma,[2] which may affect the fixed investment per grazing animal.

Higher yielding wheat areas in Kansas and Oklahoma have largely resisted pasturing activities. This may be caused by a lack of economic incentive to strive for maximum profits. Also, these farm operators are farther from, and less influenced by, large cattle ranching operations.

Type of Use

Beef calves are normally weaned at 400-500 pounds but do not enter the feedlot until they are heavier. This growing phase in the beef production chain is well served by nutritious, succulent wheat plants in a season when most forage plants are well past maturity. This

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[2]Texas was not subject to the 160 acre land settlement pattern which prevailed in adjacent states (39).

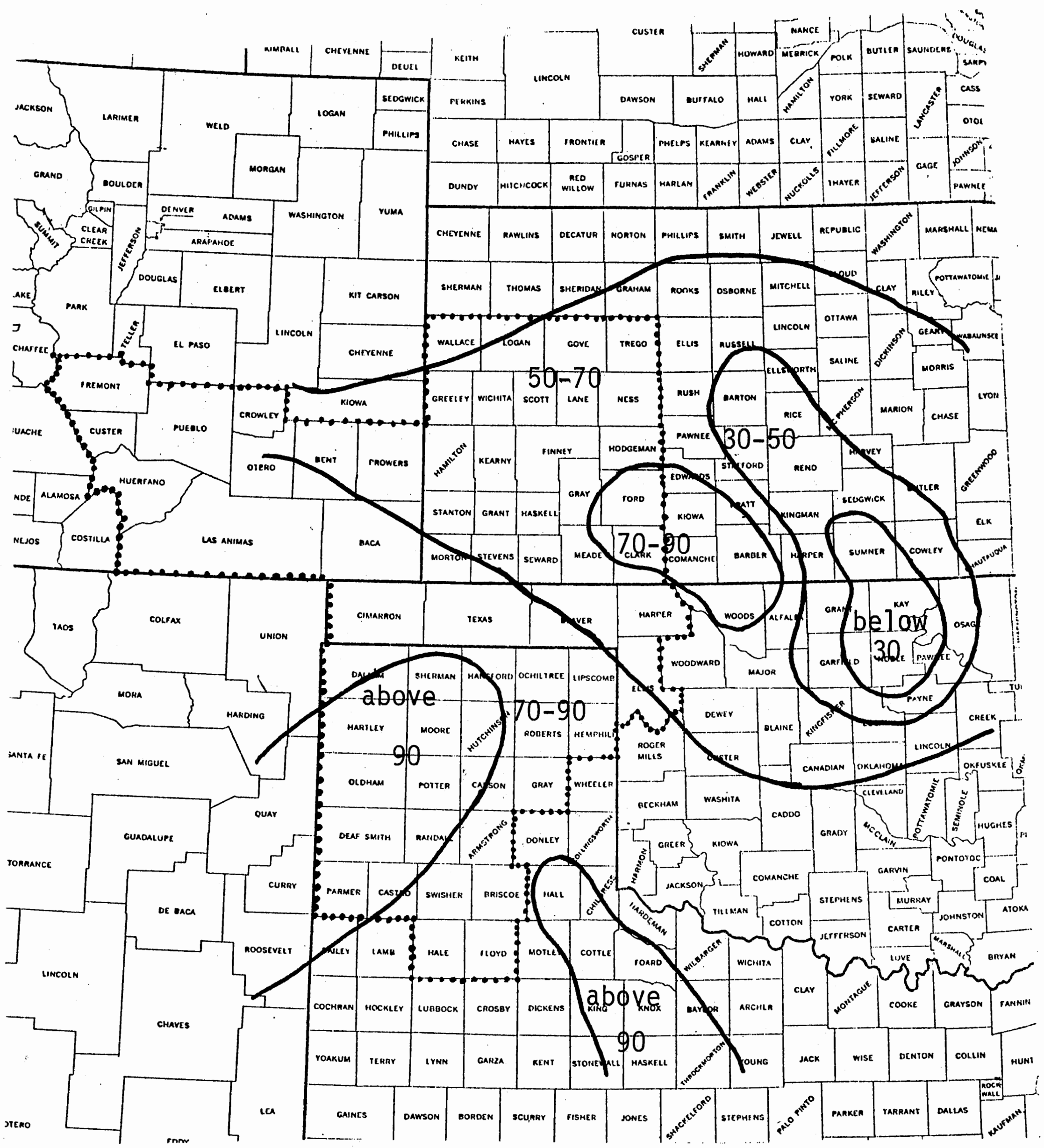

Figure 4. Percent of Available Winter Wheat Pasture Which is Utilized When Available

accounts for the prevalence of stocker cattle operations in the study area.

Stocker cattle endeavors are typified by large investment, quick turn-over, and great mobility. Factors which contribute to a successful stocker cattle industry include reliability of pasture, nearness to marketing facilities, open winters, large wheat fields, and an abundance of farm operators who are willing to graze their wheat. Skillful buying and selling are also important.

Cow-calf operators also graze wheat but utilize it more as a salvage operation. This more frequently occurs in regions where availability of wheat pasture is less dependable; where livestock facilities such as fences, corrals, and water troughs already exist; and where livestock are present to utilize whatever feed and forage may be available. However, since wheat pasture is an excellent fattening ration and the beef herd can be maintained on less nutritious forage, there may be opportunity cost associated with its use for maintenance rather than for fattening.

Figure 5 pictures percentage of wheat pasture usage by stocker cattle. It is apparent that stocker operations correlate rather closely with the wheat pasture frequencies shown in Figure 4.

Hindrances to Change

In an effort to learn why available wheat pasture is not being utilized, extension specialists in the field were asked to choose a number of possibilities and also to make additional suggestions of their own. The principal hindrances to grazing were:

(1) Large financial requirements associated with a cattle program.

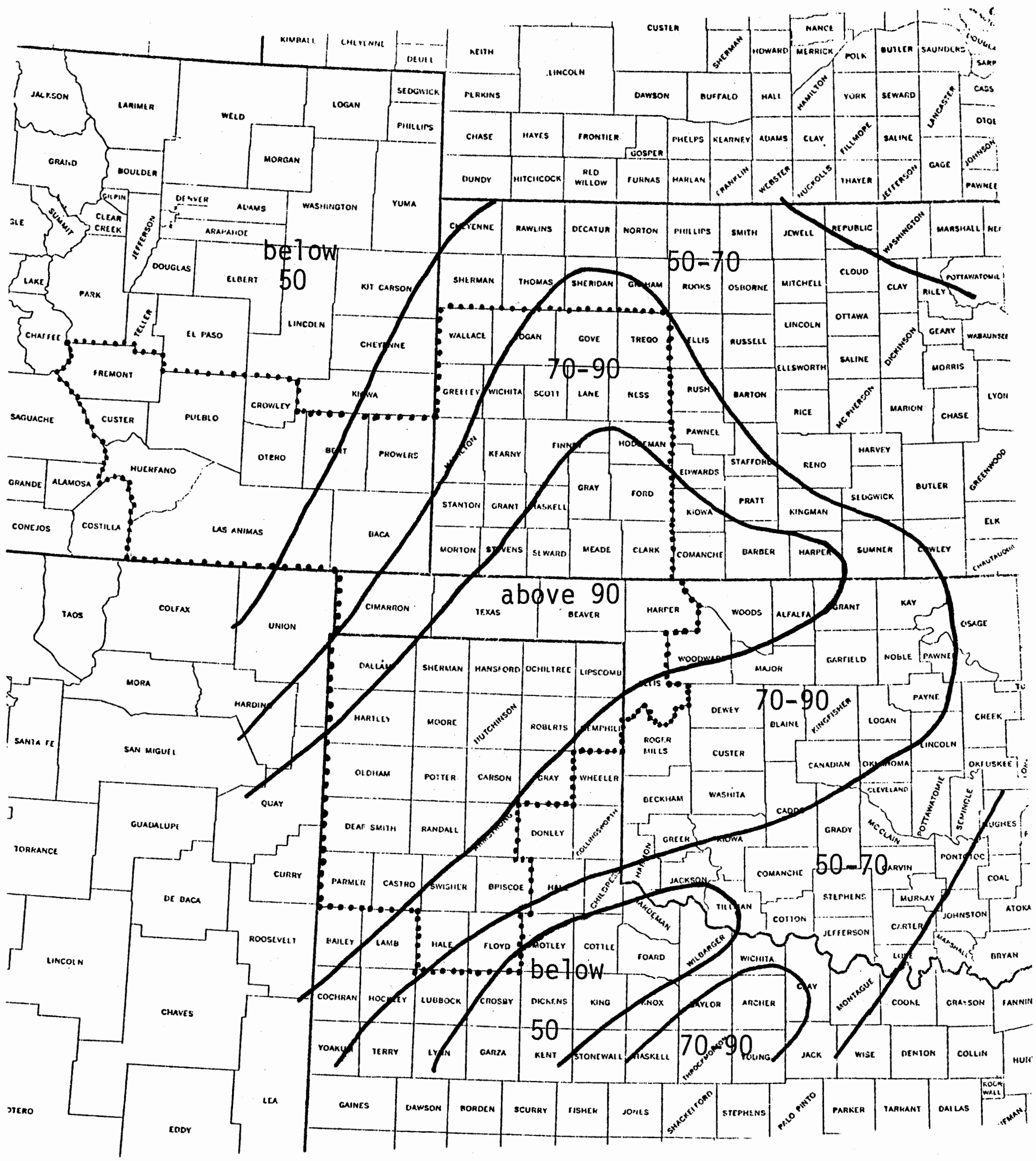

Figure 5. Percent of Winter Wheat Pasture Utilization by Stocker Cattle Operations

(2) Inadequate watering facilities, fencing and corrals.

(3) The lack of year-round pasture.

(4) Lack of knowledge or experience.

(5) Fear of reduced grain yeilds.

(6) Logistical reasons: small tract size, etc.

Related Investigations

The importance of winter wheat as a source of forage initially concerned agronomists and animal scientists. As early as 1926, researchers at Hays, Kansas were investigating "the effect of wheat pasturing on (1) grain yield and (2) the amount of pasture furnished." The experimentation, which involved grazing with horses, concluded that "the period of most severe damage was after April 1" (84).

Swanson, in 1935, introduced economic considerations by reporting on methods "to utilize the crop as a green pasture with the least reduction in the yield of grain" (84). Staten and Heller, in a study of the nutritional importance of winter pasture crops in 1949, found them "even more valuable to Oklahoma than has been suspected" (82). Two years later Swanson and Anderson noted that, under certain conditions, grazing actually increases grain yields (85). Later, Anderson generally examined winter grazing practices in Kansas and concluded "... wheat can be grazed profitably --- with proper grazing management."

Inquiry into the physical characteristics of wheat forage continues. In Texas, Pope has measured grazing response to fertilizer application (72), while Shipley and Regier have investigated the supplemental effect of crop residues on wheat pastures (78).

Extensive investigation into the economic principles of forage utilization was conducted by Heady and Olsen in 1952 (49). Their work covered substitution relationships, resource requirements, and income variability.

Estimates of the value of wheat grazing have been included in farm budgets for many years; among them are work by Moore and others in Texas in 1962 (66) and also by Green and his co-workers in Oklahoma research in 1967 (42).

Micro-economic inquiries into the relative profitability of wheat usage for forage are common; many have concerned themselves with the place of winter pasture in an optimum enterprise mix (106). One of the earlier studies came in Oklahoma in 1959 when Walker and Plaxico related weather to forage yields of winter wheat and began to develop criteria for pasture use efficiency (102). White, Plaxico, and LaGrone investigated maximum profit farm plans in northwest Oklahoma for profit variability and found that those enterprise combinations with the greatest profit included heavy wheat grazing activities; these same combinations also showed the greatest variability (105). Harwell, in work at Texas, determined the desirability of "graze-out" alternatives to be dependent on the tenure arrangement (47). Lacewell and his associates learned that a decision-makers choice of farm program alternatives is affected by the nature of stocker cattle ownership in the wheat grazing program (105).

Micro-economic relationships in the grazing of irrigated wheat in the Texas High Plains have been developed in a continuing study by Shipley and his associates. They found that wheat planted early for maximum forage growth had a positive grain yeild response from grazing. The grain yeild, however, was less than for wheat planted later in the season (79). Farmed forages complement native range; McIlvain and Shoop have worked out the relative profitability of selected complimentary forage systems (65).

Little is known about wheat grazing activity in the aggregate. The usual macro investigation largely ignores the wheat-beef relationship, both when assessing feeder cattle supply phenomena and in looking at production characteristics in the Great Plains (6, 9). Whitson, et al., stressed the need for improved firm level estimates in order to better predict aggregate adjustments in both planted acreage and pasture usage of wheat (106). Beef production from set-aside cropland in the U. S. was studied by Gilliam and other USDA researchers; they concluded that cropland temporarily diverted from major crop production was already in use producing beef in the Southern Plains, since hay and temporary pasture could be legitimately produced on such land (37). In a study of integrated weaning-to-slaughter beef cattle systems in Texas, Williams and Farris determined that, when available, wheat pasture for backgrounding returned as much as $13 per head above native grass for some systems (107).

Some studies have aggregated normative microsupply relationships for both crops and livestock as determined by linear programming solutions. Goodwin and others have done this in Oklahoma, while noting the difficulties that stem from such aggregative procedures (41). Nauheim and Ericksen have done a similar study in Kansas in 1974, where wheat pasturing activities figure more prominently in the optimum solutions (67).

Study Area

The heartland of small-grain winter pasture activity covers substantial portions of Colorado, Kansas, Oklahoma, and Texas. The study area is defined by counties in which (1) the 1972 wheat allotment[3] exceeded 10 percent of the cultivated cropland; (2) winter small-grain grazing is common and acceptable on more than 70 percent of seeded cropland, as shown in Figure 4; and (3) stocker cattle utilize more than 90 percent of small-grain forage that is grazed, as shown in Figure 5. This region has been modified to conform with boundaries of crop reporting districts of the Statistical Reporting Service of the United States Department of Agriculture.

The selected area encompasses 30,260 farms in Colorado, Kansas, Oklahoma, and Texas (94), and is presented in Figure 6. Historically, wheat for harvest in the area has exceeded 7.5 million acres, about 13 percent of which has been irrigated. The region also harvests over 3.5 million acres of feed grains, and another 1.5 million acres of cropland pasture, hay, and other miscellaneous warm season crops (100). Irrigation water is applied to more than 65 percent of the summer crops (102).

On an average January 1, some 800,000 stocker[4] cattle will be located on farms and ranches in the area. However, less than one million brood cows are normally found there. Moreover, 65 percent of

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[3]This value is used as a proxy for historical wheat acreage.

[4]Defined as total steers and heifers over 500 pounds and total steers, heifers, and bulls under 500 pounds; excluding cattle on feed and replacement heifers. Most of these animals will later enter feedlots.

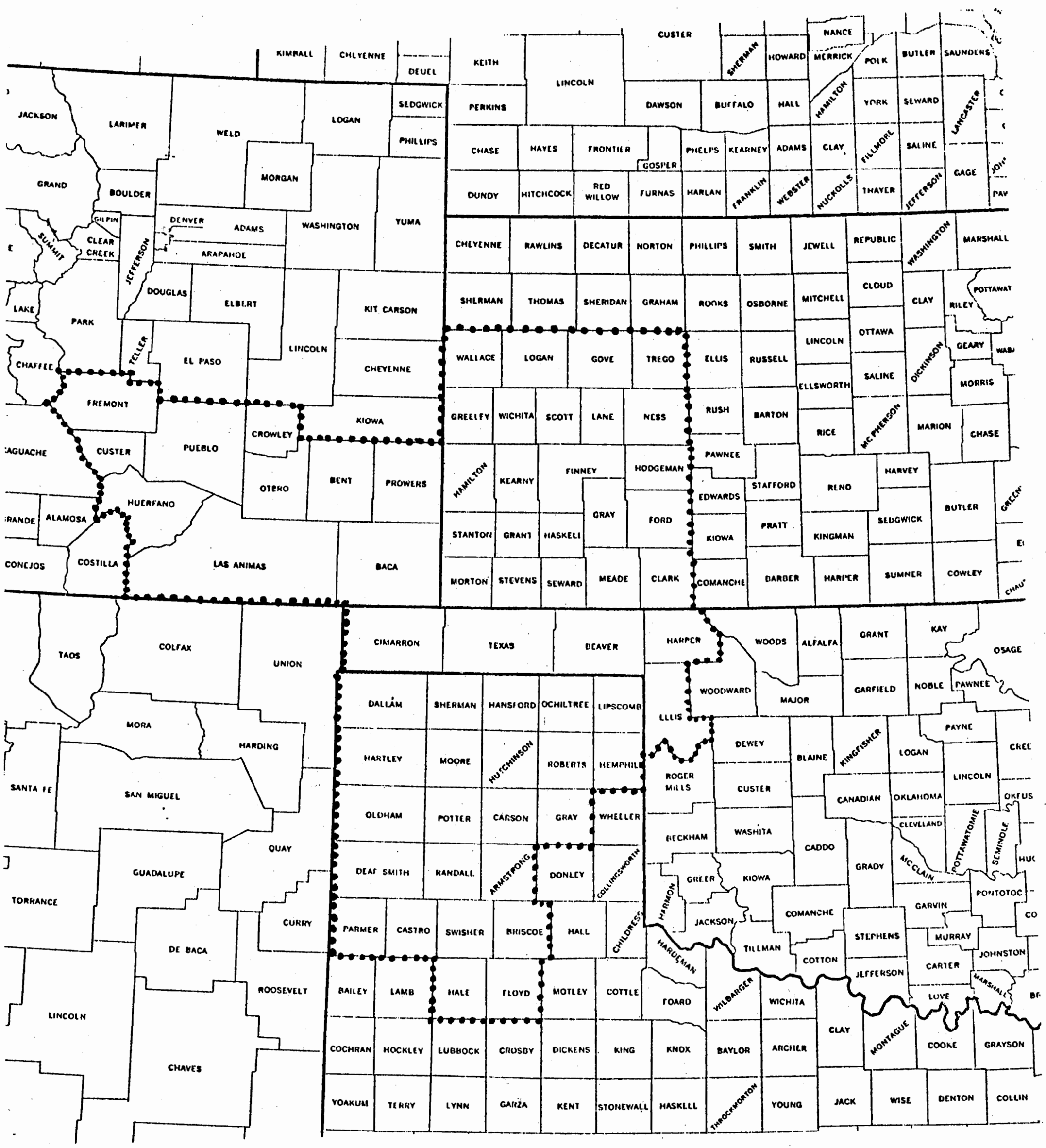

Figure 6. Wheat-Beef Study Area

the animals will weigh less than 500 pounds (96, 101). Since many of the calves born to these cows during the preceding year either have been exported or exceed 500 pounds, it is clear that large numbers of lighter weight stocker cattle are not native to the region. Many of these cattle originate in the southeastern U. S., but reliable estimates of stocker cattle flows are not available at present.

Organization of the Study

The introductory chapter is followed by five others. Chapter II discusses the theoretical base for the study and relates the application of recursive mathematical programming to problems involving aggregate production response over time. A recounting of the data accumulation and the specifications of the analytical model is presented in Chapter III.

The analytical framework is applied to specific considerations in Chapters IV and V, with a discussion of the resulting estimations developed by the model. The study is concluded and summarized in Chapter VI. Implications are also noted for future research.

CHAPTER II

THEORETICAL CONSIDERATIONS

The theoretical structure serving as a guide to this analysis is that of short-run equilibrium for a multi-product industry in a perfectly competitive market. A recursive programming model is employed to work with the theory of the firm in maximizing profit in a succession of linked production periods, the premise being that decisions in agriculture are based on optimal farm plans and that each season these plans are made anew, based on current information and constraints. This section explores theory and method as they relate to this study.

The Concept of Supply

Firm theory is that part of economic value theory which is concerned with the supply of a product. In economics, the word "supply" always refers to a schedule which relates output to market price.

Supply of the Firm

Agriculture has been depicted as perhaps the best example we have of an industry which produces under purely competitive conditions. A number of assumptions are necessary to derive a supply relation for a firm producing under pure competition: (1) profit maximization is the goal of the firm, (2) each firm is too small to individually affect the market, (3) each decision maker posesses complete knowledge about costs and operation of his firm, (4) the firm produces a homogeneous product from homogeneous inputs and (5) other things remain unchanged; this includes prices of competing products, prices of inputs, technology and available resources (103).

Stated succinctly, the resources of a theoretical firm are employed at maximum efficiency if the following conditions are satisfied: (1) the marginal rate of transformation between any factor of production and the resultant product is equal to their inverse price ratio, (2) the marginal rate of substitution between any two factors of production is equal to their inverse price ratio and (3) the marginal rate of substitution between any two competing enterprises is equal to their inverse price ratio.

The first equilibrium condition may not be satisfied by the firm with limited capital, but it does establish the maximum to which resources and output should be extended. The second condition establishes the least cost combination of resources for any level of production while the third establishes the maximum value of production for a given level of resources. These conditions are treated with varying degrees of elaboration in most production economics text books (62, 31, 74, 103).

Production theory under such conditions teaches that a firm will produce in the short run so long as marginal revenues are sufficient to cover the variable costs of production. Graphically, this refers to that portion of the marginal cost curve which lies above the variable cost curve, as shown in Figure 7. All points lying on this segment of the curve relate output to price, which is the definition of supply (62).

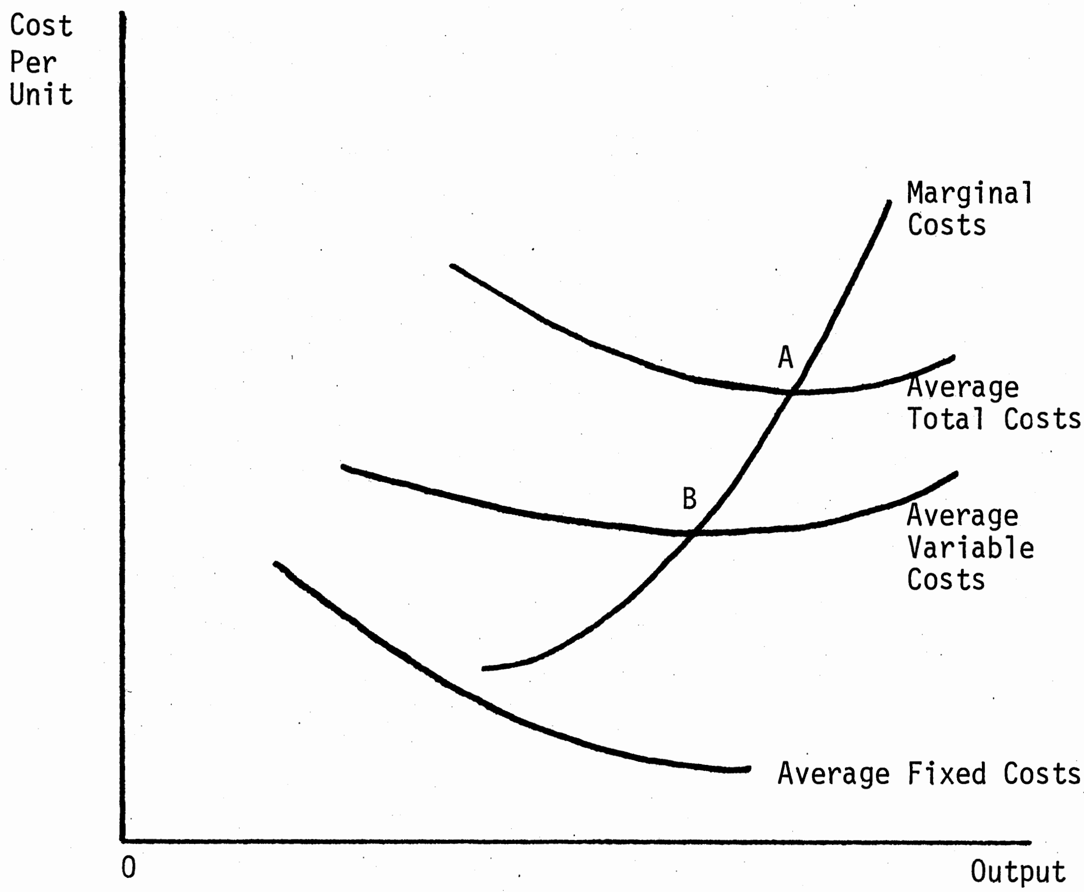

Figure 7. Short-Run Cost Curves for the Purely Competitive Firm

Industry Supply

The short run classical supply curve for the atomistic industry is obtained through summation of the quantities offered by each firm in the industry in response to alternative prices, with all other things being held equal. Both the large numbers of farms and the fact that rarely are all other things held equal render this an impractical way to obtain an industry supply curve for agriculture.

