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Economic Effect on Agricultural Production of Alternative Energy Input Prices: Texas High Plains

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ECONOMIC EFFECT ON AGRICULTURAL PRODUCTION OF ALTERNATIVE ENERGY INPUT PRICES: TEXAS HIGH PLAINS

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FOREWORD

This is a part of a larger project involved in evaluating effects of input and product price changes on cropping patterns, agricultural production and producer net returns in the Texas High Plains. This report is based on a short-run analysis and does not include any fixed costs. Therefore, these results indicate what level of energy price increase a farmer could absorb for over one to three years. However, over a period of time, reinvestment in capital facilities must be considered. This means values in this publication are inadequate for a longer-run evaluation. The effect of increased energy (natural gas) prices for an analysis of a long-run situation is presented in other Texas Water Resource Technical Reports available from Ronald D. Lacewell.

ABSTRACT

The Arab oil embargo of 1973 awakened the world to the reality of energy shortages and higher fuel prices. Agriculture in the United States is highly mechanized and thus energy intensive. This study seeks to develop an evaluative capability to readily determine the short-run effect of rising energy prices on agricultural production. The results are measured in terms of demand schedules for each input investigated, net revenue adjustments, cropping pattern shifts, and changes in agricultural output.

The High Plains of Texas was selected as a study area due to the heterogeneous nature of agricultural production in the region and highly energy intensive methods of production employed. The region is associated with a diversity in crops and production practices as well as a high degree of mechanization and irrigation, which means agriculture is very dependent upon energy inputs and, in turn, is significantly affected by energy price changes. The study area was defined by the Texas Agricultural Extension subregions of High Plains II, High Plains III, and High Plains IV. The crops chosen for study were cotton, grain sorghum, wheat, corn, and soybeans. The energy and energy-related inputs under investigation were diesel, herbicide, natural gas, nitrogen fertilizer, and water.

Mathematical linear programming was used as the analytical technique with parametric programming techniques incorporated into the LP model to evaluate effect of varying input price parameters over a specified range. Thus, demand schedules were estimated. The objective function was constructed using variable costs only; no fixed costs are considered. Therefore, the objective function maximizes net revenue above variable costs and thus limits the study to the short run.

The data bases for the model were crop enterprise budgets developed by the Texas Agricultural Extension Service. These budgets were modified to adapt them to the study. Particularly important was the substitution of owner-operated harvesting equipment for custom-harvesting costs. This procedure made possible the delineation of fuel use by crop and production alternative which was necessary information in the accounting of costs. The completed LP model was applied to 16 alternative situations made up of various input and product price combinations which are considered as feasible in the short run future.

The results reveal that diesel consumption would change very little in the short run unless commodity prices simultaneously decline below the lowest prices since 1971 or unless diesel price approaches \$2.00 per gallon. Under average commodity price conditions, natural gas consumption would not decline appreciably until the price rose above \$4.00 per 1000 cubic feet (mcf). Even when using the least product prices since 1971, natural gas would be consumed in substantial amounts as long as the price was below \$1.28 per Mcf. The findings regarding nitrogen indicate that present nitrogen prices are within a critical range such that consumption would be immediately affected by nitrogen price increases.

Water price was considered as the price a farmer can afford to pay for water above pumping and distribution costs. Application of water was defined as the price that would be paid for imported water. Under average commodity price conditions, the study results show that as water price rises from zero dollars to $22 per acre foot there would be less than a 4 percent reduction in consumption. However, as the price continues to rise, consumption would decline dramatically reaching zero at a water price of $71.75 per acre foot.

This study indicates that rising input prices would cause acreage shifts from irrigated to dryland; however, with average commodity prices, these shifts do not occur until diesel reaches $2.69 per gallon, or natural gas sells for $1.92 per Mcf, or nitrogen price is $.41 per pound, or water price reaches $14.69 per acre foot. In general, the first crops that would shift out of production as energy input prices rise would be grain sorghum and corn. Cotton does not appear to be significantly affected by feasible near future energy price rises; while wheat was found to increase in production as fuel costs increase.

Whereas rising energy prices mildly affect consumption of inputs, cropping shifts, and output, they significantly impact on net revenue to the farmer. With average product prices, the results indicate that farmers' net income above variable cost approach $500 million at present diesel prices ($.40 per gallon). A doubling of diesel price

to $.81 per gallon would cost the farmer $79 million in net revenue, and a price rise to $1.86 per gallon would cost $254 million in farmer net revenue. The results of natural gas, nitrogen, and water are similar to diesel in that the increased cost of the input directly reduces net revenue.

Throughout the analysis, commodity prices were shown to be more consequential to agricultural production and farmer welfare than are energy input prices. A synoptic statement of the findings is as follows: in the short run future assuming average prices for commodities, farmers in the Texas High Plains will continue to produce at present levels according to established cropping patterns unless diesel reaches a $2.00 per gallon price range, or natural gas price approaches $4.00 per Mcf, or nitrogen sells for around $.40 per pound. Furthermore, the importation of water is feasible only if its cost can be kept well below $70 per acre foot.

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Of course, any errors and limitations of the study are the sole responsibility of the authors.

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INTRODUCTION

Two of the most publicized, most controversial, and most crucial issues in the world today are energy and agriculture. In the summer of 1975, U.S. News and World Report cited a study by the U.S. Department of Agriculture which documents the severity of food and energy price increases. Between 1971 and 1974, world food prices rose 129 percent, petroleum prices escalated 547 percent, and fertilizer prices increased 680 percent. Food and energy price increases are certainly not mutually exclusive, and the question of the extent of their relationship must be addressed to further understand the impact of each. Just what do energy and agriculture have in common? -- history provides a point of beginning.

The methods and scale of production of food and fiber have gradually shifted in the United States over the past 200 years. In recent years, the change has been at an accelerated rate, and technology affecting agriculture has caused the production phase to boom. The "agrarian industrial revolution" has been characterized by greater yields resulting from less manpower and more machine power. In 1972, essentially the same farm acreage in the U.S. produced nearly 90 percent more than it did in 1940; whereas, farm labor used on that acreage

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The citations of the following pages follow the style of the <u>American Journal of Agricultural Economics</u>.

decreased by two-thirds. Fertilizer use on U.S. farms in 1972 was nine times as great as in 1940, and mechanical power and machinery inputs grew by 237 percent (Carter and Youde). U.S. agriculture today is a highly mechanized, input-intensive system. Changes in the price or availability of critical variables such as energy, fertilizer, and machinery impact on yields, costs, and thus profits to a greater degree than ever before.

The agricultural sector is currently in a situation of instable product prices and increasing input prices. A case in point is the dramatic advances in prices of hydrocarbon fuels. The problem is compounded because this sector of the U.S. economy is highly dependent upon petroleum. Machinery inputs, fertilizer, pesticides, and irrigation systems--all related to low cost hydrocarbons--have caused production to be highly energy intensive (Carter and Youde). Even though agricultural production is highly dependent upon energy, the production phase requires only about 4 percent of the total energy used in the United States. Considering the total U.S. food cycle, about 12 percent of the national energy budget is required (Hirst).

Until the recent energy crisis, supplies of these inexpensive petroleum products appeared unlimited, and, as a result, research directed toward measuring the effects of energy use held a low priority. Little concern has been paid to fuel use associated with various crops, cropping practices, types of machinery, irrigation systems, irrigation levels, and the like.

With the oil embargo of 1973 and tight petroleum supplies, American consumers, politicians, farmers, and researchers were awakened to the nation's dependency on petrochemicals and the possible impact of significantly increased input prices on food and fiber production. However, specific answers to repercussions of the rising fuel prices were not readily available. The need for immediate evaluation capability became acutely apparent.

The energy crisis of two years ago was a signal to draw attention to this need; events since that time have continued to emphasize the volatility of prices on agricultural inputs and products.

> Since 1972 world commodity prices have risen at rates unequalled for over a quarter of a century. A major contributor has been the nearly threefold increase in crude oil prices by the Organization of Petroleum Exporting Countries (OPEC) since October 1973. Previously, wellhead prices in current dollars had risen only modestly in 25 years (Carter and Youde).

In the twelve months preceding April 1975, prices paid by farmers increased 10 percent; whereas, prices received by farmers declined 15 percent (U.S. Department of Agriculture). Events in recent months concerning the price situation of natural gas in Texas serve as a good example of how an energy input may influence agricultural production. Thirty-nine percent of the total energy demand for agriculture in Texas is used to pump irrigation water. Over three-fourths of this energy is consumed in the form of natural gas (Coble and LePori). In less than one year, the price of natural gas has risen from an average of $.55 per thousand cubic feet (Mcf) to the late 1975 price of $.88 Mcf (Osborn 1975). This change represents a 60 percent price increase of an input that accounts for 30 percent of the state's agricultural energy demand. Users in some regions were reported to be signing contracts for natural gas at prices much higher than $.88 Mcf. Estimates of the impact of input price increase on agricultural output and local economies are needed by policy makers and local communities. Adjustments can be expected in cropping patterns and level of inputs used. These adjustments directly impact on agricultural supplies and the infrastructure of the community. Adjustments away from a particular crop leave overcapacity of facilities of processing and storing the output.

The input and product price instabilities can be expected to impact more heavily on regions of intensive production where use of inputs are relatively large and where the economy is agriculturally based. The High Plains of Texas is such a region. Level of production is highly dependent on irrigation and fertilization. Therefore, given that there is a need for ongoing capability to estimate impact of input and product price changes on cropping patterns and agricultural output, particularly in an intensive production region, the purpose of this study is to develop a flexible model for the Texas High Plains to investigate such issues.

The Study Area

The study area is made up of 26 counties in the Southern High Plains of Texas as shown in Figure 1. The counties selected correspond to three production regions as defined by the Texas Agricultural Extension Service. These regions are designated High Plains II, High Plains III, and High Plains IV (Extension Economists-Management). The area is particularly appropriate for this study because it is a highly productive, heterogeneous agricultural region. Good bases of comparison can be found because of its differing soils, crops, and farming practices.

For example, some crops produced with irrigation yield sixfold what they would in a dryland situation (Casey, Lacewell, and Jones).

High Plains II is comprised of the following 14 counties: Armstrong, Briscoe, Carson, Castro, Crosby, Deaf Smith, Floyd, Gray, Hale, Oldham, Parmer, Potter, Randall, and Swisher. The soils are principally the Pullman Clay soils south of the Canadian River, commonly referred to as the hardlands (Extension Economists-Management). Annual rainfall averages from a low of 17.36 inches in Castro county to a high of 21.32 inches in Crosby county. The average growing season within the region ranges from 183 days in the western counties to 214 in the eastern counties (The Dallas Morning News). The major crops produced in the area are corn, cotton, grain sorghum, soybeans, and wheat with the principle method of irrigation being furrow or gravity flow (Extension Economist-Management).

The nine counties of Bailey, Borden, Cochran, Dawson, Garza, Hockley, Lamb, Lubbock, and Lynn make up High Plains III. The mixed soils of the area have given rise to two principle irrigation distribution systems, furrow and sprinkler systems (Extension Economists-Management). Average moisture falls within an inch and a half of 17 inches per year. The average growing season ranges from 181 days in northwestern Bailey county to 217 days in counties to the south and east (The Dallas Morning News). Major crops produced are cotton, grain sorghum, soybeans, and wheat.

The smallest of the three regions is High Plains IV which is comprised of Gaines, Terry, and Yoakum counties. They are differentiated by the sandyland soils with the principle crops grown being cotton, grain sorghum, and wheat. The soils and terrain dictate that irrigation in the region be primarily of the sideroll and center pivot sprinkler system type (Extension Economists-Management). Rainfall averages around 16 inches annually, and the average growing season is from 199 to 210 days (The Dallas Morning News).

A more detailed and precise description of the study area and study crops is presented in Tables 1-3. Table 1 indicates that the total land acreage of High Plains II, III, and IV is over 25,000 square miles with 57 percent of it designated as cropland. Of the acres planted in 1973, nearly three-fifths were irrigated. Table 2 presents a comparison of study crops, specialty crops, and idle acres. In 1973, the study crops of corn, cotton, grain sorghum, soybeans, and wheat were planted on 82 percent of the total cropland acres and accounted for 97 percent of planted cropland acres. Table 3 shows that cotton and grain sorghum are the major crops of the study area, but sufficient acres of wheat, corn, and soybeans are produced to require their inclusion for a complete analysis.

Objectives

The primary objective of this research is to develop a linear programming model for the study area using multiple production activities of the study crops. The model for the study area will include three subregions and consider cropping pattern shifts among the three subregions. This tool is intended to determine the optimal combination of production activities given a set of input costs and commodity prices. Two subordinate objectives are to be pursued upon completion of the

Table 1. Agricultural land base in the Southern High Plains; 1973

	Region[a]			
	HPII	HPIII	HPIV	Total
	------------------1,000 acres------------------			
Total land[b]	8,917.0	5,170.0	2,059.0	16,146.0
Cropland[c]	4,529.6	3,271.7	1,372.4	9,173.7
Cropland planted[c]	3,812.6	2,866.4	1,117.6	7,796.6
Irrigated[c]	2,677.4	1,381.9	558.0	4,617.3
Dryland[c]	1,135.2	1,484.5	559.6	3,179.3

[a] (Extension Economists-Management).

[b] (The Dallas Morning News).

[c] (New).

Table 2. Major uses of cropland in the Southern High Plains, 1973[a]

Cropland Use	Region[b]						Total	
	HPII		HPIII		HPIV			
	(000)acres	%	(000)acres	%	(000)acres	%	(000)acres	%
Dryland:								
Study crops[c]	1.116.1	66	1,471.6	80	558.7	89	3,146.4	72
Specialty crops[d]	19.1	1	12.9	1	.9	*	32.9	1
Idle acres	566.7	33	353.5	19	249.8	31	1,170.0	27
Total	1,701.9	100	1,838.0	100	809.4	100	4,349.3	100
Irrigated:								
Study crops[e]	2,569.7	91	1,320.8	92	513.3	91	4,403.3	91
Specialty crops[f]	107.7	4	61.1	4	44.7	8	213.5	5
Idle acres	150.3	5	51.8	4	5.0	1	207.1	4
Total	2,827.7	100	1,433.7	100	563.0	100	4,824.4	100
Combined:								
Study crops	3,685.8	81	2,792.4	85	1,072.0	78	7,550.2	82
Specialty crops	126.8	3	74.0	2	45.6	3	246.4	3
Idle acres	717.0	16	405.3	13	254.8	19	1,377.1	15
Total	4,529.6	100	3,271.7	100	1,372.4	100	9,173.7	100

[*] Less than .5 percent.

[a] (New).

[b] (Extension Economists-Management).

[c] Includes cotton, grain sorghum, wheat.

[d] Includes alfalfa, castorbeans, vegetables and other minor crops.

[e] Includes corn (HPII only), cotton, grain sorghum, soybeans and wheat (HPII, HPIII, HPIV).

[f] Includes alfalfa, castorbeans, pasture, sugarbeets, vegetables and other minor crops.

Table 3. Acres planted to major crops in the Southern High Plains, 1973[a]

Crop	Region[b]						Total	
	HPII		HPIII		HPIV			
Corn	274.0	8	--	--	--	--	274.0	4
Cotton	588.6	16	1,397.9	57	536.4	51	2,522.9	36
Grain sorghum	1,292.3	36	910.9	37	455.0	44	2,659.2	37
Wheat	1,343.6	37	115.8	5	51.2	5	1,510.6	21
Soybeans	116.5	3	13.5	1			130.0	2
Total	3,615.0	100	2,438.1	100	1,042.6	100	7,095.7	100

[a] (Texas Department of Agriculture, June 1974, September 1974, May 1974, October 1973): the values are not adjusted for skipped rows on crops produced dryland where planting patterns as 2 in- 1 out or 2 in- 2 out are practiced.

[b] (Extension Economists-Management).

principle one. First, the linear programming model will be applied to estimate the demand schedules for diesel, natural gas, nitrogen fertilizer, and irrigation water. Secondly, the ramifications of these demand schedules will be examined; i.e., how will agricultural output and revenues that accompany crop acreage shifts be affected.

Review of Literature

In addition to considering irrigation water as an input, this study is strongly directed toward energy inputs. The value in use of hydrocarbon fuels in agriculture is a topic of relatively recent concern. Within the last few months, a study was undertaken at Texas A&M University by Casey, Lacewell, and Jones that addressed the problem of limited fuel supplies in the Southern High Plains of Texas. They employed the parametric linear programming technique to determine that irrigation fuel shortages have a more detrimental effect on agricultural output than diesel shortages during the growing season or at harvest time. Furthermore, they found that producers adjust to fuel shortages by first altering irrigation practices on grain sorghum, then cotton.

The focus of this study was to develop a model whereby the effect of alternative input prices on production and demand of inputs could be estimated. The general framework included using parametric procedures on a linear programming model. This technique has been widely used. For example, in 1971, using the Lower Rio Grande Basin as a study area, R. M. Gray examined cropping pattern shifts and enterprise combinations as they are affected by the allocation of water. He used a parametric linear programming model to determine that profitability of irrigated grain sorghum was more sensitive to rising water costs than irrigated cotton. Grain sorghum was the first crop to shift from irrigated to dryland production. In another study, the linear programming technique was employed by Lacewell and Masch to show the quantitative decline in the use of 2, 4-D as its price increased.

Moore and Hedges reported in 1963 on the application of the LP technique in estimation of static-normative demand for irrigation water in Tular County, California. Derived demand schedules for irrigation water were developed for a series of representative farms using a parametric objective function approach. These schedules were then aggregated on a weighted basis to approximate the regional demand for irrigation water.

In 1973, Shumway conducted a study for the west side of the San Joaquin Valley of California. This model, unlike that of Moore and Hedges, was based on the least cost pattern of production of a given level of outputs. The parametric objective function approach was used to generate a derived demand curve for the region directly, rather than for a series of representative farms.

Yaron's analysis of the demand for irrigation water by Israeli agriculture in 1967 has been used as a model for several of the studies reviewed; however, it differs from those previously described in its approach to generation of the demand schedule. A variable resource approach was applied to yield the marginal value product or shadow price of water.

Gisser developed a model for forecasting demand for imported water to the Pecos River Basin. Constraints were specified for local water use based on salinity conditions. He points out that estimation of groundwater pumping cost functions is critical in any study dealing with stabilization of groundwater levels. Conclusions concerning ultimate outcomes will not likely be affected, but time schedules may be grossly biased.

The energy crisis of 1973 popularized energy research in agriculture. Pimentel, et.al., writing in Science magazine, points out that agriculture is heavily dependent upon fossil fuel energy. He illustrated the present situation by offering the fact that, in the United States, it requires the energy equivalent to 80 gallons of gasoline to produce an acre of corn. The pass-through of the rising prices for hydrocarbon fuels in production cost will be substantial.

Machine power as a substitute for manpower was documented by Earle Gavett in a paper prepared for the National Conference on Agriculture and the Energy Crisis in 1973. His substantiation arises from the fact that each hour of labor in agriculture is matched by at least one gallon of fuel use.

The increase in fuel use in the U.S. food system was further documented by Steinhart and Steinhart, writing in Science magazine. They point out that the thirty years since 1940 has seen more than a 300 percent increase in energy use for food production; 25 percent of this total is for farming, 40 percent for processing, and 35 percent for home refrigeration and preparation. The appetite of the United States for energy is no different; energy consumption has been growing at a rate of three to four percent per year (Wilson). This situation of short supply and strong demand paints a picture of strained prices for the short run future.

Problem Development

The approach to the problem can be viewed as two situations. Initially, the "what is" or "what already exist" situation is developed. This phase utilizes historical data to determine a "norm" of agricultural production on the Texas High Plains. Crop budgets are a source of information that provides a framework for the "norm" structure of production. Mathematical programming techniques provide the analytical tool. By applying current prices, an indication of the current situation is estimated.

The second phase is the "what if" situation. The framework used to estimate the current situation is utilized; however, a different combination of prices is used. Input prices are predicted at what they may be in the future, and the resultant impact is estimated.

The tools for analysis are explained with a discussion of the linear programming technique. Input data are developed from crop budgets of the Texas Agricultural Extension Service, and a research model is formulated. The model is applied to selected situations of future energy resource prices, and results are interpreted. Finally, the impact upon agricultural production is evaluated with respect to the short run future.

The basis of this study is microeconomic theory which is described in detail in numerous sources such as Leftwich; Doll, Rhodes, and West; Snodgrass and Wallace; and Vincent.

ANALYTICAL TECHNIQUES

A relevant economic study requires a sound data base and appropriate technique. The analytical procedure selected to estimate the effect of changing input and product prices in agriculture on production, cropping patterns and returns was linear programming. The data base used to develop linear programming model was the Texas Enterprise Budgets developed and published by the Texas Agricultural Extension Service.

The following discussion relates to the basic principles underlying linear programming and development of the model using enterprise budgets. The focus of this chapter is concepts; hence, specific data are not reported.

The Linear Programming Technique

General Description

This study is classified under the general heading of an optimization problem. Such a problem is one in which a numerical function composed of a number of variables that are subject to a set of constraints is maximized or minimized. The concept of optimization problems can be expanded to a broader category known as programming problems. The purpose of programming is to determine optimal allocations of limited resources which are subject to a set of constraints that define the problem's objectives. Linear programming is a special type of programming problem in which all the relationships among the variables are linear. The constraints must be linear, and the function to be optimized must be linear. This latter function is known as the objective function (Hadley).

Inherent in the linear programming routine are three basic assumptions. The first is that the relations among variables are linear and additive; i.e., there is a fixed ratio of inputs to output. The second assumption is that of finiteness; there is a finite number of enterprises and restrictions. The last assumption of divisibility implies that any enterprise can be utilized at any level to satisfy the objective function (Heady and Candler).