Traditional statistical analysis of historical production data for individual commodities has frequently been employed in making supply estimates (28). The models are constrained by the same assumptions noted above; and any departures, which are almost unavoidable, distort their validity. Furthermore, such studies are largely descriptions of the past and ignore changes in the basic supply structure of agriculture. Such forecasts lost their suitability for multiple-commodity production in a dynamic framework.

The Supply Relation

In an extension of conventional supply analysis, Cochrane has introduced the concept of a response relation in agriculture, wherein the concern is with changes in the amount of a commodity offered for sale in response to a change in its price, all other things not held constant (17).

The notion of a response relation is a much more useful concept in aggregate analysis, since it allows for the interaction that inevitably occurs as activities of individual firms manifest themselves. Competing crops and/or firms may indeed affect others. Increases in cattle prices may bid up pasture prices, at least in the short run. Such action could have an opposite effect over time, however, if increased prices encouraged more production of pasture. In short, the response relation captures external economies and diseconomies which arise as the result of individual actions by firms.

The effect of incorporating externalities into an industry supply curve is demonstrated in Figure 8. Lines DD and SS represent traditional demand and supply curves, while line S_r is analogous to the response relation suggested by Cochrane. Only in some narrow range of production would the traditional assumptions be approximately realistic, represented by output P. The increased inelasticity of the response curve S_r represents the interaction effects that occur.

Beattie and his associates have mathematically incorporated externalities produced in a multiproduct case into firm theory (7). They point out that complementary ranges between products rise from (1) the by-product of one production process serving as an input for another, (2) one process using some portion of inputs which are surplus to another or (3) interaction between processes is evident (e.g., legumes increase corn production). Pursuing the by-product case, they note that assumptions of both a fixed-factor resource base and a simultaneous production period may be violated in the conventional factor-factor treatment. More importantly, they recognize that the classical treatment obscures the interdependence between products. Incorporation of externalities between products is as follows:

The production functions for Y_1 and Y_2 are

(2.1) $Y_1 = f(X_{11}, X_{21}, \ldots, X_{n1})$

(2.2) $N_1 = f(Y_1)$

(2.3) $Y_2 = f(X_{12}, X_{22}, \ldots, X_{m2}, N)$

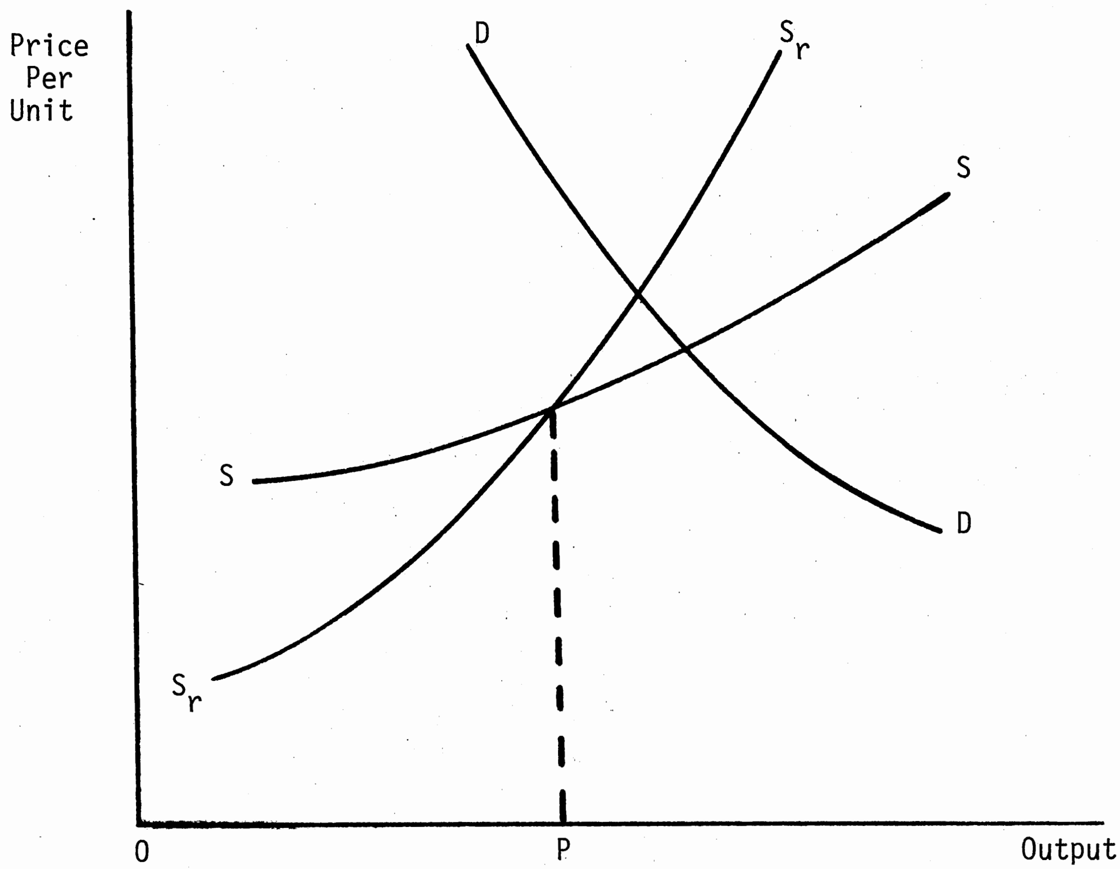

Figure 8. Hypothetical Aggregate Supply and Demand Curves

where the $X_{i1's}$ and $X_{i2's}$ are factors used in producing Y_1 and Y_2, respectively, and N_1 is a by-product of Y_1. In the general case, N can come from sources other than Y_1, as

$$(2.4) \quad n = N_1 + N_2$$

Where Y_1 and Y_2 are complementary then dN_1/dY_1 and $\partial Y_2/\partial N$ are of like sign. This would hold for interaction between legumes and corn, noted earlier. This means that the marginal value product of the $X_{i1's}$ in the production of Y_1 must reflect their value in the production of Y_2.

The profit equation for Y_1 is then

$$(2.5) \quad \Pi_1 = P_1Y_1 + SN_1 - \sum_{i=1}^{n} c_i X_{i1}$$

where P_1 is the price of Y_1, S is the shadow price of N_1 (the marginal value product of N_1 in the production of Y_2) and C_i is the cost of the ith input.

The profit equation for Y_2 is

$$(2.6) \quad \Pi_2 = P_2Y_2 - \sum_{i=1}^{m} c_iX_{i2} - SN_1 - \gamma N_i$$

with P_2 the price of Y_2, $c_{i's}$ the factor costs as before and S and γ representing the costs of the N's, from the production of Y_1 or some other source.

The multi product profit equation is

$$(2.7) \quad \Pi = P_1Y_1 + P_2Y_2 - \sum_{i=1}^{n} c_iX_{i1} - \sum_{i=1}^{m} c_iX_{i2} - \gamma N_i$$

since the value attributed to N_1 cancels out.

To obtain the first order conditions, substitution into the multi-product equation gives

$$(2.8)\quad \Pi = P_1 f(X_{11}, X_{21}, \ldots, X_{n1}) + P_2 f(X_{12}, X_{22}, \ldots, X_{m2}, N) - \sum_{i=1}^{u} c_i X_{i1} - \sum_{i=1}^{m} c_i X_{i2} - \gamma N + \gamma N_1$$

The first partial derivatives are then

$$(2.9)\quad \frac{\partial \Pi}{\partial X_{i1}} = P_1 \frac{\partial Y_1}{\partial X_{i1}} - c_i + \gamma \frac{dN_1}{dY_1} \frac{\partial Y_1}{\partial X_{i1}} \text{ for } i = 1, 1\ 1\ 1\ , n$$

$$(2.10)\quad \frac{\partial \Pi}{\partial X_{i2}} = P_2 \frac{\partial Y_2}{\partial X_{i2}} - c_i \text{ for } i = 1, \ldots, m$$

$$(2.11)\quad \frac{\partial \Pi}{\partial N} = P_2 \frac{\partial Y_2}{\partial N} - r$$

Optimal levels of Y_1 and Y_2 can then be determined by setting the partials equal to zero and solving the system of equations. The aggregate implications are given in the multi-product profit equation. Should the complementary effects of Y_1 in the production of Y_2 be between firms, then using policy as a "multiple firm" type of management, the production of Y_1 could be encouraged or penalized according to the interdependency indicated in equation (2.9).

Wheat, Beef, and Economic Theory

The usual illustrative technique applied to the "product-product" relationship in economics is the production possibilities curve. In Figure 9a this concept is applied to the production of both grain and grazing from a given tract of wheat land. The vertical axis measures wheat produced in bushels, while the horizontal axis marks the output of grazing in digestible nutrients. Line AB traces the various combinations of production that are possible from the given acre of land and other fixed resources.

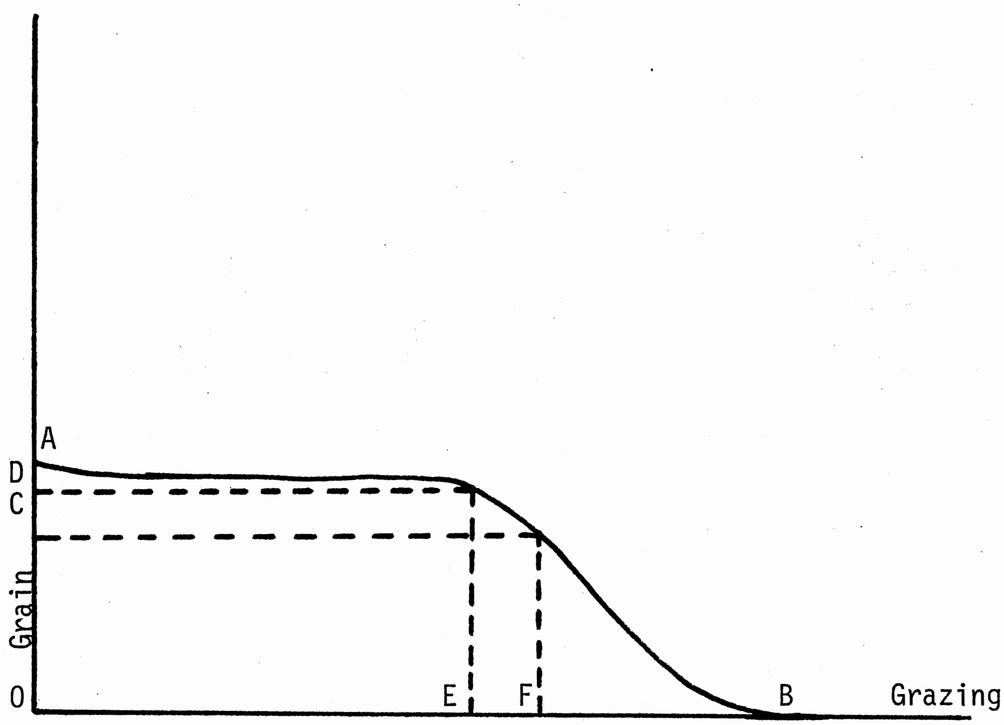

Figure 9a. Production Possibilities Between Grain and Grazing From One Unit of Wheat Land in One Cropping Season

The relationship illustrated in Figure 9a is subject to misinterpretation because wheat pasture is produced throughout the grazing season, while the grain crop is realized only when harvest time arrives. To illustrate, if the decision were made to pasture wheat until April 1, which can be represented by point F, it would be possible to produce OC bushels of grain and OF nutrients of grazing from that tract of land in that cropping season. It follows that if more than OC bushels of grain are desired, say OD, it would be necessary to terminate wheat pasture at an earlier date, which would reduce grazing output to OE.

It is apparent that, in the example, wheat and beef enjoy a supplementary relationship prior to some point in mid-March. If grazing activity persists into April, however, wheat and beef rapidly adopt a substitute relationship. The grazing of wheat into the "jointing" stage[1] severely curtails grain yields (102).

Figure 9b depicts a situation prevailing among Southern Great Plains producers who seed wheat in the early fall in anticipation of some grazing but who are more concerned with grain production. Not all wheat producers, however, think primarily in terms of grain, as is illustrated in Figure 9b. Such producers sow wheat earlier, perhaps in mid- to late August, in order to initiate pasturing activity sooner. The practice realizes more per-acre nutrient production prior to the onset of cold mid-winter weather, when wheat tends to go into a semi-dormant stage.

Figure 9b shows a complementary range between the two products when wheat is seeded early. Lush, ungrazed wheat excessively depletes

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[1]The stage of growth when the culm tips (developing heads of grain) rise in the stalk above the surface soil. Beyond this point, they may be clipped off by grazing (85).

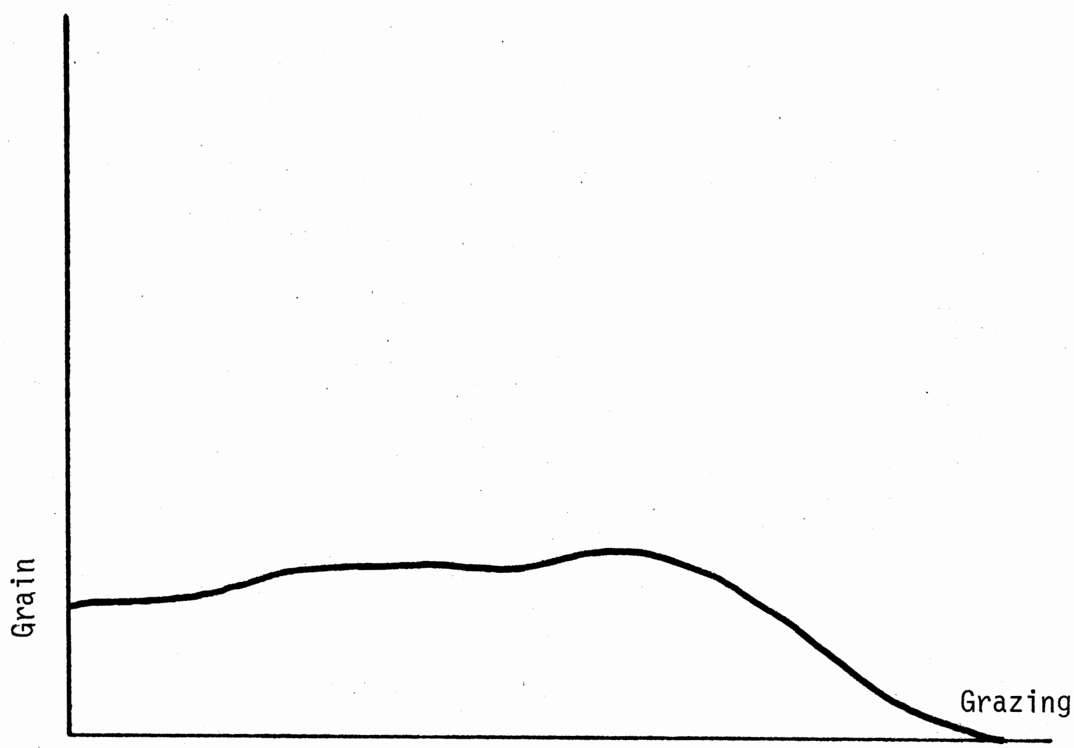


Figure 9b. Production Possibilities Between Grain and Grazing From Early Seeded Wheat Land

moisture during the fall months and is more susceptible to mid-winter freeze damage; both phenomena are detrimental to grain yields. The diagram also indicates that grain potentials are probably not so high in early seeded wheat but that grazing capability is benefited.

The Southern Great Plains is characterized by a higher skewed rainfall distribution. Dry weather prevails during more years than wet weather. During years of drought, prospects for a grain crop are markedly diminished; and it has become customary to "harvest the wheat with cattle" rather than risk a complete crop failure. Since there is little potential grain yeild to be affected, the pronounced substitute relationship between grain and grazing does not exist as portrayed above. Figure 9c indicates that not only is grain potential much less because of drought; grazing output is also curtailed.

How does a producer determine where the most optimal trade-off between grain and grazing lies? The product-product model of firm theory deals with a fixed outlay of costs; i.e., the product transformation curve depicts combinations of product (grain and forage) that can be produced at a given cost outlay. The goal is to maximize revenue to the given costs.

Figure 10 pictures both costs and returns graphically. Line AD is the product transformation curve, which represents physical trade-offs that can occur between wheat and beef cattle from a given wheat field. Expressed in terms of costs, line AD represents all the combinations of grain and grazing that can be produced at a given cost outlay, since the resources contributing to production are held constant.

Revenue lines PP and P'P' in Figure 10 are lines whose slopes are determined by ratio of product prices; although their slopes are

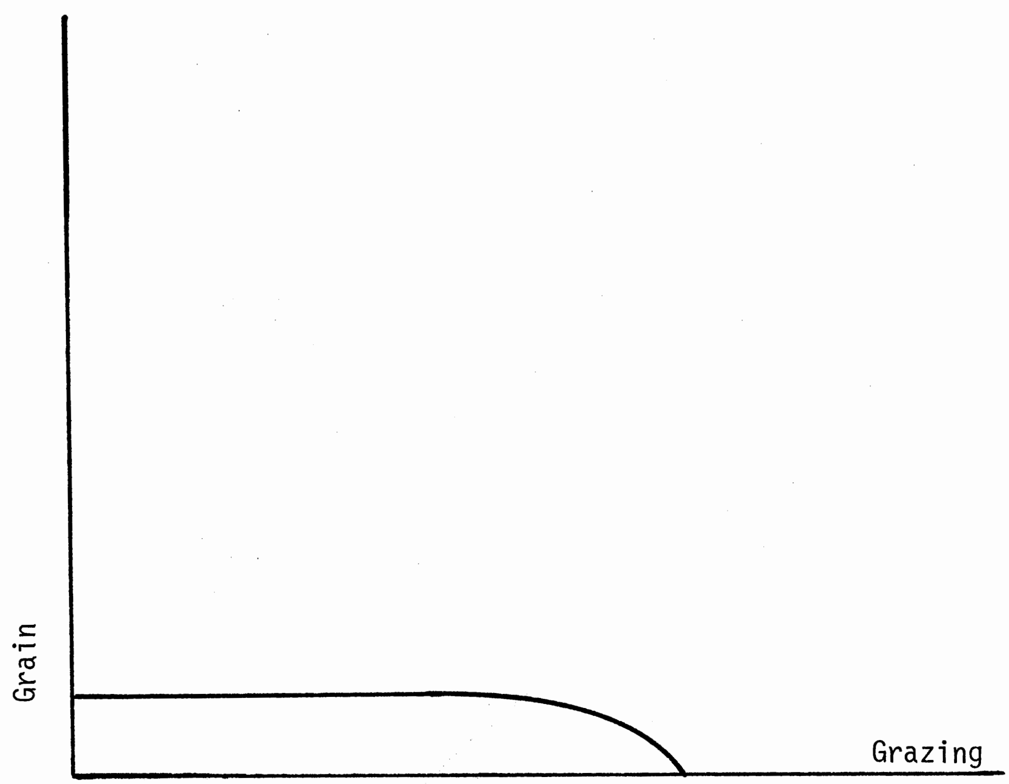


Figure 9c. Production Possibilities Between Grain and Grazing Under Circumstances of Drought

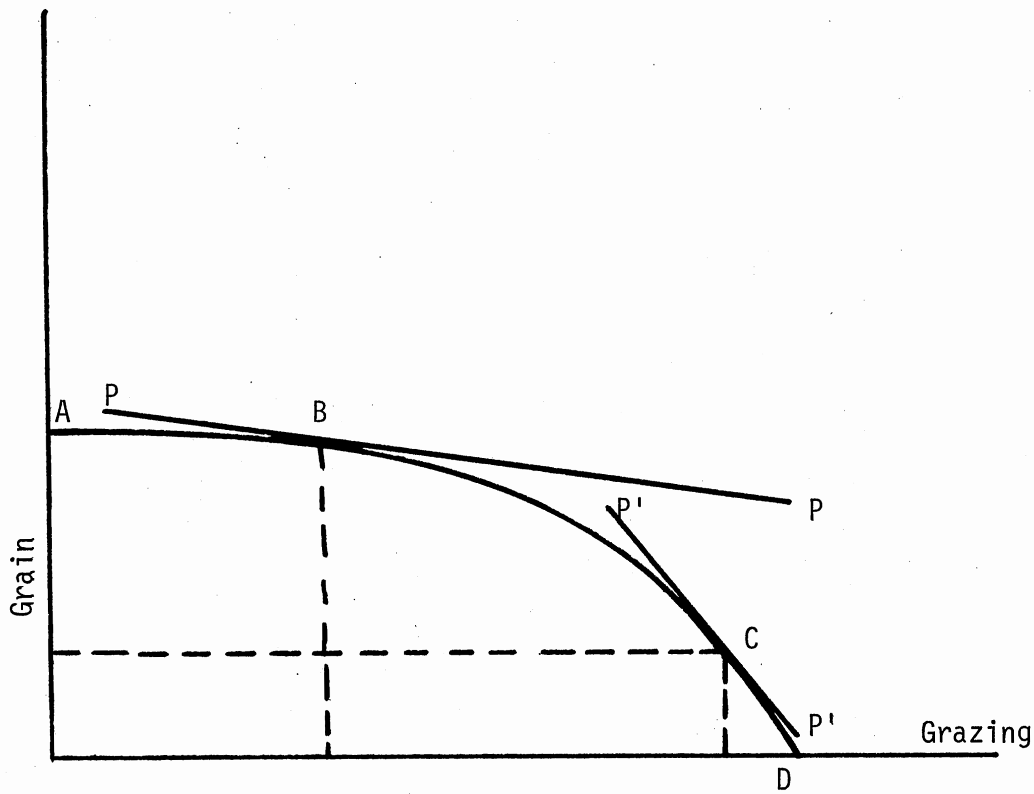


Figure 10. Aggregate Production Possibilities Between Grain and Grazing From Wheat Cropping

determined by the prices of wheat and pasture, their precise position is determined by the amount of revenue which is derived from the tract of wheat land. Per-acre revenues from the grain crop exceed those from grazing in the case of line PP, whereas line P'P' indicates the price advantage lies with pasturing the wheat.

In order to maximize profits, a decision-maker wants revenues as high as possible for a given cost outlay. This is illustrated in Figure 10. At the combination of products where the revenue line is tangent with constant cost line AD, revenues are at maximum.

Such a situation is shown in Figure 10 at points B and C. In a wheat-beef example, the maximum profit points call for varying combinations of grain and grazing in accordance with relative price positions, which is consistent with the action of better farm managers everywhere.

The product-product possibilities outlined above have involved individual firm considerations. The curve in Figure 10 has less abrupt slopes, however, than those in Figures 9a and 9b and is more illustrative of an aggregate situation rather than a single tract of wheat. Since for a given price situation all farmer decisions will not be the same, the trade-offs between grain and grazing are more gradual. Why do producer decisions differ for a given set of prices? For one thing, their costs and price expectations are different; also, because of varying technology and resource packages, the physical trade-offs themselves are different. And then, some producers do not choose the most profitable possibility, even though they think they do.

The maximum-profit position in an aggregate situation is determined in exactly the same manner as on an individual farm, although the production possibilities curve is flatter; and the constant revenue line is reflective of average prices, rather than the prices an individual might receive. Both costs and revenues are also subject to the externalities caused by many firms acting in unison. Subject to such changes in the respective slopes, the point of maximum profit will again be forthcoming at the point of tangency.