Basic Equations

The general linear programming problem involves (1) a given set of m linear inequalities or equations with r variables and (2) non-negative values of these variables which (3) will satisfy the constraints and (4) will maximize or minimize some linear function of these variables. The constraints represented symbolically are:

$$a_{i1}X_1 + a_{i2}X_2 + \dots + a_{ir}X_r \ \{\geq, =, \leq\} \ b_i \quad (i = 1, 2, \dots, m)$$

where

a = a known constant

b = a known constant

m = the number of inequalities and/or equations

r = the number of variables

Values of the variables X_j are sought such that:

$$X_j \geq 0 \qquad (j = 1, 2, \ldots, r)$$

and the following linear function is maximized or minimized:

$$Z = c_1X_1 + \ldots + c_rX_r$$

where

C = a known constant

The function to be optimized is known as the objective function. The solution to a linear programming problem lies in finding the optimal feasible solution among the many feasible solutions. The optimal feasible solution is that one which maximizes or minimizes the objective function (Hadley).

Parametric Programming

To maximize analytical capability, parametric programming was applied. Parametric programming is considered a postoptimality problem of linear programming. It investigates the sensitivity of the optimal solution when parameters are changed. If, for instance, an input price is being parameterized, the object of parametric programming is to find the change in input price required to cause a basic change in the optimal solution. The new optimal solution becomes the base solution, and the procedure is repeated. The new linear programming problem created by a new optimal solution is an extension of and is dependent upon the preceding solution. Since the procedure described above is a sequence of these dependencies, it is referred to as recursive linear programming (Day). Parametric programming was used to estimate demand schedules for diesel, natural gas, nitrogen fertilizer, and water.

Flexibility Restraints

Due to institutional restraints, massive rapid cropping pattern shifts are not expected. To impose a proxy for institutional barriers to change, flexibility restraints were introduced. Flexibility restraints were established for cropping pattern shifts between crops; these restraints act as upper and lower bounds on planted acres for any crop in each cropping region. The flexibility restraints were developed statistically in a study done by Condra and Lacewell.

Crop acreage flexibility restraints were estimated using linear regression analysis for each of the study crops in each production region. These restraints are based on historical time series data and reflect the maximum "expected" increase or decrease in acreage of a given crop in a given year. The flexibility coefficient (b) is the percentage increase or decrease in acreage allowable in a year and can be expressed (Condra and Lacewell):

$$\bar{X}_t = (1+\bar{B}) \left[\frac{\sum_{n=1}^{3} (X_{t-n})}{3}\right]$$

$$\underline{X}_t = (1-\underline{B}) \left[\frac{\sum_{n=1}^{3} (X_{t-n})}{3}\right]$$

where

$\bar{X}_t$ = upper crop acreage flexibility restraint

$\underline{X}_t$ = lower crop acreage flexibility restraint

$\bar{B}$ = upper crop acreage flexibility coefficient

$\underline{B}$ = lower crop acreage flexibility coefficient

If restraints are not put on acres planted to a particular crop, linear programming techniques shift all the cropland available to the one or two most profitable crops. This type cropping pattern shift would not be expected since there are large equipment investments, anticipation of better prices, and individual farmer biases. The study done by Condra and Lacewell provides the necessary maximum and minimum crop acreage restraints. Since most acres are planted to cotton, grain sorghum, and wheat in the study region, these three crops are limited by a maximum and minimum number of acres that can be planted to each. Corn and soybeans, being lesser crops and highly dependent on irrigation, are constrained by a maximum number of acres but not by a minimum.

Further constraints are put on the number of acres that can be planted in crops and that can be irrigated in a particular region. Within High Plains III, restraints are placed on acreage irrigated by sprinklers and acres irrigated by furrow. In High Plains IV, irrigated acres by sideroll system and center pivot system are constrained. All of these restraints are maximum limits; no minimum limits are placed on cropland or irrigated acres. The above procedure is accomplished by the addition of the flexibility constraints rows with appropriate maximum or minimum acreages placed in the right-hand side column.

This chapter highlights techniques used in the analysis and methods underlying development of model coefficients. Using the concepts described, the model was constructed and applied.

Enterprise Budgets

The Texas Crop Enterprise Budgets developed by Extension Economists-Management of the Texas Agricultural Extension Service provided the basic information required in structuring the linear programming model. Enterprise budgets for major crops in 22 production regions of Texas are available. The regions have been delineated according to soil type, irrigation series, and/or crop production differences. These data are gathered through interviews with producers, agribusiness firms, financial institutions, and field specialists. Two levels of management, and therefore two budgets exist for each production activity of a particular crop. Typical management (as opposed to high level management) represents yields and input levels of approximately 85 percent of the producers in the region. Because this study addresses the short run implications of changing prices, budgets for typical management were selected (Extension Economists-Management).

Crop budgets are stored via a computerized budget generator. The budget generator is a computer program whereby the crop budgets may be modified or updated. Data available from application of the crop budget generator ranges from monthly capital and labor requirements to hourly cost summaries for implements and power units. However, the basic enterprise budget summarizes gross receipts, variable costs, fixed costs, total costs, and net returns.

The production regions of High Plains II, High Plains III, and High Plains IV were chosen for this study. The major crop selected were corn, cotton, grain sorghum, soybeans, and wheat because they comprise 82 percent of the total acres and 97 percent of the acres planted in crops in 1973 as shown in Table 2, page 9.

The Texas Crop Budget Generator was programmed for only two budgets each for cotton, grain sorghum, and wheat (dryland and irrigated). This was a critical limitation for a study such as this. Therefore, intermediate irrigation level budgets were developed for the three crops. The intermediate irrigation level budgets were developed in cooperation with Texas Agricultural Extension Service area economist, Marvin Sartin.

For some items, the crop budgets as developed by the Texas Agricultural Extension Service were not compatable with the purposes of this study, hence, modifications were necessary. A major modification was the substitution of owner-operated equipment harvest costs for typical custom harvesting costs. This augmentation was critical to the study problem since fuel use associated with the various production activities was a major focus of the analysis. Other alternations were made in the dryland cotton and grain sorghum budgets for High Plains III and High Plains IV to allow for skipped-row planting practices. The original dryland cotton and grain sorghum budgets in both regions were developed with receipts, costs, and thus net returns figured per acre of cotton or grain sorghum. No allowances were made for skipped-row planting. In order to make the figures comparable with other budgets, computations were necessary to reflect receipts, costs and net returns per acre of land. Since the practice most common in these regions is one row skipped for every two rows planted, it was necessary to multiply the original figures by two-thirds. The resulting products indicate amounts per acre of land instead of amounts per acre of cotton or grain sorghum.

Irrigation costs were updated in all three regions. The irrigation costs in High Plains II were revised to a variable cost of \$.70 per acre inch of water and a fixed cost of \$1.05 per acre inch. The water costs in High Plains III and High Plains IV were adjusted according to the schedule presented in Table 4 (Sartin, February 1975).

Livestock were included in the model as an output alternative for wheat. Wheat can be sold as grain or grazed and marketed in the form of cattle. However, to make the pricing of cattle simplier, the AUM's (animal unit months) in the original budgets were converted into pounds of cattle.

The conversion of AUM's to pounds of cattle in the wheat budgets was made by multiplying the original AUM's by a factor of 80. This figure denotes one AUM as 80 pounds of beef. At a stocking rate of two animals per acre and an average daily gain of 1.4 pounds, the pounds of beef produced per acre per month amount to 84 pounds (1.4 pounds x 2 animals x 30 days). With a death loss of three percent, this figure is reduced by 2.52 pounds and equals 81.48. The number was then rounded to 80 pounds (Kennedy).

The Model

Assumptions

The following assumptions were made to develop the model: (1) All machinery and equipment is owner-operated. (2) All fuel use, other than that associated with irrigation, is in the form of diesel. (3) All

Table 4. Water costs by distribution system and well capacity in High Plains III and High Plains IV: 1975

Type system	Well Capacity	Cost per acre inch			
		Fuel	Maintenance	Fixed	Total
	(GPM)	------------dollars------------			
Furrow	300	.37	.32	1.33	2.03
	400	.35	.32	1.14	1.80
	600	.34	.32	1.14	1.80
Srpinkler/ sideroll	250	.51	.58	1.65	2.74
	300	.51	.58	1.65	2.74
	400	.50	.58	1.47	2.55
	600	.50	.58	1.47	2.55
Center pivot	600	.60	.76	2.24	3.60
	800	.67	.76	2.11	3.54

Source: Sartin, February 1975.

irrigation fuel use is in the form of natural gas. (4) The price of diesel and herbicide move together at a constant ratio since both originate from similar petroleum derivatives. This assumption is made for simplicity in programming, notwithstanding the fact that diesel and herbicide use do not necessarily move together. In fact, it is recognized that in certain instances they are substitutes. (5) The planning horizon is short-run; therefore, the focus is on variable costs only. (6) Management is considered to be typical.

Characteristics

The working model was developed by combining the linear programming technique and the data provided by the enterprise budgets. The fixed resource was essentially land, the enterprises were the production alternatives of the study crops, and the resources to be investigated were energy or energy-related inputs. The objective function was maximization of net returns and was comprised of enterprise costs, resource costs, and product receipts.

The following discussion of specific components of the model is directed to procedures followed and methods used to develop coefficients where data could not be directly taken from crop enterprise budgets. The linear programming matrix can be found in Appendix E.

Diesel

Fuel use in the crop enterprise budgets is divided among three type fuels, gasoline, L.P. gas, and diesel. Therefore, conversion formulas were applied to gasoline and L.P. gas to convert their quantities used into diesel fuel used. The conversion equations are:

(1) Gallons of diesel = gallons of gasoline ÷ 1.4

(2) Gallons of diesel = gallons of L.P. gas ÷ 1.78

Herbicide

Herbicides were included in the model because their petroleum base classifies them as an energy-related input; the price of petroleum affects the price of herbicides. However, the diversity of herbicide products made their comprehensive inclusion more complex than was warranted for this study. Therefore, the assumption was made that herbidice prices move with diesel prices. The rationale for this assumption stems from the fact that the petroleum base of herbicides is similar to diesel. The assumption is broad and actually grossly simplifies the price relationship between herbicide and diesel. In some cases, the two, in fact, are substitutes. However, the assumption is defendable on the grounds that the inclusion of herbicides is preferred over their exclusion.

To allow diesel and herbicide price to move together when they are being parameterized, a relationship had to be derived that would establish a constant ratio between the two. The fact that herbicide is not expressed in physical units in its resource row created a problem. The dilemma was solved with the following reasoning: (1) The cost of diesel and the cost of herbicide have a relationship in the generated enterprise budgets. (2) The cost of diesel is expressed in the objective function of the model as dollars per gallon. (3) The cost of herbicide is expressed in the objective function as percentage points per enterprise. (4) The cost of diesel in the budgets is \$.31 per gallon. (5) The cost of herbicide in the budgets is 100 percent of the dollars spent on herbicide per enterprise, regardless of the amount. (6) The ratio of cost of herbicide to cost of diesel can therefore be expressed as:

$$\frac{\text{100 percent x dollars spent on herbicide}}{\$.31}$$

or

$$\frac{\text{1.00 x dollars}}{\$.31} \approx \frac{\text{3.00 x dollars}}{\$1.00}$$

(7) This exercise means that the ratio of the cost of herbicide to the cost of diesel is approximately 300 percentage points to one dollar. (8) This ratio is interpreted in the parameterizing procedure of the model as incrementing herbicide costs by three percentage points for every one cent increment in the price of diesel.

Water costs excluding natural gas

To charge a production enterprise for the costs of irrigation other than fuel (natural gas) costs, a resource row named "water costs excluding natural gas" was added. These costs include total pumping costs of irrigation (fixed and variable), less irrigation fuel costs. They were computed by the following process: (1) The amount of water per acre foot used by the enterprise is multiplied by the published cost of irrigation water per acre foot. These costs are differentiated by region, crop, distribution system, and number of applications (Lacewell, Sprott, and Beattie). The derived product is the cost of irrigation water for that enterprise. (2) The cost of irrigation fuel that appears in each budget is then subtracted from total irrigation cost figured in step one. The remaining difference is the irrigation water cost excluding natural gas. These differences became the coefficients in this resource row.

The objective function

The objective function for this problem is a measurement of net revenue and is to be maximized. The objective function value for each crop enterprise was formed by the variable costs of each enterprise less the costs of diesel, nitrogen fertilizer, herbicide, and irrigation water and was entered as a negative value. The objective function value for the energy-related inputs above is the price per unit for that input. It also was entered as a negative value; i.e., buy activities for inputs. For the products, the objective function value is the price per unit received by the farmer; i.e., sell activities for products.

With the model so constructed, the objective function is reduced by the variable cost value (not including energy-related inputs) when one acre of a crop comes into solution. In turn, the quantity of energy inputs (diesel, natural gas, nitrogen, and water) required are forced to be purchased at specified prices; this procedure further reduces the net value of objective function. At the same time, the quantity of product produced is sold and thereby adds to the net value of the objective function. The buy and sell activities are necessary to facilitate use of the parameterizing routine and to maximize flexibility of the model by permitting rapid product price changes. Transfer rows are required for the buy and sell columns.

Given the above basic description of the model, it is appropriate to identify some of the more important data that are included in it.

INPUT DATA AND RESEARCH PLAN

As reported in the previous chapter, basic data for the model were developed using the budget generator. This chapter emphasizes data that are particularly important to the study. The model is presented in Appendix E; hence, there is little discussion of specific coefficients.

Crops

The crops selected for the study are corn, cotton, grain sorghum, soybeans, and wheat. Cotton, grain sorghum, and wheat are included for all three study regions. In High Plains II, there is one production alternative for corn, three for cotton, three for grain sorghum, one for soybeans, and three for wheat. In High Plains III, where two different irrigation distribution systems are utilized, nine production alternatives exist for cotton, nine for grain sorghum, one for soybeans, and two for wheat. In High Plains IV, cotton has seven alternative production levels, grain sorghum has five, and wheat has two. In all, 46 activities for five crops exist.

The production alternatives for each region are presented in Table 5. Cotton, grain sorghum, and wheat are planted on the most acres and can be produced with less water than soybeans or corn; hence, more production alternatives are available for them. Corn and soybeans are included at only one irrigation level.

Table 5. Production activities, by region, included in the analysis for the Texas High Plains

Item	Dryland	Irrigated								
		System[a]				Level[b]				
		FW	SP	SR	CP	PP	PP+1	PP+2	PP+3	PP+4
High Plains II										
Corn									X	
Cotton	X	X					X	X		
Grain sorghum	X	X						X	X	
Soybeans		X						X		
Wheat	X	X							X	X
High Plains III										
Cotton	X									
Cotton		X				X	X	X	X	
Cotton			X			X	X	X	X	
Grain sorghum	X									
Grain sorghum		X					X	X	X	X
Grain sorghum			X				X	X	X	X
Soybeans			X						X	
Wheat	X		X						X	
High Plains IV										
Cotton	X									
Cotton				X		X	X	X	X	
Cotton					X			X	X	
Grain sorghum	X									
Grain sorghum				X				X	X	
Grain sorghum					X				X	X
Wheat	X			X					X	

[a] FW refers to a furrow type distribution system; SP refers to a sprinkler type system; SR refers to a sideroll type system; CP refers to a center pivot type system.

[b] PP refers to a preplant irrigation; the number following PP is the number of postplant irrigations.

Irrigation Water

The irrigation water applied to the crops refers to "effective" water reaching the root zone of the plant and not necessarily to "pumped" water. The amount of irrigation water varies with the time of application and with the distribution system. Preplant applications of irrigation water are typically six inches of water for furrow systems and four inches for sprinkler, sideroll, and center pivot systems. Postplant applications of irrigation water amount to four inches for furrow and three inches for sprinkler, sideroll, and center pivot.

Acreage Restraints

The flexibility restraints on acreage developed by Condra and Lacewell serve as the right-hand side in the linear programming model. Table 6 presents a schedule of these acreage limitations.

Commodity Prices

The short run nature of the study dictates that relatively recent prices be used. The prices received by farmers from 1971 through 1974 in the Texas Agricultural Extension Districts 1-N and 1-S were obtained for analysis (Canion). These prices are representative of a wide variation in conditions and do not give a skewed sample of prolonged high or prolonged low prices, but a mix of both. Three price levels of high, low and average were selected for the analysis. The high price for each commodity is the upper bound of the range, and the low price is the lower bound of the range. The rationale for the decision to use these

Table 6. Acreage restraints on cropland, irrigated cropland, and the study crops in the study area, by region

	Region					
	High Plains II		High Plains III		High Plains IV	
	Max	Min	Max	Min	Max	Min
	---1,000 acres---					
Total cropland	3,686	0	2,792	0	1,072	0
Irrigated cropland	2,750	0	1,321	0	513	0
Furrow	--	--	786	0	--	--
Sprinkler	--	--	535	0	--	--
Sideroll	--	--	--	0	439	0
Center pivot	--	--	--	--	74	--
Corn	730	0	--	--	--	--
Cotton	684	544	1,439	1,184	598	427
Grain sorghum	1,315	1,028	883	674	426	329
Soybeans	120	0	17	0	--	--
Wheat	1,529	1,127	291	118	335	48

Source: Condra and Lacewell

is that they are inclusive of what is expected to happen to commodity prices in the short run future. The intermediate price used is the simple forty-eight month average from 1971 through 1974. Table 7 indicates the prices that were used in the analysis. The price fluctuation of cottonseed and cattle is less significant to the problem. Therefore, their prices were held constant throughout the model; cottonseed was set at $100 per ton and cattle at $20 per hundredweight.

Input Prices

The present situation regarding energy and energy-related prices is unstable and uncertain. Predictions of future prices in these times are risky. Therefore, it was decided to begin with current prices of inputs. In the case of natural gas and nitrogen fertilizer, there is widespread speculation of significant price increases in the near future. Diesel prices are somewhat more stable. Therefore, the crop enterprise budget price of diesel was slightly increased to a current price of $.40 per gallon (Grubb). With a direct relationship between herbicide and diesel price assumed in the model, the price of herbicide had to be increased 20 percent above the crop budget price. Natural gas was priced at $.88 per 1000 cubic feet (Mcf) based on information from production specialists in the area. A higher cost of $1.25 per Mcf was used for selected situations (Osborn 1975). Nitrogen fertilizer was priced at $.20 per pound with $.30 per pound used in selected situations. With these basic input prices, the price of natural gas, nitrogen, diesel, and water was parameterized separately under alternative specified conditions.

Table 7. The high, low and forty-eight month average price for the study crops in Texas Agricultural Extension Districts 1-N and 1-S; 1971-74

Crop	Unit	Price per unit High	 Average	 Low
		---------dollars-------------		
Cotton lint	lb	.67	.31	.18
Grain sorghum	cwt	5.96	3.10	1.86
Soybeans	bu	7.75	4.27	2.30
Wheat	bu	5.35	2.60	1.34
Corn	bu	3.46	1.94	1.12

Source: Canion

These prices were used in the model when the price of an input was held constant. When the price of a particular input was being parameterized, it varied over a specified range. The price of diesel was varied over a range from zero to $5.00 per gallon; natural gas, from zero to $10.00 per Mcf; nitrogen fertilizer, from zero dollars to $2.00 per pound; and water, from zero dollars to $100.00 per acre foot.

Alternative Situations

Of the numerous price combinations possible within the model, 16 were selected to test. Table 8 presents the price specifications for the selected alternative situations. Four input prices were parameterized; diesel, natural gas, nitrogen, and water. Each group of situations deals with a particular resource. In situations 01 through 09 involving diesel, natural gas, and nitrogen, the three commodity price levels of high, average, and low were used as the price of the resource being tested was varied. The input prices not being tested were held constant at current price levels. Situations 10 through 16 tested other selected conditions.

Diesel Group

Situations 01, 02, 03, 10, and 11 indicate that the price of diesel was increased to $5.00 per gallon to estimate demand schedules for this input. The alternatives with high commodity prices and low commodity prices should bracket the area of activity for diesel fluctuations. Situation 10 was intended to investigate the effect of a higher price for

Table 8. Summary of price specifications for the alternative situations analyzed

Situation number	Operation	Unit	Maximum price	Inputs DSL[b]	NGS[c]	NIT[d]	WTR[e]	Commodity Prices
			--------	--------	dollars	--------	--------	
01	Parameterize Diesel	gal	5	--	.88	.20	0	High
02	Parameterize Diesel	gal	5	--	.88	.20	0	Low
03	Parameterize Diesel	gal	5	--	.88	.20	0	Average
10	Parameterize Diesel	gal	5	--	1.25	.20	0	Average
11	Parameterize Diesel	gal	5	--	1.25	.30	0	Average
04	Parameterize Nat Gas	Mcf	10	.40	--	.20	0	High
05	Parameterize Nat Gas	Mcf	10	.40	--	.20	0	Low
06	Parameterize Nat Gas	Mcf	10	.40	--	.20	0	Average
12	Parameterize Nat Gas	Mcf	10	.40	--	.30	0	Average
07	Parameterize Nitrogen	lb	2	.40	.88	--	0	High
08	Parameterize Nitrogen	lb	2	.40	.88	--	0	Low
09	Parameterize Nitrogen	lb	2	.40	.88	--	0	Average
13	Parameterize Nitrogen	lb	2	.40	1.25	--	0	Average
14	Parameterize Water	ac ft	100	.40	.88	.20	--	Average
15	Parameterize Water	ac ft	100	.40	.88	.20	--	High
16	Parameterize Water	ac ft	100	.40	1.25	.20	--	Average

[a] See Table 7 for prices of commodities.

[b] DSL refers to diesel; unit of measurement is gallons.

[c] NGS refers to natural gas; unit of measurement is 1000 cu/ft.

[d] NIT refers to nitrogen; unit of meausrement is pounds.

[e] WTR refers to water; unit of measurement is acre foot.

natural gas; whereas, situation 11 looked at the effect of higher than current prices for both natural gas and nitrogen.

Natural Gas Group

Situations 04, 05, 06, and 12 show that the price of natural gas was parameterized up to $10.00 per Mcf. Situation 12 sought to investigate the effect of a $.30 rather than $.20 per pound nitrogen.

Nitrogen Group

Situations 07, 08, 09, and 13 parametrically investigated the price of nitrogen fertilizer up to $2.00 per pound. Situation 13 examined the effect of $1.25 per Mcf natural gas price.

Water Group

Situation 14, 15, and 16 parameterized the price of water to $100 per acre foot up above the costs of pumping and distribution. This activity was incorporated into the model so that estimates could be made relative to how much can be paid for water imported into the region. Only average and high commodity prices were used for these situations.

This discussion provides an indication of the methods of analysis and data used in the model. By applying the model, the effect of changing price conditions in agriculture was estimated.

RESULTS AND INTERPRETATIONS

Application of the model provides an estimate of the expected effects of alternative input and product prices in agriculture. Product prices were set at three separate levels as described in Chapter IV. The primary focus of analysis was, therefore, to evaluate expected adjustments in agriculture that would be associated with changes in input prices; namely, diesel, natural gas, nitrogen, and water. Estimated demand curves are presented for diesel, natural gas, nitrogen, and water. Associated with the changes in quantity of each input demanded at different input price levels are adjustments in agricultural production and producer net revenue. Ouptut adjustments occur due to acreage shifts between dryland and irrigation and cropping shifts among the various crops. This examination is organized by focusing on one input at a time; first, diesel; then, natural gas, nitrogen and water, in that order.

An analysis relative to intraregional cropping pattern shifts associated with alternative sets of diesel and natural gas prices concludes the study. The results, in this case, are based on average commodity prices only.

Effects of Alternative Diesel Prices

Diesel prices are parameterized assuming average, high, and low crop prices with current input prices. Average crop prices are then assumed with a high natural gas price only and then with a high price for natural gas and nitrogen.

Quantity of Diesel Demanded

Expected quantity of diesel demanded by agricultural producers in the study area, as a function of price, is presented in Figure 2 assuming high, low, and average product prices and average input prices. Figure 2 along with Tables 9, 10, and 11 reveals that at higher prices of diesel there is a wide variation in quantity of diesel used among the three commodity price levels. However, until diesel reaches the \$.55 to \$.60 per gallon price range, the quantity used at high, average and low commodity price levels is similar. At \$.56 per gallon and low commodity prices (Table 10), nearly 102 million gallons of diesel are used. At the same diesel price and high commodity prices (Table 9), just over 109 million gallons are used. A seven million gallon increase (7 percent) in quantity of diesel used is indicated as commodity prices change from low to high at a diesel price of \$.56 per gallon.

Diesel consumption at low commodity prices falls off substantially above the \$.56 per gallon price level and continues to decrease fairly rapidly until the price reaches \$2.43 per gallon. At high commodity prices (Table 9), diesel is relatively inelastic until the price exceeds \$4.50 per gallon. Even at average commodity prices (Table 11), the demand for diesel remains about the same until diesel gets in the \$2.00 per gallon price range. These results indicate that the demand for diesel is relatively inelastic at current price levels and will remain

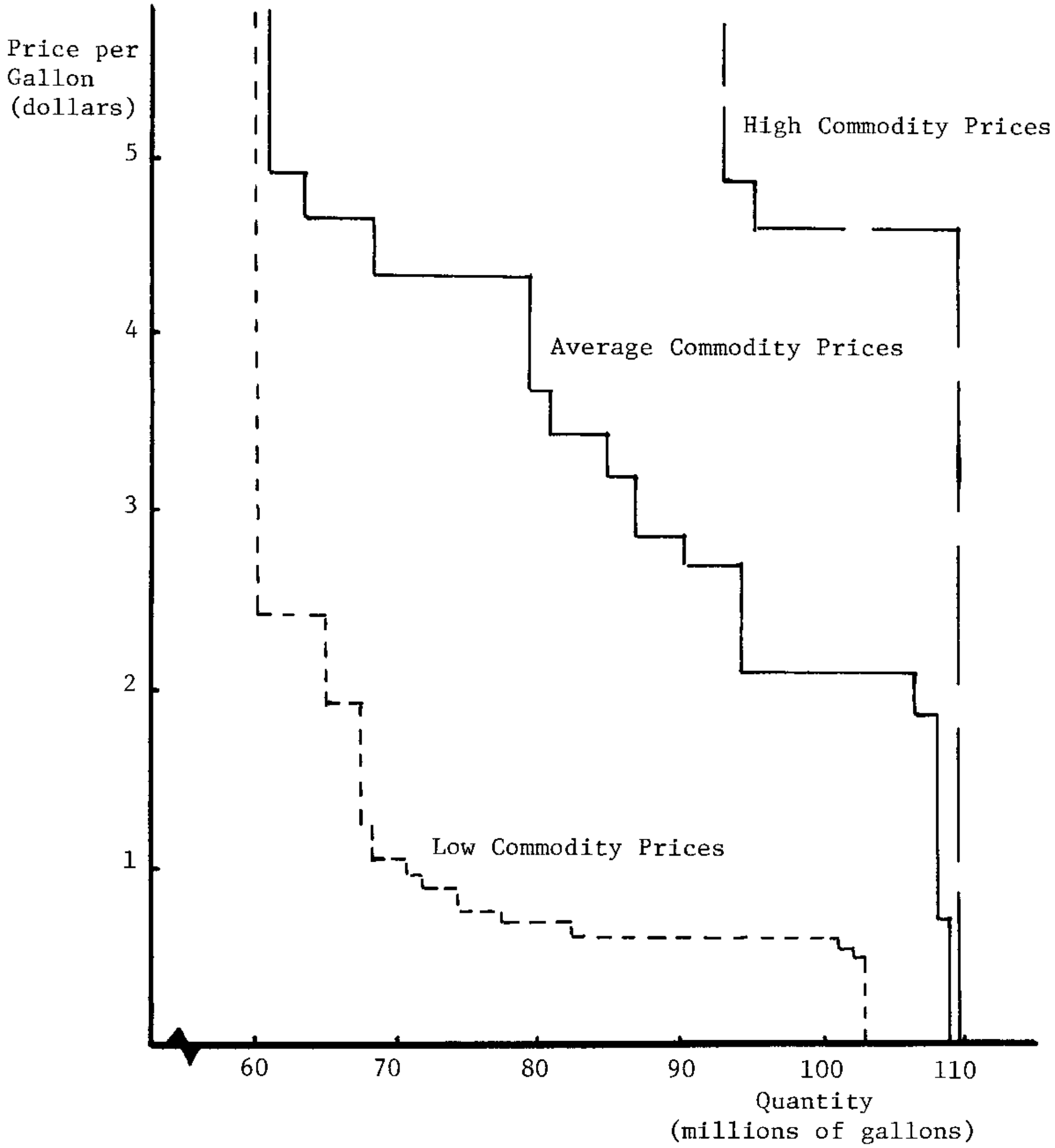

Figure 2. Estimated agricultural use of diesel with high, average, and low commodity prices: Texas High Plains

Table 9. Estimated quantity of diesel used in agricultural production at selected diesel prices with associated dryland and irrigated acres and producer net returns based on high commodity prices[a] and current input prices:[b] Texas High Plains

Diesel		Acres of Cropland		
Price per gallon	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 gallons)	---------1,000-------		($1,000,000)
0	109,695	3,146	4,404	1,515
.11	109,391	3,146	4,404	1,497
.70	109,395	3,146	4,404	1,395
1.31	109,702	3,146	4,404	1,292
4.00	109,214	3,146	4,404	837
4.60	95,242	3,146	4,404	737
4.87	93,617	3,146	4,404	697

[a] High commodity prices are defined as: cotton lint--$0.67 per pound; cottonseed--$100.00 per ton; grain sorghum--$5.96 per cwt; soybeans--$7.75 per bushel; wheat--$5.35 per bushel; corn--$3.46 per bushel.

[b] Current input prices are defined as: natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

Table 10. Estimated quantity of diesel used in agricultural production at selected diesel prices with associated dryland and irrigated acres and producer net returns based on low commodity prices[a] and current input prices:[b] Texas High Plains

Diesel		Acres of Cropland		
Price per gallon	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 gallons)	-------1,000--------		($1,000,000)
0	103,025	3,559	3,953	178
.01	104,781	3,559	3,953	176
.46	102,160	3,559	3,813	101
.56	101,729	3,559	3,813	86
.61	82,371	4,874	2,498	78
.67	77,410	5,418	1,954	70
.76	74,282	6,036	1,336	60
.89	72,425	6,036	1,216	46
.97	71,446	6,204	1,048	38
1.03	68,432	6,739	513	32
1.27	67,778	6,679	513	10
1.93	65,920	6,392	513	-51
2.43	60,613	5,722	513	-96
3.23	60,146	5,669	513	-163
4.25	60,290	5,779	439	-271

[a] Low commodity prices are defined as: cotton lint--$0.18 per pound; cottonseed--$100.00 per ton; grain sorghum--$1.86 per cwt; soybeans--$2.30 per bushel; wheat--$1.34 per bushel; corn--$1.12 per bushel.

[b] Current input prices are defined as: natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

Table 11. Estimated quantity of diesel used in agricultural production at selected diesel prices with associated dryland and irrigated acres and producer net returns based on average commodity prices[a] and current input prices:[b] Texas High Plains

Diesel		Acres of Cropland		
Price per gallon	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 gallons)	--------1,000-------		($1,000,000)
0	109,046	3,146	4,404	554
.72	108,559	3,146	4,404	433
.81	108,563	3,146	4,404	417
.91	108,548	3,146	4,404	401
1.38	108,117	3,146	4,404	323
1.86	106,799	3,146	4,404	242
2.12	93,929	3,146	4,404	200
2.53	93,241	3,146	4,404	141
2.69	90,467	4,442	3,108	118
2.90	86,604	4,089	3,108	90
3.20	85,619	3,816	3,108	51
3.43	80,657	4,360	2,564	24
3.72	79,544	4,343	2,564	-9
4.14	79,113	4,373	2,534	-56
4.38	68,379	4,775	1,834	-81
4.64	63,116	4,369	1,834	-107
4.91	61,323	4,082	1,834	-131

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

so unless commodity prices decline to abnormally low levels or diesel price approaches $2.00 per gallon.

Two other factors are tested to see if they will significantly influence the quantity of diesel demanded. First, the price of natural gas is raised from $.88 per Mcf to $1.25 per Mcf at average commodity prices. Appendix Table 25 indicates diesel demand with average commodity prices and the higher natural gas price. Again diesel quantity consumed changes little until the price reaches well above $2.00 per gallon. In fact, the quantity demanded at $2.12 per gallon of diesel is actually greater at $1.25 per Mcf of natural gas than at $.88 Mcf.

A further extension of the analysis is to set natural gas at $1.25 per Mcf and nitrogen at $.30 per pound (a high nitrogen price). These results are presented in Appendix Table 26 and are similar except that these conditions result in quantity of diesel demanded declining markedly at a price of diesel somewhat below $2.00 per gallon rather than above. Consumption falls to 93 million gallons when diesel price reaches $1.93 per gallon.

One paradoxical aspect of the demand schedules for diesel is worthy of mention and warrants an explanation. Instances appear in the schedules where quantity demanded increases when the price goes up. For example, in Table 9 as the price of diesel rises from $.11 per gallon, to $.70, to $1.31, the quantity used in agriculture increases. This situation is caused by the model being structured with diesel and herbicide prices moving together. The objective function in the model may be optimized at a higher diesel price with an enterprise that requires a greater quantity of diesel but less herbicide.

Producer Net Returns

The most significant adjustments that occur when diesel prices rise are in net revenues above variable costs as shown in Tables 9, 10, 11 and Appendix Tables 25 and 26. When commodity prices are high (Table 9), net revenue falls from $1.5 billion at zero price diesel to $697 million at $4.87 per gallon of diesel. When average commodity prices are tested (Table 11), net revenue is $554 million at zero price diesel and becomes negative somewhere between $3.43 per gallon and $3.72 per gallon. The negative figures appear because the minimum number of acres of certain crops are being forced into production due to model formulation and study assumptions. Even with diesel selling for $.90 per gallon (approximately double its current price), producer net returns are above $400 million. At low commodity prices (Table 10), zero price diesel earns farmers only $178 million in net revenue, and diesel around $1.40 per gallon causes net revenue to decline to zero for the same reasons as described above.

To emphasize the significant impact that commodity prices have, computations were made to figure net revenue per acre above variable costs with zero price diesel. At low commodity prices, farmers earn $23.58 per acre; average commodity prices yield $73.38 per acre; and high commodity prices earn the farmer $200.66 per acre. A similar exercise was figured with diesel approximately $.70 per gallon. Net revenue per acre above variable costs is $8.74 at low prices, $56.95 at average prices, and $184.77 at high prices. Obviously, commodity prices are more impactual on the farmers' welfare than are diesel prices.

The tests made with higher prices for natural gas and nitrogen simply indicate the pass-through of these higher prices to reduce net returns. For example, the higher natural gas price reduces net returns by $19 million over the total study area with $.72 diesel and average commodity prices (see Appendix Table 25).

Irrigated Acres of Cropland

Another factor of concern exists in the acreage shifts between dryland and irrigated, see Tables 9, 10, 11 and Appendix Tables 25 and 26. At high commodity prices (Table 9), irrigated acres remain at the maximum limit through $5.00 per gallon diesel. Average commodity prices (Table 11) result in a maximum level of irrigation until diesel reaches $2.69 per gallon. Then some irrigated acres switch to dryland, and, at $2.90 per gallon, some acres go out of production.

It is significant to note that, within present product and input price levels, diesel price has virtually no effect on the number of acres of irrigated cropland. However, at low prices of commodities (Table 10), acres begin shifting from irrigated to dryland and $.46 per gallon of diesel, and irrigated acres continue to decline as the price of diesel increases. Surprisingly, thirty-eight thousand idle acres are indicated with low commodity prices and diesel at a price of zero.

Higher prices for natural gas and nitrogen cause irrigated acres to shift to dryland at lower prices of diesel. With a natural gas price of $1.25 per Mcf and nitrogen $.30 per pound, acres begin shifting out of irrigation at $.37 per gallon of diesel as shown in Appendix Table 26.

Agricultural Output

The effects of alternative diesel prices on the expected output of the five crops are presented in Table 12 and Appendix Tables 27, 28, 29 and 30. High commodity prices and low commodity prices are tested in Appendix Tables 27 and 28, respectively. Average commodity results are in Table 12.

The price of diesel has very little effect on cotton production, particularly with average and high cotton prices. In fact, over two million bales of cotton are still being produced with diesel selling for over $4.00 per gallon. The slight adjustment that cotton production does make to diesel price, however, is inversely related; as the price of diesel goes up, cotton output goes down.

Grain sorghum production adjustments are somewhat more erratic than cotton over the five dollar range that diesel price is tested. At a much more relevant price range, from $1.38 per gallon and less, grain sorghum output is steady for high and average milo prices. Production is maintained between 103 million hundredweight and 117 million hundredweight. Low grain sorghum prices, as shown in Appendix Table 28, cause output to drop significantly. Soybeans are in solution at average and low commodity prices; soybean production does not decline in these two cases until diesel price is $2.53 per gallon. In a short run diesel price range, soybean output is steady, having no relation

Table 12. Estimated crop output at selected diesel prices based on average commodity prices[a] and current input prices:[b] Texas High Plains

Diesel price per gallon	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	---------1,000,000 bu--------		
0	2,475	103,132	4.2	23.6	80.3
.72	2,431	103,132	4.2	25.1	80.3
.91	2,430	103,132	4.2	25.1	80.3
1.38	2,348	105,611	4.2	26.1	80.3
1.86	2,348	98,761	4.2	31.5	80.3
2.53	2,314	63,039	.6	62.2	80.3
3.43	2,101	38,386	.6	29.8	80.3
4.14	2,101	40,022	0.0	25.9	77.0

[a] Commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

to rising diesel prices.

Corn production, like soybeans, is either in or out for the most part. Rising diesel prices affect its production little, if any. Wheat, though, tells an entirely different story from the other crops. At all three commodity price levels, the production of wheat steadily increases as the price of diesel rises to the $2.00 per gallon range. This evidence suggests a direct relationship between wheat output and diesel price; as diesel goes up, wheat production goes up. A logical interpretation of this situation is that wheat production is less diesel intensive than the other crops. When the price of the fuel increases, the model brings into solution an activity that uses less diesel, namely wheat.

The results of other factors that are tested are outlined in Appendix Tables 29 and 30. First, natural gas price is fixed at $1.25 per Mcf (Appendix Table 29); then nitrogen is raised to $.30 per pound along with the $1.25 Mcf natural gas (Appendix Table 30). An examination of these results reveal a similar pattern of relationships. In summary, diesel prices appear to have relatively little effect on crop output within any reasonable price range, and the volume of production is influenced to a much greater extent by the commodity price level than by the diesel price level.

Cropping Patterns

The information in Table 13 and Appendix Tables 31 and 32 relates expected cropping patterns (acres planted) to the price of diesel. Average commodity prices are used in all three tables. Table 13

Table 13. Estimated planted cropland by crop, at selected diesel prices based on average commodity prices[a] and current input prices:[b] Texas High Plains

Diesel price per gallon	Acres Planted											
	Total		Cotton		Grain sorghum		Soybeans		Wheat		Corn	
	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total
(dollars)												
0	7,550	100	3,013	40	2,168	29	120	2	1,519	20	730	10
.71	7,550	100	2,886	38	2,168	29	120	2	1,646	22	730	10
.81	7,550	100	2,884	38	2,168	29	120	2	1,648	22	730	10
1.38	7,550	100	2,810	37	2,168	29	120	2	1,722	23	730	10
1.86	7,550	100	2,810	37	2,031	27	120	2	1,859	25	730	10
2.13	7,550	100	2,793	37	2,031	27	137	2	1,859	25	730	10
2.17	7,550	100	2,781	37	2,031	27	137	2	1,871	25	730	10
2.52	7,550	100	2,781	37	2,031	27	17	d	1,991	27	730	10
2.90	7,197	95	2,428	32	2,031	27	17	d	1,991	27	730	10
3.20	6,924	92	2,155	29	2,031	27	17	d	1,991	27	730	10
3.49	6,907	92	2,155	29	2,031	27	0	0	1,991	27	730	10
3.61	6,907	92	2,155	29	2,288	30	0	0	1,734	23	730	10
4.14	6,907	92	2,155	29	2,318	31	0	0	1,734	23	700	9
4.27	6,907	92	2,155	29	2,318	31	0	0	2,136	28	298	4
4.37	6,609	88	2,155	29	2,318	31	0	0	2,136	28	0	0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum-- $3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

[c] The cropland restriction (acres available) is 7,550,000 acres.

[d] Less than .5 percent.

indicates acreage shifts with natural gas at $.88 per Mcf and nitrogen at $.20 per pound. All available acres are planted until diesel reaches $2.90 per gallon; then idle acres begin to emerge. The crop mix at a zero price of diesel is 40 percent wheat, and nearly 10 percent corn. The adjustment with an increasing diesel price up to $1.50 per gallon is cotton acreage shifting to wheat acreage. Over the entire price range tested, cotton acreage is steadily reduced as diesel price increases. Grain sorghum acreage goes down until diesel reaches $3.61 per gallon, and wheat acreage steadily increases. Soybean acreage is essentially the same up to a $3.49 per gallon diesel, and corn acreage is at its maximum until diesel reaches $4.14 per gallon.

Appendix Table 31 indicates a similar test made with natural gas at $1.25 per Mcf instead of $.88 per Mcf. The results change little as can be seen when acreages are compared for a similar diesel price. Appendix Table 32 outlines the same test made with $1.25 per Mcf natural gas and $.30 per pound of nitrogen. Idle acres appear at $2.28 per gallon of diesel, and, in each case, idle acres come from decreased cotton acres. Corn acreage is somewhat more sensitive, but the overall results are essentially consistent with the analysis using average crop prices and current input prices (Table 13).

Effects of Alternative Natural Gas Prices

The price of natural gas is parametrically tested using high, low, and average commodity prices together with current input prices. One additional test is made with average commodity prices, current diesel price, and a higher nitrogen price.

Quantity of Natural Gas Demanded

The estimated demand schedules for natural gas under high, average, and low commodity prices are presented in Figure 3. The results in tabular form are presented in Table 14 and Appendix Tables 33, 34, and 35. For average commodity prices, over 51 million cubic feet of natural gas are consumed at a zero price (see Table 14). In this case, quantity of natural gas demanded by agriculture in the study area does not begin to decrease appreciably until gas prices rise above $4.00 per Mcf; quantity demanded then falls off steadily to near zero at $6.38 per Mcf for natural gas. A small acreage of irrigated soybeans in High Plains II stays in solution until natural gas reaches $9.12 per Mcf. Above that price, irrigated crops are no longer in solution, and no natural gas is consumed. This information suggests that,under average commodity price conditions, natural gas will be purchased in substantial quantities up to $4.00 per Mcf and will continue to be bought at double that price. With high commodity price conditions, the demand for natural gas is relatively inelastic. Over fifty-four million cubic feet of natural gas are consumed at a price of zero (see Appendix Table 33). The quantity consumed by agriculture declines only about 8 percent as the price is increased to $10.00 per Mcf.

For low commodity prices, the analysis indicates that irrigation will cease in the Texas High Plains when natural gas rises to a price of $2.48 per Mcf (see Appendix Table 34). Even at low commodity prices, quantity demanded does not fall off in great amounts until natural gas price reaches well above one dollar, specifically $1.28 per Mcf.