Recursive Programming and Supply Response

The programming formulation used in this study employs a representative farm as a proxy for a large number of farms with similar characteristics. Such a technique is susceptible to two special forms of bias. First, an aggregation problem arises from reliance upon a programmed representative farm to approximate area supply functions, which are in fact a summation of the supply response of all farms in the state. Also, specification error stems from wrong assumptions about input-output coefficients, prices, management, technical possibilities, and numerous other factors. This is compounded by the fact that firms acting in unison frequently cannot do what is simple for a firm acting alone. These again are external effects encountered previously of the real world.

Economic models are accepted as abstractions of the real world, yet they are subject to certain tests of what is economically "reasonable." This is determined by whether or not the model's results are consistent with what has been observed empirically or what would appear to be plausible under the stated conditions and assumptions.

A recursive programming model is a formulation of linked optimization problems, each of which is dependent on aspects of a solution determined earlier in the series. According to Day (26), such models may be used to (1) stimulate behavior of an economic unit, (2) to explore assumptions of economic behavior as an aid to theory development and (3) to break complex optimization problems down into a sequence of simpler optimization problems.

The principle of recursive optimization over a relatively short planning horizon was employed at least as early as Cournot (25), who used it as a base for his theory of duopolistic competition. The "cobweb" model has been used for more than fifty years to apply the same principle to explanation of firm activities under pure competition.

Follow Day (51), let "regional agriculture" be a set of firms, each of which produces two homogeneous commodities and uses two resources, say land and capital. Each firm maximizes its position by allocating available resources to production based on maximum short-run profits. The area agricultural industry can then be represented by the linear programming problem.

Maximize

(2.12) $\Pi(t) = [Z_1(t)X_1 + Z_2(t)X_2]$ (Objective function)

Subject to

(2.13) $X_1 + X_2 = L$ (Land constraint)

(2.14) $C_1Y_1 + C_2Y_2 = K(t)$ (Capital constraint)

$X_1, X_2 \geq 0$

where $\Pi(t)$ is regional short run profit in time period t, $Z_1(t)$ and $Z_2(t)$ are anticipated per acre profits for the two commodities, $X_1(t)$ and $X_2(t)$ are amounts in acres devoted to production of the two commodities, L is the land constraint and C_1 and C_2 are the per acre capital requirements for production of the two commodities in period t. They are limited by K(t), total capital available in the period. For simplicity, the model assumes no exchanges of land or capital.

If each producer faces the same decisions and posesses identical bundles of resources, then the optimal decision of the linear programming problem (2.12) - (2.14), say $X_1(t)$ and $X_2(t)$, will yield the total supply in acres of the two commodities in year t. Further, the anticipated marginal net revenues of the two factors are given by the dual problem to (2.12) - (2.14), which is

Minimize

$$(2.15) \quad \rho(t) = [r_1 L + r_2 K(t)]$$

Subject to

$$(2.16) \quad r_1 + C_1 r_2 \geq Z_1(t)$$

$$(2.17) \quad r_1 + C_2 r_2 \geq Z_2(t)$$

$$r_1, r_2 \geq 0$$

where $r_1(t)$ and $r_2(t)$ are the marginal net revenues for land and capital, respectively.

Continuing the formulation in the "cobweb" framework (producers expected prices are the previously received actual prices), anticipated per acre profits are defined by

$$(2.18) \quad Z_i(t) = P_i(t - 1) - c_i, \qquad i = 1, 2$$

where $P_i(t)$ is the market price received in year t.

Capital use is limited to last years sales minus payments to overhead, as

$$(2.19) \quad K(t) = \Sigma_i \; P_i(t - 1) \; X_i(t - 1) - h$$

where h represents the overhead expenditures.

In order to determine the price at which the commodities sell at the end of period t, assuming a perfectly competitive equilibrium and linear demand functions, the solution is solely a function of the amounts supplied of each commodity, as

Maximize

(2.20) $P_i(t) = [0_1 \; a_i + b_i \; X_i(t)]$ $\qquad i = 1, 2$

The system is a recursive programming model. The combined primal and dual problems (2.12) - (2.17) describe the optimization component, functions (2.19) - (2.20) along with definition (2.18) describe the feedback component.

Day goes on to note that the model is feasible so long as the maximized value of

(2.21) $\Sigma_i \; [0_1 \; a_i + b_i \; X_i \; (t - 1)] \; X_i \; (t - 1) \geq h$

that is, the sum of profits in the prior year must meet overhead requirements. Otherwise, the solution is infeasible and the system is no longer viable--the analytical connotation here for bankruptcy.

Agricultural Policy and Supply

Various interest groups have seen fit to press for legislation which placed constraints on production and marketing activities in U. S. agricultural economy. Past periods of crisis have usually provided the setting for additional government intervention. The objectives of society are both normative and varied; Doll and his associates have listed some characteristics of the agricultural economy which have given rise to society's concern (27): (1) there are pressures on the individual farmer to adopt new technology and no incentive to restrict output, (2) the price elasticity of demand for agricultural products is such that a small change in output leads to a large change in price, (3) the supply of and demand for agricultural products is constantly changing, (4) agricultural prices and incomes are unstable, and (5) resources within agriculture are not quick to adjust to new supply and demand situations.

There are economic principles available to support efforts to control farm output. First, production theory teaches that an individual producer faces a horizontal demand curve. His output, then, is highly sensitive to this cost structure; cost-reducing technologies are constantly being sought and adopted. Furthermore, the only way for a farmer to increase his income in this situation is to increase his production.

A second phenomena in which economic theory bolsters government agricultural policy, referred to earlier in this section, involves the low-price elasticity of demand for agricultural produces. For such commodities, increases in production mean less total revenue for the industry. The conclusion is that individual producers, in attempting to maximize profits, will be unable to restrain output. Evidence supports the suggestion that producer's efforts to become more efficient only make matters worse.

The preceeding argument gives rise to a third line of economic reasoning, which begins with the position that total revenues in agriculture are inefficient. Price supports are adopted. Production becomes such that supplies, in addition to pressing downward on prices, begin to accumulate in quantities sufficient to cause surplus storage problems. Costs of such burdens are borne by the taxpayer; the incentive is to control production.

Additionally, economic theory encourages advocates of government supply controls because of asset fixity in agriculture. The problem occurs because changes in output are not as sensitive to declining prices as to increasing prices. When prices are increasing, investments of many kinds are lured into agriculture, resulting in increased output, which in turn depresses commodity markets. When price movements begin declining, many of these assets remain locked into agricultural uses; their salvage value is even lower than their value in production. Because of the high proportion of such costs, which are incurred regardless of production levels, the maximum profit position is to continue high production, even though prices have declined.

Production adjustment operations by the U. S. Department of Agriculture were first applied to specific commodities in 1933, with passage of the Agricultural Adjustment Act. Programs in operation in the initial years modified supplies and prices for cotton, corn, peanuts, and tobacco, in addition to minor commodities like turpentine, figs, and prunes. Since 1938, some form of price support and supply control program has been in effect on certain basic crops, although the exact nature of control and the number of commodities affected has varied.

Conditions generated by World War II increased both export and domestic demand far faster than supply, resulting in a three-fold increase in prices during the decade of the 1940's. Legislation during the period centered on tying farm prices to the parity concept.

At the end of the Korean War, farm surpluses again became a concern. Commodity Credit Corporation inventories ballooned. The old problem of deficient supply was set aside. While farm production rose 20 percent between 1950 and 1959, the index of farm prices declined from 302 to 240 (27). Policy makers had difficulty recognizing that increasing technology was having a positive and permanent effect on production. In addition to stop-gap measures aimed at specific commodities, Congress enacted two important bills directed toward the general problems that confronted agriculture. The Agricultural Trade Development and Assistance Act of 1954, popularly called Public Law 480, was designed to move surplus commodities to overseas recipients. The other bill was the Agricultural Act of 1958, or Soil Bank Act. This was intended to curtail excessive supplies through long-term land retirement.

No less than eight major pieces of agricultural legislation between 1961 and 1965 enforced mandatory acreage diversions and payments for the major farm commodities. The Food and Agriculture Act of 1965 eventually became a five-year control program.

The Agricultural Act of 1970 initiated a cropland set-aside approach for participating producers, removing mandatory controls from wheat, feed grains, and cotton. Incentive payments were substantial, however, although a payment limitation was imposed.

The early 1970's brought substantial declines in inventories of U. S. farm products. Rising demand in many countries, bouyed by shifts in international monetary rates, lifted export levels of agricultural commodities to more than 15 billion dollars by 1973, from perhaps half that level ten years earlier (94). The concept of established or "target" prices was embodied into 1973 farm legislation. Under the plan, if market prices fall short of the target, producers are eligible to be compensated for the difference. Set-aside provisions have been temporarily halted and are reconsidered on a year-to-year basis. It remains for the future to dictate further legislation.

CHAPTER III

MODEL DEVELOPMENT

As noted in Chapter I, regional analyses of joint crop-livestock supply response are not common. The intricate nature of the relation between the production of wheat and beef cattle in the study area makes it essential that the requirements of the analytical model be firmly in mind.

Conceptual Base

Flow charts aid in the conceptualization process. Figure 13 pictures the wheat-beef producing sector as a part of the Great Plains crop-beef cattle complex. The chart shows the movement of cattle both into and out of the system and also crop flows which orginate within the system and move into on-farm use as well as commercial marketing channels.

Cattle orginating from outside the Great Plains consist mainly of stocker and feeder calves; there are small receipts of breeding animals. Movements out of the region are chiefly finished cattle, although some are destined for pastures and feedlots in other regions. Great Plains producers export breeding cattle also. Production from cropland has many destinations. All forage, most hay, and some silage are utilized on the farm. Nearly all grain, however, makes its way off the farm to merchants and processors.

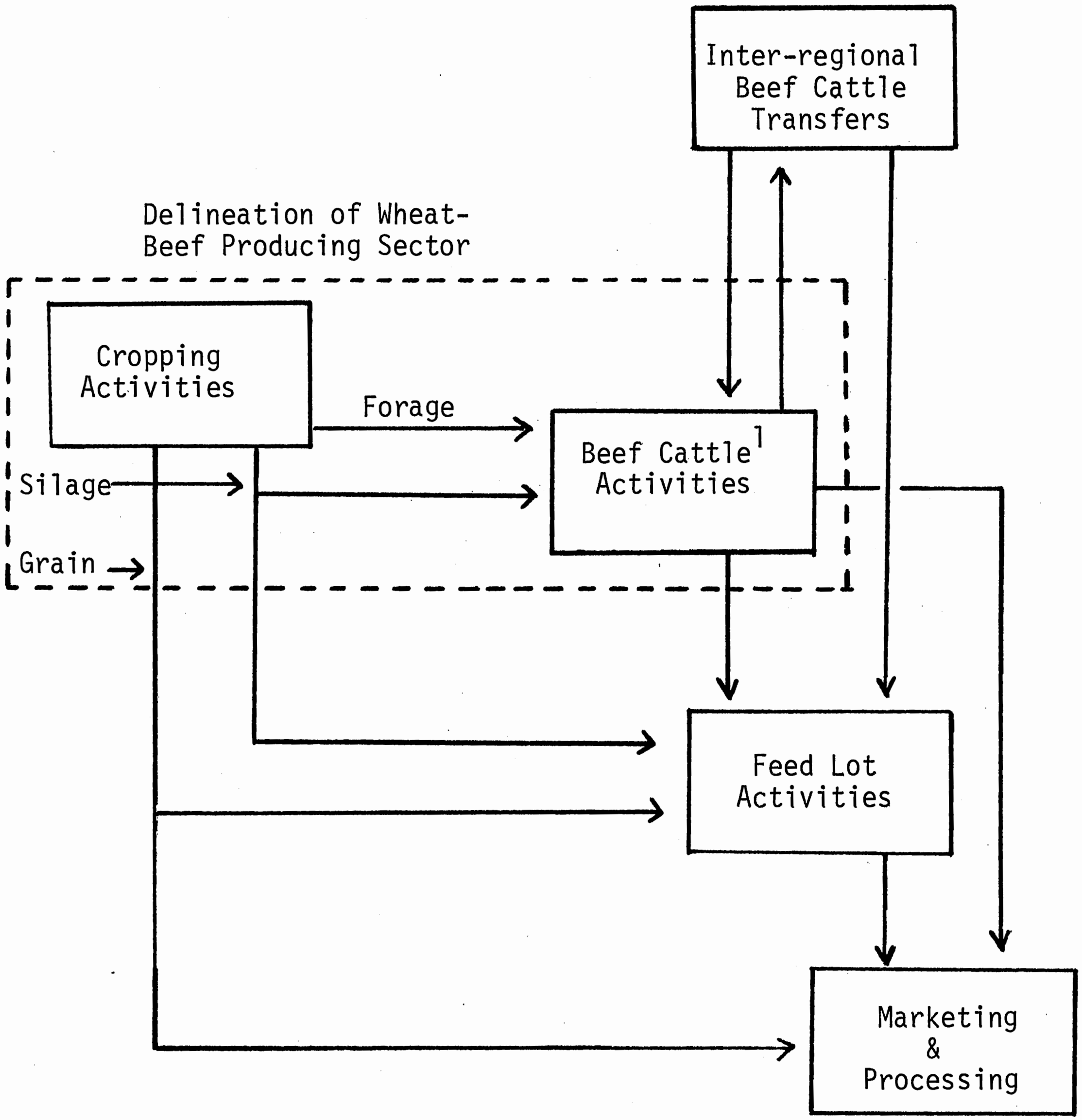
That portion of Figure 11 which has been set off by a dashed line is pertinent to this study. All farm-crop and beef-cattle producing activities are included. Finishing, processing, and marketing activities, such as feedlot and slaughter operations and local grain elevator business, are outside the producing section.

Those channels remaining outside the framed area do not directly affect operations of the model. To the extent they are held to have an indirect affect, they are assumed to remain constant unless specifically manipulated as exogenous variables.

The wheat-beef production flows described above are interrelated. They (1) come from a common regional resource base; (2) compete for scarce inputs; (3) can be produced with alternative combinations of resources; and (4) are managed in an assumed profit-maximizing format. Such circumstances suggest a mathematical programming formulation.

A number of specific capabilities are desired in a model that can aid in an analysis of the interdependent production characteristics of wheat and beef. Certainly such a model should include the following:

1. Production periods should be based on the biological production process rather than the calendar year.
2. Decisions should be made at times consistent with production periods.
3. Provision is needed for inclusion of government policy influence.
4. Inclusion of stochastic components, such as weather, should be provided.
5. Planning horizons should be longer than one production period.
6. Decisions should be dependent on earlier optimizing choices,



[1]Cattle on feed in farm feedlots are excluded.

Figure 11. Flow Chart of Southern Great Plains Crop-Beef Cattle Complex

and influence later ones.

Items 1-4 in the list above are adaptable to conventional linear programming; items 5-6, however, involve the passage of time. A model which is dynamic in the Hicks sense, that is, one which involves a single optimization over time, can provide the extended planning horizon called for in item 5 and can give an improved view of adjustments over time.

It cannot, however, make adjustments as a result of a developing set of circumstances, nor can it provide a sequence of decision opportunities, as called for in item 7. Recursive programming can provide an adequate time dimension.

In recursive programming, economic plans are provided by a sequence of optimizing decisions. A schematic diagram of the recursive programming model used in this study is pictured in Figure 12.

The illustration shows a series of linked linear programming models distributed diagonally across the recursive programming matrix. Each linear programming formulation represents one semiannual production period.

A new optimizing decision is made at the beginning of each period from within a dynamic linear programming format, extending across <u>two</u> production periods. This allows the extended planning horizon.

There is an overlapping effect, with each production period a part of two subsequent optimization decisions. The model, then, is a dynamic, recursive linear programming type; dynamic in that it allows a simultaneous solution of a multi-period planning horizon, and recursive in that it allows a new solution for each production period which is conditional upon the solution determined in the prior period.

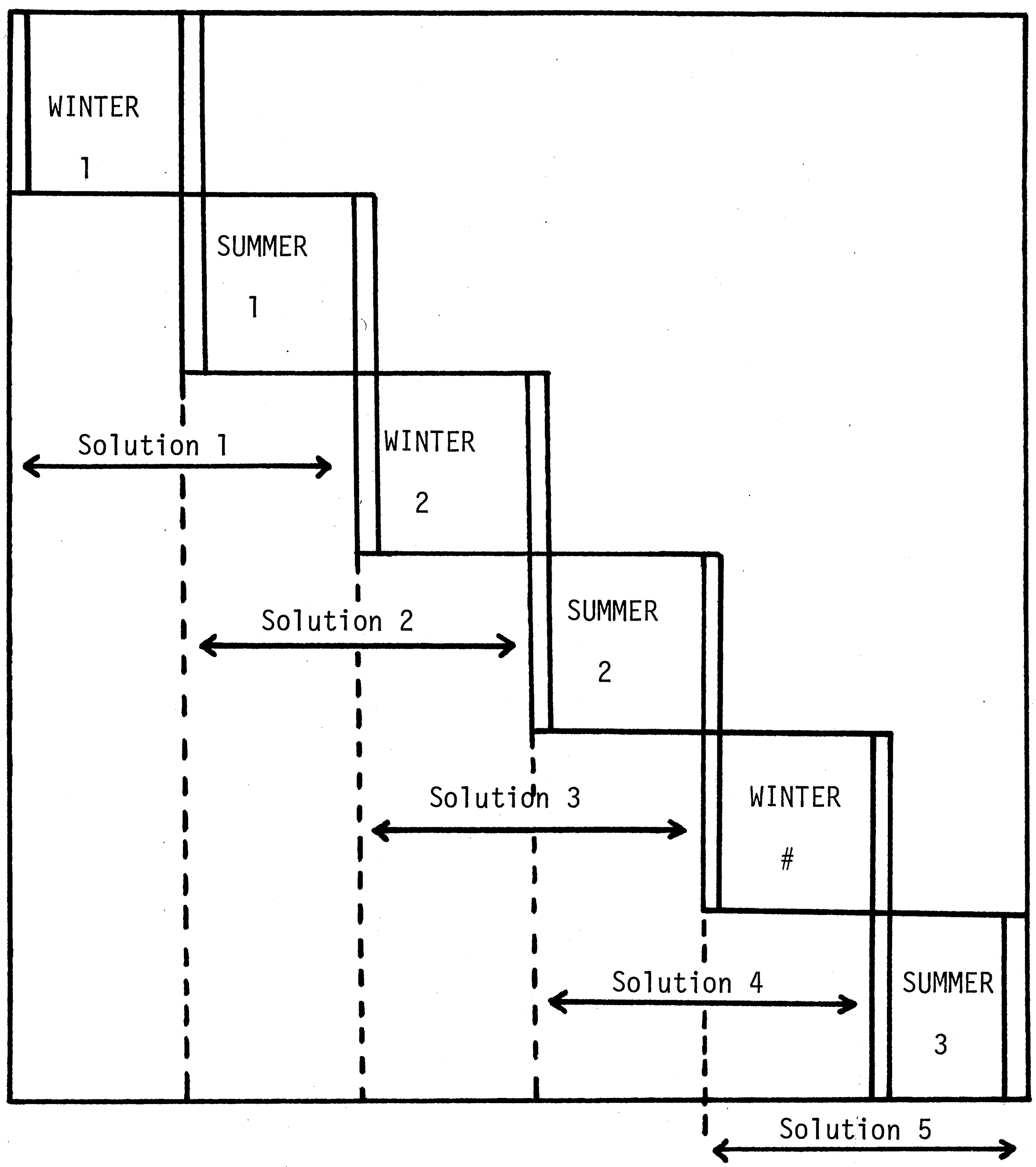


Figure 12. Recursive Programming Model--Southern Plains Wheat-Beef Producing Sector

The choice of length of run is arbitrary. Desired accuracy is a factor; there is the possibility of errors being compounded over time. Certainly the model should sequence enough times to allow adjustments to become apparent. For additional fallow land to be made available, planted to a desired crop, and harvested, requires three production periods. For a heifer calf to be added to the cow herd as an additional producer requires four periods. The length of run chosen for this analysis is five periods, or approximately two and one-half years calendar time.

Model Construction

Producing Activities

The model generates supply response in both crops and beef cattle with emphasis on interactive forces which operate between the two. Crops are divided into five categories: (1) small grains, (2) feed grains, (3) miscellaneous crops, (4) cropland pasture and (5) hay. Rangeland is also incorporated. Production from cropland is utilized as a livestock nutrient in three ways: (1) as green forage, (2) as fodder (crop residues) and (3) as hay. A fourth form of feed use occurs as range grazing.

All beef cattle are produced within the system, with the exception of lightweight stocker cattle, which may be purchased from outside the area. There are three kinds of beef cattle activities: (1) cow-calf, (2) replacement heifers and (3) stockers. Selected classes (either weights or rations) of each call for a total of 37 winter and 62 summer beef cattle producing activities.

Producing Periods

The year is divided into two consecutive periods of producing activity, which begin at times critical to wheat grazing operations. One begins on September 1 at wheat planting time and includes all traditional winter grazing activities, terminating at the end of March. The beginning of the second period coincides with the April 1 decision on whether to harvest the wheat crop as grain harvesters or to graze it out with cattle. Cropping activities within the two periods are different. The classes of livestock are unchanged; but rations differ between seasons, and calf crops and cattle inventories are not the same.

The recursive linkage ties one production period to the next, alternating between two slightly different dynamic linear programming formats (winter preceding summer versus summer preceding winter) at each link. The formats differ not only as to order of period, but because some transfer activities are different. Unused summer range for instance, can be shifted for use to the following winter, but no transfers occur from winter to summer. Transfers of unused hay are always carried forward, regardless of season. In the case of warm season crops, most are planted after April 1 and harvested after September 1; with winter wheat, the converse is true. Livestock activities may be of even longer term, but some may be completed in only one period (winter grazing of wheat with stockers, for example).

The normal life of most cropping or beef cattle activities extends more than six months. Thus, semiannual production periods require that cropping activities in a particular period either originate or terminate in a different season. Put another way, either prior expense has been incurred; or subsequent expense and income is yet to be realized. A cropping activity with a multi-period time dimension demands unique specification if included in a recursive linear programming format. If such a solution is to render an economic decision based on profits, both expenses and revenues generated outside the period must be accounted for. The model makes such provision in the objective function values of the transfer columns by deleting such costs or including such revenues.

Linking Variables

When a solution for a particular production period is obtained based on current information and future expectations, selected results of the solution are carried forward to be incorporated into the decision framework for the subsequent period. These results are in the form of inventories of beef cattle, feedstuffs, and planted crops. Cattle inventories reflect purchases and sales of all classes of cattle as well as calf crops and transfers of replacement heifers and stocker cattle. Carryovers of unutilized range and hay also give signs of beef cattle activity and general crop conditions.

Exogenous Variables

The analytical model treats price as an exogenous variable. Discussion in Chapter II, while noting that individual agricultural producers faced a horizontal demand curve, placed an aggregation of such producers in a position to affect price as they varied output. It is assumed, therefore, that subsequent prices, whether constant or changing, reflect the impact of regional activity in the prior period.

Price adjustments in the model can be used to represent inflationary or deflationary forces over time. They can also simulate changes in supply-demand relationships for various commodities. Another use of price changes is to represent selected segments of the beef cattle cycle; a price trough or peak may be indicated by appropriate manipulation of cattle prices.

A second variable treated exogenously is that of weather, which is captured in cropping yields. Weather conditions are also reflected in rates of gain among beef animals; the model assumes a constant rate of gain, which at times is unrealistic. However, to the extent that additional forage or fodder becomes available because a crop is too poor to harvest for cash sale, the error may be partially offset.

Policy adjustments are also handled exogenously. The Agricultural Act of 1973 brought a virtual cessation of supply-limiting policy activities, although provisions were included for future restoration of acreage controls and price supports. It is possible to vary prices, production costs, harvested acreage, and yields in various combinations within the model in order to simulate governmental commodity program activity.

Data Base

Land Resources

Acreages of cropland, both dryland and irrigated, and also rangeland, are presented in Table I. The data were developed from the National Inventory of Soil and Water Conservation Needs, prepared by the Soil Conservation Service (18, 57, 69, 86).