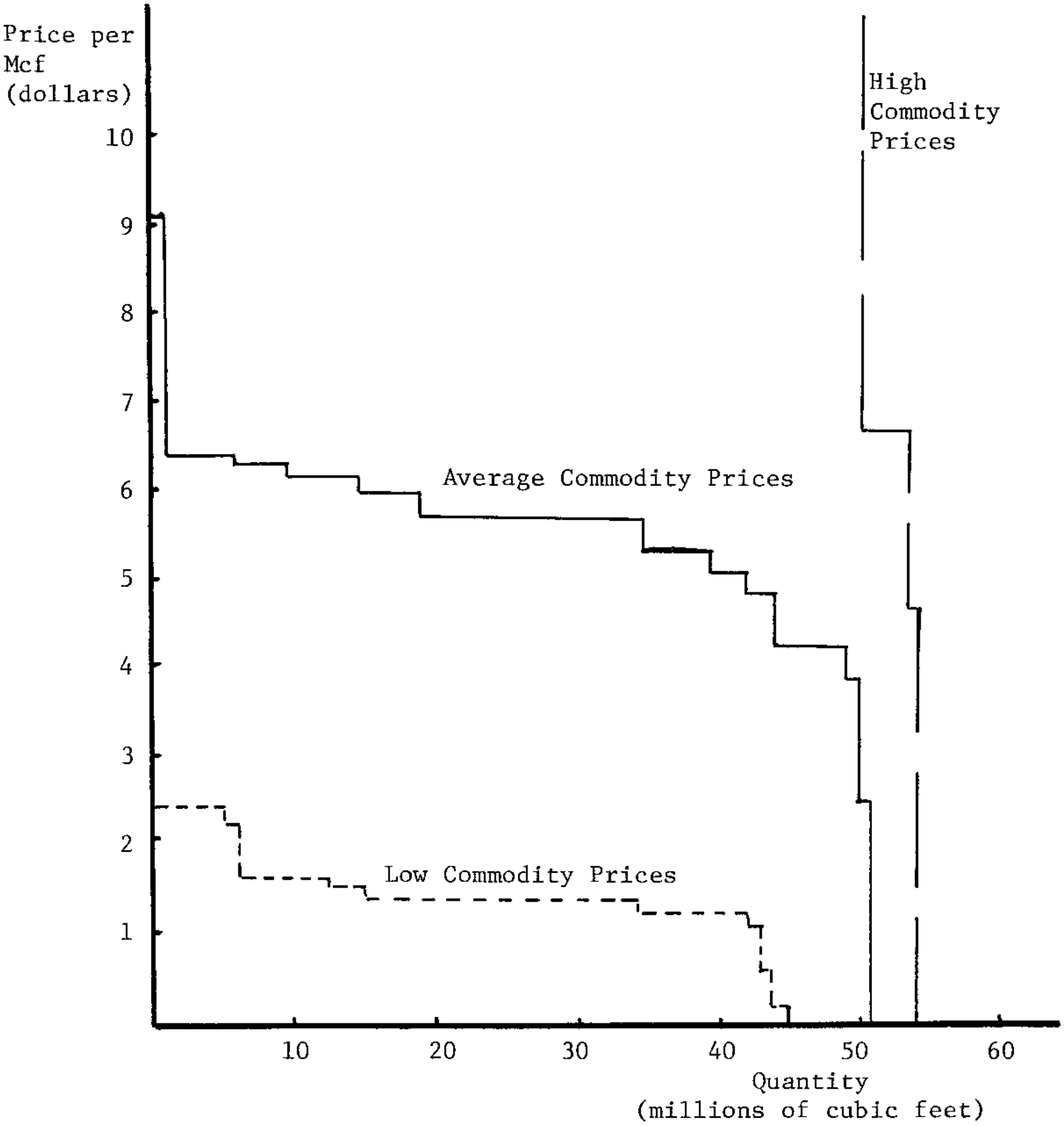

Figure 3. Estimated agricultural use of natural gas with high, average and low commodity prices: Texas High Plains

Table 14. Estimated quantity of natural gas used in agricultural production at selected natural gas prices with associated dryland and irrigated acres and producer net returns based on average commodity prices[a] and current input prices:[b] Texas High Plains

Natural Gas		Acres of Cropland		
Price per Mcf	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000,000 cu ft)	--------1,000-------		($1,000,000)
0	51,310	3,146	4,404	531
1.66	51,299	3,146	4,404	446
1.92	51,139	3,157	4,393	433
2.54	50,703	3,157	4,393	401
2.89	50,576	3,157	4,393	383
3.86	49,528	3,157	4,393	334
4.26	44,265	3,559	3,991	314
4.85	42,682	3,559	3,991	289
5.08	39,911	3,753	3,797	279
5.33	35,031	4,151	3,399	269
5.68	19,129	5,618	1,932	257
6.00	15,220	5,969	1,581	251
6.14	10,247	6,653	897	249
6.26	6,460	6,991	559	248
6.38	1,719	7,392	158	247
9.12	0	7,392	0	243

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; nitrogen--$0.20 per pound.

For the three commodity price levels, a comparison of the quantity of natural gas used up to a price of $1.28 per Mcf is revealing. At a natural gas price of $1.28 per Mcf and high commodity prices, 54,642,000 cubic feet are used; under average commodity prices, 51,310,000 cubic feet are used; and under low commodity prices, 41,935,000 cubic feet are used. Therefore, very large reductions in commodity prices, from a two-thirds to three-fourths decrease, cause only a 23 percent decrease in the amount of natural gas used. This analysis suggests that natural gas will be consumed in substantial amounts at prices up to $1.28 per Mcf, even with a large degree of variation in prices of the commodities.

One important point needs to be emphasized here. Within the model, the objective function is being optimized with only variable costs included. Production can and will occur not only where profits are being maximized but also where losses are being minimized. Therefore, the inferences drawn from the results must be applied for the short run only. Actually, if total costs (fixed and variable) were being accounted for, the changes in quantity of natural gas demanded would occur at lower natural gas prices .

Appendix Table 35 summarizes the analysis assuming average commodity prices, current diesel price, and high nitrogen price, $.30 per pound. The quantity of natural gas used at each natural gas price is less when the price of nitrogen is higher. These results are to be expected.

Producer Net Returns

As in the case of diesel prices, the most impactual adjustments to farmers under rising natural gas prices are net revenue reductions. Table 14 and Appendix Tables 33 and 34 indicate net revenue changes.

Again, the commodity prices bear most heavily on net revenue. For example, with high commodity prices and natural gas at $6.77 per Mcf, farmers are still netting $149.27 per acre above variable costs. Whereas, with low commodity prices and free natrual gas, farmers net only $20.00 per acre above variable costs.

To dramatize the benefits of irrigation, some net revenue figures from Table 14 are utilized where average commodity prices exist. With natural gas priced at $1.66 per Mcf and a typical farmer's cropped acreage allocated as 42 percent dryland and 58 percent irrigated, the farmer will realize an average return above variable costs of $59.07 per acre. If the alternative of farming without irrigation were chosen, the land would be expected to return $32.87 per farmed acre above variable costs.

Irrigated Acres of Cropland

Natural gas prices obviously affect acreage shifts between irrigated and dryland. These shifts are noted in Table 14 and Appendix Tables 33 and 34. Table 14 with average commodity prices is most relevant in the short run. Acres do not begin to shift out of irrigation until the price of natural gas reaches $1.92 per Mcf. Significant acreages are expected to remain under irrigation with natural gas prices in the $4.00 to $5.00 per Mcf range over the short run. Irrigated soybeans in High Plains II remain in production with natural gas at $9.00 per Mcf.

Agricultural Output

Table 15 indicates that crop output essentially does not change from a price of zero for natural gas to a price of $2.54 per Mcf under average commodity price conditions. Above $2.54 per Mcf, cotton production increases slightly up to 2.7 million bales then declines while grain sorghum output declines throughout. Wheat production reaches a maximum at around $5.00 per Mcf, soybeans continue to be produced until natural gas price reaches $9.12 per Mcf, and corn production steadily declines and reaches zero at a natural gas price of $9.12 per Mcf. Appendix Table 36 presents results of a similar analysis with nitrogen fertilizer at $.30 instead of $.20 per pound. The same trends hold; similar adjustments occur except at lower prices of natural gas.

Cropping Patterns

Table 16 and Appendix Table 37 likewise present shifts among crops using average commodity prices; however, here the shifts are measured in acres rather than output. The results follow the same pattern as agricultural output; rising natural gas prices have no effect on cropping pattern shifts in the short run until the price reaches the $2.50 per Mcf range. Beyond $2.50 per Mcf, the shifts are from the irrigated crops to the dryland crops. The same basic results are shown in Appencis Table 37 as nitrogen is raised to $.30 per pound.

Table 15. Estimated crop output at selected natural gas prices based on average commodity prices[a] and current input prices:[b] Texas High Plains

Natural gas price per Mcf	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	--------1,000,000 bu-----		
0	2,475	103,132	4.2	23.6	80.3
1.66	2,478	102,943	4.2	23.7	80.3
1.92	2,478	102,943	4.2	23.4	80.3
2.54	2,478	110,443	4.2	23.4	63.8
2.89	2,498	108,150	4.8	23.4	63.8
3.86	2,745	92,507	4.8	23.4	63.8
4.26	2,745	92,507	4.8	29.4	19.6
5.08	2,664	83,878	4.8	29.4	19.6
6.00	2,267	34,614	4.2	25.9	4.2
6.38	1,328	34,614	4.2	25.6	4.2
9.12	1,328	34,614	0	25.6	0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; nitrogen--$0.20 per pound.

Table 16. **Estimated planted cropland** by crops, at selected natural gas prices based on average commodity prices[a] and current input prices:[b] Texas High Plains

Natural gas price per Mcf	Acres Planted											
	Total[c]		Cotton		Grain sorghum		Soybeans		Wheat		Corn	
	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total
(dollars)												
0	7,550	100	3,013	40	2,168	29	120	2	1,519	20	730	10
1.66	7,550	100	3,011	40	2,168	29	120	2	1,521	20	730	10
2.54	7,550	100	3,011	40	2,318	31	120	2	1,521	20	580	8
2.89	7,550	100	2,994	40	2,318	31	137	2	1,521	20	580	8
3.86	7,550	100	2,785	37	2,527	34	137	2	1,521	20	580	8
4.26	7,550	100	2,785	37	2,527	34	137	2	1,923	26	178	2
5.14	7,550	100	2,821	37	2,527	34	137	2	1,886	25	178	2
6.00	7,550	100	3,360	45	2,318	31	120	2	1,713	23	38	d
6.38	7,550	100	3,379	45	2,318	31	120	2	1,695	23	38	d
9.12	7,392	98	3,379	45	2,318	31	0	2	1,695	23	0	d

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; nitrogen--$0.20 per pound.

[c] The cropland restriction (acres available) is 7,550,000 acres.

[d] Less than .5 percent.

Effects of Alternative Nitrogen Prices

As in the case of diesel and natural gas, the price of nitrogen is parameterized under all three commodity price levels with current input prices. Nitrogen price is also tested with a higher price for natural gas, current price for diesel, and average prices for commodities.

Quantity of Nitrogen Demanded

Demand curves for nitrogen at three commodity price levels are presented in Figure 4. When compared to the demand schedules for diesel and natural gas given earlier, these curves are more elastic. The price of nitrogen, even with the current price range, has a definite effect on the quantity used. At high commodity prices, nitrogen use drops nearly 30 percent as the price per pound rises from zero to $1.00. For the same nitrogen price rise, quantity used declines 51 percent under average commodity price conditions and 88 percent under low commodity price conditions.

Specific values are presented in Table 17 and Appendix Tables 38 and 39 as to the impact of an increasing nitrogen price. Significant adjustments in nitrogen use are indicated within the relevant short run price range. With average commodity prices and an average price of $.12 per pound for nitrogen, which is within the range of immediate past prices, an estimated quantity of 430,911,000 pounds of nitrogen is consumed (Table 17). When the price rises to $.33 per pound, which is within the feasibility range of the short run future, quantity used declines to 328,586,000 pounds. This decrease represents a 24 percent decline. A nitrogen price increase to $.84 per pound results in consumption of

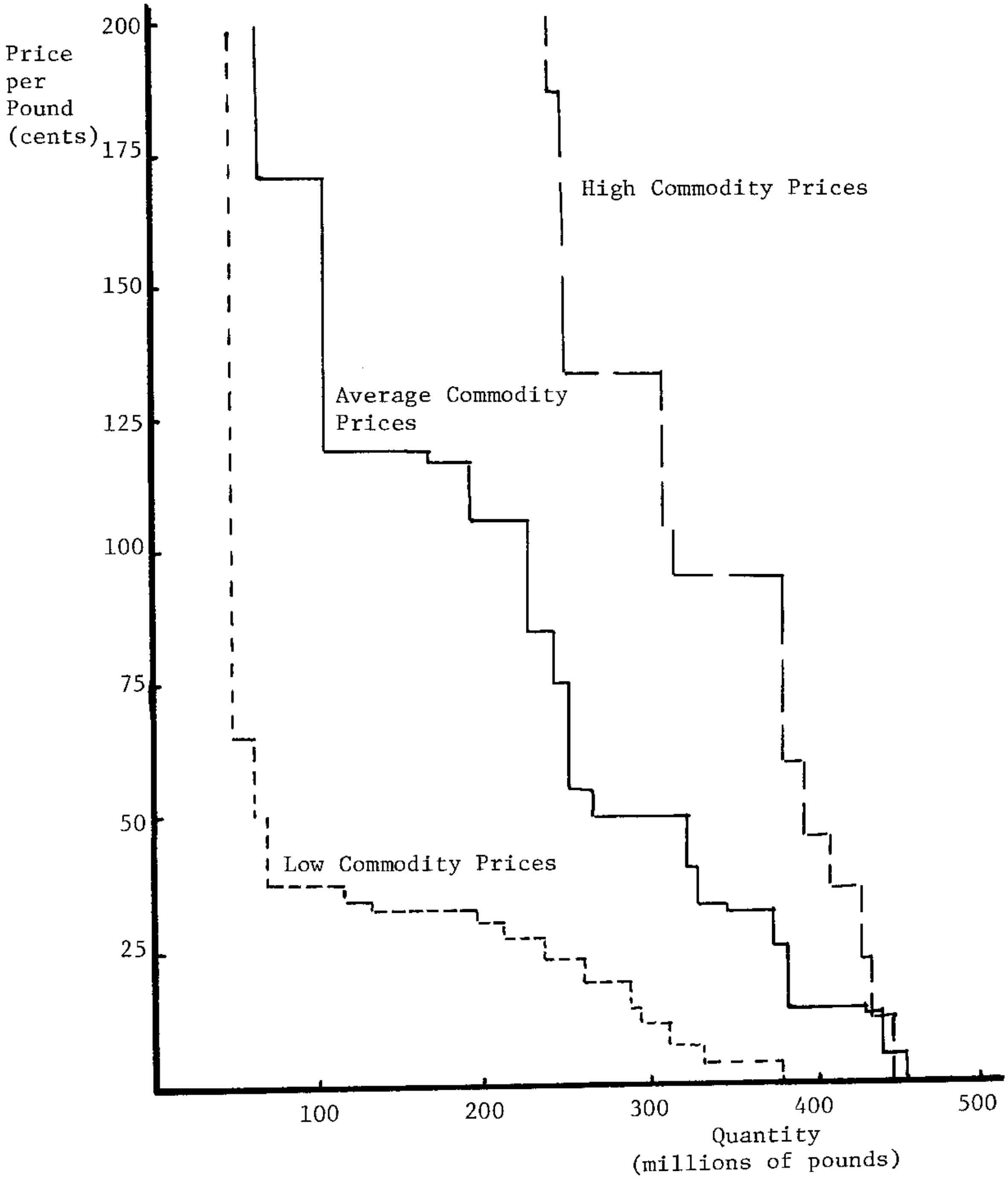

Figure 4. Estimated agricultural use of nitrogen fertilizer with high, average, and low commodity prices: Texas High Plains

Table 17. Estimated quantity of nitrogen fertilizer used in agricultural production at alternative nitrogen prices with associated dryland and irrigated acres and producer net returns based on average commodity prices[a] and current input prices:[b] Texas High Plains

Nitrogen		Acres of Cropland		
Price per pound	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 lbs)	-------1,000--------		($1,000,000)
0	452,031	3,146	4,404	571
.05	445,311	3,146	4,404	549
.12	430,911	3,146	4,404	518
.13	384,311	3,146	4,404	514
.26	379,946	4,146	4,404	462
.32	343,986	3,146	4,404	440
.33	328,586	3,146	4,404	437
.41	325,795	3,157	4,393	411
.50	265,495	3,559	3,991	383
.54	253,860	2,463	3,991	369
.75	248,160	3,464	3,953	319
.84	222,845	3,753	3,759	298
1.06	196,383	4,177	3,335	247
1.16	164,360	4,345	2,880	228
1.18	101,951	5,558	1,667	225
1.21	81,880	5,891	1,334	222
1.71	63,910	5,977	1,248	183
2.00	63,910	5,977	1,248	165

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[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; natural gas--$0.88 per Mcf.

about one-half on what it is at $.12 per pound, a drop from 431 million pounds to 223 million pounds. Since present nitrogen prices fall within a relatively elastic range of the demand curve, this research appears to be supported by present market conditions. Low commodity prices (Appencis Table 39), when tested, create an even more elastic demand relationship for nitrogen. High commodity prices (Appendix Table 38), reveal a less elastic curve within the current nitrogen price range, but consumption is still affected by price.

An additional test is made with average commodity prices and a high price of natural gas (see Appendix Table 40). High natural gas prices cause a substantial reduction in the amount of nitrogen used at each nitrogen price level, compared to the lower natural gas price. At a price of $.10 per pound of nitrogen, 445 million pounds are used with natural gas at $.88 per Mcf; whereas, 394 million pounds are used at $1.25 per Mcf natural gas. This represents nearly a 12 percent difference. However, as the price of nitrogen rises, the difference in quantity demanded at a particular price for these two conditions becomes less.

Producer Net Returns

The net revenues given in Table 17 and Appendix Tables 38 and 39 reveal again the financial impact of rising prices to the farmer. When nitrogen is $.10 to $.12 per pound, high commodity prices earn him an average of $197 per acre above variable costs; average commodity prices yield an average return of $69 per acre above variable costs; and low commodity prices earn him an average of $18 per acre above variable costs. When nitrogen sells for \$.26 to \$.27 per pound, high commodity prices earn the farmer variable costs plus \$185 per acre; average commodity prices net him variable costs plus \$61 per acre; and low commodity prices earn him variable costs plus \$13 per acre.

Another interpretation of this price of nitrogen can be viewed with ratios. At high commodity prices, the farmer spends an average of \$14.92 per acre for nitrogen. The ratio of this cost to his yield above variable cost is one to 12, or .08 to one. For every dollar in yield he earns, he has spent eight cents on nitrogen. When this pattern of analysis is applied with average commodity prices, the farmer spends \$.22 for nitrogen for every dollar that he earns. At low commodity prices, his one dollar in net above variable costs must be matched by a \$.55 expenditure for nitrogen.

Irrigated Acres of Cropland

The acreage shifts to dryland from irrigated begin to occur at a price of nitrogen of \$1.04, \$.41, and \$.04 at high, average, and low commodity prices, respectively (Table 17 and Appendix Table 38 and 39). Therefore, when nitrogen reaches \$.41 per pound under average commodity price conditions, cropland will begin to be switched from irrigated production to dryland. However, even with a nitrogen price of \$2.00 per pound, a million and a quarter acres are still being irrigated under average commodity price conditions.

Agricultural Output

The estimated crop production figures under average commodity prices with two sets of input conditions are presented in Tables 18 and Appendix Table 41. Table 18 outlines a test with current prices of diesel and natural gas. As nitrogen prices rise, cotton production peaks at 2,954,000 bales and $.75 per pound nitrogen. Grain sorghum ouptut consistently declines with rising nitrogen prices; therefore, its production is inversely related to nitrogen price. Soybeans come into production at $.13 nitrogen and remain in solution because no nitrogen is used in soybean production. Wheat production peaks at 30.9 million bushels and $.50 nitrogen and does not begin to decline until nitrogen reaches $1.18 per pound. Corn is initially grown at its maximum permitted production, but it decreases rapidly and is zero when nitrogen reaches $.75 per pound. It appears soybeans come into solution and replace some grain sorghum output. When cotton and wheat production peak together, they also seem to be substituted for grain sorghum and, to some extent, corn.

Appendix Table 41 outlines results of a similar analysis except a natural gas price of $1.25 per Mcf is assumed. Under these conditions, grain sorghum stays in production through a higher nitrogen price than before. The other trends are the same as in Table 18 and simply indicate cost increases for the same cropping patterns.

Cropping Patterns

Table 19 is a schedule of crop acreages planted under selected

Table 18. Estimated crop output at selected nitrogen fertilizer prices based on average commodity prices[a] and current input prices:[b] Texas High Plains

Nitrogen price per pound	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	------1,000,000 bu--------		
0	2,410	124,847	0	20.6	80.3
.05	2,475	118,127	0	23.6	80.3
.13	2,475	103,131	4.2	23.6	80.3
.32	2,745	92,507	4.8	23.7	63.8
.50	2,841	92,507	4.8	30.9	41.8
.75	2,954	83,878	4.8	30.9	0
1.06	2,491	80,639	4.8	30.9	0
1.18	2,286	30,309	4.8	27.8	0
1.71	1,731	30,309	4.8	28.9	0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; natural gas--$0.88 per Mcf.

Table 19. Estimated planted cropland by crops, at selected nitrogen prices based on average commodity prices[a] and current input prices:[b] Texas High Plains

Nitrogen price per pound	Acres Planted											
	Total[c]		Cotton		Grain sorghum		Soybeans		Wheat		Corn	
	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total
(dollars)												
0	7,550	100	2,068	41	2,400	32	0	0	1,352	18	730	10
.05	7,550	100	3,013	40	2,288	30	0	0	1,519	20	730	10
.12	7,550	100	3,013	40	2,168	29	120	2	1,519	20	730	10
.26	7,550	100	2,994	40	2,168	29	137	2	1,521	20	580	8
.32	7,550	100	2,785	37	2,527	34	137	2	1,521	20	38	[d]
.50	7,550	100	2,798	37	2,527	34	137	2	2,050	27	0	0
.75	7,416	98	2,702	36	2,527	34	137	2	2,050	27	0	0
1.06	7,512	99	3,007	40	2,318	31	137	2	2,050	27	0	0
1.16	7,225	96	3,090	41	2,031	27	137	2	1,967	26	0	0
1.27	7,225	96	3,106	41	2,031	27	137	2	1,951	26	0	0
1.71	7,225	96	3,094	41	2,031	27	137	2	1,963	26	0	0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cotton seet--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; natural gas--$0.88 per Mcf.

[c] The cropland restriction (acres available) is 7,550,000 acres.

[d] Less than .5 percent.

nitrogen prices and average commodity prices. It supplements the information gained from the crop production figures in Table 18. Cotton acreage is comparably low at $.75 nitrogen; however, cotton production is high; therefore, this situation reveals that yield per acre is high and cotton is being produced under irrigation at this nitrogen price. Grain sorghum acreage goes down, up, then down as nitrogen prices rise with steadily declining production. Grain sorghum acres are switching to dryland. Wheat acreage increases up to a nitrogen price of $.50 (consistent with output in Table 18) and remains constant as nitrogen continues to rise in price. Idle acres become evident at a nitrogen price of $.75 per pound.

Appendix Table 42 (natural gas at $1.25) shows idle acres appearing at $.53 nitrogen. A higher cost of natural gas is interpreted as higher irrigation costs; hence, production stops at a lower nitrogen price. This demonstrates the greater cost to a crop that is heavily fertilized with nitrogen and is irrigated.

Effects of Alternative Water Prices

The test situations are narrowed to three as the price of water is being parameterized. First, varying the price of water is examined under high commodity prices and current input prices. Second, average commodity prices and current input prices are used. Then finally, average commodity prices, current diesel and nitrogen price, and a high natural gas price are assumed.

A definition of water price as it is being used in this context is needed. Water price refers to that price which a farmer can afford to pay above pumping and distribution costs. The cost of water at this water price does not include any fixed costs. In essence, if the farmer were buying water as a commodity, this water price would be the charge to him for the commodity.

Water importation has been considered for the Texas High Plains, and this analysis is useful in determining the quantity of water that would be demanded at alternative prices. It also stipulates the maximum that could be charged for water at alternative quantities.

Quantity of Water Demanded

The demand curves for irrigation water, as shown in Figure 5, are presented for high and average commodity prices only since irrigation water use was zero at low crop prices. The effect of the prices received for the crop output is quite significant. Table 20 and Appendix Table 43 indicate the wide differences in quantity used at a particular price for the average and high commodity price levels.

When irrigation water sells for $34 per acre foot, six million acre feet are used with commodities at high prices; whereas, three and three quarters million acre feet are consumed with commodities at average prices. When irrigation water is priced at $41 per acre foot, six million acre feet are still used under high commodity price levels; however, less than two million acre feet are used under average commodity price conditions. With average commodity prices, water use goes to zero at $71.75 per acre foot. At that same price of water with high commodity prices, over five and half million cubic feet of water are

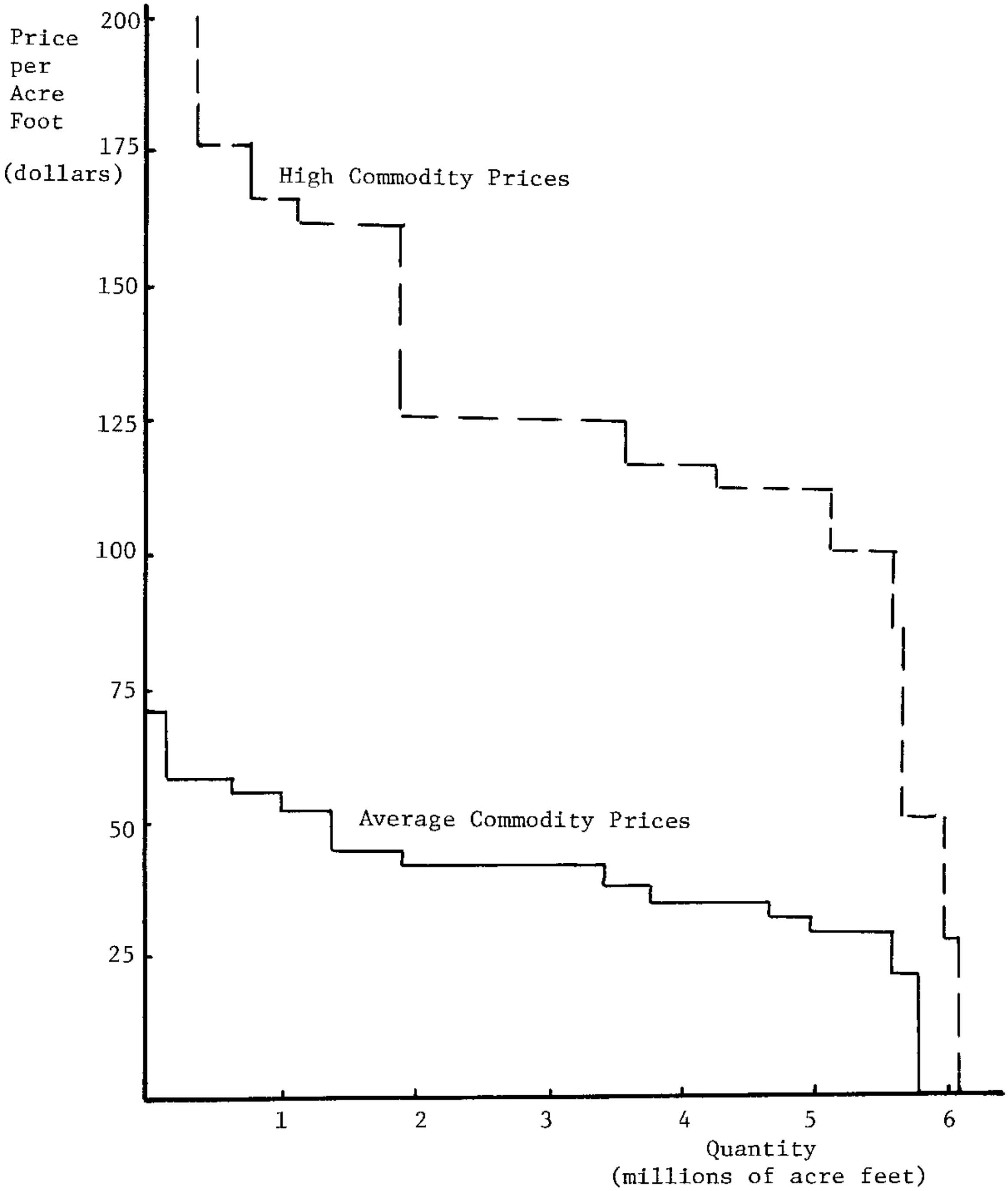

Figure 5. Estimated agricultural use of water (excluding pumping and distribution costs) with high and average commodity prices: Texas High Plains

Table 20. Estimated quantity of water used in agricultural production at selected water prices with associated dryland and irrigated acres and producer net returns based on average commodity prices[a] and current input prices:[b] Texas High Plains

Water		Acres of Cropland		
Price per acre-foot	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 ac ft)	-------1,000--------		($1,000,000)
0	5,787	3,146	4,404	486
5.90	5,785	3,146	4,404	452
14.69	5,717	3,157	4,393	401
22.37	5,560	3,157	4,393	358
29.58	4,957	3,559	3,991	318
32.23	4,602	3,753	3,797	304
34.40	3,781	4,177	3,373	295
38.94	3,436	4,345	3,205	278
41.74	1,896	5,660	1,890	268
46.07	1,329	6,344	1,206	260
53.76	1,075	6,579	971	250
56.10	615	6,953	559	247
60.24	140	7,392	120	245
71.75	0	7,392	0	243

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cotton seed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

still being utilized. Under high commodity prices, it requires a water price of $220.68 per acre foot to cause consumption to go to zero.

Appendix Table 44 summarizes results of a test made with average commodity prices and a high natural gas price. The adjustments are similar to those made with the current price of natural gas. This indicates that an increased natural gas price creates no major alterations in quantity of water demanded. It does effect a somewhat lower price of water at which these adjustments occur and, of course, results in less net revenue.

Producer Net Returns

Table 20 and Appendix Table 43 reflect the significant adjustments that are being made in net revenue as the price of irrigation water increases. As the water price rises from zero to $100 per acre foot under high commodity prices and current input prices, net revenue to the farmer declines some 40 percent. A water price of $175 per acre foot causes a decline of 54 percent. With average commodity prices, net revenue is much lower. At a zero price of water, revenues above variable costs are $486 million; they are reduced by 50 percent to $243 million with water selling for $71.75 per acre foot. If the farmer is receiving high prices for his goods, he can afford to pay up to $175 per acre foot for irrigation water and still be better off than if he pays nothing for irrigation water and is receiving average prices. Again, sensitivity to product prices is emphasized.

Irrigated Acres of Cropland

Appendix Table 43 indicates that the farmer can pay up to $51.96 for water before any irrigated acreage shifts to dryland, given high commodity prices. This shift is made at a water price of $14.69 per acre foot under conditions of average commodity prices, see Table 20.

Agricultural Output and Cropping Shifts

Tables 21, 22 and Appendix Table 45 indicate adjustments among crops measured first in output (Table 21 and Appendix Table 45), then in acres (Table 22). High commodity prices and current input prices are used in Appendix Table 44. Average commodity prices are used in Tables 21 and 22. The general trend for all crops except wheat is decreased output as the price of irrigation water increases. Obviously, as irrigation declines, yields follow. Wheat, on the other hand, is being produced in greater amounts as the price of water rises. An explanation of this situation can be noted from Table 22 than indicates an upward trend in acreage being planted to wheat.

Using average commodity prices (Tables 21 and 22) and over a water price range from zero to $71.75 per acre foot, cotton acreage increases by 12 percent but output declines by 46 percent; grain sorghum acreage climbs by 7 percent as output drops by 66 percent; and wheat acreage rises by 12 percent and output rises by 8 percent. Soybeans and corn, both irrigated crops, eventually go out of production as water price rises. Soybeans stay in production, though, until water reaches $71.75 per acre foot.

Table 21. Estimated crop output at selected water prices based on average commodity prices[a] and current input prices:[b] Texas High Plains

Water price per acre-foot	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	------1,000,000 bu--------		
0	2,475	103,132	4.2	23.6	80.3
5.89	2,478	102,943	4.2	23.6	80.3
14.69	2,478	110,443	4.2	23.4	63.8
23.37	2,745	92,507	4.8	23.4	63.8
29.58	2,745	92,507	4.8	29.4	19.6
32.23	2,745	83,878	4.8	29.4	19.6
36.00	2,396	80,639	4.2	29.4	19.6
41.74	2,447	34,614	4.2	28.4	4.2
53.76	1,934	34,614	4.2	26.3	4.2
54.57	1,934	34,614	4.2	26.3	0
60.24	1,328	34,614	4.2	25.6	0
71.75	1,328	34,614	0	25.6	0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cotton seed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; natural gas--$0.88 per Mcf; nitrogen $0.20 per pound.

Table 22. **Estimated planted cropland** by crop, at selected water prices based on average commodity prices[a] and current input prices:[b] Texas High Plains

Water price per acre-foot	Acres Planted											
	Total[c]		Cotton		Grain sorghum		Soybeans		Wheat		Corn	
	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total
(dollars)												
0	7,550	100	3,013	40	2,168	29	120	2	1,519	20	730	10
14.69	7,550	100	3,011	40	2,318	31	120	2	1,521	20	580	8
22.37	7,550	100	2,785	37	2,527	34	137	2	1,521	20	580	8
29.58	7,550	100	2,785	37	2,527	34	137	2	1,923	26	178	2
36.00	7,550	100	3,011	40	2,318	31	120	2	1,923	26	178	2
41.74	7,550	100	3,208	43	2,318	31	120	2	1,866	25	38	d
54.74	7,512	99	2,324	44	2,318	31	120	2	1,750	23	0	0
71.75	7,392	98	3,379	45	2,318	31	0	0	1,695	23	0	0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

[c] The cropland restriction (acres available) is 7,550,000 acres.

[d] Less than .5 percent.

Intraregional Cropping Pattern Shifts

Results of model application that have not been interpreted thus far are the intraregional adjustments. Some adjustments of interest are the cropping pattern shifts that are taking place within a region as prices rise. Table 23 outlines shifts that occur as the price of diesel increases. Average commodity prices and current input prices are used for this analysis. The percentage figures present total crop acreage, dryland and irrigated, as a percentage of total cropland available in that region. Diesel prices beyond $3.00 per gallon were not considered in this analysis.

In High Plains II, rising diesel prices impact primarily on grain sorghum and wheat acreage. Grain sorghum shifts from irrigated to dryland at $2.53 diesel, and acres shift from grain sorghum to wheat. In High Plains III, some cotton acreage goes to idle acreage at a price above $2.00 per gallon for diesel. Other acreages remain the same throughout the price range of diesel. In High Plains IV, a trade-off occurs between cotton and wheat with cotton declining and wheat acreage increasing as diesel price rises. Grain sorghum acreage holds constant, and soybeans come into production at $2.13 per gallon diesel. These adjustments indicate which production alternatives are more machinery intensive; i.e., diesel users. Cotton production appears to be more sensitive to rising diesel prices; whereas, wheat as a relatively low diesel user is not.

Table 24 indicates the adjustments that take place when natural gas price rises. There is no change in High Plains II until natural

Table 23. Estimated dryland and irrigated acres planted by crop and region for selected diesel prices based on average commodity prices[a] and current input prices:[b] Texas High Plains

Diesel price per gallon	Region[c]	Acres Planted														
		Cotton			Grain sorghum			Soybeans			Wheat			Corn		
		Dryland	Irri-gated	% of[d] Total	Dryland	Irri-gated	% of[d] Total	Dryland	Irri-gated	% of[d] Total	Dryland	Irri-gated	% of[d] Total	Dryland	Irri-gated	% of[d] Total
(dollars)		-----1,000----			-------1,000-----			---1,000---			-----1,000------			--1,000--		
0	HPII	0	544	15	0	1,165	32	0	120	3	1,116	11	31	0	730	20
.72	HPII	0	544	15	0	1,165	32	0	120	3	1,116	11	31	0	730	20
1.86	HPII	0	544	15	0	1,028	28	0	120	3	1,116	148	34	0	730	20
2.53	HPII	0	544	15	1,028	0	28	0	0	0	88	1,296	37	0	730	20
0	HPIII	1,182[e]	647	66	0	674	24	0	0	0	289	0	10	0	0	0
.72	HPIII	1,182[e]	647	66	0	674	24	0	0	0	289	0	10	0	0	0
2.13	HPIII	1,180[e]	630	65	0	674	24	0	17	1	291	0	10	0	0	0
2.90	HPIII	827[e]	630	52	0	674	24	0	17	1	291	0	10	0	0	0
0	HPIV	129[e]	513	60	329	0	31	0	0	0	103	0	9	0	0	0
.72	HPIV	0	513	48	329	0	31	0	0	0	230	0	21	0	0	0
1.37	HPIV	0	439	41	255	74	31	0	0	0	304	0	28	0	0	0
2.53	HPIV	0	427	40	243	86	31	0	0	0	316	0	29	0	0	0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: natural gas--$.88 per Mcf; nitrogen--$.20 per pound.

[c] The cropland restriction (acres available) is 3,686,000 acres in HPII, 2,792,000 acres in HPIII and 1,072,000 acres in HPIV.

[d] Rounded to nearest whole percentage, hence may not add to 100.

[e] Skipped-row planted; 2 in-1 out; i.e., one unplanted row between each two planted rows.

Table 24. **Estimated dryland and irrigated** acres planted by crop and retion, at **selected natural gas prices based on average** commodity prices[a] and current input prices:[b] Texas High Plains

Natural gas price per Mcf	Region[c]	Acres Planted														
		Cotton			Grain sorghum			Soybeans			Wheat			Corn		
		Dryland	Irri- gated	% of Total[d]	Dryland	Irri- gated	% of Total[d]	Dryland	Irri- gated	% of Total[d]	Dryland	Irri- gated	% of Total[d]	Dryland	Irri- gated	% of Total[d]
(dollars)		----1,000----			---1,000----			--1,000,--			----1,000---			---1,000---		
0	HPII	0	544	15	0	1,165	32	0	120	3	1,116	11	31	0	730	20
1.67	HPII	0	544	15	0	1,165	32	0	120	3	1,116	11	31	0	730	20
2.54	HPII	0	544	15	0	1,315	36	0	120	3	1,127	0	31	0	580	16
4.27	HPII	0	544	15	0	1,315	36	0	120	3	1,529	0	42	0	178	5
0	HPIII	1,182	647	66	0	674	24	0	0	0	289	0	10	0	178	5
1.67	HPIII	1,175	651	65	4	670	24	0	0	0	291	0	10	0	178	5
2.89	HPIII	1,124	686	65	58	618	24	0	0	1	291	0	10	0	178	5
3.86	HPIII	491	1,110	57	689	194	32	0	0	1	291	0	10	0	178	5
0	HPIV	127	513	60	329	0	31	0	0	1	103	0	10	0	178	5
1.66	HPIV	127	513	60	329	0	31	0	0	1	103	0	10	0	178	5
5.14	HPIV	237	439	60	329	0	31	0	0	1	67	0	6	0	178	5

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Current input prices are defined as: natural gas--$.88 per Mcf; nitrogen--$.20 per pound.

[c] The cropland restriction (acres available) is 3,686,000 acres in HPII, 2,792,000 acres in HPIII and 1,072,000 acres in HPIV.

[d] Rounded to nearest whole percentage, hence may not add to 100.

[e] Skipped-row planted; 2 in-1 out; i.e., one unplanted row between each two planted rows.

gas reaches $2.54 per Mcf. At that natural gas price, grain sorghum acreage increases, and corn acreage declines. Cotton, grain sorghum, soybeans, and corn are irrigated in High Plains II; whereas, wheat is produced almost entirely dryland. High Plains III reflects a situation of stability until natural gas sells for $2.89 per Mcf. At that price, irrigated grain sorghum begins to shift to dryland, and irrigated soybeans come into production. At $3.86 per Mcf for natural gas, cotton changes to heavily irrigated production, and grain sorghum switches to dryland production. Rising natural gas prices have even less effect on cropping shifts in High Plains IV. No change occurs until natural gas reaches $5.14 per Mcf. At that price, which is most probably beyond the short run, some wheat acreage shifts to cotton production.

In summary, rising diesel and natural gas prices have little effect on intraregional cropping pattern shifts when probable short run prices for these two energy inputs are considered.

SUMMARY AND CONCLUSIONS

In 1973, the Arab oil embargo dramatically awakened the world to the reality of energy shortages. Forces of basic economics surrounding the situation brought about energy price rises and concern about the impact of these increases. It became important that answers to energy related questions be supported by objective research. Among the many important questions is what effect does increasing prices for energy related inputs have on agriculture.

The High Plains of Texas is a highly productive agricultural region. However, due to its semi-arid climate, productivity is closely related to irrigation from groundwater. With irrigation and a highly developed degree of mechanization, agricultural production is energy intensive. With a great dependence on energy for a high level of agricultural production, the High Plains of Texas provide an ideal study area for evaluating effect of rising energy prices.

The principle energy and energy-related inputs in agricultural production on the Texas High Plains were identified as diesel, natural gas, herbicide, nitrogen fertilizer, and water. The purpose of the study was to quantify the effect on agriculture of rising prices of these inputs. This effect would be expressed in quantity of the input demanded, in crop production, in cropping patterns, and in net revenue.

Methodology

Linear Programming

The analytical technique employed was mathematical linear programming where a linear objective function is optimized subject to a set of linear constraints. Parametric programming was utilized so that the price parameters of the resources may be varied over a specified range.

Enterprise Budgets

Enterprise budgets taken from the Crop Budget Generator of the Texas Agricultural Extension Service provide the data base for the working model. The typical management budgets for cotton, grain sorghum, soybeans, wheat, and corn from the three production regions of High Plains II, High Plains III, and High Plains IV were selected for use. Intermediate level irrigation budgets were built for cotton, grain sorghum, and wheat in High Plains II. All harvesting costs were converted from custom harvesting to owner-operated equipment. Adjustments were made in the dryland cotton budgets for High Plains III and High Plains IV to allow for skipped-row planting, and irrigation costs in all the budgets were updated. Other minor modifications included changing the unit measurements for cotton lint and for cattle.

The Model

The model was structured from the data in the budgets applied to the linear programming framework. The enterprises in the model are comprised of 46 dryland and various level irrigation budgets of the five study crops from the three production regions. The resources are diesel, herbicide, natural gas, nitrogen fertilizer, and water. The objective function is maximization of revenue above variable costs. Maximum shifts in crop acres, by subregion, were incorporated by specifying an upper and lower bound on permitted acres of each crop.

Scope of Analysis

The finalized model was applied for 16 alternative sets of conditions. Nine of the applications were made to test separately the effect of sequentially higher prices of diesel, natural gas, nitrogen and water with high commodity prices, average commodity prices, and low commodity prices. These commodity prices were taken from historical data reported in Texas Agricultural Extension Districts 1-N and 1-S from 1971 through 1974. High price refers to the highest price in the range; low price, to the lowest price in the range; and average price, to the forty-eight month average price. Prices of those inputs not being analyzed were set at their approximate current levels.