TABLE I

LAND RESOURCES FOR WHEAT-BEEF ANALYTICAL MODEL

Crop Reporting District	Rangeland	Total Cropland	Irrigated Cropland
	----------------	1,000 acres	----------------
Colorado SE	6,621.6	1,753.7	201.6
Kansas WC	1,739.4	3,217.0	122.2
Kansas SW	2,085.4	5,140.5	673.4
Oklahoma Pn	2,658.2	2,249.4	530.9
Texas 1N	7,743.7	6,758.9	2,609.0
	20,842.9	19,119.5	4,137.1

Source: Conservation Needs Inventories for Colorado, Kansas, Oklahoma and Texas, Soil Conservation Service, USDA.

Production Data

Crop and livestock production data are periodically published by the Statistical Reporting Service. These reports include planted and harvested acreages, yields, and prevailing market prices for selected times and localities. Annual SRS state reports group many data according to Crop Reporting Districts (19, 60, 70, 87).

Colorado, Kansas, Oklahoma, and Texas Agricultural Experiment Stations have collected and published costs and returns data at irregular intervals for many years (21, 42). These publications present collections of crop and livestock budgets for selected geographical areas and soil types. Budgets used as a base for the production coefficients used in this study were prepared by researchers for loam soils of northwest Oklahoma. They are given in Appendix A.

Production constraints and input-out coefficients in the analytical model were developed from data reporting 1970-74 crop production and beef cattle and calves on farms. Acreages and yields used for the selected crop groupings are shown in Table II.

Table III shows the benchmark production expenses for typical study area crops. The individual crops shown are those used to develop the cropping groups employed in the analytical model. Column 2 in the table indicates the weights, based on historical production, which were used to determine values for the groups.

Prices

Benchmark prices for both inputs and products are those prevailing in the study region during 1972-73. Selected deviations were obtained

TABLE II

BENCHMARK CROP CONSTRAINTS AND INPUT-OUTPUT COEFFICIENTS FOR WHEAT-BEEF MODEL

Crop Group	Crop Constraint	Yield/Acre Unit	Yield/Acre Amount
	-- 1,000 acres --		
Small Grain, dryland	6,500.0	bu.	18.0
		tdn.	86.8
Small Grain, irrigated	1,400.0	bu.	55.0
		tdn.	694.4
Total	7,900.0		
Feed Grain, dryland	1,030.4	cwt.	11.4
		tdn.	50.0
Feed Grain, irrigated	2,545.2	cwt.	64.9
		tdn.	351.0
Total	3,575.6		
Cropland Pasture	388.1	tdn.	500.0
Miscellaneous Crops	866.6	$1	210.79
		tdn.	10.0
Hay		tdn.	1,404.7
Small Grain Graze-out, dryland		tdn.	60.0
Small Grain Graze-out, irrigated		tdn.	477.0

[1] Based on historical acreage, 1970-74.

[2] No cropland constraints were placed on hay production

[3] In lieu of grain harvest.

TABLE III

PER ACRE PRODUCTION COSTS,[1]
WHEAT-BEEF MODEL

Producing Activity	1972-73 (Benchmark)	Weights
Small Grain		
Dryland wheat	17.09	1.00
Irrigated Small Grain		
Irrigated wheat	70.87	1.00
Feed Grain		
Dryland grain sorghum	18.83	1.00
Irrigated Feed Grain		
Irrigated corn	134.97	.2695
Irrigated grain sorghum	95.12	.7305
Cropland Pasture		
Irrigated alfalfa-brome	99.95	.05
Dryland hybrid forage	19.23	.95
Miscellaneous Crops		
Irrigated corn silage	93.84	.3761
Irrigated soybeans	67.92	.1264
Dryland cotton	63.39	.0537
Irrigated cotton	166.88	.4438
Hay		
Irrigated alfalfa	151.93	.10
Dryland hybrid forage	44.24	.80
Irrigated hybrid forage	125.48	.10

[1]Includes operating, capital, ownership, and labor costs.

by applying factors of .8, 1.2, 1.4, 1.6, and 2.0 to the base prices. The benchmark prices are presented in Table IV.

Unlike cropping activities, many of the variable inputs in beef cattle production are intermediate products. They may be the sole output from a producing activity, such as hay or silage; or they may be supplementary products, like small grain grazing. Also, variable expenditures for beef cattle are normally higher in winter than in summer. Model specifications require that these costs be accounted for separately.

Tables V and VI contain summaries of costs for beef cattle production. It is difficult to find comparable budgets for specific classes fo cattle of specific poundage. However, the National Research Council has computed nutritional requirements for a wide variety of classes and weights of cattle (68).

Nutrient requirements are an integral part of the beef cattle producing activities in the model; these requirements were used as weighting factors in assigning the variable-cost values. Specifications in Tables V and VI are included for only four beef cattle budgets. Two budgets per production period, one for cows and one for stocker steers, were used as bases from which to develop remaining cost values. The weighting factors and variable costs of production are shown in Table VII. The NRC specifications for beef cattle nutritional requirements are presented in Appendix B.

Rations

Beef cattle utilize feedstuffs in varying combinations, depending on feed available and often in response to price ratios. This principle

TABLE IV

SELECTED COMMODITY PRICES, WHEAT-BEEF MODEL

Commodity	Price[1]
Crops	
Feed grain	2.96
Miscellaneous crops	111.14
Small grain	2.11
Beef Cattle - Winter	
Buy Light Stkr. Steers	143.61
Light Stkr. Heifers	123.47
Sell Steer Calves	188.23
Heifer Calves	157.65
Light Stkr. Steers	191.53
Light Stkr. Heifers	167.51
Heavy Stkr. Steers	232.54
Heavy Stkr. Heifers	200.89
Young Rpmt. Heifers	173.70
Mod. Rpmt. Heifers	220.40
Older Rpmt. Heifers	270.20
Young Cows	216.22
Older Cows	207.97
Cull Cows	159.32
Beef Cattle - Summer	
Buy Light Stkr. Steers	152.63
Light Stkr. Heifers	131.23
Sell Steer Calves	193.60
Heifer Calves	162.15
Light Stkr. Steers	204.30
Light Stkr. Heifers	178.68
Heavy Stkr. Steers	249.05
Heavy Stkr. Heifers	215.16
Young Rpmt. Heifers	173.70
Lut. Rpmt. Heifers	220.40
Older Rpmt. Heifers	270.20
Young Cows	184.05
Older Cows	178.17
Cull Cows	143.15

[1]Based on 1972-73 average prices.

TABLE V

VARIABLE PRODUCTION COSTS, WINTER PRODUCTION PERIOD; TWO CLASSES OF CATTLE

Month	Operating Inputs	Labor	Capital & Ownership[1]	Total
Beef Cows				
September	1.68	1.68		
October	3.24	1.56		
November	5.79	1.08		
December	8.06	1.20		
January	13.08	1.32		
February	7.34	1.56		
March	6.06	1.32		
Total	45.25	9.72	32.88	87.85
Stocker Steers, 400 lbs.				
September				
October				
November	11.08	1.44		
December	1.08	1.04		
January	1.18	1.04		
February	1.08	1.04		
March	5.26	1.04		
Total	19.68	5.60	9.23	34.51

[1]Total annual capital and ownership costs are allocated proportionally to the 7 month winter production period.

TABLE VI

VARIABLE PRODUCTION COSTS, SUMMER PRODUCTION PERIOD; TWO CLASSES OF CATTLE

Month	Operating Inputs	Labor	Capital & Ownership[1]	Total
Beef Cows				
April	4.28	1.32		
May	.38	.96		
June	2.49	.96		
July	.71	.96		
August	3.61	2.04		
Total	11.47	6.24	23.48	41.19
Stocker Steers, 500 lbs.				
April	3.42	.68		
May	.37	1.04		
June	.37	1.04		
July	.37	1.04		
August	5.49	1.04		
Total	10.02	4.84	4.70	19.56

[1]Total annual capital and ownership costs are allocated proportionally to the 5 month summer production period.

TABLE VII

VARIABLE COSTS OF PRODUCTION, BEEF CATTLE ACTIVITIES, WHEAT-BEEF MODEL

Class of Cattle	Winter Costs		Summer Costs	
	Factor[1]	Amount	Factor	Amount
1972-73				
Young cows	1.0000	$ 87.85	1.0000	$41.49
Older cows	1.0803	94.90	1.0803	44.50
Light stkr. steers	1.0000	34.51	.7280	14.24
Light stkr. heifers	.9560	32.99	.6960	13.61
Heavy stkr. steers	1.3736	47.40	1.0000	19.56
Heavy stkr. heifers	1.3637	47.06	.9928	19.42
Young rpmt. heifers	.9886	34.12	.7197	14.08
Int. rpmt. heifers	1.4208	49.03	1.0344	20.23
Older rpmt. heifers	1.8875	65.14	1.3741	26.88
1974-75				
Young cows	1.0000	103.35	1.0000	48.81
Older cows	1.0803	111.65	1.0803	52.73
Light stkr. steers	1.0000	40.13	.7280	16.18
Light stkr. heifers	.9560	38.36	.6960	15.47
Heavy stkr. steers	1.3736	55.12	1.0000	22.23
Heavy stkr. heifers	1.3637	54.73	.9928	22.07
Young rpmt. heifers	.9886	39.67	.7197	16.01
Int. rpmt. heifers	1.4208	57.02	1.0344	22.99
Older rpmt. heifers	1.8875	75.75	1.3741	30.54

[1]Weighting factor based on National Research Council nutrient requirements for various classes of cattle, as presented in Appendix C.

is incorporated into the model in the form of selected alternative rations available to each class of cattle. Thus, there is a management choice selection among the classes and, within a chosen class, a choice among rations. Differences among rations, with respect to direct production costs shown in Table V, arise only because of differences in protein supplement purchased. All rations, however, involve the consumption of intermediate products and, as such, are affected by the costs of such production. All other feedstuffs are produced internally in the model; and it is assumed that labor, ownership, and capital costs remain constant across all rations for a given class of cattle.

The selected rations were chosen from prevailing management practices in the field and were developed after consultation with extension specialists and farm operators across the area. Research management studies and budget publications were also evaluated (12, 56).

Feed composition analyses are available from the National Research Council. Those used in this analysis to compute forage, fodder, hay, and range production values appear in Appendix C. Coefficients depicting feedstuff use are also based on NRC published research.

The ration formulations integrated into the model were developed by applying the NRC specifications, both for feedstuff analysis and cattle nutrient requirements, to prevailing practices in the region. They are shown in Appendix D.

Weather Variables

Historical wheat yields in northwestern Oklahoma since 1960 range from a low of 11.1 bushels in 1967 to a high of 25.4 bushels in 1974 (70). The distribution is skewed slightly to the left; the mean yield is 17.1 bushels. This means that, despite the fact that 15 percent of the crop is irrigated, yields fall below the mean more than half the years. Yields of summer crops exhibit skewness to the right, influenced by the 70 percent irrigated portion. To represent periods of weather extremes, arbitrarily selected crop yields were used. These fields are given in Table VIII.

Policy Variables

It was noted earlier in the chapter that certain institutional supply control programs could be simulated in the model. Table IX presents combinations of acreage constraints and prices used to represent both a wheat and feed grain policy control program.

TABLE VIII

SELECTED YIELDS, ALTERNATIVE WEATHER CONDITIONS,
WHEAT-BEEF MODEL

Crop Group	Units	Mean Yield 1960-74	Yield Range 1960-74	Poor Weather	Normal Weather	Good Weather
<u>Winter Crops</u>						
Small Grain	bu.	17.1	11.1-25.24			
Dryland, grain	bu.			12.0	18.0	22.0
Dryland, forage	tdn.			30.0	86.8	110.0
Dryland, graze-out	tdn.			25.0	59.6	70.0
Irrigated, grain	bu.			40.0	55.0	60.0
Irrigated, forage	tdn.			400.0	694.4	750.0
Irrigated, graze-out	tdn.			450.0	476.6	500.0
<u>Summer Crops</u>						
Feed Grain	cwt.	23.6	13.05-28.78			
Dryland Grain	cwt.			8.00	11.40	22.00
Dryland Fodder	tdn.			70.00	50.00	60.00
Irrigated Grain	cwt.			60.00	64.91	70.00
Irrigated Fodder	tdn.			350.00	351.00	350.00
<u>Miscellaneous Crops</u>						
Returns	$1			$100.00	$111.14	$125.00
Fodder	tdn.			10.00	10.00	10.00
<u>Cropland Pasture</u>						
Summer, forage	tdn.			150.00	350.00	450.00
Winter, fodder	tdn.			150.00	150.00	150.00
Hay	tdn.			600.00	1,404.76	1,800.00
Range	tdn.			40.00	103.62	120.00

TABLE IX

ACREAGE AND SELLING PRICE COEFFICIENTS, SIMULATED WHEAT AND FEED GRAIN PROGRAMS, WHEAT-BEEF MODEL

	Wheat Program		Feed Grain Program	
Commodity	Allotted Acres	Selling Price	Allotted Acres	Selling Price
Small Grain	6,500	$3.38/bu.	Open	$2.11/bu.
Irrigated Small Grain	1,400	$3.38/bu.	Open	$2.11/bu.
Feed Grain	Open	$2.96/cwt.	1,030	$4.74/cwt.
Irrigated Feed Grain	Open	$2.96/cwt.	2,545	$4.74/cwt.

CHAPTER IV

WHEAT-BEEF INTERACTION: PRICE ADJUSTMENT ANALYSIS

Any of a number of factors may cause farm decision makers to alter their production plans. Circumstances may induce voluntary adjustments; or, in many cases, the producer is forced to adopt changes. Regardless of motivation, the aggregate effect is a change in regional supply response. This chapter and the next present analyses of selected casual forces and the resulting adjustments which are predicted by the analytical model. The present chapter is directed toward analysis of price-induced adjustments, while Chapter V is concerned with aggregate response to weather and institutional changes.

Commodity Price Changes

Price changes may cause producer reaction through their effect on changes in revenue and/or shifts in the costs of production. Individual commodities are subject to unique pressures and may experience cost-and-returns changes in concert with other products or proceed along a seemingly independent path. In terms of regional supply, the important change is the shift in competitive position among alternative enterprises.

General Selling-Price Changes

As a starting point for the analysis of price-induced adjustment, a change in commodity-selling prices was introduced. The prices were modified across all selling activities by a common percentage.[1] This allowed the analytical model to capture shifts in the competitive position among producing activities and to trace out the aggregate effect of such changes over time.

The benchmark configuration for the regional model was specified in Chapter III. The period-by-period optimum solution for selected output, inventory, and consumption variables is given in Table X. The model was then reconstructed, with all selling prices increased 60 percent, and rerun. These results also appear in Table X and are contrasted with the benchmark results.

The benchmark run itself does not begin in equalibrium. The assumed prices, and production coefficients bring adjustment forces into play. Contrasting the benchmark values with those of an alternative run, then, compares both the direction and the rate of change shown by the two sets of solutions. Crop acreages and livestock inventories were held to historical levels during the initial solution in each run so that comparisons between runs would be meaningful. In addition, lower bounds were placed on winter stocker cattle to hold traditional wheat pasture operations at or above minimum levels.

The sequence of production periods in a full run of the model begins with a winter format and runs through five solutions. Thus,

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[1]Since cropping activities are linked to beef cattle enterprises through production of intermediate products, costs of production were also affected (7).

TABLE X

HARVESTED ACRES, BEEF CATTLE INVENTORIES AND INTERACTION ACTIVITIES, TWO COMMODITY PRICE LEVELS, WHEAT BEEF MODEL

Activity	Winter 1			Summer 1			Winter 2			Summer 2			Winter 3		
	BM[1]	1.6[2]	Change	BM	1.6	Change	BM	1.6	Change	BM	1.6	Change	BM	1.6	Change
Cropping Activity							1,000 Acres								
Small grain[3]	7,526	7,632	+106				9,258	9,331	+73				10,329	9,332	-997
Small harvested				2,189	3,830	+1,641				0	5,529	+5,529			
Small grazed out				5,337	3,802	-1,535				9,258	3,802	-5,456			
Feed grain				6,526	6,548	+ 22				4,434	6,541	-2,107			
Cropland pasture				0	0	--				0	0	--			
Miscellaneous crops				3,645	3,533	- 112				4,712	3,515	-1,197			
Hay harvested				53	59	+ 6				115	83	- 32			
Fallow in	14,071	14,071	--	11,593	11,487	- 106	9,258	9,331	+73	9,861	9,788	- 73	10,329	9,331	-998
unused	6,545	6,440	-105	1,732	1,700	- 32	0	0	--	1,071	0	-1,071	0	0	--
out	11,593	11,487	-106	9,258	9,331	+ 73	9,861	9,788	-73	10,329	9,331	- 998	8,790	9,788	+998
Beef Cattle Activity							1,000 Head								
Cow herd	1,074	1,074	--	885	901	+ 16	921	921	--	902	905	+ 3	921	921	--
Replacements	307	307	--	318	264	- 54	264	264	--	288	264	- 24	264	264	--
Stockers	803	803	--	273	273	--	273	273	--	273	273	--	273	273	--
Total[4]	2,184	2,184	--	1,476	1,438	- 38	1,458	1,458	--	1,463	1,442	- 21	1,458	1,458	--
Interaction Activity							1,000,000 Pounds TDN								
Range use	972	972	--	532	532	--	1,088	1,088	--	679	532	- 147	941	1,088	+147
Forage use	1,682	1,752	+ 70	838	792	- 46	946	946	--	655	797	+ 142	1,167	947	-220
Fodder use	522	509	- 13	278	280	+ 2	363	363	--	294	280	- 14	269	362	+ 93
Hay use	281	226	- 55	--	--	--	115	117	+ 2	--	--	--	162	117	- 45
Total	3,457	3,459	+ 2	1,648	1,604	- 44	2,512	2,514	+ 2	1,628	1,609	- 19	2,539	2,514	- 25
	1.58	1.58		1.12	1.12		1.72	1.72		1.11	1.12		1.74	1.72	

[1]Assumed benchmark selling price levels, based on 1970-74 average prices for the region.

[2]Benchmark prices increased by 40 percent.

[3]Acres available for harvest.

[4]This total does not include unweaned calves.

the last period in the sequence is also a winter period. All solutions have the benefit of an extended planning horizon, that is, the final winter period is optimized after "looking ahead" into the following summer, but the choices made in that next summer are not considered in the analysis.

A period-by-period enumeration of a given run is tedious, but it is helpful to identify the interactive forces as they manifest themselves over time. The initial analysis, that of the general selling price increase, is handled in a period-by-period fashion; subsequent analyses present only the significant points that appear in the tabular summarizations that accompany the text.

Solution 1. (Winter 1 - Summer 1) Since beginning inventories for beef cattle were fixed and important crops were closely constrained at the outset, there was little chance for the two runs to differ during the first winter production period. The assumed price-cost relationships and beginning restrictions were such that all available land was not planted to small grain in the benchmark run, that land instead being transferred forward as fallow.

The price increase, however, placed additional value on wheat production, making both grain and grazing attributes more profitable. As a result, 106,000 fewer acres were transferred forward as fallow into the succeeding summer period.

Although initial beef cattle inventories were fixed, Table X shows that calf sales during the first winter were 20,000 head greater at the higher price. This allowed less calves to be transferred forward as stockers into the subsequent summer period.

Shifts in feedstuff utilization also occurred. The influences of higher prices caused 20 percent less hay (39,000 acres) and 13 percent less fodder (13,000 acres) to be consumed during the winter, while forage consumption increased (70,000 acres).

Solution 2. (Summer 1 - Winter 2) Production changes became more apparent during the following summer. The benchmark solution called for 70 percent of the small grains to be grazed out. Historical data shows that spring grazing has never been this heavy, but proper price ratios do exert a strong influence (79). When prices were increased, the amount of graze-out called for in the optimal solution was reduced to 50 percent. This management change affected more than 1.5 million acres of small grain, as shown in Table X. The initial inventory levels constituted one influence calling for abnormally high graze-out operations. Up to that time, there was no opportunity to increase wheat seedings and very little chance to reduce livestock numbers.

The price change also eliminated 112,000 acres of miscellaneous crops (mainly soybeans, silage, and sugar beets). Feed grain and hay acreages were increased slightly, but most of the released land was transferred forward as fallow to be used the following winter. Offsetting the small acreage devoted to miscellaneous crops, Table X pictures a 22,000 acre increase in feed grains, 6,000 acres more hay, and 73,000 acres additional fallow during the summer period, as a result of the higher prices.

In the benchmark run, livestock numbers were reduced substantially from the previous winter. Some cows were sold off (189,000); and stocker numbers were reduced even more, kept in the solution only at lower-bound levels.

The adjustment in selling prices softened the rate of decline in cow numbers. Whereas the base solution had reduced beef cow inventories to 885,000, the comparable value for the price change was 901,000. Pressure to dispose of replacement heifers, however, was stronger. The initial inventory level was 318,000; higher selling prices caused this value to be reduced to 264,000. Thus, 54,000 fewer replacements were held into winter.

The price increase did not affect rangeland use, adjustments instead being made in the use of forage and fodder associated with cropping activities. The net consumption was smaller at 1.6 price levels. Total roughage consumption fell from 1,648 to 1,604 million pounds of tdn, while beef cattle numbers (less calves) decreased from 1,476 to 1,438 thousand head.

Indications through the first two periods are that the relative profitability of winter cropping has been enhanced by the price adjustments. Certainly, spring graze-out activities on small grains play less of a role. Also, less fallow was moved forward for summer cropping. The cow herd did undergo a smaller reduction in the short run, but benchmark provisions for herd expansion have given way, in part, to increased sales of heifer calves and available replacements.

<u>Solution 3</u>. (Winter 2 - Summer 2) Benchmark values from the second winter's solution differed significantly in several respects from those of the first winter. One, the acreage planted to small grain was 1,732,000 acres higher, an increase of 23 percent. Second, winter use of rangeland increased by 1.12 million acres; and third, cow numbers declined by 153,000 head, although they were 36,000 head lighter than during the previous summer. The undulating movement in beef cow numbers from period to period indicates that an equilibrium

was being achieved, although it would be finally dependent on stability in land use. Further, the variation from summer to winter would probably remain, since replacements do not flow uniformly into the cow herd; and one season may be a more desirable time than another to make cow disposals.

The effects of increased prices upon optimum production levels in the second winter were minor. Small grain plantings increased 73,000 acres from the benchmark values, the gain coming from increased fallow receipts, which were mentioned above in the discussion of Solution 2.

As in the benchmark run, no available fallow land was transferred forward for later use. It was noted above that acreages of crops in the initial period were fixed. This accounts for the large fallow transfers which were apparent in the first winter period but did not manifest themselves in the second. Livestock activities were unaffected by the price increase; for this reason the interaction activities also remained unchanged.

Solution 4. (Summer 2 - Winter 3) The optimum benchmark production choices for the second summer showed substantial deviation from the decisions made a year earlier. All small grain acreage was found to be more profitable when grazed out, while only 70 percent had been so treated the prior summer. Feed grain acreage was reduced by 32 percent, a shift of over 2 million acres. Acreage devoted to miscellaneous crops was 30 percent greater, and hay harvestings more than doubled.

Benchmark cow numbers were two percent larger than in the previous year, and replacement numbers were 10 percent greater. Inventories of stocker cattle, however, were unchanged; and calf sales increased only slightly. The exact values of the comparisons are given in Table X.

Consumption of forages by beef cattle was slightly less in total (only about 1.5 percent), but the mix was quite different. Summer range use was nearly 30 percent heavier; overall forage use declined by about the same amount, while fodder use was slightly greater.

When selling price adjustments are considered in the optimum solution for the second summer, cropping shifts were in favor of conventional small grain harvesting and feed grain plantings. Those activities falling from favor were graze-out operations and miscellaneous crop production.

Beef cattle activities in this period were only slightly affected by the price changes. Replacement heifer numbers were reduced by 24,000 animals (nine percent); other shifts were minor. This was necessitated by lessened emphasis on small grain grazing.

The first three periods had indicated no changes in the use of range land from that found to be optimal under benchmark assumptions. There was a significant departure in the second summer. Although the price change reduced total interaction activity by only about one percent (from 1,628 to 1,609 units), over 1.4 million acres of rangeland was deferred for use the following winter period. This 22 percent change in range consumption was almost entirely offset by increased summer forage use. Thus, cropland was returned for summer use, while still maintaining beef cattle production.