The analysis was extended to consider effect of increasing diesel prices assuming average commodity prices, but with (1) a high natural gas price and current nitrogen price and (2) a high price for both natural gas and nitrogen. Similarly, the expected effect of an increasing price for natural gas under conditions of a high nitrogen price, current diesel price, and average commodity prices was investigated. The effect of rising nitrogen prices was investigated using a high natural gas price, current diesel price, and average commodity prices. These situations were intended to approximate the range of probable price activity for diesel, natural gas, and nitrogen for the short run future. For the analysis, herbicide price was linked to diesel price since the price of both is dependent upon a similar petroleum derivation.

Analysis of increasing irrigation water costs (costs above pumping) was made assuming current prices of inputs with high and average commodity prices. An extension of the water cost study considered current prices for diesel and nitrogen and a high price for natural gas.

Results

Application of the model results in large quantities of data. For presentation, a synthesis was necessary. Therefore, the study results were classified as: (1) schedules of demand for each input, (2) producer net returns, (3) associated dryland and irrigated acres, (4) crop output, (5) acres of each crop, and (6) intraregional cropping pattern shifts. The following discussion briefly highlights these results.

Diesel

The demand curves for diesel at high, average, and low commodity prices reveal wide variations in the demand for diesel particularly when the price exceeds $2.00 per gallon. Above $.56 per gallon, low commodity prices cause the quantity of diesel used to fall off substantially. However, the quantity used under high and average commodity price conditions remains in the 108 to 110 million gallon range up to $1.38 per gallon. Therefore, it would require either unusually low commodity prices and $.60 per gallon diesel or diesel price increases threefold from its present price to effect any major adjustments in consumption. Consequently, the short run impact on usage of diesel due to moderately higher prices is minimal.

The primary effect would be significant adjustments in net revenues realized by farmers as diesel prices rise. The figures show that the level of commodity prices has the most impact on profits. Even with low commodity prices, however, farmers continue to realize positive net revenues in the short run with diesel prices below $1.40 per gallon. A diesel price of about $3.50 per gallon would be necessary to cause all profits above variable costs to be lost under average commodity price conditions.

Acreage shifts from irrigated to dryland production begin to occur under low commodity prices at $.46 per gallon of diesel and under average commodity prices at $2.69 per gallon. Maximum irrigation continues to be utilized at a diesel price of $5.00 per gallon with high commodity prices. As diesel prices rise, the acreage planted in cotton decreases; the acreage planted in grain sorghum increases slightly; the acreage planted in wheat increases; and the acreage devoted to soybean and corn eventually leaves production. Rising diesel prices cause cotton output to decline, grain sorghum output to fall off severely, and wheat output to decline. The same basic results are obtained when a higher nitrogen and natural gas price were assumed.

More specifically, under conditions of average commodity prices and current input prices, a rise in diesel price from zero cents to $.72 per gallon causes less than a .5 percent reduction in consumption of diesel for agriculture, no reduction in acres of cropland planted (either dryland or irrigated), but a 22 percent decrease in net revenue. A rise from $.72 to $1.38 per gallon still reduces diesel consumption by less than .5 percent, does not affect planted acres, but again causes net revenue to fall another 25 percent.

In summary, rising diesel prices in the short run are expected to cause diesel usage to change very little. The greatest impact is the pass-through of these costs to the farmers' income statements; higher costs of diesel mean less profits. The results show, as expected, that the price the farmer receives for his product is a much greater influence on his welfare than what he pays for diesel.

Natural Gas

The second resource examined was natural gas. Again, the demand curves developed under the three commodity price levels show significant differences at the higher prices paid for natural gas. However, natural gas prices do not cause reduced consumption under any commodity price conditions until natural gas price exceeds $1.00 per Mcf. Looking at the probable short run situation; i.e., average commodity prices and current input prices, natural gas price must reach $4.00 per Mcf and above to cause a significant reduction in consumption. A zero price of natural gas indicates that 51.3 billion cubic feet will be consumed;

whereas a price jump to $4.26 Mcf indicates that consumption will decline to 44.3 billion cubic feet, only a 14 percent reduction in consumption. A higher nitrogen price does not change this conclusion. This analysis is based on variable costs only and over time, with fixed costs included, reductions in natural gas used would occur at lower prices than indicated in this study.

Obviously, net revenues are affected by rising costs of natural gas. Acreage shifts from irrigated to dryland are directly affected by rising natural gas prices. The acres planted to the five crops remain almost constant until natural gas reaches a price of $2.54 per Mcf. Correspondingly, crop output up to this price is stable. The first crops to begin to leave irrigated production are grain sorghum and corn.

The inference is that natural gas prices can rise substantially before their effect will be felt in consumption of natural gas or acreage shifts. However, the increased expense to the farmer will certainly be noticed on his income statement. If he pays nothing for natural gas under average commodity prices, his net revenue is $531 million; if he pays $1.66 per Mcf, his net revenue falls 16 percent to $446 million; if he pays $2.54 per Mcf, his net revenue drops another 10 percent to $401 million.

Nitrogen

The demand curves developed for nitrogen are more elastic within the short run than are those for diesel and natural gas. A small nitrogen price increase above current levels causes a change in quantity used by agriculture. A price rise from the $.18 current rate to $.33 per pound causes a 24 percent reduction in consumption at average commodity prices. Nitrogen prices decidedly affect net revenues. A doubling of nitrogen price from $.13 per pound to $.26 per pound causes a 10 percent decline in net revenues. Another twofold increase in price to $.54 per pound causes another 20 percent deduction in net revenues. With nitrogen selling for $.26 per pound, the farmer spends $.22 for nitrogen for every $1.00 that he earns above variable cost.

Rising nitrogen prices are not as impactual on acreage shifts as they are on quantity used and net revenue. Irrigated production does not begin to shift to dryland until nitrogen price reaches $.41 per pound under average commodity prices. Within relevant short run price ranges, cotton output increases in spite of declining acreages. Grain sorghum acreage increases, but output declines; whereas, wheat output increases along with acreage.

The results of the examination of rising nitrogen prices suggest that nitrogen is presently priced within a critical range. Quantity demanded is sensitive to prices that currently prevail, and increases can be expected to cause rapid adjustments in use and, consequently, in agricultural output.

Irrigation Water

Considering only average prices for commodities, the quantity of water demanded is highly dependent upon the price charged. As the price of irrigation water rises from $14.69 per acre foot to $41.74, quantity demanded goes from 5.7 million acre feet to 1.9 million acre feet, a 67 percent drop. A price of $71.75 per acre foot causes consumption to fall to zero. With the high commodity prices, the price must go to $220.68 per acre foot before water is no longer purchased for irrigation. Imported water is a current consideration for the area under study; therefore, these water costs are important in determining just how much will be demanded, or can be afforded, at alternative prices.

Over the price range of water from zero to $71.75 per acre foot at average commodity prices, cotton and grain sorghum output trend downward significantly while their acreages trend upward. This is explained by a shift to dryland production. Wheat output trends upward with a small increase in acreage. Irrigated corn and soybeans are reduced both in acreage and output, although they are both still in production at a price of $54 for water and average prices for commodities.

Intraregional Cropping Pattern Shifts

The short run effects of rising diesel prices on cropping pattern shifts within High Plains II, High Plains III, and High Plains IV are slight. In High Plains II, some grain sorghum and soybeans shift to wheat. A few acres of cotton shift to wheat while most shift to idle acres in High Plains III. High Plains IV cotton acreage transfers to wheat. All of these adjustments, except in High Plains IV, are being made at about $2.50 per gallon for diesel.

Alternative natural gas prices cause cropping pattern changes in High Plains II from grain sorghum and corn to wheat. Rising costs for natural gas cause a shift in High Plains III from cotton to grain sorghum. And a slight alteration is made in High Plains IV from wheat to cotton. Essentially, no cropping pattern shifts occur until natural gas reaches $2.50 per Mcf. Most cropping pattern adjustments occur at about $4.00 or more per Mcf for natural gas.

Conclusions

In summary, the energy price increases that are probably imminent in the near future will have only a minimal impact on the quantity of energy and energy-related inputs demanded on the Texas High Plains. The price of nitrogen is presently within a range that affects quantity used, but the price of diesel and natural gas is not. If and when a charge is placed on irrigation water as in the case of imported water, then the price of it will also quickly approach a range that affects the quantity consumed.

If energy prices are to increase dramatically, the data suggest reduced consumption and a shift in cropping patterns and output. Wheat is the crop that would gain in total acreage and output at the expense of grain sorghum and, to a lesser degree, cotton. This outcome could possibly be inferred for the long run.

The greatest impact of rising energy costs is on the profit and loss statement of the farmer. Even if results indicate that the consumption of energy remains essentially the same, his profit margin shrinks by the amount that energy costs go up. A major short coming of this result is not considering possible commodity price adjustments which could compensate for increased input prices, or perhaps increase the adverse income effects.

Limitations

The study was conducted recognizing the following limitations:

1. There is a fixed efficiency factor at the level of production for which the enterprise budgets were developed. One area where substantial improvement may be possible is in irrigation pump efficiencies.

2. In a short run analysis, no allowance is made for such items as maintenance and reinvestment; therefore, their relation to energy price increases has not been measured.

3. No consideration has been made for different size farms; i.e., economics of size have not been taken into account.

4. Risk has not been considered; furthermore, no aspect of the study attempted to identify "attractive" commodity prices in the producers' crop selection decision.

5. No attempt has been made to measure the impact of the government programs in effect during the period when much of the historical data were gathered.

6. The personal preferences and biases of individual farmers are recognized to play a major role in cropping decisions; however, the linear programming technique assumes that producers will tend to base cropping decisions on the optimum crop selection over a period of time.

7. The price of water as considered in this study excluded pumping and distribution costs. Therefore, an assumption implicit in the water importation concept in this study is storage by aquifer recharge or

refill.

Further Study

The short run nature of this study, in itself, suggests a need for further development. A study of the long run impact, taking into account fixed costs, is pertinent. Analysis directed toward measuring the impact of rising energy prices on the regional economy of the area would be timely. As is pointed out in this research, commodity prices are the most consequential item affecting producer decisions. Therefore, further study of their relation to energy prices is warranted.

Lastly, this study was limited to only a portion of the Texas High Plains. There are other areas with irrigated agriculture in Texas where the predominant price of natural gas is higher and depth of pumping groundwater greater. Therefore, results of this study are not applicable to these other regions. There is a need to expand the model to include these other regions.

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APPENDIX A

Table 25. Estimated quantity of diesel used in agricultural production at selected diesel prices with associated dryland and irrigated acres and producer net returns based on average commodity prices,[a] current nitrogen price and high natural gas price:[b] Texas High Plains

Diesel		Acres of Cropland		
Price per gallon	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 gallons)	---------1,000-------		($1,000,000)
0	109,094	3,146	4,404	535
.08	109,046	3,146	4,404	521
.62	109,050	3,146	4,404	430
.72	108,563	3,146	4,404	414
1.41	108,132	3.146	4,404	297
1.70	108,117	3,146	4,404	249
1.88	108,093	3,157	4,393	220
2.12	106,402	3,294	4,256	181
2.40	90,467	4,442	3,108	142
2.90	86,604	4,089	3,108	76
3.08	85,619	3,816	2,108	53
3.20	80,657	4,360	2,564	38
3.57	80,459	4,360	2,564	-4
3.86	74,515	4,775	2,132	-35
4.14	68,379	4,775	1,834	-66
4.56	63,116	4,369	1,834	-106
5.00	61,323	4,082	1,834	-147

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[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; corn--$1.94 per bushel; wheat--$2.60 per bushel.

[b] Input prices are defined as: natrual gas--$1.25 per Mcf; nitrogen--$0.20 per pound.

Table 26. Estimated quantity of diesel used in agricultural production at selected diesel prices with associated dryland and irrigated acres and producer net returns based on average commodity prices,[a] high nitrogen and natural gas prices:[b] Texas High Plains

Diesel		Acres of Cropland		
Price per gallon	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 gallons)	---------1,000-------		($1,000,000)
0	108,917	3,146	4,404	498
.28	109,179	3,146	4,404	451
.37	109,155	3,157	4,393	434
.57	108,669	3,157	4,393	401
.67	108,620	3,157	4,393	383
1.52	109,945	3,157	4,393	242
1.75	108,334	3,294	4,256	204
1.93	93,263	4,322	3,228	175
2.28	92,839	4,226	3,228	128
2.54	90,420	4,491	2,963	93
2.90	85,706	4,081	2,963	48
3.15	74,883	4,792	2,132	20
3.41	68,529	4,792	1,834	-9
3.90	68,355	4,775	1,834	-57
4.37	68,333	5,039	1,834	-103
4.56	61,232	4,082	1,834	-122
5.00	60,946	5,048	1,187	-161

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[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; corn--$1.94 per bushel; wheat--$2.60 per bushel.

[b] Input prices are defined: natural gas--$1.25 per Mcf; nitrogen--$0.20 per pound.

Table 27. Estimated crop output at selected diesel prices based on high commodity prices[a] and current input prices:[b] Texas High Plains

Diesel price per gallon	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	----------1,000,000 bu--------		
0	2,615	110,891	0.0	23.0	80.3
.11	2,615	110,147	0.0	23.6	80.3
.70	2,618	109,958	0.0	23.7	80.3
1.31	2,478	117,938	0.0	23.7	80.3
4.00	2,433	117,938	0.0	25.2	80.3
4.59	2,433	71,066	0.0	53.1	80.3
4.86	2,433	61,433	0.0	60.0	80.3

[a] High commodity prices are defined as: cotton lint--$0.67 per pound; cottonseed--$100.00 per ton; grain sorghum--$5.96 per cwt; soybeans--$7.75 per bushel; wheat--$5.35 per bushel; corn--$3.46 per bushel.

[b] Current input prices are defined as: natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

Table 28. Estimated crop output at selected diesel prices based on low commodity prices;[a] current input prices:[b] Texas High Plains

Diesel price per gallon	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	----------1,000,000 bu-------		
0	2,593	108,150	4.8	30.9	0.0
.46	2,701	92,507	4.8	30.9	0.0
.56	2,619	94,986	4.8	31.8	0.0
.67	2,225	49,219	4.8	32.0	0.0
.89	1,978	37,351	.6	32.0	0.0
1.03	1,437	37,351	0.0	32.0	0.0
1.93	1,410	32,158	0.0	32.0	0.0
2.43	1,410	32,158	0.0	22.7	0.0
3.23	1,270	37,382	0.0	19.6	0.0
4.52	1,227	37,382	0.0	19.6	0.0

[a] Low commodity prices are defined as: cotton lint--$0.18 per pound; cottonseed--$100.00 per ton; grain sorghum--$1.86 per cwt; soybeans--$2.30 per bushel; wheat--$1.34 per bushel; corn--$1.12 per bushel.

[b] Current input prices are defined as: natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

Table 29. Estimated crop output at selected diesel prices based on average commodity prices[a] and high natural gas prices:[b] Texas High Plains

Diesel price per gallon	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	--------1,000,000 bu---------		
0	2,475	110,632	4.2	23.6	63.8
.62	2,478	102,943	4.2	23.7	80.3
.72	2,433	102,943	4.2	25.2	80.3
1.41	2,352	105,422	4.2	26.1	80.3
1.88	2,348	105,611	4.2	25.8	80.3
2.40	2,314	63,386	.6	29.8	80.3
3.20	2,101	38,386	.6	29.8	80.3
4.14	2,101	40,022	0.0	32.0	0.0

[a] Average commodity prices are defined as: cotton lint--$0.31; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Input prices are defined as: natural gas--$1.25 per Mcf; nitrogen--$0.20 per pound.

Table 30. Estimated crop output at selected diesel prices based on average commodity prices[a] and high natural gas and nitrogen price:[b] Texas High Plains

Diesel price per gallon	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	---------1,000,000 bu-----		
0	2,638	108,150	4.8	23.7	48.4
.37	2,498	108,150	4.8	23.4	63.8
.71	2,701	85,007	4.8	24.9	80.3
1.52	2,619	87,486	4.8	25.8	80.3
1.93	2,619	44,656	4.8	27.8	80.3
2.54	2,719	36,285	.6	32.0	64.4
3.41	2,101	39,091	.6	32.0	0.0
4.37	1,788	47,124	0.0	32.0	0.0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; corn--$1.94 per bushel; wheat--$2.60 per bushel.

[b] Input prices are defined as: natural gas--$1.25 per Mcf; nitrogen--$0.30 per pound.

Table 31. Estimated planted cropland by crop at selected diesel prices based on average[a] commodity prices and a high natural gas price:[b] Texas High Plains

Diesel price per gallon	Acres Planted											
	Total[c]		Cotton		Grain sorghum		Soybeans		Wheat		Corn	
	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total
(dollars)												
0	7,550	100	3,013	40	2,318	31	120	2	1,519	20	580	8
.08	7,550	100	3,013	40	2,168	29	120	2	1,519	20	730	10
.62	7,550	100	3,011	40	2,168	29	120	2	1,521	20	730	10
.72	7,550	100	2,884	38	2,168	29	120	2	1,648	22	730	10
1.41	7,550	100	2,810	37	2,168	29	120	2	1,722	23	730	10
1.93	7,550	100	2,810	37	2,031	27	120	2	1,859	25	730	10
2.12	7,550	100	2,798	37	2,031	27	120	2	1,971	25	730	10
2.13	7,550	100	2,781	37	2,031	27	137	2	1,871	25	730	10
2.40	7,550	100	2,781	37	2,031	27	17	d	1,991	26	730	10
2.90	7,197	95	2,428	32	2,031	27	17	d	1,991	26	730	10
3.20	6,924	92	2,155	29	2,031	27	17	d	1,991	26	730	10
3.58	6,907	92	2,155	29	2,031	27	0	0	1,991	26	730	10
3.61	6,907	92	2,155	29	2,288	30	0	0	1,734	23	730	10
3.80	6,907	92	2,155	29	2,318	31	0	0	1,734	23	730	10
3.85	6,907	92	2,155	29	2,318	31	0	0	2,136	28	700	9
4.14	6,609	88	2,155	29	2,318	31	0	0	2,136	28	298	4
4.20	6,805	90	2,351	31	2,318	31	0	0	2,136	28	0	0

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[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Input prices are defined as: natural gas--$1.25 per Mcf; nitrogen--$0.20 per pound.

[c] The cropland restriction (acres available) is 7,550,000 acres.

[d] Less than .5 percent.

Table 32. Estimated planted cropland, by crop, for selected diesel prices based on average commodity prices[a] and high nitrogen and natural gas prices:[b] Texas High Plains

	Acres Planted											
Diesel price per gallon	Total[c] (1,000)	Total[c] % of Total	Cotton (1,000)	Cotton % of Total	Grain sorghum (1,000)	Grain sorghum % of Total	Soybeans (1,000)	Soybeans % of Total	Wheat (1,000)	Wheat % of Total	Corn (1,000)	Corn % of Total
(dollars)												
0	7,550	100	3,134	42	2,318	31	137	2	1,521	20	440	6
.28	7,550	100	2,994	40	2,318	31	137	2	1,521	20	580	8
.57	7,550	100	2,867	38	2,318	31	137	2	1,648	22	580	8
.67	7,550	100	2,867	38	2,168	29	137	2	1,648	22	730	10
.71	7,550	100	2,658	35	2,377	32	137	2	1,648	22	730	10
1.52	7,550	100	2,584	34	2,377	32	137	2	1,722	23	730	10
1.59	7,550	100	2,584	34	2,240	30	137	2	1,859	25	730	10
2.01	7,550	100	2,572	34	2,240	30	137	2	1,871	25	730	10
2.28	7,454	99	2,476	33	2,240	30	137	2	1,871	25	730	10
2.40	7,454	99	2,476	33	2,240	30	17	d	1,991	26	730	10
2.54	7,454	99	2,476	33	2,240	30	17	d	2,136	28	585	8
2.68	7,245	96	2,476	33	2,031	27	17	d	2,136	28	585	8
2.90	7,044	93	2,275	30	2,031	27	17	d	2,136	28	585	8
2.97	7,044	93	2,275	30	2,318	31	17	d	2,136	28	298	4
3.15	6,924	92	2,155	29	2,318	31	17	d	2,136	28	298	4
3.41	6,626	88	2,155	29	2,318	31	17	d	2,136	28	0	0
3.89	6,609	88	2,155	29	2,318	31	0	0	2,136	28	0	0
4.36	6,873	91	2,419	32	2,318	31	0	0	2,136	28	0	0

[a] Average commodity prices are defined as: cotton lint--\$0.31 per pound; cottonseed--\$100.00 per ton; grain sorghum--\$3.10 per cwt; soybeans--\$4.27 per bushel; wheat--\$2.60 per bushel; corn--\$1.94 per bushel.

[b] Input prices are defined as: natural gas--\$1.25 per Mcf; nitrogen--\$0.30 per pound.

[c] The cropland restriction (acres available) is 7,550,000 acres.

[d] Less than .5 percent.

APPENDIX B

Table 33. Estimated quantity of natural gas used in agricultural production at selected natural gas prices with associated dryland and irrigated acres and producer net returns based on high commodity prices[a] and current input prices:[b] Texas High Plains

Natural Gas		Acres of Cropland		
Price per Mcf	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000,000 cu ft)	-------1,000---------		($1,000,000)
0	54,642	3,146	4,404	1,495
1.45	54,631	3,146	4,404	1,415
4.69	53,583	3,146	4,404	1,239
6.65	53,423	3,157	4,393	1,133
6.77	50,091	3,157	4,393	1,127

[a] High commodity prices are defined as: cotton lint--$0.67 per pound; cottonseed--$100.00 per ton; grain sorghum--$5.96 per cwt; soybeans--$7.75 per bushel; wheat--$5.35 per bushel; corn--$3.46 per bushel.