Solution 5. (Winter 3 - Summer 3) The benchmark run showed that cropping adjustments were still being made in the third winter, although beef cattle numbers had stabilized. Wheat acreage increased nearly 1.1 million acres, but the rate of adjustment fell from 23 percent in the first year to 12 percent in the second.

Hay use by livestock in the period was 115,000 acres, 40 percent higher than the previous winter. An exchange from range use to winter forage use occurred, which was a reversal of the previous winter's adjustment. This was permitted because winter small grain acreages had reached sufficient volume to allow a summer range and green winter forage program.

The optimum solution is not contradictory but rather illustrates the order and time involvement of adjustments that must occur at the regional level before an equilibrium can be attained. In this instance, price increases called for more cash crops and somewhat reduced beef cattle production. Before such levels could stabilize, harvested wheat and feed grain acreage first had to give way to the forage demands of the existing beef herd. As beef replacements, stockers and calves were sold off; and as fallow land became available for use in making cropping decisions, additional wheat was planted. The additional small grain forage allowed cow numbers to be accommodated without utilizing feed grain land or graze-out practices on small grains. It was only then that feed grain production rose, and more wheat was harvested for grain.

When the effect of a price increase was gauged against the benchmark solution for the period, small grain acreage was reduced by nearly one million. However, this value of 9.3 million acres, as shown in Table X, was nearly identical to the like figure of the previous winter. The higher price level drove the model toward an equilibrium level of small grain production much sooner than benchmark prices. As was noted previously, equilibrium among beef cattle numbers had been attained in the winter a year earlier.

As with small grains, winter hay consumption in the period was influenced more strongly at the higher price; the values for the second and third winters were the same. Uses of range, forage, and fodder were all settled into an oscillatory pattern by the fifth solution, but only at the higher selling prices. In contrast, beef inventory values were stabilized for either price level, but did swing back and forth between seasons.

A view of the adjustment sequence through five production periods confirms only part of what was suspected after the second period. Spring graze-out of small grains continued to be less profitable. This indicates that the profitability balance was shifting toward crops. Earlier indications that winter crops were placed in a better position has not been substantiated. Both runs reduced livestock numbers to the same level by the fifth solution, although it occurred more quickly at the higher price.

Under the assumptions, the model finds the use of small grains to be very economical for grazing. This is true, not only for conventional winter pasture, but also for graze-out activities in the spring. This has not been a conventional practice, although wheat-beef price ratios were such in the late 1970's and early 1970's that the enterprise was rapidly gaining favor.

The foregoing discussion has been concerned only with the sequence of events over time and the interaction between beef and crop adjustments. The questions of increasing returns to the region's producers through the adjustment process and also the cumulative effects on aggregate supply response have not been covered. They will be discussed in turn.

<u>Income Implications</u>. Table XI compares the optimized values of the objective function, period by period, for the two sets of runs. The absolute magnitudes may be difficult to precisely define, since objective function values for transfer activities estimate net cash flow for the life of the enterprise; in addition, the optimized values of the planned activities to occur in the following period are included in each optimal solution. However, the objective function values do represent returns to land, overhead, risk, and management for the activities included in the programming matrix. As such, they are valid for comparative purposes.

TABLE XI

OPTIMIZED OBJECTIVE FUNCTION VALUES, TWO PRICE LEVELS, WHEAT-BEEF MODEL

Period	Selling Price Level	
	BM	1.6
	----------- 1,000,000 dollars ---------	
Winter 1	21.562	34.527
Summer 1	82.701	123.020
Winter 2	86.158	133.683
Summer 2	108.349	132.445
Winter 3	110.485	133.040

Obviously, optimized values are higher at higher prices. More importantly, are they trending higher than in previous periods at the same price, and are the values approaching stability?

Examination of Table XI indicates immediately that the assumed price-cost structure and beginning crop acreages produced far less returns in the beginning period than subsequent organizations did. Both the extent and the rapidity of the change was substantial. This was influenced by two factors: (1) initial crop acreages were based on historical data, much of which reflected the constraint of federal acreage control programs; and (2) beginning beef cattle inventories were held by the model to be excessive under the assumptions; the excesses were worked off as sales in subsequent periods. The sales, of course, constituted income.

Observing the optimized objective function values in sequence at each price level indicates that optimum organization is obtained more quickly at higher prices. Incomes, at more than 130 million dollars, were very near their ultimate levels by the second period with the higher price level; this was not achieved under benchmark rates until the fourth period. Higher prices permitted a quicker adjustment because forage use requirements were lower in the second period, permitting a transition from grazeout to grain at an earlier date.

Stability of objective function values over time will occur in the model so long as parameters remain fixed. This did occur at the higher price level. However, cropping adjustments at benchmark prices were not all worked out (largely because of extensive shifts in range use and small grain grazing in the latter periods), although period-to-period changes exhibit a stabilizing pattern.

<u>Cumulative Production</u>. The effect over time on aggregate supply response should be considered. Although each run of the regional model consists of three winter periods but only two summer periods, comparing cumulative production totals is helpful. Totals for selected enterprises are presented in Table XII.

TABLE XII

CUMULATIVE PRODUCTION TOTALS, TWO PRICE LEVELS, WHEAT-BEEF MODEL

Commodity	Unit	Selling Price Level BM	Selling Price Level 1.6
Small grain	1,000 ac.		
for harvest		2,189	9,359
for grazeout		14,595	7,604
Feed grain	1,000 ac.	10,960	13,089
Miscellaneous crops	1,000 ac.	8,357	7,048
Stocker cattle	1,000 hd.	1,374	1,374
Stocker cattle sales	1,000 hd.	1,489	1,560
Calf sales	1,000 hd.	482	468
Other sales[1]			

[1]Cow disposals and replacement heifer sales.

Generally, cumulative small grain acreages were unaffected by the increase in prices; the higher price level called in 16.96 million acres; comparable benchmark value was 179,000 acres less. The big difference was in the disposition of small grain acreage. The advance in selling prices reduced total grazeout operations from 86 percent of total acres down to 45 percent, which represents an adjusted practice on nearly 7,000,000 acres.

Feed grain acreage harvested across the time period increased about 20 percent, while acreage devoted to miscellaneous crop production fell by more than 15 percent. Cropland usage in total was up slightly at the higher price pattern, caused by some decrease in fallow practices.

Stocker cattle activities were not encouraged at either level of selling prices because profit opportunities remained best with crops. After beginning stocker inventories were disposed of, production came in only at lower restraint levels, which were set to simulate minimum wheat pasture activity. Table XII shows calf sales 71,000 head higher and sales of cows and replacements 24,000 head lower at increased price levels. Both changes were largely a factor of the more rapid reduction in cow herd numbers at benchmark prices.

Variations in Crop Prices

The solutions in the preceding section, using 1972-73 costs of production and 1970-74 average prices, reflected an advantage for cropping enterprises. That is, cash crops occupied most of the available land, particularly at higher prices, while beef cattle activities tended toward lower bounds as crop prices rose. This may not be a real world phenomena. Time series data do not support instances of simultaneous and proportional price increases in both crops and livestock; the likelihood of such phenomena is exceedingly remote. While there may be other than economic motivation for maintaining a cow herd, historic cyclical changes in cattle numbers have been generally in response to price (4).

To capture the effect of changes in crop prices on livestock enterprises when additional crop acreage is not available, cropping constraints were imposed at historical levels for all periods.[2] Thus, the benchmark constraints on crops values originate at the same point as in the previous section but carry upper bounds in all solutions. Therefore, Table XIII refers to the benchmark run as Benchmark 2. Estimates were made for five selected crop price levels, all multiples of benchmark prices -- .8, 1.0, 1.2, 1.6, and 2.0. Livestock prices were held at the benchmark level. Results from the .8 run were no different from the benchmark and will not be discussed. Selected results of the four remianing runs are summarized in Table XIII.

As might be expected, the table presents essentially stable results, since benchmark beef prices do not encourage expansion, and since crop acreages are limited. Small grain seedings increased only by the small amount of slippage allowed in the model as additional fallow land became available. The proportion of small grain which was harvested mechanically was much higher, however. Cattle grazed out only 11 percent (827,000) acres of the wheat at benchmark prices during the first summer period; at 2.0 prices, grazeout activity took only two percent (141,000 acres).

The factor which caused additional wheat to be harvested for grain was the limitation placed on summer crops. In the prior analysis, no restrictions had been placed on individual crops beyond the initial period and profit maximization dictated that land resources be

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[2]Based on 1970-74 data.

TABLE XIII

HARVESTED ACRES, BEEF CATTLE INVENTORIES AND INTERACTION ACTIVITIES, SELECTED CROP PRICES, WHEAT BEEF MODEL

Activity	Winter 1				Summer 1				Winter 2			
	BM[1]	1.2[2]	1.6[2]	2.0[2]	BM	1.2	1.6	2.0	BM	1.2	1.6	2.0
<u>Cropping Activity</u>					1,000 Acres							
Small grain[3]	7,632	7,632	7,632	7,632					7,656	7,656	7,723	7,723
Small harvested					6,803	6,986	7,464	7,490				
Small grazed out					827	645	167	141				
Feed grain					2,531	2,531	2,531	2,531				
Cropland pasture					431	431	431	431				
Miscellaneous crops					1,867	1,867	1,867	1,867				
Hay harvested					186	182	176	176				
Fallow in	12,081	12,081	13,801	14,071	9,497	9,497	11,218	11,487	12,342	12,345	14,071	14,341
unused	4,450	4,450	6.170	6,440	4,711	4,714	6,439	6,709	4,685	4,688	6,348	6,618
out	9,497	9,497	11,218	11,487	12,342	12,345	14,071	14,341	9,471	9,471	11,126	11,396
<u>Beef Cattle Activity</u>					1,000 Head							
Cow herd	1,030	1,030	1,030	1,030	939	939	901	901	971	956	921	921
Replacements	307	307	307	307	318	264	264	264	324	288	264	264
Stockers	543	543	543	543	273	273	273	273	273	273	273	273
Total[4]	1,880	1,880	1,880	1,880	1,530	1,476	1,438	1,438	1,568	1,517	1,458	1,458
<u>Interaction Activity</u>					1,000,000 Pounds TDN							
Range use	972	972	972	972	891	922	942	952	729	698	678	668
Forage use	1,900	1,900	1,787	1,912	669	582	372	362	1,682	1,619	1,516	1,558
Fodder use	514	514	514	511	312	299	290	290	331	318	310	307
Hay use	281	281	225	225					261	257	247	247
Total	3,667	3,667	3,498	3,620	1,872	1,803	1,604	1,604	3,003	2,892	2,751	2,780

TABLE XIII (CONTINUED)

Activity	Summer 2 BM	Summer 2 1.2	Summer 2 1.6	Summer 2 2.0	Winter 3 BM	Winter 3 1.2	Winter 3 1.6	Winter 3 2.0
Cropping Activity				1,000 Acres				
Small grain[3]					7,657	7,657	7,814	7,814
Small harvested	6,797	7,004	7,554	7,580				
Small grazed out	860	652	168	142				
Feed grain	2,506	2,507	2,441	2,441				
Cropland pasture	431	431	431	431				
Miscellaneous crops	1,867	1,867	1,867	1,867				
Hay harvested	187	182	176	176				
Fallow in	9,472	9,472	11,126	11,396	12,367	12,371	14,162	14,432
unused	4,710	4,714	6,439	6,709	4,710	4,714	6,348	6,618
out	12,367	12,371	14,162	14,432	9,472	9,472	11,035	11,305
Beef Cattle Activity				1,000 Head				
Cow herd	943	941	901	903	978	957	921	921
Replacements	324	264	264	264	324	288	286	286
Stockers	273	273	273	273	273	273	273	273
Total[4]	1,540	1,478	1,438	1,440	1,575	1,518	1,480	1,480
Interaction Activity				1,000,000 Pounds TDN				
Range use	888	922	942	952	732	698	678	668
Forage use	712	586	372	363	1,684	1,620	1,517	1,559
Fodder use	281	300	290	290	332	219	310	307
Hay use					263	256	247	247
Total	1,881	1,808	1,604	1,605	3,011	2,893	2,752	2,781

[1]Assumed benchmark selling price levels, based on 1970-74 average prices for the region.

[2]Benchmark prices multiplied by the factor indicated.

[3]Acres available for harvest.

[4]This total does not include unweaned calves.

exploited. The most profitable alternative was to maintain the cow herd with small grain grazing in the spring and summer range while devoting summer cropland pasture to feed grain and miscellaneous crops.

Cropland pasture and miscellaneous crops remained at upper bounds (431,000 and 1,867,000 acres, respectively) throughout the run. Hay production became smaller as prices increased but also remained stable throughout the run.

The regional model elected to maintain more land in fallow at higher prices, which was permitted because of lessened beef cattle operations. This called for less hay, as was noted above, and also for less forage. As small grain prices permitted more profit per acre, the desirability of maintaining sufficient wheat grazeout to support the cow herd began to disappear.

Beef cattle numbers went quickly to levels dictated by crop prices and remained stable throughout the remainder of the run. The optimum number for beef cows in the summer period ranged from about 940,000 head downward to about 900,000 head as crop prices increased. The comparable rnage for the winter period, as given in Table XIII, ranged from near 980,000 to just over 920,000 head.

Replacement and stocker inventory levels also appear in Table XIII. As in the previous analysis, stocker numbers remained at lower bounds, reflecting the unattractive profit position of the assumed costs and prices. Replacement numbers were consistent with adjustments in the cow herd, as discussed above. Cumulative values for all five production periods in the consumption of range, forage and fodder are shown in Table XIV. All values appear consistent with the conclusions drawn above. Range usage shifted between periods, but all available range was used. Forage, fodder and hay consumption declined by thirteen, four and eleven percent, respectively at the extreme price differences. The intermediate values for the adjustment path are given in the table. This is consistent with the seven percent difference in beef cattle numbers in the final production period, as computed from Table XIII.

TABLE XIV

CUMULATIVE RANGE, FORAGE AND FODDER USE, FOUR CROP PRICE LEVELS, WHEAT-BEEF MODEL

	1.0	1.2	1.6	2.0
		1,000,000 tdn.		
Range use	40,643	40,643	40,643	40,643
Forage use	6,652	6,307	5,530	5,754
Fodder use	1,770	1,750	1,714	1,705
Hay use	805	793	719	719

Interaction activities were in less demand as beef cattle declined at higher crop prices. Summer range production became more valuable as grazeout activity was reduced; this was also true of fodder coming from summer period residues.

It should be noted that the levels of graze-out activity more nearly approach real world levels. The rationale within the model is that the alternative for planting summer cash crops has been removed because of acreage restrictions. Dry weather in the Southern Great Plains could have such an effect in two ways: (1) Insufficient moisture would be available for summer crops, and (2) existing crops might be reduced to serving as salvageable grazing for cattle on hand.

As discussed in the earlier section dealing with a general increase in all selling prices, stocker cattle activities played little part in the optimized values. Only because they were constrained on the lower side were they included. Evidence in runs of the model to this point indicates that the assumed price-cost structure is not conductive to pasturing purchased stocker cattle. Ignoring land, management, and risk charges in the model accounts for part of this. As was noted earlier, the objective function values on the transfer activities are discounted streams of net revenue. Short-run activities, like stocker cattle, ignore fewer overhead costs than longer-run cow and replacement enterprises. Since the influence of particular beef prices was unclear, it was decided to make several runs of the regional model at selected prices, holding crop prices constant. This is the topic for the next section.

Beef Price Variations

In order to capture the effects of selected beef prices on cropping activities, the regional model was constrained to allow cow herds to build only to a level permitted by retaining replacement heifers annually not to exceed 20 percent of the cow herd. Crops were limited only to cropland available.

Transfer of cropland from summer to winter activities, or vice-versa, is accomplished in the model by transferring fallow land on to the subsequent period in lieu of planting to a current crop. Such action may be contrary to the objective of maximizing short-run profits; hence, land transfers within the model do not occur rapidly.

Results of the alternative beef price runs appear in Table XV. In addition to the benchmark run, as discussed originally in the section on a general price increase, runs were made at 80, 160 and 200 percent of benchmark beef cattle prices. The results are consistent with an increasing advantage of beef cattle over cash crops.

Summer cropping changes were centered around the disappearance of feed grains and miscellaneous crops, as beef prices were increased. In both the first and second summers, 2.0 prices reduced miscellaneous crop levels to about one-sixth where they had been in both the .8 and benchmark runs. Table XV shows the earlier summers reduction fell from about 3.9 million acres to 531,000. During that same period, cropland devoted to feed grains was reduced from 6.5 down to 3.7 million acres.

Most of the released land was transferred out of the summer period as unused fallow, to be planted later in the year to small grains. This, in turn, freed rangeland normally held for winter use.

Winter cropping increased substantially. When prices were applied to a factor of 2.0, small grain acreage rose from 7.5 to 11.9 million acres by the third winter. This was an increase of 63 percent, markedly greater than the 25 percent increase achieved at benchmark prices. The additional value in beef cattle prices translated into additional value for small grain because of its forage producing ability.

Beef cattle operations behaved in a manner consistent with small grain acreage. The table shows that winter stocker numbers grew from 319,000 to 882,000 between the second and third winters, this at 2.0

TABLE XV

HARVESTED ACRES, BEEF CATTLE INVENTORIES AND INTERACTION ACTIVITIES SELECTED BEEF CATTLE PRICES, WHEAT-BEEF MODEL

Activity	Winter 1				Summer 1				Winter 2			
	.8[2]	BM[1]	1.6[2]	2.0[2]	.8	BM	1.6	2.0	.8	BM	1.6	2.0
Cropping Activity					1,000 Acres							
Small grain[3]	7,526	7,526	7,526	7,526					9,258	9,258	10,361	11,891
Small harvested					2,189	2,189	1,716	1,511				
Small grazed out					5,337	5,337	5,810	6,015				
Feed grain					6,526	6,526	4,318	3,659				
Cropland pasture					0	0	112	157				
Miscellaneous crops					3,909	3,645	1,867	531				
Hay harvested					53	53	53	69				
Fallow in	14,071	14,071	14,071	14,071	11,593	11,593	11,593	11,593	9,258	9,258	10,361	11,891
unused	6,545	6,545	6,545	6,545	1,732	1,732	2,835	4,365	522	0	0	0
out	11,593	11,593	11,593	11,593	9,258	9,258	10,361	11,891	9,957	9,861	6,350	4,416
Beef Cattle Activity					1,000 Head							
Cow herd	1,074	1,074	1,074	1,074	885	885	901	901	921	921	921	921
Replacements	307	307	296	281	318	318	264	264	264	264	264	241
Stockers	803	803	803	803	269	273	312	419	273	273	273	319
Total[4]	2,184	2,184	2,173	2,158	1,472	1,476	1,477	1,584	1,458	1,458	1,458	1,481
Interaction Activity					1,000,000 Pounds TDN							
Range use	972	972	972	972	532	532	784	795	1,088	1,088	836	825
Forage use	1,682	1,682	1,569	1,517	838	838	631	736	954	946	1,193	1,179
Fodder use	522	522	522	522	278	278	283	290	361	363	369	371
Hay use	281	281	281	242	-	-	-	-	115	115	116	157
Total	3,457	3,457	3,344	3,253	1,648	1,648	1,698	1,821	2,518	2,512	2,514	2,532

TABLE XV (CONTINUED)

Activity	Summer[2] .8	Summer[2] BM	Summer[2] 1.6	Summer[2] 2.0	Winter[3] .8	Winter[3] BM	Winter[3] 1.6	Winter[3] 2.0
<u>Cropping Activity</u>					1,000 Acres			
Small grain[3]					9,410	10,329	10,360	11,889
Small harvested	0	0	0	0				
Small grazed out	9,258	9,258	8,029	11,891				
Feed Grain	4,434	4,434	2,602	0				
Cropland pasture	0	0	560	966				
Miscellaneous crops	4,808	4,712	1,755	531				
Hay harvested	115	115	401	584				
Fallow in	9,957	9,861	6,350	4,416	9,410	10,329	10,360	11,889
unused	840	1,071	412	26	0	0	0	0
out		10,329			9,824	8,790	6,792	5,043
<u>Beef Cattle Activity</u>					1,000 Head			
Cow herd	902	902	902	902	921	921	921	921
Replacements	288	288	288	288	264	264	264	264
Stockers	270	273	327	385	273	273	875	882
Total[4]	1,460	1,463	1,517	1,575	1,458	1,458	2,064	2,067
<u>Interaction Activity</u>					1,000,000 Pounds TDN			
Range use	679	679	947	968	941	941	673	652
Forage use	647	655	464	477	1,154	1,167	1,969	1,951
Fodder use	294	294	291	286	269	269	361	405
Hay use	-	-	-	-	161	162	196	198
Total	1,620	1,628	1,702	1,731	2,525	2,539	3,199	3,206

[1]Based on 1970-74 prices. Crop constraints imposed only on initial production period.

[2]Benchmark prices increased by 40 percent

[3]Acres available for harvest

[4]This total does not include unweaned calves.

prices. Comparable benchmark values had shown no growth. Summer stocker activity fell somewhat, however, as cropping patterns changed. As Table XV indicates, 2.0 stocker numbers were 419,000 during the first summer and only 385,000 a year later.

Measures of interaction between beef cattle and crops were mixed. All range production is utilized, although it moves from winter to summer use, contrary to the cropping adjustments. By the final period in each run, benchmark prices dictated that 58 percent of the range production be consumed in the winter period. At 2.0 prices, the optimum solution called for only 40 percent to be utilized as winter forage. Forage consumption complemented the use of range declining somewhat in summer and increasing sharply in winter as prices moved higher.

The results of increasing beef prices emphasize the dependence of beef cattle production on cropping patterns. The emphasis on the use of stocker cattle operations to expand beef output suggests that native ranges historically have been fully grazed and that major grazing adjustments in the study area will occur in the fall and winter months.

CHAPTER V

WHEAT-BEEF INTERACTION: ENVIRONMENTAL AND INSTITUTIONAL STIMULI

In addition to price phenomena, environmental and institutional stimuli also profoundly influence wheat-beef production patterns. Weather is recognized by Great Plains producers as being the most important risk element they face. Commodity control programs of the U. S. Department of Agriculture often limit the alternatives available to the farmers. Other forces, some of them cyclical like the cattle cycle, and some of them sporadic such as monetary revaluation, must be contended with.

Weather Influences

The immediate effect of weather is upon yield, although at the macro level there may be price effects. As the passage of time is considered, the influence of weather patterns must be examined -- that is, the particular sequence of weather phenomena.

The regional model was tested using five selected weather patterns. Three of the variations called for "good" and "poor" weather in alternative combinations; the other two were designed to explore the effects of dry weather at different points in the time sequence. The yields used to simulate weather conditions were presented in Table VIII of Chapter III.

Weather Patterns

The three combinations of good and poor weather were run after a benchmark run, in which all five periods experienced normal weather. The three sequences were: (1) bad-bad-bad-bad-bad, (2) bad-bad-normal-good-good, and (3) good-good-normal-bad-bad. Runs (1) and (2) were not viable; the system was unable to produce enough feed to support the livestock at the levels which were forced into the initial solution. Both runs went infeasible at that point. Run (3), however, optimized throughout the five-period time span. The comparison available for analysis, then, is between the benchmark run and run (3), which opened with two periods of good weather followed by one normal period and then closed with three successive periods of poor growing conditions.

Constraints were minimal. Beginning beef cattle inventories were set; this was also true for crops. The only other limitations were the upper and lower bounds set on terminal transfer activities, which has been true for all runs in this analysis.

Three separate evaluations can be made with respect to the two runs. An individual analysis can be made of each run as it passes through time, or the two runs can be compared at different points in the sequence. Selected acreage, feedstuff use, and inventory values from both runs appear in Table XVI. The comparative differences are also presented. Information from the initial solution, that is, the first winter period, is not included because the fixed inventory values held differences to near zero.

Wheat Acreage. As in previous analyses, the benchmark assumptions led to increased small grain emphasis and, until cattle numbers were

TABLE XVI

PRODUCTION AND INVENTORY ANALYSIS, SELECTED WEATHER PATTERNS, WHEAT-BEEF MODEL

		Summer 1			Winter 2		
		Benchmark	Run 3		Benchmark	Run 3	
Commodity	Units	NNNNN	GGNBBB	Difference	NNNNN	GGNBBB	Difference
Cropping Activity							
Small grain, planted	1,000 ac.				9,258	4,047	-5,211
harvested	1,000 ac.	2,189	1,546	-643			
graze-out	1,000 ac.	5,337	5,606	+269			
Feed grain	1,000 ac.	6,526	6,448	- 78			
Cropland pasture		0	0	-			
Miscellaneous crops		3,645	4,038	+393			
Hay harvested		83	59	- 24			
Beef Cattle Activity							
Cow herd	1,000 hd.	884	885	+ 1	921	922	+ 1
Replacements	1,000 hd.	318	318	-	264	264	-
Stockers	1,000 hd.	273	0	-	273	273	-
Total		1,475	1,203	-272	1,458	1,464	+ 6
Interaction Activity							
Hay use	1M TDN				115	115	-
Range use	1M TDN	532	532	-	1,088	1,088	-
Forage use	1M TDN	838	762	- 76	946	946	-
Fodder use	1M TDN	278	269	- 9	363	363	-
Total		1,648	1,563	- 85	2,512	2,512	-

TABLE XVI (CONTINUED)

Commodity	Summer 2			Winter 3		
	Benchmark	Run 3		Benchmark	Run 3	
	NNNNN	GGNBBB	Difference	NNNNN	GGNBBB	Difference
Cropping Activity						
Small grain, planted				10,329	9,976	-353
harvested	0	0	-			
graze-out	9,258	4,047	-5,211			
Feed grain	4,434	0	-4,434			
Cropland pasture	0	5,739	+5,739			
Miscellaneous crops	4,712	3,610	-1,102			
Hay harvested	115	148	+ 33			
Beef Cattle Activity						
Cow herd	902	902	+ 5	921	920	- 1
Replacements	288	264	- 24	264	264	- -
Stockers	0	0	-	273	258	- 15
Total	1,190	1,171	- 19	1,458	1,442	- 16
Interaction Activity						
Hay use				162	205	+ 43
Range use	679	532	- 147	941	1,090	+149
Forage use	6,552	1,115	+ 460	1,167	787	-380
Fodder use	294	291	- 3	269	419	+150
Total	7,525	1,938	-5,587	2,539	2,501	- 38

reduced and more winter grazing made available, to heavy graze-out operations in the spring. Table XVI shows that marginal growing conditions in the second summer and third winter period hampered the influence of small grain in the production plan over time. This was particularly true during the second winter. Thus, the benchmark solution showed 9.26 million acres of small grains the second winter, while the variable weather pattern called for 5.21 million less.

Why were the poorer weather conditions blocking faster increases in wheat acreages? The answer lies in the inability of the model to account for factors which lay behind the planning horizons. This is consistent with agricultural planning, especially in high-risk areas.

When the second winter was optimized, the weather for that period, which was normal for both runs, plus the expected weather of the following period, was considered. In the case of the variable weather pattern, poorer weather was anticipated, unlike the normal weather expected in the benchmark run. As a result, wheat plantings were reduced to allow for cropland pasture in the coming season. What the model could not see was how prospects would look after the commitment to more or less wheat was made.

Results for the following period, the second summer, reflect the cropland pasture commitment. Benchmark conditions required no summer forage to be planted on cropland; poorer weather called in 8.5 million acres of such forage. Not only was cropland pasture necessary, but low yields made it even higher. So, the cropping repercussions, which flowed from the poor weather anticipated during the second summer, began with reduced wheat seeding the previous winter and carried through to increased wheat seeding the following winter.

By the third winter, wheat seedings for harvest increased in both runs; and most of the disparity between the two had been closed. The difference, however, was still in excess of 350,000 acres, as Table XVI shows.

Wheat Grazing. The proportion of wheat harvested conventionally increased under poor weather conditions, although much less wheat was available. The benchmark acreage was all consumed by grazing. When weather caused wheat acreage to be reduced and land to be shifted forward into cropland pasture and feed grain the following summer, there was less need for spring forages. By the second summer, Table XVI shows all 9.26 million acres of wheat grazed out under benchmark conditions. In contrast, the variable weather called for only 111,000 acres grazed out on the much smaller 4.05 million acre crop. All grazed-out wheat was grown under irrigation.

Other Crops. By the second summer the model had freed itself of most of the constraints which had been initially imposed upon cropland use. Cropland pasture was called for in both runs, but was used much more extensively under adverse weather, as was pointed out in the previous section. Utilization was at 2.11 million acres for benchmark needs but had to be increased to 8.52 million acres under the variable weather patterns.

Feed grain acreage also continued to increase in both sets of solutions. Of course, the increase was not so fast as weather conditions worsened, since cropland pasture competes with feed grains for the land resource. Table XVI shows that feed grain acreage in the second summer was 7.94 million acres under benchmark assumptions, while poorer weather dictated only 7.33 million acres.

Miscellaneous crops were not a factor at the assumed prices and costs; they would have been less so as weather condition worsened. More acreage had to be devoted to necessary hay production. Consumption requirements called in 83,000 acres the second winter; and the comparable value a year later was 115,000 acres with the normal weather of the benchmark format and 146,000 acres under poor weather.

Beef Cattle Changes. Lower levels of prices in Chapter IV held beef cattle inventories at levels required when replacements sought their lower bounds; the same was true for the weather investigations. Under such conditions, the options were to let the model seek a lower bound with beef cattle and obtain the fluctuations among crops or to hold crop acreages to some level and release bounds on beef. It was decided that the former alternative was the more realistic, since cattle owners resist decreasing their inventories when feed is available and prices are good.

Cow numbers stabilized very soon under the assumed conditions, fluctuating from their 900,000 in summer to about 920,000 head in winter. Sales of calves, replacement heifers, and older cows tended to rise in winter and diminish in summer as weather worsened. This is consistent with cropping patterns.

Weather Timing

In the previous analysis, no reference was made to the cumulative effect of weather patterns on production. However, since forces causing adjustment sent processes into motion which subside only through time, it follows that the timing of such forces could influence cumulative production.

In order to test the timing effect of aberrations in weather, two runs were made which were identical in all but one feature. The runs enjoyed normal weather throughout; except in that one period, the weather reverted to poor. However, in one run (#4) the poor weather came during the second winter; while in the other run (#5), it came one period later, the following summer. The two runs will be referred to as having either adverse winter weather or adverse summer weather. Table XVII gives a summary of the two runs.

Cropping Activity. Although wheat acreage had little chance to adjust in the first summer, that proportion which was grazed out changed considerably. The optimal plan for the period considered expectations for the coming winter, the production period in which the dry weather was experienced. The results show that 3.74 million acres of small grain, or 49 percent of the total, were grazed out. With poor weather coming one period later, 71 percent of the crop was consumed by grazing.

With the arrival of the second winter period, the amount of wheat seeded was affected, dropping from 10.51 million acres to 4.05 million acres; and the onset of dry weather was delayed. As encountered in earlier analyses, the land was moved forward to provide cropland pasture for the following summer.

Graze-out operations in the second summer adopted the same pattern as a year earlier, but the effect of poor weather was even greater. When poor growing conditions came in summer, the graze-out acreage increased from 40 percent to 100 percent.

Feed grain activity in the two summer periods was little affected when the poor growing conditions came in wintertime; this is not contrary to what might be expected. Table XVII shows that acreage rose from 5.08

TABLE XVII

TIMING OF ADVERSE WEATHER,
WHEAT-BEEF MODEL

Commodity	Summer 1			Winter 2		
	Run #4	Run #5	Change	Run #4	Run #5	Change
<u>Cropping Activity</u>						
Small grain, planted				10,509	4,047	-6,462
harvested	3,790	2,189	-1,601			
graze-out	3,736	5,336	+1,600			
Feed grain	5,083	6,526	+1,443			
Cropland pasture	179	0	- 179			
Miscellaneous crops	3,607	3,645	+ 38			
Hay harvested	119	54	- 65			
<u>Beef Cattle Activity</u>						
Cow herd	884	885	+ 1	921	922	+ 1
Replacements	264	318	+ 54	264	264	-
Stockers	273	273	-	273	273	-
Total	1,421	1,476	+ 55	1,458	1,459	+ 1
<u>Interaction Activity</u>						
Hay, used				208	117	- 91
Range use	532	532	-	1,088	1,088	-
Forage use	818	338	- 480	798	946	+ 148
Fodder use	298	278	- 20	419	363	- 56
Total	1,648	1,148	- 500	2,513	2,514	+ 1

TABLE XVII (CONTINUED)

Commodity	Summer 2 Run #4	Summer 2 Run #5	Summer 2 Change	Winter 3 Run #4	Winter 3 Run #5	Winter 3 Change
Cropping Activity						
Small grain, planted				10,509	10,930	+421
harvested	6,304	0	-6,304			
graze-out	4,204	4,047	- 157			
Feed grain	5,290	0	-5,290			
Cropland pasture	0	5,043	+5,043			
Miscellaneous crops	3,588	3,900	+ 312			
Hay, harvested	91	140	+ 49			
Beef Cattle Activity						
Cow herd	903	905	+ 2	920	921	+ 1
Replacements	264	264	-	264	264	-
Stockers	273	273	-	273	273	-
Total	1,440	1,442	+ 2	1,457	1,458	+ 1
Interaction Activity						
Hay, used				128	197	+ 69
Range use	532	790	+ 258	1,088	829	-259
Forage use	803	1,014	+ 211	1,003	1,162	+159
Fodder use	295	291	- 4	301	368	+ 67
Total	1,630	2,095	+ 465	2,520	2,556	+ 36

million acres during the first summer to 5.29 million one year later. The response was very pronounced, however, when the poor growing conditions initiated a period later, in summertime, planting fell from 6.53 million acres to zero. Feed grain planting in the earlier summer at 5.08 million acres reflected normal prospects for the coming winter; when the expectations for the future period dimmed, summer cropland committed to feed grain rose to 6.53 million acres.

Cropland pastures, since they are complements with graze-out acres in the production of summer forage, responsed to the dry weather in a similar manner. Consequently, the table shows that cropland pasture also exactly replaced feed grain during the second summer when the dry weather occurs during that time.

Miscellaneous crops were little affected by the dry weather phenomena, holding a stable pattern throughout both runs between 3.5 and 4.0 million acres. Winter hay needs did require more acres as weather conditions worsened during the summer growing season, but total hay acreage requirements have never been large for the topics covered thus far in the study.

As mentioned above, beef cattle operations were confined to near levels required by the lower bounds which were in effect on replacements for both runs. It follows that the use of range, forage, and fodder varied little in total. Dry weather coming in the winter period caused little effect on range use, since winter use of range under benchmark assumptions tended to be heavy. As Table XVII pictures, the arid conditions which came later in summer shifted rangeland back to summer use, moving between bounds from 10.5 million acres in the first instance to 8.0 million in the later period.

Commodity Program Influences

Supply control programs of the U. S. Department of Agriculture, since their inception of the 1930's, have taken many forms. The various effects caused, or thought to be caused, by farm programs have been the topics for numerous research efforts (93, 123).

The commodity programs were simulated in the analytical model, one curtailing the acreage and raising the price of wheat, and one doing the same for feed grains.

Wheat Program Activities

The results are shown in Table XVIII and are contrasted with the benchmark run. Again, the first winter's solution is eliminated because the differences were minimal. For the wheat supply control investigation, wheat acreage was restricted to 55 percent of historical value; and prices were set up 1.2 times the benchmark price.

In summary, so long as cattle numbers remain high, any curtailment of wheat planting placed a premium on wheat grazing. The amount of wheat graze-out increased greatly, from 1.13 to 3.36 million acres in the first summer and from 1.15 to 3.30 in the second, even though total wheat seeding was much lower. Feed grain acreage did increase by 34 percent in the first summer and 36 percent a year later. Cropland pasture was never a factor, and miscellaneous crops were virtually unaffected; winter hay consumption declined slightly in both years.

Range use was much lower in summer and higher in winter under the wheat program. The rangeland shifts were necessary because of lower production of winter forage. There were no changes in beef cattle activities.

TABLE XVIII

WHEAT PROGRAM ACTIVITY, WHEAT-BEEF MODEL

Commodity	Units	Summer 1		Winter 2	
		Benchmark	Wheat Program	Benchmark	Wheat Program
Cropping Activity					
Small grain, planted	1,000 ac.			11,408	6,320
harvested	1,000 ac.	6,499	4,277		
graze-out	1,000 ac.	1,132	3,355		
Feed grain	1,000 ac.	4,446	5,947		
Cropland pasture	1,000 ac.	0	0		
Miscellaneous crops	1,000 ac.	3,527	3,532		
Hay, harvested	1,000 ac.	91	65		
Beef Cattle Activity					
Cow herd	1,000 hd.	885	885	921	921
Replacements	1,000 hd.	318	319	264	264
Stockers	1,000 hd.	273	273	273	273
Total		1,481	1,482	1,458	1,458
Interaction Activity					
Hay, used	1M TDN			167	131
Range use	1M TDN	697	579	973	1,042
Forage use	1M TDN	653	771	1,193	1,017
Fodder use	1M TDN	298	298	258	333
Total		1,648	1,648	2,591	2,523

TABLE XVIII (CONTINUED)

Commodity	Summer 2 Benchmark	Summer 2 Wheat Program	Winter 3 Benchmark	Winter 3 Wheat Program
Cropping Activity				
Small grain, planted			11,409	6,320
harvested	10,259	3,017		
graze-out	1,150	3,304		
Feed grain	4,442	6,027		
Cropland pasture	0	0		
Miscellaneous crops	3,502	3,539		
Hay, harvested	116	92		
Beef Cattle Activity				
Cow herd	902	902	921	920
Replacements	288	264	264	264
Stockers	273	273	273	273
Total	1,468	1,439	1,458	1,457
Interaction Activity				
Hay, used			163	129
Range use	672	572	948	105
Forage use	662	762	1,111	1,007
Fodder use	294	295	257	337
Total	1,628	1,629	2,479	1,578

Feed Grain Program Activity

The feed grain program run is contrasted with benchmark values in Table XIX. As with the wheat program, acreage constraints were set at 55 percent of historical level; and prices were increased by 20 percent.

With wheat allowed to come in at any level and feed grains severely curtailed, almost all cropland was planted to wheat. Very little adjustment was made in acreages of other crops; the ratio of range, forage, and fodder consumed from season to season also remained stable. In short, the results of the two runs indicate that imposition of a feed grain commodity program would have less effect on beef cattle or other crops than a similar program for wheat.

TABLE XIX

FEED GRAIN PROGRAM ACTIVITY, WHEAT-BEEF MODEL

Commodity	Units	Summer 1 Benchmark	Summer 1 Feed Grain Program	Winter 2 Benchmark	Winter 2 Feed Grain Program
Cropping Activity					
Small grain, planted	1,000 ac.			11,408	15,020
harvested	1,000 ac.	6,499	4,340		
graze-out	1,000 ac.	1,132	3,292		
Feed grain	1,000 ac.	4,446	824		
Cropland pasture	1,000 ac.	0	0		
Miscellaneous crops	1,000 ac.	3,527	3,524		
Hay, harvested	1,000 ac.	91	102		
Beef Cattle Activity					
Cow herd	1,000 hd.	885	884	921	921
Replacements	1,000 hd.	318	264	264	264
Stockers	1,000 hd.	273	273	273	273
Total		1,476	1,421	1,458	1,458
Interaction Activity					
Hay, used	1M TDN			167	184
Range use	1M TDN	697	532	923	1,088
Forage use	1M TDN	653	818	1,193	1,193
Fodder use	1M TDN	298	298	258	76
Total		1,648	1,648	2,541	2,541

TABLE XIX (CONTINUED)

Commodity	Summer 2 Benchmark	Summer 2 Feed Grain Program	Winter 3 Benchmark	Winter 3 Feed Grain Program
Cropping Activity				
Small grain, planted			11,409	15,020
harvested	10,259	12,127		
graze-out	1,150	2,894		
Feed grain	4,442	820		
Cropland pasture	0	0		
Miscellaneous crops	3,502	3,497		
Hay, harvested	116	131		
Beef Cattle Activity				
Cow herd	902	902	921	921
Replacements	288	288	264	264
Stockers	273	273	273	273
Total	1,463	1,463	1,458	1,458
Interaction Activity				
Hay, used			163	184
Range use	672	946	98	1,088
Forage use	662	803	1,171	1,192
Fodder use	294	295	257	76
Total	1,628	2,044	1,689	2,540

CHAPTER VI

SUMMARY AND CONCLUSIONS

Recent changes in both domestic and foreign demand have reduced traditionally large U. S. grainstocks. Consumer acceptance of meat products has continued strong, but organized resistance has manifested itself at very high price levels. Under such conditions, typical supply control programs of the U. S. Department of Agriculture, in use since the 1930's, tend to be misdirected; U. S. supply capacity is being challenged.

Most U. S. farmers produce more than a single commodity. These products compete for resources, which make their interrelationship increase in importance as this competition becomes sharper. There is a need for developing a system which will analyze these interactions at an aggregate level and pursue their interplay through time.

Producers in the Southern Great Plains have two major crops: wheat and beef cattle. Not only is there competition for resources; but, in its growing stage, wheat serves as an intermediate product in the production of beef.

Wheat-Beef Parameters

The frequency with which productive grazing seasons occur is paramount in the determination of the winter grazing area. This frequency is affected by rainfall, either too little or too much; by soil conditions; by planting dates and by the onset of cold temperatures.

Another important descriptive characteristic concerns the utilization of available wheat plants for grazing. Attitudes of producers are involved, which include the training and experience necessary for keeping livestock, traditions, marketing and transportation facilities for beef animals and beliefs concerning the effect of grazing upon grain yields.

The type of cattle which grazes winter wheat identifies other facets of the wheat-beef picture. Stocker cattle operations are more common in the areas which are heavily utilized. The presence of brood cow operations; the dependability of wheat as a winter feed; the size of wheat fields and the availability of fences, water and working facilities all exert an influence.

The key hindrances to change in present wheat-beef grazing patterns are closely allied to these descriptive measures and center around financing barriers, producer attitudes and logistical problems.

The Analytical Model

A recursive programming model, utilizing a dynamic linear programming format was developed to evaluate regional interaction between wheat and beef in the Southern Great Plains. Features of the model, discussion of the results and additional implications are presented in the following sections.

The model encompassed a dynamic linear programming format containing six production periods, each of which approximated six months time. The periods were delineated at times crucial to the wheat-beef production process. A recursive operator optimized across two periods simultaneously, sequentially moving forward one period at each new solution, thus permitting both a slightly extended planning horizon and a unique optimization at each period. Subsequent solutions were linked by carryovers of crop and beef cattle inventories.

The area chosen for analysis is the heart of the winter wheat grazing area and consists of the panhandles of Oklahoma and Texas and adjacent areas to the north in Colorado and Kansas. Principal crops, which were grouped according to their contribution to beef cattle production, were: (1) small grains, (2) feed grains, (3) cropland pasture, (4) miscellaneous crops, and (5) hay. Rangeland covers almost half the available area and was incorporated into the model.

Discussion of Results

Topics selected for analysis were presented in two sections. Price induced changes were investigated first; the topics included an increase in the general level of selling price, variation in crop prices, and selected changes in beef prices. Environmental and institutional forces which promote change were also explored. They included analysis of weather patterns, the timing of weather changes and imposition of commodity control programs, one each for wheat and feed grains.

In all analyses, interdependence of wheat and beef cattle activities was important. In order for optimizing adjustments to occur, a particular sequence of operational changes was necessary. The needed changes frequently had to wait on reductions in beef numbers and shifts in land use. The specific adjustments are outlined below.

Price Adjustments

A proportional increase in selling prices caused subtle changes in the relative profitability of competing activities. The substitution of crops for forage crops was less frequent at higher prices. At benchmark prices feed grain acreage declined from 6.5 million acres to 4.4 million acres between the first and second summers, 54 percent of which was replaced by miscellaneous crops and hay. Winter forage crops consumed the remaining cropland. At the higher prices, feed grain and miscellaneous summer acreage remained unchanged. This was also true for winter small grain crops.

Interaction activities (range, forage, fodder and hay use) were lower in both the first and second summers at the higher price levels, reflecting the decreased influence of beef cattle operations. Winter beef cattle consumption patterns were unaffected. The model found wheat to be an efficient producer of forage, including not only conventional grazing practices but also spring graze-out operations.

Increased prices also drove the model toward equilibrium levels of cattle and crops more quickly. At benchmark prices, approximate equilibrium was attained in the second summer but higher selling prices caused a similar solution a full production period earlier. The model showed increased profitability through time at both price levels.

The income implication is that not only are higher prices more profitable, but that the adjustment comes more quickly. Forage needs were met by increased graze-out operations on wheat in the summer period and by increased range use in winter. Cumulative acreage of wheat production changed little as prices increased, but profitability of graze-out practices was reduced substantially. Feed grain acreage increased about 20 percent, while acres devoted to miscellaneous crops declined. Additional beef cattle activities were not encouraged.

Selected increases in the prices of cash crops placed a premium on summer range use by virtue of the reduced competitive position of summer pasture crops. Forage use from winter crops also declined. The only significant increases in crop production occurred in irrigated wheat; irrigated feed grain declined slightly. Cumulative totals of production across the time span showed decreases in range, forage, and fodder use. The beef herd size was affected. As crop prices increased, cow numbers fell by 5 percent.

Alternative beef prices, ranging from .8 to 2.0 of benchmark levels, were applied simultaneously across all classes of cattle. The price increases increased the profitability of cropland pasture over miscellaneous crops and placed a premium on small grain, particularly on graze-out operations, instead of conventional harvest methods. Most of the increased forage capability was utilized in the production of stocker cattle.

Environmental and Institutional Changes

Weather patterns, expressed as modifications in yields, caused significant cropping adjustments in the model. Poor weather during the first production period caused the model to go infeasible, since yields of feedstuffs were insufficient for beginning cattle inventories. When weather conditions progressed from good to bad through the time sequence, cash crop alternatives were replaced by cropland pasture and graze-out operations on small grains. The sequence necessary for maintaining forage production called for first releasing wheat land for summer forage; moving summer range use to winter use; and finally, to increasing wheat acreage. As forage-producing ability declined, beef cattle numbers were held to their lower bounds.

Timing of periods of dry weather were found to be important. Whether the poor weather fell in the summer or winter midway in the time sequence changed the way the model provided for necessary forage. When dry weather came in winter, forage shifts first had to go to graze-out and cropland pasture and then back to winter grazing. Curtailed growing conditions in summer had less effect on forage patterns. In both cases, production of the appropriate cash crops, either small grains in winter or feed grains and miscellaneous crops in summer, was reduced.

Commodity program activity encouraged production of the crop being controlled to the extent allotments permitted, but the deferred land was shifted to other uses. The wheat program moved range use to the winter period and increased summer forage production on cropland. The feed grain commodity control program had little effect on cropping patterns, since wheat pasture production was economically superior under assumed cost-price pattern.

Limitations of the Study

The limitations of linearity, additivity, and indivisibility are inherent to the linear programming process. The likelihood of aggregation error and specification error were discussed in Chapter II. In addition, the historical data used to represent certain production and right-hand-side coefficients may not, in fact, be truly representative of the study area.

Farm operators hold goals other than maximizing returns above variable cost. A combination of such goals is difficult to quantify in the objective function. To the extent that other goals take precedence over profits, the objective function is misspecified.

Groups of producing activities replaced separate enterprises in the model in order to simplify the interaction between beef and wheat. This has been a starting point; how individual livestock activities relate to individual crops is a much more complex process. The model continues many simplifications. To lay claim to the importance of specific values in the optimum solutions would be premature.

Objective function values were applied to transfer activities in order to set up an economic choice between selling and transferring forward certain classes of livestock and crops. Land and management costs are ignored for both values, yet one involves only a single period, while the other may cover multiple periods. The choice may not be a just one.

Solutions are simultaneously optimized across two periods but sequentially move ahead only one period. Any cumulative treatments of the optimized values, then, would involve double counting.