[b] Input prices are defined as: diesel--$0.40 per gallon; nitrogen--$0.20 per pound.

Table 34. Estimated quantity of natural gas used in agricultural production at selected natural gas prices with associated dryland and irrigated acres and producer net returns based on low commodity prices[a] and current input prices:[b] Texas High Plains

Natural Gas		Acres of Cropland		
Price per Mcf	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000,000 cu ft)	-------1,000--------		($1,000,000)
0	45,033	3,559	3,991	151
.24	44,409	3,559	3,953	140
.64	43,360	3,559	3,953	122
1.14	41,935	3,559	3,813	101
1.28	34,575	4,177	3,195	95
1.41	15,651	6,036	1,336	91
1.58	12,734	6,278	1,094	88
1.62	6,411	6,813	559	87
2.35	5,047	6,825	427	83
2.48	0	7,252	0	83

[a] Low commodity prices are defined as: cotton lint--$0.18 per pound; cottonseed--$100.00 per ton; grain sorghum--$1.86 per cwt; soybeans--$2.30 per bushel; wheat--$1.34 per bushel; corn--$1.12 per bushel.

[b] Input prices are defined as: diesel--$0.40 per gallon; nitrogen--$0.20 per pound.

Table 35. Estimated quantity of natural gas used in agricultural production at selected natural gas prices with associated dryland and irrigated acres and producer net returns based on average commodity prices,[a] current diesel price and high nitrogen price:[b] Texas High Plains

Natural Gas		Acres of Cropland		
Price per Mcf	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000,000 cu ft)	-------1,000--------		($1,000,000)
0	51,172	3,146	4,404	493
1.23	50,576	3,157	4,393	430
2.10	49,120	3,157	4,393	387
3.12	43,858	3,559	3,991	337
4.16	41,868	3,559	3,991	292
4.82	35,266	4,077	3,473	265
5.18	19,714	5,566	1,984	253
5.69	11,881	6,269	1,281	244
5.99	1,222	7,392	120	241
9.12	0	7,392	0	238

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Input prices are defined as: diesel--$0.40 per gallon; nitrogen--$0.30 per pound.

Table 36. Estimated crop output at selected natural gas prices based on average commodity prices,[a] high nitrogen price and current diesel price:[b] Texas High Plains

Natural gas price per Mcf	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	-------1,000,000 bu--------		
0	2,498	100,650	4.8	23.7	80.3
1.23	2,498	108,150	4.8	23.4	63.8
2.10	2,885	92,507	4.8	23.4	48.4
3.12	2,885	92,507	4.8	29.4	4.2
4.16	2,783	92,507	4.8	29.4	4.2
5.18	2,492	34,614	4.8	29.0	4.2
5.99	1,629	34,614	4.2	25.6	0
9.12	1,328	34,614	0	25.6	0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Input prices are defined as: diesel--$0.40 per gallon; nitrogen--$0.30 per pound.

Table 37. Estimated planted cropland, by crop, at selected natural gas prices based on average commodity prices,[a] current diesel price and high nitrogen price:[b] Texas High Plains

Natural gas price per Mcf	Acres Planted											
	Total[c]		Cotton		Grain sorghum		Soybeans		Wheat		Corn	
	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total
(dollars)												
0	7,550	100	2,994	40	2,168	29	137	2	1,521	20	730	10
1.23	7,550	100	2,994	40	2,318	31	137	2	1,521	20	580	8
2.10	7,550	100	2,925	39	2,527	34	137	2	1,521	20	440	6
3.12	7,550	100	2,925	39	2,318	34	137	2	1,923	26	38	d
4.82	7,550	100	3,084	41	2,318	41	137	2	1,923	26	38	d
5.18	7,550	100	3,170	42	2,318	31	137	2	1,887	25	38	d
5.99	7,512	99	3,379	45	2,318	31	120	2	1,695	22	0	0
9.12	7,392	98	3,379	45	2,318	31	0	0	1,695	22	0	0

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[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Input prices are defined as: diesel--$0.40 per gallon; nitrogen--$0.30 per pound.

[c] The cropland restriction (acres available) is 7,550,000 acres.

[d] Less than .5 percent.

APPENDIX C

Table 38. Estimated quantity of nitrogen fertilizer used in agricultural production at selected nitrogen prices with associated dryland and irrigated acres and producer net returns based on high commodity prices[a] and current input prices:[b] Texas High Plains

Nitrogen		Acres of Cropland		
Price per pound	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 lbs)	-------1,000--------		($1,000,000)
0	446,413	3,146	4,404	1,535
.11	435,214	3,146	4,404	1,487
.22	433,357	3,146	4,404	1,436
.36	408,397	3,146	4,404	1,379
.46	394,357	3,146	4,404	1,336
.60	381,186	3,146	4,404	1,283
.95	316,951	3,050	4,404	1,167
1.04	315,851	3,061	4,393	1,136
1.34	255,551	3,463	3,991	1,043
1.86	249,851	3,463	3,953	909
2.00	249,851	3,463	3,953	874

[a] High commodity prices are defined as: cotton lint--$0.67 per pound; cottonseed--$100.00 per ton; grain sorghum--$5.96 per cwt; soybeans--$7.75 per bushel; wheat--$5.35 per bushel; corn--$3.46 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; natural gas--$0.88 per Mcf.

Table 39. Estimated quantity of nitrogen fertilizer used in agricultural production at selected nitrogen prices with associated dryland and irrigated acres and producer net returns based on low commodity prices[a] and current input prices:[b] Texas High Plains

Nitrogen		Acres of Cropland		
Price per pound	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 lbs)	--------1,000--------		($1,000,000)
0	378,220	3,146	4,404	174
.04	330,200	3,559	3,991	160
.06	310,720	3,559	3,991	154
.10	295,320	3,559	3,991	140
.14	289,365	3,559	3,953	128
.19	259,795	3,559	3,953	114
.23	236,525	3,753	3,759	104
.27	205,465	4,177	3,195	94
.29	194,585	4,177	3,195	90
.31	128,835	5,492	1,880	87
.33	118,770	5,660	1,712	84
.34	103,450	6,278	1,094	82
.35	72,370	6,796	576	82
.52	63,040	6,521	564	70
.67	45,915	6,948	137	60
2.00	45,915	6,948	137	-1

[a] Low commodity prices are defined as: cotton lint--$0.18 per pound; cottonseed--$100.00 per ton; grain sorghum--$1.86 per cwt; soybeans--$2.30 per bushel; wheat--$1.34 per bushel; corn--$1.12 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; natural gas--$0.88 per Mcf.

Table 40. Estimated quantity of nitrogen fertilizer used in agricultural production at selected nitrogen prices with associated dryland and irrigated acres and producer net returns based on average commodity prices,[a] current diesel prices and high natural gas price:[b] Texas High Plains

Nitrogen		Acres of Cropland		
Price per pound	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 lbs)	-------1,000--------		($1,000,000)
0	452,031	3,146	4,404	551
.10	393,911	3,146	4,404	505
.22	384,057	3,146	4,404	461
.30	368,346	3,157	4,393	430
.41	325,795	3,157	4,393	393
.53	253,860	3,463	3,991	357
.71	248,160	3,464	3,953	311
.77	222,845	3,753	3,759	299
.99	197,385	4,177	3,335	249
1.10	110,561	5,843	1.669	227
1.19	77,440	5,965	1,260	219
1.61	63,910	5,977	1,248	186
1.87	59,595	6,404	821	170
1.97	45,915	7,088	137	164
2.00	45,915	7,088	137	163

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum;--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Input prices are defined as: diesel--$0.40 per gallon; natural gas--$1.25 per Mcf.

Table 41. Estimated crop output at selected nitrogen fertilizer prices based on average commodity prices,[a] current diesel price and high natural gas price:[b] Texas High Plains

Nitrogen price per pound	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	------1,000,000 bu-------		
0	2,410	124,847	0	20.6	80.3
.10	2,475	109,132	0	23.6	80.3
.22	2,478	102,943	4.2	23.7	80.3
.30	2,498	108,150	4.8	23.4	63.8
.53	2,954	83,878	4.8	30.9	41.8
.77	2,738	83,878	4.8	30.9	0
1.10	2,286	34,614	4.8	27.8	0
1.61	1,731	30,309	4.8	28.9	0
1.97	1,301	30,309	4.8	26.3	0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum;--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Input prices are defined as: diesel--$0.40 per gallon; natural gas--$1.25 per Mcf.

Table 42. **Estimated planted cropland,** by crop, at selected nitrogen prices based on average commodity prices,[a] current diesel price and high natural gas price:[b] Texas High Plains

Nitrogen price per pound	Acres Planted											
	Total[c]		Cotton		Grain sorghum		Soybeans		Wheat		Corn	
	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total	(1,000)	% of Total
(dollars)												
0	7,550	100	3,068	41	2,400	32	0	0	1,352	18	730	10
.10	7,550	100	3,013	40	2,288	30	0	0	1,519	20	730	10
.25	7,550	100	2,994	40	2,318	31	137	2	1,521	20	580	8
.32	7,550	100	2,925	39	2,527	34	137	2	1,521	20	440	6
.53	7,454	99	2,702	36	2,527	34	137	2	2,050	27	38	d
.77	7,512	99	2,798	37	2,527	34	137	2	2,050	27	0	0
1.08	7,512	99	3,090	41	2,318	31	137	2	1.967	26	0	0
1.19	7,225	96	3,106	41	2,031	27	137	2	1,951	26	0	0
1.26	7,225	96	3,094	41	2,031	27	137	2	1,963	26	0	0
1.98	7,225	96	3,304	41	2,031	27	137	2	1,752	23	0	0

[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Input prices are defined as: diesel--$0.40 per gallon; natural gas--$1.25 per Mcf.

[c] The cropland restriction (acres available) is 7,550,000 acres.

[d] Less than .5 percent.

APPENDIX D

Table 43. Estimated quantity of water used in agricultural production at selected water prices with associated dryland and irrigated acres and producer net returns based on high commodity prices[a] and current input prices:[b] Texas High Plains

Water		Acres of Cropland		
Price per acre-foot	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 ac ft)	-------1,000--------		($1,000,000)
0	6,164	3,146	4,404	1,447
4.30	6,163	3,146	4,404	1,420
28.49	6,023	3,146	4,404	1,270
50.27	6,005	3,146	4,404	1,140
51.96	5,626	3,157	4,393	1,130
88.02	5,554	3,157	4,393	927
101.78	5,199	3,351	4,199	851
113.55	4,285	3,804	3,746	790
117.90	3,649	4,229	3,321	771
127.30	1,937	5,660	1,890	737
163.57	1,195	6,344	1,206	670
166.95	729	6,418	1,094	666
176.45	381	6,691	701	659

[a] High commodity prices are defined as: cotton lint--$0.67 per pound; cottonseed--$100.00 per ton; grain sorghum--$5.96 per cwt; soybeans--$7.75 per bushel; wheat--$5.35 per bushel; corn--$3.46 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

Table 44. Estimated quantity of water used in agricultural production at selected water prices with associated dryland and irrigated acres and producer net returns based on average commodity prices,[a] current diesel and nitrogen price[b] and high natural gas price: Texas High Plains

Water		Acres of Cropland		
Price per acre-foot	Quantity used	Dryland	Irrigated	Producer net returns
(dollars)	(1,000 ac ft)	--------1,000--------		($1,000,000)
0	5,787	3,146	4,404	467
5.87	5,767	3,157	4,393	433
19.60	5,560	3,157	4,393	355
26.35	4,957	3,559	3,991	317
31.66	3,781	4,177	3,373	292
38.52	1,897	5,660	1,890	267
42.85	1,329	6,344	1,206	259
51.11	996	6,653	897	248
54.91	574	6,991	521	246
56.19	140	7,392	120	245
68.53	0	7,392	0	243

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[a] Average commodity prices are defined as: cotton lint--$0.31 per pound; cottonseed--$100.00 per ton; grain sorghum--$3.10 per cwt; soybeans--$4.27 per bushel; wheat--$2.60 per bushel; corn--$1.94 per bushel.

[b] Input prices are defined as: diesel--$0.40 per gallon; natural gas--$1.25 per Mcf.

Table 45. Estimated crop output at selected water prices based on high commodity prices[a] and current input prices:[b] Texas High Plains

Water price per acre foot	Production				
	Cotton	Grain sorghum	Soybeans	Wheat	Corn
(dollars)	(1,000 bales)	(1,000 cwt)	-------1,000,000 bu--------		
0	2,615	110,147	0	23.6	80.3
28.49	2,865	94,314	0	23.7	80.3
51.96	2,865	86,299	0	23.4	80.3
88.02	2,885	92,507	.6	23.4	61.6
101.78	2,885	83,878	.6	23.4	61.6
117.90	2,515	80,639	0	29.4	17.4
163.57	1,996	34,614	4.2	28.4	41.8
176.45	1,647	34,614	0	25.6	0

[a] High commodity prices are defined as: cotton lint--$0.67 per pound; cottonseed--$100.00 per ton; grain sorghum--$5.96 per cwt; soybeans--$7.75 per bushel; wheat--$5.35 per bushel; corn--$3.46 per bushel.

[b] Current input prices are defined as: diesel--$0.40 per gallon; natural gas--$0.88 per Mcf; nitrogen--$0.20 per pound.

APPENDIX E

Coding and Description of Each Linear Programming Activity

Rows

OBJF1 - Objective function.

OBJPARA - CHROW used in parameterizing prices.

OBJF2 - Not used.

RXDIESEL - Diesel fuel required per acre (gallons).

RXCHGDSL - CHROW (change row) used in simultaneous parameterization of diesel and herbicide prices.

RXNATGAS - Natural gas required per acre (Mcf, or thousand cubic feet).

RXCHGNGS - CHROW used in parameterizing natural gas price.

RXNITROF - Nitrogen required per acre (pounds).

RXCHGNIT - CHROW used is parameterizing nitrogen price .

RXHERBCD - Herbicide required per acre (dollars).

RXWATERQ - Irrigation water required per acre (acre feet).

RXCHGWTR - CHROW used in parameterizing water price.

RXWTRXNG - Variable costs (less fuel cost) per acre of pumping groundwater (dollars).

R2LIRRIG - Irrigated land restraint (acres) for HPII (High Plains II).

R2LTOTAL - Total cropland restraint (acres) for HPII.

R2LCOTMX - Upper cotton acreage flexibility restraint (acres) for HPII.

R2LCOTMN - Lower cotton acreage flexibility restraints (acres) for HPII.

R2LGSOMX - Upper grain sorghum acreage flexibility restraint (acres) for HPII.

R2LGSOMN - Lower grain sorghum acreage flexibility restraint (acres) for HPII.

R2LSOYMX - Upper soybean acreage flexibility restraint (acres) for HPII.

R2LSOYMN - Lower soybean acreage flexibility restraint (acres) for HPII.

R2LWHTMX - Upper wheat acreage flexibility restraint (acres) for HPII.

R2LWHTMN - Lower wheat acreage flexibility restraint (acres) for HPII.

R2LCRNMX - Upper corn acreage flexibility restraint (acres) for HPII.

R2LCRNMN - Lower corn acreage flexibility restraint (acres) for HPII.

R3LSPRKL - Sprinkler irrigated land restraint (acres) for HPIII (High Plains III).

R3LFURRW - Furrow irrigated land restraint (acres) for HPIII.

R3LIRRIG - Total irrigated land restraint (acres) for HPIII.

R3LTOTAL - Total cropland restraint (acres) for HPIII.

R3LCOTMX - Upper cotton acreage flexibility restraint (acres) for HPIII.

R3LCOTMN - Lower cotton acreage flexibility restraint (acres) for HPIII.

R3LGSOMX - Upper grain sorghum acreage flexibility restraint (acres) for HPIII.

R3LGSOMN - Lower grain sorghum acreage flexibility restraint (acres) for HPIII.

R3LSOYMX - Upper soybean acreage flexibility restraint (acres) for HPIII.

R3LSOYMN - Lower soybean acreage flexibility restraint (acres) for HPIII.

R3LWHTMX - Upper wheat acreage flexibility restraint (acres) for HPIII.

R3LWHTMN - Lower wheat acreage flexibility restraint (acres) for HPIII.

R4LSROLL - Sideroll irrigated land restraint (acres) for HPIV (High Plains IV).

R4LCNPVT - Center pivot irrigated land restraint (acres) for HPIV.

R4LIRRIG - Total irrigated land restraint (acres) for HPIV.

R4LTOTAL - Total cropland restraint (acres) for HPIV.

R4LCOTMX - Upper cotton acreage flexibility restraint (acres) for HPIV.

R4LCOTMN - Lower cotton acreage flexibility restraint (acres) for HPIV.

R4LGSOMX - Upper grain sorghum acreage flexibility restraint (acres) for HPIV.

R4LGSOMN - Lower grain sorghum acreage flexibility restraint (acres) for HPIV.

R4LWHTMX - Upper wheat acreage flexibility restraint (acres) for HPIV.

R4LWHTMN - Lower wheat acreage flexibility restraint (acres) for HPIV.

RXSELCOT - Cotton lint production per acre (bales).

RXSELCOS - Cottonseed production per acre (tons).

RXSELGSO - Grain sorghum production per acre (hundredweight).

RXSELSOY - Soybean production per acre (bushels).

RXSELWHT - Wheat production per acre (bushel).

RXSELBEF - Wheat pasture grazing production per acre (pounds of cattle).

RXSELCRN - Corn production per acre (bushels).

R2COTACR - Cotton acreage accounting row (acres) for HPII.

R2GSOACR - Grain acreage accounting row (acres) for HPII.

R2SOYACR - Soybean acreage accounting row (acres) for HPII.

R2WHTACR - Wheat acreage accounting row (acres) for HPII.

R2CRNACR - Corn acreage accounting row (acres) for HPII.

R3COTACR - Cotton acreage accounting row (acres) for HPIII.

R3GSOACR - Grain sorghum acreage accounting row (acres) for HPIII.

R3SOYACR - Soybean acreage accounting row (acres) for HPIII.

R3WHTACR - Wheat acreage accounting row (acres) for HPIII.

R4COTACR - Cotton acreage accounting row (acres) for HPIV.

R4GSOACR - Grain sorghum acreage accounting row (acres) for HPIV.

R4WHTACR - Wheat acreage accounting row (acres) for HPIV.

R9CRNACR - Corn acreage accounting row (acres) for total study area.

R9COTACR - Cotton acreage accounting row (acres) for total study area.

R9GSOACR - Grain sorghum acreage accounting row (acres) for total area.

R9SOYACR - Soybean acreage accounting row (acres) for total study area.

R9WHTACR - Wheat acreage accounting row (acres) for total study area.

R9LIRRIG - Irrigated land accounting row for total study area.

R9LTOTAL - Total cropland accounting row for total study area.

Columns

C2CRNFW3 - Corn production, 1 preplant plus 3 postplant furrow irrigations, in HPII.

C2COTDRY - Cotton production, dryland, in HPII.

C2COTFW1 - Cotton production, 1 preplant plus 1 postplant furrow irrigations, in HPII.

C2COTFW2 - Cotton production, 1 preplant plus 2 postplant furrow irrigations, in HPII.

C2GSODRY - Grain sorghum production, dryland, in HPII.

C2GSOFW2 - Grain sorghum production, 1 preplant plus 2 postplant furrow irrigations, in HPII.

C2GSOFW3 - Grain sorghum production, 1 preplant plus 3 postplant furrow irrigations, in HPII.

C2SOYFW2 - Soybean production, 1 preplant plus 2 postplant furrow irrigations, in HPII.

C2WHTDRY - Wheat production, dryland, in HPII.

C2WHTFW3 - Wheat production, 1 preplant plus 3 postplant furrow irrigations, in HPII.

C2WHTFW4 - Wheat production, 1 preplant plus 4 postplant furrow irrigations, in HPII.

C3COTDRY - Cotton production, dryland, in HPIII.

C3COTSK0 - Cotton production, 1 preplant sprinkler irrigation, in HPIII.

C3COTFW0 - Cotton production, 1 preplant furrow irrigation, in HPIII.

C3COTSK1 - Cotton production, 1 preplant plus 1 postplant sprinkler irrigation, in HPIII.

C3COTFW1 - Cotton production, 1 preplant plus 1 postplant furrow irrigation, in HPIII.

C3COTSK2 - Cotton production, 1 preplant plus 2 postplant sprinkler irrigations, in HPIII.

C3COTFW2 - Cotton production, 1 preplant plus 2 postplant furrow irrigations, in HPIII.

C3COTSK3 - Cotton production, 1 preplant plus 3 postplant sprinkler irrigations, in HPIII.

C3COTFW3 - Cotton production, 1 preplant plus 3 postplant furrow irrigations, in HPIII.

C3GSODRY - Grain sorghum production, dryland, in HPIII.

C3GSOSK1 - Grain sorghum production, 1 preplant plus 1 postplant sprinkler irrigation, in HPIII.

C3GSOFW1 - Grain sorghum production, 1 preplant plus 1 postplant furrow irrigation, in HPIII.

C3GSOSK2 - Grain sorghum production, 1 preplant plus 2 postplant furrow irrigations, in HPIII.

C3GSOFW2 - Grain sorghum production, 1 preplant plus 2 postplant furrow irrigations, in HPIII.

C3GSOSK3 - Grain sorghum production, 1 preplant plus 3 postplant sprinkler irrigations, in HPIII.

C3GSOFW3 - Grain sorghum production, 1 preplant plus 3 postplant furrow irrigations, in HPIII.

C3GSOSK4 - Grain sorghum production, 1 preplant plus 4 postplant sprinkler irrigations, in HPIII.

C3GSOFW4 - Grain sorghum production, 1 preplant plus 4 postplant furrow irrigations, in HPIII.

C3SOYSK3 - Soybean production, 1 preplant plus 3 postplant sprinkler irrigations, in HPIII.