The assumed cost-price relationships usually did not lead to solutions which valued beef cattle activity; this is contrary to historical evidence. One explanation is that average 1970-74 prices were computed from highly variable data. Livestock producers have suffered much during these period.

Implication for Further Research

This study attempted to combine recursive programming with dynamic programming in order to better understand and predict aggregate supply response. It is viewed by some as primitive; needed refinement will have become obvious. Although the technique has been suggested by Day and others (26), the author could locate no working models.

The constraints placed on terminal transfer activities in the two-period dynamic linear programming format serve as non-rigid flexibility restraints. They served to bound beef herd numbers rather firmly. By moving to a three or more period format, perhaps more desirable restraints could have been achieved. The use of the technique to build restraints which respond to varying degrees of economic stimuli needs investigation.

Little effort has been made to incorporate livestock into complex supply-response models. The model illustrates it can be done, although it also points to the need for further development.

Investigation should be made into the need for adding additional detail. This includes increased length of run, broader delineation of enterprises, and more varied resource uses. The model used here is quite basic, yet detail often became a burden. Also, improved forms for displaying the results should be developed. The time dimension is difficult to discuss.

Stochastic weather generators are available which could be incorporated to the model. This would open the way for developing distributions of crop and livestock production. Additional use of ranging techniques would also be helpful for placing bounds on expected production.

In high-risk areas, planted acreage in poor years bears little resemblance to harvested acreage. In addition, small grain grazing in the winter season is sometimes the only production forthcoming. Conventional linear programming methodology is not obviously available to treat these phenomena adequately.

Finally, the scope of the study incorporated only the very heart of wheat-grazing lands. As shown in Chapter I, adjacent areas differ in competing crops, type of livestock activity, growing conditions, and attitudes of producers. The potential for developing additional wheat-grazing activity is perhaps better than in the study area. The possibility should be investigated.

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APPENDIX A

OKLAHOMA CROP BUDGETS USED TO DEVELOP COEFFICIENTS IN THE MODEL

TABLE XX

OKLAHOMA CROP BUDGETS USED TO DEVELOP COEFFICIENTS IN THE MODEL

Irrigated Alfalfa Hay
33" Irrigation Water Oklahoma Panhandle
Surface Irrigation

Category	Units	Price	Quantity	Value
Production:				
Alfalfa	Tons	35.000	6.500	227.50
Total Receipts				227.50
Operating Inputs:				
Alfalfa Seed	Lbs.	0.750	4.000	3.00
Seed Treatment	Acre	0.500	0.200	0.10
Nitrogen	Lbs.	0.140	2.000	0.28
Phosphate	Lbs.	0.125	20.000	2.50
Phosphate	Lbs.	0.125	100.000	12.50
Insecticide	Acre	6.740	1.000	6.74
Windrower	Acre	3.500	4.000	14.00
Baler	Bl.	0.170	195.000	33.15
Stacker	Bl.	0.120	195.000	23.40
Irrig & Chem Appl.	Acin	0.948	3.600	3.41
Tractor Fuel Cost	Acre			0.30
Tract Repair Cost	Acre			0.30
Tractor Lube Cost	Acre			0.04
Equip Repair Cost	Acre			0.34
Irrig Fuel Cost	Acre			8.05
Irrig Lube Cost	Acre			1.48
Irrig Repair Cost	Acre			3.69
Total Operating Cost				113.27
Returns to Land, Labor, Capital, Machinery, Overhead, Risk, and Management				114.23
Capital Cost:				
Annual Operating Capital		0.090	62.448	5.62
Tractor Investment		0.090	4.518	0.41
Equipment Investment		0.090	2.775	0.25
Irrigation System Investment		0.090	61.820	5.56
Total Interest Charge				11.84
Returns to Land, Labor, Machinery, Overhead, Risk and Management				102.39
Ownership Cost: (Depreciation, Taxes, Insurance)				
Tractor	Dol.			0.55
Equipment	Dol.			0.36
Irrigation System	Dol.			11.72
Total Ownership Cost				12.64
Returns to Land, Labor, Overhead, Risk and Management				89.75
Labor Cost:				
Machinery Labor	Hr.	2.000	0.463	0.93
Irrigation Labor	Hr.	2.000	6.626	13.25
Total Labor Cost				14.18
Returns to Land, Overhead, Risk and Management				

Surface Irrigation
400 Ft. Well, 275 Ft. Lift, 100 G.P.M., Nat. Gas .40 — 10/22/73 — Area: Peters, 10-30-73 A

Budget Identification Number --- 8110199001150 0
Annual Capital Month: 6
Date Printed: 10/22/73

TABLE XX (CONTINUED)

Irrigated Corn
Surface Irrigation
24 In. Irr. Water, Okla. Panhandle

Category	Units	Price	Quantity	Value
Production:				
Corn	Bu.	1.380	130.000	179.40
Grazing	Aums	0.0	1.400	0.0
Total Receipts				179.40
Operating Inputs:				
Corn Seed	Lbs.	0.520	20.000	10.40
Nitrogen	Lbs.	0.070	150.000	10.50
Nitrogen	Lbs.	0.140	50.000	7.00
Phosphate	Lbs.	0.125	40.000	5.00
Herbicide	Acre	5.630	1.000	5.63
Insecticide	Acre	7.110	1.000	7.11
Crop Insurance	Dol.	0.120	80.000	9.60
Custom Combine	Bu.	0.100	130.000	13.00
Custom Hauling	Bu.	0.080	130.000	10.40
Tractor Fuel Cost	Acre			1.35
Tract Repair Cost	Acre			1.35
Tractor Lube Cost	Acre			0.20
Equip Repair Cost	Acre			1.41
Irrig Fuel Cost	Acre			5.85
Irrig Lube Cost	Acre			1.07
Irrig Repair Cost	Acre			2.91
Total Operating Cost				92.79
Returns to Land, Labor, Capital, Machinery, Overhead, Risk, and Management				86.61
Capital Cost:				
Annual Operating Capital		0.090	34.512	3.11
Tractor Investment		0.090	20.401	1.84
Equipment Investment		0.090	14.787	1.33
Irrigation System Investment		0.090	61.840	5.57
Total Interest Charge				11.84
Returns to Land, Labor, Machinery, Overhead, Risk and Management				74.78
Ownership Cost: (Depreciation, Taxes, Insurance)				
Tractor	Dol.			2.49
Equipment	Dol.			2.30
Irrigation System	Dol.			11.72
Total Ownership Cost				16.52
Returns to Land, Labor, Overhead, Risk and Management				58.26
Labor Cost:				
Machinery Labor	Hr.	2.000	2.090	4.18
Irrigation Labor	Hr.	2.000	4.819	9.64
Total Labor Cost				13.82
Returns to Land, Overhead, Risk and Management				44.44

Surface Irrigation
350 Ft. Well, 250 Ft. Lift, 900 G.P.M. Nat. Gas .40

Area
Peters
10/22/73 10-30-73 A

Budget Identification Number --- 7210086001150 0
Annual Capital Month: 6
Date Printed: 10/22/73

TABLE XX (CONTINUED)

Irrigated Corn Silage
Surface Irrigation
Oklahoma Panhandle

Category	Units	Price	Quantity	Value
Production:				
Silage	Tons	6.750	20.000	135.00
Total Receipts				135.00
Operating Inputs:				
Silage Seed	Lbs.	0.260	20.000	5.20
Nitrogen	Lbs.	0.070	150.000	10.50
Nitrogen	Lbs.	0.140	50.000	7.00
Phosphate	Lbs.	0.125	40.000	5.00
Herbicide	Acre	5.630	1.000	5.63
Insecticide	Acre	7.110	1.000	7.11
Tractor Fuel Cost	Acre			1.21
Tract Repair Cost	Acre			1.21
Tractor Lube Cost	Acre			0.18
Equip Repair Cost	Acre			1.26
Irrig Fuel Cost	Acre			5.85
Irrig Lube Cost	Acre			1.07
Irrig Repair Cost	Acre			2.93
Total Operating Cost				54.17
Returns to Land, Labor, Capital, Machinery, Overhead, Risk, and Management				80.83
Capital Cost:				
Annual Operating Capital		0.090	20.232	1.82
Tractor Investment		0.090	18.313	1.65
Equipment Investment		0.090	13.461	1.21
Irrigation System Investment		0.090	61.840	5.57
Total Interest Charge				10.25
Returns to Land, Labor, Machinery, Overhead, Risk and Management				70.59
Ownership Cost: (Depreciation, Taxes, Insurance)				
Tractor	Dol.			2.24
Equipment	Dol.			2.06
Irrigation System	Dol.			11.72
Total Ownership Cost				16.03
Returns to Land, Labor, Overhead, Risk and Management				54.56
Labor Cost:				
Machinery Labor	Hr.	2.000	1.876	3.75
Irrigation Labor	Hr.	2.000	4.819	9.64
Total Labor Cost				13.39
Returns to Land, Overhead, Risk and Management				41.17

Surface Irrigation
350 Ft. Well, 250, 900 G.P.M., Nat. Gas .40 10/22/73

Area
Peters
10-30-73 A

Budget Identification Number --- 8610056001150 1
Annual Capital Month: 6
Date Printed: 10/22/73

TABLE XX (CONTINUED)

Grain Sorghum, Clay Dryland
Northwest Okla. and Okla. Panhandle

Category	Units	Price	Quantity	Value
Production:				
Milo	CWT.	2.340	11.000	25.74
Grazing	Aums	0.0	0.750	0.0
Total Receipts				25.74
Operating Inputs:				
Milo Seed	Lbs.	0.270	4.000	1.08
Insecticide	Acre	2.200	1.000	2.20
Crop Insurance	Dol.	0.060	20.000	1.20
Custom Combine	Acre	4.000	1.000	4.00
Custom Hauling	CWT.	0.080	11.000	0.88
Tractor Fuel Cost	Acre			0.78
Tract Repair Cost	Acre			0.78
Tractor Lube Cost	Acre			0.12
Equip Repair Cost	Acre			0.47
Total Operating Cost				11.50
Returns to Land, Labor, Capital, Machinery, Overhead, Risk, and Management				14.24
Capital Cost:				
Annual Operating Capital		0.090	5.900	0.53
Tractor Investment		0.090	11.701	1.05
Equipment Investment		0.090	7.805	0.70
Total Interest Charge				2.29
Returns to Land, Labor, Machinery, Overhead, Risk and Management				11.96
Ownership Cost: (Depreciation, Taxes, Insurance)				
Tractor	Dol.			1.43
Equipment	Dol.			1.22
Total Ownership Cost				2.64
Returns to Land, Labor, Overhead, Risk and Management				9.31
Labor Cost:				
Machinery Labor	Hr.	2.000	1.199	2.40
Total Labor Cost				2.40
Returns to Land, Overhead, Risk and Management				6.91

Dryland Northwest Okla. & Okla. Panhandle
Clay Soils
10/22/73

Area
Peters
10-30-73 A

Budget Identification Number --- 7310420501100 0
Annual Capital Month: 6
Date Printed: 10/22/73

TABLE XX (CONTINUED)

Irrigated Grain Sorghum 24 In. Irrigation Water
Surface Irrigation, Oklahoma Panhandle

Category	Units	Price	Quantity	Value
Production:				
Milo	CWT.	2.340	62.000	145.08
Sorghum Stubble	Aums	0.0	1.400	0.0
Total Receipts				145.08
Operating Inputs:				
Milo Seed	Lbs.	0.270	10.000	2.70
Nitrogen	Lbs.	0.070	125.000	8.75
Nitrogen	Lbs.	0.140	25.000	3.50
Herbicide	Acre	5.630	1.000	5.63
Insecticide	Acre	2.200	1.000	2.20
Crop Insurance	Dol.	0.060	80.000	4.80
Custom Combine	CWT.	0.120	62.000	7.44
Custom Hauling	CWT.	0.080	62.000	4.96
Tractor Fuel Cost	Acre			1.35
Tract Repair Cost	Acre			1.35
Tractor Lube Cost	Acre			0.20
Equip Repair Cost	Acre			1.41
Irrig Fuel Cost	Acre			5.85
Irrig Lube Cost	Acre			1.07
Irrig Repair Cost	Acre			2.91
Total Operating Cost				54.13
Returns to Land, Labor, Capital, Machinery, Overhead, Risk, and Management				90.95
Capital Cost:				
Annual Operating Capital		0.090	21.336	1.92
Tractor Investment		0.090	20.401	1.84
Equipment Investment		0.090	14.787	1.33
Irrigation System Investment		0.090	61.840	5.57
Total Interest Charge				10.65
Returns to Land, Labor, Machinery, Overhead, Risk and Management				80.30
Ownership Cost: (Depreciation, Taxes, Insurance)				
Tractor	Dol.			2.49
Equipment	Dol.			2.30
Irrigation System	Dol.			11.72
Total Ownership Cost				16.52
Returns to Land, Labor, Overhead, Risk and Management				63.79
Labor Cost:				
Machinery Labor	Hr.	2.000	2.090	4.18
Irrigation Labor	Hr.	2.000	4.819	9.64
Total Labor Cost				13.82
Returns to Land, Overhead, Risk and Management				49.97

Surface Irrigation		Area
400 Ft. Well, 275 Ft. Lift		Peters
1000 G.P.M. - Natural Gas	10/23/73	10-30-73 A

Budget Identification Number --- 7310116001150 0
Annual Capital Month: 6
Date Printed: 10/23/73

TABLE XX (CONTINUED)

Dryland Wheat
Oklahoma Panhandle

Category	Units	Price	Quantity	Value
Production:				
Wheat	Bu.	2.050	16.500	33.82
Grazing	AUMS	10.000	0.350	3.50
Total Receipts				37.32
Operating Inputs:				
Wheat Seed	Bu.	2.750	0.750	2.06
Crop Insurance	Dol.	0.120	15.000	1.80
Custom Combine	Acre	3.750	1.000	3.75
Custom Hauling	Bu.	0.080	16.500	1.32
Nitrogen	Lbs.	0.070	30.000	2.10
Tractor Fuel Cost	Acre			0.40
Tract Repair Cost	Acre			0.40
Tractor Lube Cost	Acre			0.06
Equip Repair Cost	Acre			0.59
Total Operating Cost				12.48
Returns to Land, Labor, Capital, Machinery, Overhead, Risk, and Management				24.84
Capital Cost:				
Annual Operating Capital		0.090	4.865	0.44
Tractor Investment		0.090	6.063	0.55
Equipment Investment		0.090	6.670	0.60
Total Interest Charge				1.58
Returns to Land, Labor, Machinery, Overhead, Risk and Management				23.26
Ownership Cost: (Depreciation, Taxes, Insurance)				
Tractor	Dol.			0.74
Equipment	Dol.			1.05
Total Ownership Cost				1.79
Returns to Land, Labor, Overhead, Risk and Management				21.47
Labor Cost:				
Machinery Labor	Hr.	2.000	0.621	1.24
Total Labor Cost				1.24
Returns to Land, Overhead, Risk and Management				20.23

Dryland — Area
Fertilizer 30-0-0 — Peters
10/22/73 — 10-30-73 A

Budget Identification Number --- 7610400001100 0
Annual Capital Month: 6
Date Printed: 10/22/73

APPENDIX B

NATIONAL RESEARCH COUNCIL SPECIFICATIONS ON NUTRIENT REQUIREMENTS OF BEEF CATTLE

TABLE XXI

NUTRIENT REQUIREMENTS OF BEEF CATTLE
(NUTRIENTS PER ANIMAL)

Body Weight	TDN (kg) Daily	TDN (lbs) Daily	TDN (lbs) Monthly	Factor
Young Cows				
Dry - 450 kg	3.4			
Nursing - 400 kg	5.3			
Average - 425 kg (937 lbs)	4.35	9.59	287.70	1.000
Old Cows				
Dry - 500 kg	3.8			
Nursing - 450 kg	5.6			
Average - 475 kg (1047 lbs)	4.70	10.36	310.80	1.0803
Replacement 1 - 175 kg 386 lbs, 1.1 gain/day	2.75	6.06	181.80	.6319
Replacement 2 - 250 kg 551 lbs, 1.1 gain/day	3.95	8.71	261.30	.9082
Replacement 3 - 350 kg 772 lbs, 1.1 gain/day	5.25	11.57	347.10	1.2065
Light Stocker Steer - 180 kg 397 lbs, 1.1 gain/day	2.78	6.13	183.90	.6392
Light Stocker Heifer - 170 kg 375 lbs, 1.1 gain/day	2.66	5.86	175.80	.6111
Heavy Stocker Steer - 255 kg 562 lbs, 1.1 gain/day	3.82	8.42	252.60	.8780
Heavy Stocker Heifer 540 lbs, 1.1 gain/day	3.79	8.36	250.80	.8717

Source: Nutrient Requirements of Beef Cattle, National Research Council, Washington, D.C.

APPENDIX C

SELECTED COMPOSITION OF FEEDS COMMONLY USED IN BEEF CATTLE RATIONS

TABLE XXII

COMPOSITION OF FEEDS COMMONLY USED IN BEEF CATTLE RATIONS (NATIONAL RESEARCH COUNCIL)

Crop	Dry Matter Percent	TDN Beef Cattle Percent	Dig. Protein Percent
Alfalfa hay, mature	91.2	55.0	9.5
Buffalograss, fresh	47.7	59.0	5.7
Corn fodder, sun-cured	82.4	65.0	4.1
Blue grama, fresh	41.0	64.0	9.0
Prairie hay, mature	92.3	54.0	1.3
Grain sorghum fodder, suncured	90.3	58.0	2.6
Sorghum Sudangrass hay	88.9	59.0	5.5
Sorghum Sudangrass, fresh, immature	17.6	70.0	12.2
Wheat, straw	90.1	48.0	.4
Wheat, fresh, immature	21.5	73.0	22.2

Source: Nutrient Requirements of Beef Cattle, National Research Council, Washington, D.C.

APPENDIX D

RATIONS USED TO DEVELOP BEEF CATTLE PRODUCING ACTIVITIES IN THE ANALYTICAL MODEL

TABLE XXIII

LIVESTOCK RATIONS, WINTER PERIOD

	WINTER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Young Cows				
Ration 1	9/1 to 12/1 range only	12/1 to 4/1 range plus protein suppl.		
Range	9.585	8.460	--	1877.850
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	--	1.125	--	135.000
Total	9.585	9.585	--	2012.850
Ration 2	9/1 to 12/1 range only	12/1 to 2/1 stalks plus protein suppl.	2/1 to 4/1 range plus protein suppl.	
Range	9.585	--	8.460	1370.250
Forage	--	--	--	--
Fodder	--	8.460	--	507.600
Hay	--	--	--	--
Supplement	--	1.125	1.125	135.000
Total	9.585	9.585	9.585	2012.850
Ration 3	9/1 to 11/1 range only	11/1 to 4/1 wheat plus required hay		
Range	9.585	--	--	575.100
Forage	--	7.615	--	1142.250
Fodder	--	--	--	--
Hay	--	1.970	--	295.500
Supplement	--	--	--	--
Total	9.585	9.585	--	2012.850
Ration 4	9/1 to 11/1 range only	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay	
Range	9.585	--	--	575.100
Forage	--	7.668	8.405	1172.310
Fodder	--	1.917	--	230.040
Hay	--	--	1.180	35.400
Supplement	--	--	--	--
Total	9.585	9.585	9.585	2012.850

TABLE XXIII (CONTINUED)

	WINTER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Old Cows				
Ration 2	9/1 to 12/1 range only	12/1 to 2/1 stalks plus protein suppl.	2/1 to 4/1 range plus protein suppl.	
Range	10.365	--	9.148	1481.730
Forage	--	--	--	--
Fodder	--	9.148	--	548.880
Hay	--	--	--	--
Supplement	--	1.217	1.217	146.040
Total	10.365	10.365	10.365	2176.650
Ration 3	9/1 to 11/1 range only	11/1 to 4/1 wheat plus required hay		
Range	10.365	--	--	621.900
Forage	--	8.235	--	1235.250
Fodder	--	--	--	--
Hay	--	2.130	--	319.500
Supplement	--	--	--	--
Total	10.365	10.365	--	2176.650
Ration 4	9/1 to 11/1 range only	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay	
Range	10.365	--	--	621.900
Forage	--	8.292	9.089	1267.710
Fodder	--	2.073	--	248.760
Hay	--	--	1.276	38.280
Supplement	--	--	--	--
Total	10.365	10.365	10.365	2176.650
Replacements 1				
Ration 1	9/1 to 12/1 range only	12/1 to 4/1 range plus protein suppl.		
Range	6.058	5.347	--	1186.888
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	--	.711	--	85.277
Total	6.058	6.058	--	1272.165

TABLE XXIII (CONTINUED)

	WINTER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 2	9/1 to 12/1 range only	12/1 to 2/1 stalks plus protein suppl.	2/1 to 4/1 range plus protein suppl.	
Range	6.058	--	5.347	866.071
Forage	--	--	--	--
Fodder	--	5.347	--	320.817
Hay	--	--	--	--
Supplement	--	.711	.711	85.277
Total	6.058	6.058	6.058	1272.165
Ration 3	9/1 to 11/1 range only	11/1 to 4/1 wheat plus required hay		
Range	6.058	--	--	363.477
Forage	--	4.814	--	721.926
Fodder	--	--	--	--
Hay	--	1.245	--	186.762
Supplement	--	--	--	--
Total	6.058	6.058	--	1272.165
Ration 4	9/1 to 11/1 range only	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay	
Range	6.058	--	--	363.478
Forage	--	4.846	5.312	740.878
Fodder	--	1.212	--	145.438
Hay	--	--	.746	22.371
Supplement	--	--	--	--
Total	6.058	6.058	6.058	1272.165
Replacements 2				
Ration 1	9/1 to 12/1 range only	12/1 to 4/1 range plus protein suppl.		
Range	8.704	7.682	--	1705.297
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	--	1.022	--	122.595
Total	8.704	8.704	--	1827.892

TABLE XXIII (CONTINUED)

	WINTER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 2	9/1 to 12/1	12/1 to 2/1 stalks plus protein suppl.	2/1 to 4/1 range plus protein suppl.	
Range	8.704	--	7.682	1244.339
Forage	--	--	--	--
Fodder	--	7.682	--	460.958
Hay	--	--	--	--
Supplement	--	1.022	1.022	122.595
Total	8.704	8.704	8.704	1827.892
Ration 3	9/1 to 11/1 range only	11/1 to 4/1 wheat plus required hay		
Range	8.704	--	--	522.255
Forage	--	6.916	--	1037.291
Fodder	--	--	--	--
Hay	--	1.788	--	268.346
Supplement	--	--	--	--
Total	8.704	8.704	--	1827.892
Ration 4	9/1 to 11/1 range only	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay	
Range	8.704	--	--	522.255
Forage	--	6.964	7.633	1064.588
Fodder	--	1.740	--	208.902
Hay	--	--	1.071	32.147
Supplement	--	--	--	--
Total	8.704	8.704	8.704	1827.892
<u>Replacements 3</u>				
Ration 1	9/1 to 12/1 range only	12/1 to 4/1 range plus protein suppl.		
Range	11.570	10.212	--	2266.754
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	--	1.358	--	162.959
Total	11.570	11.570	--	2429.713

TABLE XXIII (CONTINUED)

	WINTER RATIONS			
		Pounds Per Day		Pounds Per Period[1]
Ration 2	9/1 to 12/1 range only	12/1 to 2/1 stalks plus protein suppl.	2/1 to 4/1 range plus protein suppl.	
Range	11.570	--	10.212	1654.025
Forage	--	--	--	--
Fodder	--	10.212	--	612.724
Hay	--	--	--	--
Supplement	--	1.358	1.358	162.964
Total	11.570	11.570	11.570	2429.713
Ration 3	9/1 to 11/1 range only	11/1 to 4/1 wheat plus required hay		
Range	11.570	--	--	694.204
Forage	--	9.192	--	1378.805
Fodder	--	--	--	--
Hay	--	2.378	--	356.704
Supplement	--	--	--	--
Total	11.570	11.570	--	2429.713
Ration 4	9/1 to 11/1 range only	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay	
Range	11.570	--	--	694.203
Forage	--	9.256	10.145	1415.074
Fodder	--	2.314	--	277.683
Hay	--	--	1.425	42.753
Supplement	--	--	--	--
Total	11.570	11.570	11.570	2429.713
Light Stocker Steers				
Ration 2	9/1 to 12/1 range only	12/1 to 2/1 stalks plus protein suppl.	2/1 to 4/1 range plus protein suppl.	
Range	6.122	--	5.403	875.169
Forage	--	--	--	--
Fodder	--	5.403	--	324.200
Hay	--	--	--	--
Supplement	--	.719	.719	86.224
Total	6.122	6.122	6.122	1285.593

TABLE XXIII (CONTINUED)

	WINTER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 3	9/1 to 11/1 range only	11/1 to 4/1 wheat plus required hay		
Range	6.122	--	--	367.312
Forage	--	4.864	--	729.547
Fodder	--	--	--	--
Hay	--	1.258	--	188.734
Supplement	--	--	--	--
Total	6.122	6.122	--	1285.593
Ration 4	9/1 to 11/1 range only	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay	
Range	6.122	--	--	367.312
Forage	--	4.899	5.368	748.746
Fodder	--	1.223	--	146.925
Hay	--	--	.754	22.610
Supplement	--	--	--	--
Total	6.122	6.122	6.122	1285.593
Ration 5	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay		
Range	--	--	--	--
Forage	4.899	4.864	--	733.672
Fodder	1.223	--	--	146.869
Hay	--	1.258	--	37.742
Supplement	--	--	--	--
Total	6.122	6.122	--	918.283
Ration 6	11/1 to 4/1 wheat plus required hay			
Range	--	--	--	--
Forage	4.864	--	--	729.573
Fodder	--	--	--	--
Hay	1.258	--	--	188.710
Supplement	--	--	--	--
Total	6.122	--	--	918283

TABLE XXIII (CONTINUED)

	WINTER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Light Stocker Heifers				
Ration 2	9/1 to 12/1 range only	12/1 to 2/1 stalks plus protein suppl.	2/1 to 4/1 range plus protein suppl.	
Range	5.863	--	5.175	838.155
Forage	--	--	--	--
Fodder	--	5.175	--	310.490
Hay	--	--	--	--
Supplement	--	.688	.688	82.578
Total	5.863	5.863	5.863	1231.223
Ration 3	9/1 to 11/1 range only	11/1 to 4/1 wheat plus required hay		
Range	5.863	--	--	351.778
Forage	--	4.658	--	698.693
Fodder	--	--	--	--
Hay	--	1.205	--	180.752
Supplement	--	--	--	--
Total	5.863	5.863	--	1231.223
Ration 4	9/1 to 11/1 range only	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay	
Range	5,863	--	--	351.778
Forage	--	4.691	5.141	717.081
Fodder	--	1.172	--	140.710
Hay	--	--	.722	21.654
Supplement	--	--	--	--
Total	5.863	5.863	5.863	1231.223
Ration 5	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay		
Range	--	--	--	--
Forage	4.691	4.659	--	702.644
Fodder	1.172	--	--	140.657
Hay	--	1.205	--	36.146
Supplement	--	--	--	--
Total	5.863	5.863	--	879.447

TABLE XXIII (CONTINUED)

	WINTER RATIONS			
		Pounds Per Day		Pounds Per Period[1]
Ration 6	11/1 to 4/1 wheat plus required hay			
Range	--	--	--	--
Forage	4.658	--	--	698.718
Fodder	--	--	--	--
Hay	1.205	--	--	180.729
Supplement	--	--	--	--
Total	5.863	--	--	879.447
Heavy Stocker Steer				
Ration 3	9/1 to 11/1 range only	11/1 to 4/1 wheat plus required hay		
Range	8.417	--	--	505.057
Forage	--	6.687	--	1003.134
Fodder	--	--	--	--
Hay	--	1.730	--	259.512
Supplement	--	--	--	--
Total	8.417	8.417	--	1767.703
Ration 4	9/1 to 11/1 range only	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay	
Range	8.417	--	7.381	505.057
Forage	--	6.734	--	1029.534
Fodder	--	1.683	--	202.023
Hay	--	--	1.036	31.089
Supplement	--	--	--	--
Total	8.417	8.417	8.417	1767.703
Ration 5	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay		
Range	--	--	--	--
Forage	5.165	6.687	--	1008.769
Fodder	1.291	--	--	201.938
Hay	--	1.730	--	51.894
Supplement	--	--	--	--
Total	8.417	8.417	--	1262.601

TABLE XXIII (CONTINUED)

WINTER RATIONS				
	Pounds Per Day			Pounds Per Period[1]
Ration 6	11/1 to 4/1 wheat plus required hay			
Range	--	--	--	--
Forage	5.129	--	--	1003.132
Fodder	--	--	--	--
Hay	1.327	--	--	259.469
Supplement	--	--	--	--
Total	8.417	--	--	1262.601
Heavy Stocker Heifer				
Ration 3	9/1 to 11/1 range only	11/1 to 4/1 wheat plus required hay		
Range	8.355	--	--	501.315
Forage	--	6.637	--	995.700
Fodder	--	--	--	--
Hay	--	1.718	--	257.588
Supplement	--	--	--	--
Total	8.355	8.355	--	1754.603
Ration 4	9/1 to 11/1 range only	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay	
Range	8.355	--	--	501.315
Forage	--	6.685	7.326	1021.904
Fodder	--	1.670	--	200.525
Hay	--	--	1.029	30.859
Supplement	--	--	--	--
Total	8.355	8.355	8.355	1754.603
Ration 5	11/1 to 3/1 wheat plus 20% stubble	3/1 to 4/1 wheat plus required hay		
Range	--	--	--	--
Forage	6.685	6.638	--	1001.331
Fodder	1.670	--	--	200.448
Hay	--	1.717	--	51.511
Supplement	--	--	--	--
Total	8.355	8.355	--	1253.290

TABLE XXIII (CONTINUED)

	WINTER RATIONS				
		Pounds Per Day			Pounds Per Period[1]
Ration 6	11/1 to 4/1 wheat plus required hay				
Range	--	--		--	--
Forage	6.638	--		--	995.735
Fodder	--	--		--	--
Hay	1.717	--		--	257.555
Supplement	--	--		--	--
Total	8.355	--		--	1253.290

[1]Winter period is seven months long.

TABLE XXIV

LIVESTOCK RATIONS, SUMMER PERIOD

	SUMMER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Young Cows				
Ration 1	4/1 to 5/1 range plus protein suppl.	5/1 to 9/1 range only		
Range	8.460	9.585	--	1404.000
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	1.125	--	--	33.750
Total	9.585	9.585	--	1437.750
Ration 2	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 range only		
Range	--	--	--	--
Forage	8.405	9.585	--	1402.350
Fodder	--	--	--	--
Hay	1.180	--	--	35.400
Supplement	--	--	--	--
Total	9.585	9.585	--	1437.750
Ration 3	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 range only		
Range	--	9.585	--	1150.200
Forage	--	--	--	--
Fodder	8.460	--	--	253.800
Hay	--	--	--	--
Supplement	1.125	--	--	33.750
Total	9.585	9.585	--	1437.750
Ration 4	4/1 to 5/1 range + protein suppl.	5/1 to 9/1 crop pasture		
Range	8.460	--	--	253.800
Forage	--	9.585	--	1150.200
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	1.125	--	--	33.750
Total	9.585	9.585	--	1437.750

TABLE XXIV (CONTINUED)

	SUMMER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 5	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	8.405	9.585	--	1402.350
Fodder	--	--	--	--
Hay	1.180	--	--	35.400
Supplement	--	--	--	--
Total	9.585	9.585	--	1437.750
Ration 6	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	--	9.585	--	1150.200
Fodder	8.460	--	--	253.800
Hay	--	--	--	--
Supplement	1.125	--	--	33.750
Total	9.585	9.585	--	1437.750
<u>Old Cows</u>				
Ration 1	4/1 to 5/1 range plus protein suppl.	5/1 to 9/1 range only		
Range	9.149	10.365	--	1518.286
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	1.216	--	--	36.497
Total	10.365	10.365	--	1554.783
Ration 2	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 range only		
Range	--	--	--	--
Forage	9.089	10.365	--	1516.501
Fodder	--	--	--	--
Hay	1.276	--	--	38.282
Supplement	--	--	--	--
Total	10.365	10.365	--	1554.783

TABLE XXIV (CONTINUED)

	SUMMER RATIONS Pounds Per Day			Pounds Per Period[1]
Ration 3	4/1 to 5/1 residues plus protein suppl.	5/1 to 9/1 range only		
Range	--	10.365	--	1243.826
Forage	--	--	--	--
Fodder	9.149	--	--	274.460
Hay	--	--	--	--
Supplement	1.216	--	--	36.497
Total	10.365	10.365	--	1554.783
Ration 4	4/1 to 5/1 range + protein suppl.	5/1 to 9/1 crop pasture		
Range	9.149	--	--	274.460
Forage	--	10.365	--	1243.826
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	1.216	--	--	36.497
Total	10.365	10.365	--	1554.783
Ration 5	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	9.089	10.365	--	1516.501
Fodder	--	--	--	--
Hay	1.276	--	--	38.282
Supplement	--	--	--	--
Total	10.365	10.365	--	1554.783
Ration 6	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	--	10.365	--	1243.826
Fodder	9.149	--	--	274.460
Hay	--	--	--	--
Supplement	1.216	--	--	36.497
Total	10.365	10.365	--	1554.783

TABLE XXIV (CONTINUED)

SUMMER RATIONS				
	Pounds Per Day			Pounds Per Period[1]
Replacements 1				
Ration 1	4/1 to 5/1 range plus protein suppl.	5/1 to 9/1 range only		
Range	5.346	6.057	--	887.187
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	.711	--	--	21.327
Total	6.057	6.057	--	908.514
Ration 2	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 range only		
Range	--	--	--	--
Forage	5.311	6.057	--	886.145
Fodder	--	--	--	--
Hay	0.746	--	--	22.369
Supplement	--	--	--	--
Total	6.057	6.057	--	908.514
Ration 3	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 range only		
Range	--	6.057	--	726.811
Forage	--	--	--	--
Fodder	5.346	--	--	160.376
Hay	--	--	--	--
Supplement	.711	--	--	21.327
Total	6.057	6.057	--	908.514
Ration 4	4/1 to 5/1 range + protein suppl.	5/1 to 9/1 crop pasture		
Range	5.346	--	--	160.376
Forage	--	6.057	--	726.811
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	.711	--	--	21.327
Total	6.057	6.057	--	908.514

TABLE XXIV (CONTINUED)

SUMMER RATIONS				
	Pounds Per Day			Pounds Per Period[1]
Ration 5	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	5.311	6.057	--	886.145
Fodder	--	--	--	--
Hay	.746	--	--	22.369
Supplement	--	--	--	--
Total	6.057	6.057	--	908.514
Ration 6	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 crop pastures		
Range	--	--	--	--
Forage	--	6.057	--	726.811
Fodder	5.346	--	--	160.376
Hay	--	--	--	--
Supplement	.711	--	--	21.327
Total	6.057	6.057	--	908.514
Replacements 2				
Ration 1	4/1 to 5/1 range plus protein suppl.	5/1 to 9/1 range only		
Range	7.683	8.705	--	1275.113
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	1.022	--	--	30.652
Total	8.705	8.705	--	1305.765
Ration 2	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 range only		
Range	--	--	--	--
Forage	7.633	8.705	--	1273.614
Fodder	--	--	--	--
Hay	1.072	--	--	32.151
Supplement	--	--	--	--
Total	8.705	8.705	--	1305.765

TABLE XXIV (CONTINUED)

	SUMMER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 3	4/1 to 5/1 residues plus protein suppl.	5/1 to 9/1 range only		
Range	--	8.705	--	1044.612
Forage	--	--	--	--
Fodder	7.683	--	--	230.501
Hay	--	--	--	--
Supplement	1.022	--	--	30.652
Total	8.705	8.705	--	1305.765
Ration 4	4/1 to 5/1 range + protein suppl.	5/1 to 9/1 crop pasture		
Range	7.683	--	--	230.501
Forage	--	8.705	--	1044.612
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	1.022	--	--	30.652
Total	8.705	8.705	--	1305.765
Ration 5	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	7.633	8.705	--	1273.614
Fodder	--	--	--	--
Hay	1.072	--	--	32.151
Supplement	--	--	--	--
Total	8.705	8.705	--	1305.765
Ration 6	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	--	8.705	--	1044.612
Fodder	7.683	--	--	230.501
Hay	--	--	--	--
Supplement	1.022	--	--	30.652
Total	8.705	8.705	--	1305.765

TABLE XXIV (CONTINUED)

	SUMMER RATIONS Pounds Per Day			Pounds Per Period[1]
Replacements 3				
Ration 1	4/1 to 5/1 range plus protein suppl.	5/1 to 9/1 range only		
Range	10.207	11.564	--	1693.926
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	1.357	--	--	40.719
Total	11.564	11.564	--	1734.645
Ration 2	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 range only		
Range	--	--	--	--
Forage	10.141	11.564	--	1691.935
Fodder	--	--	--	--
Hay	1.424	--	--	42.710
Supplement	--	--	--	--
Total	11.564	11.564	--	1734.645
Ration 3	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 range only		
Range	--	11.564	--	1387.716
Forage	--	--	--	--
Fodder	10.207	--	--	306.210
Hay	--	--	--	--
Supplement	1.357	--	--	40.719
Total	11.564	11.564	--	1734.645
Ration 4	4/1 to 5/1 range + protein suppl.	5/1 to 9/1 crop pasture		
Range	10.207	--	--	306.210
Forage	--	11.564	--	1387.716
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	1.357	--	--	40.719
Total	11.564	11.564	--	1734.645

TABLE XXIV (CONTINUED)

	SUMMER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 5	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	10.141	11.564	--	1691.935
Fodder	--	--	--	--
Hay	1.424	--	--	42.710
Supplement	--	--	--	--
Total	11.564	11.564	--	1734.645
Ration 6	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	--	11.564	--	1387.716
Fodder	10.207	--	--	306.210
Hay	--	--	--	--
Supplement	1.357	--	--	40.719
Total	11.564	11.564	--	1734.645
<u>Light Stocker Steers</u>				
Ration	r/1 to 5/1 range plus protein suppl.	5/1 to 9/1 range only		
Range	5.408	6.127	--	897.437
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	0.719	--	--	21.573
Total	6.127	6.127	--	919.010
Ration 2	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 range only		
Range	--	--	--	--
Forage	5.373	6.127	--	896.382
Fodder	--	--	--	--
Hay	0.754	--	--	22.628
Supplement	--	--	--	--
Total	6.127	6.127	--	919.010

TABLE XXIV (CONTINUED)

	SUMMER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 3	4/1 to 5/1 residues plus protein suppl.	5/1 to 9/1 range only		
Range	--	6.127	--	735.208
Forage	--	--	--	--
Fodder	5.408	--	--	162.229
Hay	--	--	--	--
Supplement	0.719	--	--	21.573
Total	6.127	6.127	--	919.010
Ration 4	4/1 to 5/1 range + protein suppl.	5/1 to 9/1 crop pasture		
Range	5.408	--	--	162.229
Forage	--	6.127	--	735.208
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	0.719	--	--	21.573
Total	6.127	6.127	--	919.010
Ration 5	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	5.373	6.127	--	896.382
Fodder	--	--	--	--
Hay	0.754	--	--	22.628
Supplement	--	--	--	--
Total	6.127	6.127	--	919.010
Ration 6	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	--	6.127	--	735.208
Fodder	5.408	--	--	162.229
Hay	--	--	--	--
Supplement	0.719	--	--	21.573
Total	6.127	6.127	--	919.010

TABLE XXIV (CONTINUED)

	SUMMER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 7		6/1 to 9/1 range only		
Range	--	6.127	--	551.406
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	--	--	--	--
Total	--	6.127	--	551.406
Ration 8		6/1 to 9/1 crop pasture only		
Range	--	--	--	--
Forage	--	6.127	--	551.406
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	--	--	--	--
Total	--	6.127	--	551.406
Light Stocker Heifers				
Ration 1	4/1 to 5/1 range plus protein suppl.	5/1 to 9/1 range only		
Range	5.170	5.857	--	857.984
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	0.687	--	--	20.625
Total	5.857	5.857	--	878.609
Ration 2	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 range only		
Range	--	--	--	--
Forage	5.136	5.857	--	856.976
Fodder	--	--	--	--
Hay	0.721	--	--	21.633
Supplement	--	--	--	--
Total	5.857	5.857	--	878.609

TABLE XXIV (CONTINUED)

	SUMMER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 3	4/1 to 5/1 residues plus protein suppl.	5/1 to 9/1 range only		
Range	--	5.857	--	702.887
Forage	--	--	--	--
Fodder	5.170	--	--	155.097
Hay	--	--	--	--
Supplement	0.687	--	--	20.625
Total	5.857	5.857	--	878.609
Ration 4	4/1 to 5/1 range + protein suppl.	5/1 to 9/1 crop pasture		
Range	5.170	--	--	155.097
Forage	--	5.857	--	702.887
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	0.687	--	--	20.625
Total	5.857	5.857	--	878.609
Ration 5	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	5.136	5.857	--	856.976
Fodder	--	--	--	--
Hay	0.721	--	--	21.633
Supplement	--	--	--	--
Total	5.857	5.857	--	878.609
Ration 6	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	--	5.857	--	702.887
Fodder	5.170	--	--	155.097
Hay	--	--	--	--
Supplement	0.687	--	--	20.625
Total	5.857	5.857	--	878.609

TABLE XXIV (CONTINUED)

	SUMMER RATIONS			
		Pounds Per Day		Pounds Per Period[1]
Ration 7		6/1 to 9/1 range only		
Range	--	5.857	--	527.165
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	--	--	--	--
Total	--	5.857	--	527.165
Ration 8		6/1 to 9/1 crop pasture only		
Range	--	--	--	--
Forage	--	5.857	--	527.165
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	--	--	--	--
Total	--	5.857	--	527.165
<u>Heavy Stocker Steers</u>				
Ration 1	4/1 to 5/1 range plus protein suppl.	5/1 to 9/1 range only		
Range	7.428	8.416	--	1232.712
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	0.988	--	--	29.633
Total	8.416	8.416	--	1262.345
Ration 2	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 range only		
Range	--	--	--	--
Forage	7.380	8.416	--	1231.263
Fodder	--	--	--	--
Hay	1.036	--	--	31.082
Supplement	--	--	--	--
Total	8.416	8.416	--	1262.345

TABLE XXIV (CONTINUED)

	SUMMER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 3	4/1 to 5/1 residues + 1.5 lbs/day protein suppl.	5/1 to 9/1 range only		
Range	--	8.416	--	1009.876
Forage	--	--	--	--
Fodder	7.428	--	--	222.836
Hay	--	--	--	--
Supplement	0.988	--	--	29.633
Total	8.416	8.416	--	1262.345
Ration 4	4/1 to 5/1 range + protein suppl.	5/1 to 9/1 crop pasture		
Range	7.428	--	--	222.836
Forage	--	8.416	--	1009.876
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	0.988	--	--	29.633
Total	8.416	8.416	--	1262.345
Ration 5	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	7.380	8.416	--	1231.263
Fodder	--	--	--	--
Hay	1.036	--	--	31.082
Supplement	--	--	--	--
Total	8.416	8.416	--	1262.345
Ration 6	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	--	8.416	--	1009.876
Fodder	7.428	--	--	222.836
Hay	--	--	--	--
Supplement	0.988	--	--	29.633
Total	8.416	8.416	--	1262.345

TABLE XXIV (CONTINUED)

	SUMMER RATIONS			
		Pounds Per Day		Pounds Per Period[1]
Ration 7		6/1 to 9/1 range only		
Range	--	5.857	--	527.165
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	--	--	--	--
Total	--	5.857	--	527.165
Ration 8		6/1 to 9/1 crop pasture only		
Range	--	--	--	--
Forage	--	5.857	--	527.165
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	--	--	--	--
Total	--	5.857	--	527.165
Heavy Stocker Steers				
Ration 1	4/1 to 5/1 range plus protein suppl.	5/1 to 9/1 range only		
Range	7.428	8.416	--	1232.712
Forage	--	--	--	--
Fodder	--	--	--	--
Hay	--	--	--	--
Supplement	0.988	--	--	29.633
Total	8.416	8.416	--	1262.345
Ration 2	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 range only		
Range	--	--	--	--
Forage	7.380	8.416	--	1231.263
Fodder	--	--	--	--
Hay	1.036	--	--	31.082
Supplement	--	--	--	--
Total	8.416	8.416	--	1262.345

TABLE XXIV (CONTINUED)

	SUMMER RATIONS			
	Pounds Per Day			Pounds Per Period[1]
Ration 5	4/1 to 5/1 graze-out plus required hay	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	7.327	8.356	--	1222.429
Fodder	--	--	--	--
Hay	1.029	--	--	30.858
Supplement	--	--	--	--
Total	8.356	8.356	--	1253.287
Ration 6	4/1 to 5/1 residues + protein suppl.	5/1 to 9/1 crop pasture		
Range	--	--	--	--
Forage	--	8.356	--	1002.629
Fodder	7.375	--	--	221.238
Hay	--	--	--	--
Supplement	0.981	--	--	29.420
Total	8.356	8.356	--	1253.287

[1]Summer period is five months long.

APPENDIX E

MAIL QUESTIONNAIRE USED TO SURVEY EXTENSION PERSONNEL ON GRAZING ACTIVITY IN SOUTHERN GREAT PLAINS

Wheat Pasture Usage in ______________ County

[ ] Request for summary of wheat pasture information

1. During a five-year period, estimate in how many of those years winter wheat will provide sufficient grazing to be an important factor in available winter pasture.

   [ ] 1 year, [ ] 2 years, [ ] 3 years, [ ] 4 or more years

2. When it is available, estimate what percentage of the farm operators actually utilize (either with their own cattle or renting to others) winter wheat pasture. ________%

3. Separate the percentage given in (2) above between those operators who a) utilize wheat grazing primarily in a cow-calf operation and b) those who utilize it mainly with "stocker" cattle.

   cow-calf ________& stocker ________%

4. Do farmers in your county generally distinguish between themselves as being either a "grain farmer" or a "livestock farmer?"

   [ ] yes [ ] no

5. Have contitions during the past five years caused any appreciable shift in winter wheat usage for pasture?

   [ ] yes [ ] no

   In which direction was the change?

   [ ] more usage [ ] less usage

   How great was the change?

   [ ] fairly small [ ] substantial

6. We are interested in why some farm operators do not graze their wheat, choosing from among the reasons given below. Indicate, in order of importance, the three main reasons you feel available wheat forage is not pastured in your county.

Rankings	Reason for not Grazing Wheat
________	a. Small wheat fields
________	b. Large financial requirements
________	c. Do not enjoy working with cattle
________	d. Lack of knowledge or experience
________	e. Opposition by landlord
________	f. Inadequate water, fencing, corrals,etc.
________	g. Lack of year-round pasture
________	h. Other (please state the reason)

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VITA

Richard Lynn Harwell

Candidate for the Degree of

Doctor of Philosophy

Thesis: ECONOMIC INTERACTION BETWEEN WHEAT AND BEEF IN THE SOUTHERN GREAT PLAINS

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Vega, Texas, March 4, 1929, the son of Mr. and Mrs. Roddy Harwell.

Education: Graduated from Vega High School, Vega, Texas, in May, 1947; received the Bachelor of Business Administration degree from The University of Texas-Austin in May, 1951; received Master of Science degree from Texas A&M University in January, 1970; completed requirements for Doctor of Philosophy degree at Oklahoma State University in May, 1976.

Professional Experience: Statistical Clerk; The Shamrock Oil and Gas Corporation, 1951-1955; Self-employed farmer, Oldham County, Texas, 1955-1968; Research Assistant, Texas A&M University, 1968-1969; Agricultural Economist, Economic Research Service, United States Department of Agriculture, 1969-1975; Agricultural Finance Extension Specialist, Clemson University, June, 1975 to present.