C3WHTDRY - Wheat production, dryland, in HPIII.

C3WHTSK3 - Wheat production, 1 preplant plus 3 postplant sprinkler irrigations, in HPIII.

C4COTDRY - Cotton production, dryland, in HPIV.

C4COTSR0 - Cotton production, 1 preplant sideroll irrigation, in HPIV.

C4COTSR1 - Cotton production, 1 preplant plus 1 postplant sideroll irrigations, in HPIV.

C4COTSR2 - Cotton production, 1 preplant plus 2 postplant sideroll irrigations, in HPIV.

C4COTCP2 - Cotton production, 1 preplant plus 2 postplant center pivot irrigations, in HPIV.

C4COTSR3 - Cotton production, 1 preplant plus 3 postplant sideroll irrigations, in HPIV.

C4COTCP3 - Cotton production, 1 preplant plus 3 postplant center pivot irrigations, in HPIV.

C4GSODRY - Grain sorghum production, dryland, in HPIV.

C4GSOSR2 - Grain sorghum production, 1 preplant plus 2 postplant sideroll irrigations, in HPIV

C4GSOSR3 - Grain sorghum production, 1 preplant plus 3 postplant sideroll irrigations, in HPIV.

C4GSOCP3 - Grain sorghum production, 1 preplant plus 3 postplant center pivot irrigations, in HPIV.

C4GSOCP4 - Grain sorghum production, 1 preplant plus 4 postplant center pivot irrigations, in HPIV.

C4WHTDRY - Wheat production, dryland, in HPIV.

C4WHTSR3 - Wheat production, 1 preplant plus 3 postplant sideroll irrigations, in HPIV.

CXBUYDSL - Diesel fuel purchasing activity.

CXBUYNGS - Natural gas fuel purchasing activity.

CXBUYNIT - Nitrogen fertilizer purchasing activity.

CXBUYHBC - Herbicide purchasing activity.

CXBUYWTR - Irrigation water purchasing activity.

CXBUYWXG - Activity for charging variable costs of pumping groundwater.

CXSELCOT - Cotton lint selling activity.

CXSELCOS - Cottonseed selling activity.

CXSELGSO - Grain sorghum selling activity.

CXSELSOY - Soybean selling activity.

CXSELWHT - Wheat selling activity.

CXSELBEF - Activity for selling wheat grazing.

CXSELCRN - Corn selling activity.

The Matrix of the Linear Programming Model

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              EXECUTOR.     MPS/360 V2-M11                                                                   PAGE    19  -   75/307

             C2CRNFW3       C2COTDRY       C2COTFW1       C2COTFW2       C2GSODRY       C2GSOFW2       C2GSOFW3                        1....1

OBJF1        70.81000-      31.20000-      77.00000-      85.58000-       9.83000-      31.47000-      43.08000-     OBJF1
OBJPARA      70.81000-      31.20000-      77.00000-      85.53000-       9.83000-      31.47000-      43.08000-     OBJPARA
OBJF2       205.01000-      61.17000-     152.39000-     169.78000-      37.30000-     126.96000-     146.34000-     OBJF2
RXDIESEL     20.59000        9.60000       18.72000       18.72000        6.25000       20.91000       20.91000      RXDIESEL
RXNATGAS     13.09000         .             7.27000       10.18000         .            10.13000       13.09000      RXNATGAS
RXNITROF    150.00000         .            20.00000       40.00000       30.00000       80.00000      120.00000      RXNITROF
RXHERBCD       .             4.88000        7.32000        7.32000         .             3.85000        3.85000      RXHERBCD
RXWATERQ      1.50000         .              .83000        1.17000         .             1.17000        1.50000      RXWATERQ
RXWTRXNG     10.98000         .             6.06000        8.58000         .             8.58000       10.98000      RXWTRXNG
R2LIRRIG      1.00000         .             1.00000        1.00000         .             1.00000        1.00000      R2LIRRIG
R2LTOTAL      1.00000        1.00000        1.00000        1.00000        1.00000        1.00000        1.00000      R2LTOTAL
R2LCOTMX       .             1.00000        1.00000        1.00000         .              .              .          R2LCOTMX
R2LCOTMN       .             1.00000        1.00000        1.00000         .              .              .          R2LCOTMN
R2LGSOMX       .              .              .              .            1.00000        1.00000        1.00000      R2LGSOMX
R2LGSOMN       .              .              .              .            1.00000        1.00000        1.00000      R2LGSOMN
R2LCRNMX      1.00000         .              .              .              .              .              .          R2LCRNMX
R2LCRNMN      1.00000         .              .              .              .              .              .          R2LCRNMN
RXSELCOT       .              .30000         .85000        1.00000         .              .              .          RXSELCOT
RXSELCOS       .              .12000         .34000         .40000         .              .              .          RXSELCOS
RXSELGSO       .              .              .              .           15.00000       50.00000       57.00000      RXSELGSO
RXSELCRN    110.00000         .              .              .              .              .              .          RXSELCRN
R2COTACR       .             1.00000        1.00000        1.00000         .              .              .          R2COTACR
R2GSOACR       .              .              .              .            1.00000        1.00000        1.00000      R2GSOACR
R2CRNACR      1.00000         .              .              .              .              .              .          R2CRNACR
R9CRNACR      1.00000         .              .              .              .              .              .          R9CRNACR
R9COTACR       .             1.00000        1.00000        1.00000         .              .              .          R9COTACR
R9GSOACR       .              .              .              .            1.00000        1.00000        1.00000      R9GSOACR
R9LIRRIG      1.00000         .             1.00000        1.00000         .             1.00000        1.00000      R9LIRRIG
R9LTOTAL      1.00000        1.00000        1.00000        1.00000        1.00000        1.00000        1.00000      R9LTOTAL
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          EXECUTOR.     MPS/360 V2-M11                                                                       PAGE    20  -  75/307

            C2SOYFW2         C2WHTDRY         C2WHTFW3         C2WHTFW4         C3COTDRY         C3COTSKO         C3COTFWO                       2....1

OBJF1       35.77000-        15.86000-        32.05000-        39.95000-        32.52000-        58.91000-        56.78000-     OBJF1
OBJPARA     35.77000-        15.86000-        32.05000-        39.96000-        32.52000-        58.91000-        56.78000-     OBJPARA
OBJF2       98.06000-        45.78000-        92.05000-       102.06000-        66.12000-       114.51000-       113.08000-     OBJF2
RXDIESEL    15.43000          9.15000         11.29000         11.29000         10.94000         15.11000         15.11000      RXDIESEL
RXNATGAS    10.18000           .              11.63000         14.55000           .               3.71000          4.04000      RXNATGAS
RXNITROF      .                .              80.00000        100.00000           .              20.00000         20.00000      RXNITROF
RXHERBCD     5.00000           .               1.50000          1.50000          2.17000          5.20000          5.20000      RXHERBCD
RXWATERQ     1.17000           .               1.33000          1.67000           .                .33000           .50000      RXWATERQ
RXWTRXNG     8.58000           .               9.72000         12.24000           .               2.47000          5.40000      RXWTRXNG
R2LIRRIG     1.00000           .               1.00000          1.00000           .                .                .           R2LIRRIG
R2LTOTAL     1.00000          1.00000          1.00000          1.00000           .                .                .           R2LTOTAL
R2LSOYMX     1.00000           .                .                .                .                .                .           R2LSOYMX
R2LSOYMN     1.00000           .                .                .                .                .                .           R2LSOYMN
R2LWHTMX      .               1.00000          1.00000          1.00000           .                .                .           R2LWHTMX
R2LWHTMN      .               1.00000          1.00000          1.00000           .                .                .           R2LWHTMN
R3LSPRKL      .                .                .                .                .               1.00000           .           R3LSPRKL
R3LFURRW      .                .                .                .                .                .               1.00000      R3LFURRW
R3LIRRIG      .                .                .                .                .               1.00000          1.00000      R3LIRRIG
R3LTOTAL      .                .                .                .               1.00000          1.00000          1.00000      R3LTOTAL
R3LCOTMX      .                .                .                .                .67000          1.00000          1.00000      R3LCOTMX
R3LCOTMN      .                .                .                .                .67000          1.00000          1.00000      R3LCOTMN
RXSELCOT      .                .                .                .                .44000           .75000           .75000      RXSELCOT
RXSELCOS      .                .                .                .                .15000           .26000           .26000      RXSELCOS
RXSELSOY    35.00000           .                .                .                .                .                .           RXSELSOY
RXSELWHT      .              15.00000         33.00000         40.00000           .                .                .           RXSELWHT
RXSELBEF      .                .90000          1.50000          2.00000           .                .                .           RXSELBEF
R2SOYACR     1.00000           .                .                .                .                .                .           R2SOYACR
R2WHTACR      .               1.00000          1.00000          1.00000           .                .                .           R2WHTACR
R3COTACR      .                .                .                .               1.00000          1.00000          1.00000      R3COTACR
R9COTACR      .                .                .                .               1.00000          1.00000          1.00000      R9COTACR
R9SOYACR     1.00000           .                .                .                .                .                .           R9SOYACR
R9WHTACR      .               1.00000          1.00000          1.00000           .                .                .           R9WHTACR
R9LIRRIG     1.00000           .               1.00000          1.00000           .               1.00000          1.00000      R9LIRRIG
R9LTOTAL     1.00000          1.00000          1.00000          1.00000          1.00000          1.00000          1.00000      R9LTOTAL
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          EXECUTOR.    MPS/360 V2-M11                                                    PAGE     21  -   75/307

           C3COTSK1      C3COTFW1      C3COTSK2      C3COTFW2      C3COTSK3      C3COTFW3      C3GSODRY                   3....1

OBJF1       66.89000-     64.29000-     79.29000-     77.22000-     87.43000-     83.09000-     15.85000-    OBJF1
OBJPARA     66.89000-     64.29000-     79.29000-     77.22000-     87.43000-     83.09000-     15.85000-    OBJPARA
OBJF2      134.54000-    132.82000-    158.11000-    155.77000-    176.70000-    173.07000-     45.78000-    OBJF2
RXDIESEL    15.88000      15.88000      15.88000      15.88000      16.77000      16.77000      12.01000     RXDIESEL
RXNATGAS     6.49000       6.73000       9.27000       8.65000      11.32000      11.13000        .          RXNATGAS
RXNITROF    40.00000      40.00000      60.00000      60.00000      60.00000      60.00000        .          RXNITROF
RXHERBCD     5.20000       5.20000       5.20000       5.20000       5.20000       5.20000        .          RXHERBCD
RXWATERQ      .58000        .83000        .83000       1.17000       1.08000       1.50000        .          RXWATERQ
RXWTRXNG     5.27000       8.95000       7.55000      10.96000       7.99000      13.86000        .          RXWTRXNG
R3LSPRKL     1.00000        .            1.00000        .            1.00000        .             .          R3LSPRKL
R3LFURRW      .            1.00000        .            1.00000        .            1.00000        .          R3LFURRW
R3LIRRIG     1.00000       1.00000       1.00000       1.00000       1.00000       1.00000        .          R3LIRRIG
R3LTOTAL     1.00000       1.00000       1.00000       1.00000       1.00000       1.00000       1.00000     R3LTOTAL
R3LCOTMX     1.00000       1.00000       1.00000       1.00000       1.00000       1.00000        .          R3LCOTMX
R3LCOTMN     1.00000       1.00000       1.00000       1.00000       1.00000       1.00000        .          R3LCOTMN
R3LGSOMX      .             .             .             .             .             .            1.00000     R3LGSOMX
R3LGSOMN      .             .             .             .             .             .            1.00000     R3LGSOMN
RXSELCOT      .90000        .90000       1.10000       1.10000       1.24000       1.24000        .          RXSELCOT
RXSELCOS      .32000        .32000        .39000        .39000        .43000        .43000        .          RXSELCOS
RXSELGSO      .             .             .             .             .             .           15.50000     RXSELGSO
R3COTACR     1.00000       1.00000       1.00000       1.00000       1.00000       1.00000        .          R3COTACR
R3GSOACR      .             .             .             .             .             .            1.00000     R3GSOACR
R9COTACR     1.00000       1.00000       1.00000       1.00000       1.00000       1.00000        .          R9COTACR
R9GSOACR      .             .             .             .             .             .            1.00000     R9GSOACR
R9LIRRIG     1.00000       1.00000       1.00000       1.00000       1.00000       1.00000        .          R9LIRRIG
R9LTOTAL     1.00000       1.00000       1.00000       1.00000       1.00000       1.00000       1.00000     R9LTOTAL
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              EXECUTOR.   MPS/360 V2-M11                                                            PAGE    22  -  75/307

              C3GSOSK1     C3GSOFW1     C3GSOSK2     C3GSOFW2     C3GSOSK3     C3GSOFW3     C3GSOSK4                      4....1

OBJF1         23.07000-    20.78000-    28.21000-    27.24000-    38.99000-    34.98000-    41.37000-    OBJF1
OBJPARA       23.07000-    20.78000-    28.21000-    27.24000-    38.99000-    34.98000-    41.37000-    OBJPARA
OBJF2         66.40000-    71.02000-    82.35000-    87.70000-   105.17000-   107.88000-   119.19000-    OBJF2
RXDIESEL      12.14000     12.41000     12.58000     13.02000     13.68000     13.96000     13.96000     RXDIESEL
RXNATGAS       6.49000      6.73000      9.09000      8.65000     11.32000     11.13000     14.55000     RXNATGAS
RXNITROF      60.00000     60.00000     80.00000     80.00000    100.00000    100.00000    120.00000     RXNITROF
RXHERBCD        .            .            .           3.85000      3.85000      3.85000      3.95000     RXHERBCD
RXWATERQ        .58000       .83000       .83000      1.17000      1.08000      1.50000      1.33000     RXWATERQ
RXWTRXNG       5.27000      8.95000      7.65000     10.96000      7.89000     13.86000      9.72000     RXWTRXNG
R3LSPRKL       1.00000       .           1.00000       .           1.00000       .           1.00000     R3LSPRKL
R3LFURRW        .           1.00000       .           1.00000       .           1.00000       .          R3LFURRW
R3LIRRIG       1.00000      1.00000      1.00000      1.00000      1.00000      1.00000      1.00000     R3LIRRIG
R3LTOTAL       1.00000      1.00000      1.00000      1.00000      1.00000      1.00000      1.00000     R3LTOTAL
R3LGSOMX       1.00000      1.00000      1.00000      1.00000      1.00000      1.00000      1.00000     R3LGSOMX
R3LGSOMN       1.00000      1.00000      1.00000      1.00000      1.00000      1.00000      1.00000     R3LGSOMN
RXSELGSO      25.00000     30.00000     35.00000     40.00000     45.00000     50.00000     53.00000     RXSELGSO
R3GSOACR       1.00000      1.00000      1.00000      1.00000      1.00000      1.00000      1.00000     R3GSOACR
R9GSOACR       1.00000      1.00000      1.00000      1.00000      1.00000      1.00000      1.00000     R9GSOACR
R9LIRRIG       1.00000      1.00000      1.00000      1.00000      1.00000      1.00000      1.00000     R9LIRRIG
R9LTOTAL       1.00000      1.00000      1.00000      1.00000      1.00000      1.00000      1.00000     R9LTOTAL
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            EXECUTOR.    MPS/360 V2-M11                                                        PAGE   23  -  75/307

                  C3GSOFW4        C3SOYSK3        C3WHTDRY        C3WHTSK3        C4COTDRY        C4COTSRO        C4COTSP1                   5....1

OBJF1            36.44000-       36.12000-       14.14000-       37.37000-       30.40000-       53.68000-       60.54000-   OBJF1
OBJPARA          36.44000-       36.12000-       14.14000-       37.37000-       30.40000-       53.68000-       60.54000-   OBJPARA
OBJF2           122.36000-       97.56000-       40.84000-       87.38000-       58.76000-      102.18000-      119.39000-   OBJF2
RXDIESEL         14.23000        10.60000         5.57000         8.62000         9.92000        12.70000        12.70000    RXDIESEL
RXNATGAS         13.60000        11.82000          .             11.82000          .              3.71000         6.49000    RXNATGAS
RXNITPCF        120.00000          .               .             80.00000        13.33000        30.00000        40.00000    RXNITPCF
RXHERBCD          3.85000         4.00000          .               .              1.67000         4.00000         4.00000    RXHERBCD
RXWATERQ          1.83000         1.08000          .              1.08000          .               .33000          .58000    RXWATERQ
RXWTRXNG         16.90000         6.59000          .              6.59000          .              2.99000         5.27000    RXWTRXNG
R3LSPRKL           .              1.00000          .              1.00000          .               .               .         R3LSPRKL
R3LFURRW          1.00000          .               .               .               .               .               .         R3LFURRW
R3LIRRIG          1.00000         1.00000          .              1.00000          .               .               .         R3LIRRIG
R3LTOTAL          1.00000         1.00000         1.00000         1.00000          .               .               .         R3LTOTAL
R3LGSCMX          1.00000          .               .               .               .               .               .         R3LGSOMX
R3LGSOMN          1.00000          .               .               .               .               .               .         R3LGSOMN
R3LSOYMX           .              1.00000          .               .               .               .               .         R3LSOYMX
R3LSOYMN           .              1.00000          .               .               .               .               .         R3LSOYMN
R3LWHTMX           .               .              1.00000         1.00000          .               .               .         R3LWHTMX
R3LWHTMN           .               .              1.00000         1.00000          .               .               .         R3LWHTMN
R4LSROLL           .               .               .               .               .              1.00000         1.00000    R4LSROLL
R4LIRRIG           .               .               .               .               .              1.00000         1.00000    R4LIRRIG
R4LTOTAL           .               .               .               .              1.00000         1.00000         1.00000    R4LTOTAL
R4LCOTMX           .               .               .               .               .67000         1.00000         1.00000    R4LCOTMX
R4LCOTMN           .               .               .               .               .67000         1.00000         1.00000    R4LCOTMN
RXSELCOT           .               .               .               .               .35000          .65000          .80000    RXSELCOT
RXSELCOS           .               .               .               .               .13000          .23000          .28000    RXSELCOS
RXSELGSO         60.00000          .               .               .               .               .               .         RXSELGSO
RXSELSOY           .             35.00000          .               .               .               .               .         RXSELSOY
RXSELWHT           .               .             18.00000        35.00000          .               .               .         RXSELWHT
RXSELBEF           .               .               .40000         2.00000          .               .               .         RXSELBEF
R3GSOACR          1.00000          .               .               .               .               .               .         R3GSOACR
R3SOYACR           .              1.00000          .               .               .               .               .         R3SOYACR
R3WHTACR           .               .              1.00000         1.00000          .               .               .         R3WHTACR
R4COTACR           .               .               .               .              1.00000         1.00000         1.00000    R4COTACR
R9COTACR           .               .               .               .              1.00000         1.00000         1.00000    R9COTACR
R9GSOACR          1.00000          .               .               .               .               .               .         R9GSOACR
R9SOYACR           .              1.00000          .               .               .               .               .         R9SOYACR
R9WHTACR           .               .              1.00000         1.00000          .               .               .         R9WHTACR
R9LIRRIG          1.00000         1.00000          .              1.00000          .              1.00000         1.00000    R9LIRRIG
R9LTOTAL          1.00000         1.00000         1.00000         1.00000         1.00000         1.00000         1.00000    R9LTOTAL
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              EXECUTOR.    MPS/360 V2-M11                                                            PAGE    24  -   75/307

             C4COTSR2      C4COTCP2      C4COTSR3      C4COTCP3      C4GSODRY      C4GSOSR2      C4GSOSR3                    6....1

OBJF1        69.81000-     72.71000-     77.07000-     79.52000-     15.15000-     24.71000-     33.03000-    OBJF1
OBJPARA      69.81000-     72.71000-     77.07000-     79.52000-     15.15000-     24.71000-     33.03000-    OBJPARA
OBJF2       136.45000-    144.54000-    159.32000-    170.10000-     41.39000-     82.00000-     95.67000-    OBJF2
RXDIESEL     12.86000      12.86000      12.86000      12.86000      11.59000      11.69000      12.16000     RXDIESEL
RXNATGAS      9.27000      10.91000      11.82000      14.18000        .            9.27000      11.82000     RXNATGAS
RXNITROF     60.00000      60.00000      60.00000      60.00000      20.00000      60.00000      80.00000     RXNITROF
RXHERBCD      4.00000       4.00000       4.00000       4.00000        .             .             .          RXHERBCD
RXWATERQ       .83000        .83000       1.08000       1.08000        .             .83000       1.08000     RXWATERQ
RXWTRXNG      6.06000       4.06000       6.59000       5.29000        .            6.06000       6.59000     RXWTRXNG
R4LSROLL      1.00000        .            1.00000        .             .            1.00000       1.00000     R4LSROLL
R4LCNPVT       .            1.00000        .            1.00000        .             .             .          R4LCNPVT
R4LIRRIG      1.00000       1.00000       1.00000       1.00000        .            1.00000       1.00000     R4LIRRIG
R4LTOTAL      1.00000       1.00000       1.00000       1.00000       1.00000       1.00000       1.00000     R4LTOTAL
R4LCOTMX      1.00000       1.00000       1.00000       1.00000        .             .             .          R4LCOTMX
R4LCOTMN      1.00000       1.00000       1.00000       1.00000        .             .             .          R4LCOTMN
R4LGSOMX       .             .             .             .            1.00000       1.00000       1.00000     R4LGSOMX
R4LGSOMN       .             .             .             .            1.00000       1.00000       1.00000     R4LGSOMN
RXSELCOT       .95000        .95000       1.10000       1.10000        .             .             .          RXSELCOT
RXSELCOS       .33000        .33000        .39000        .39000        .             .             .          RXSELCOS
RXSELGSO       .             .             .             .           13.50000      35.00000      40.00000     RXSELGSO
R4COTACR      1.00000       1.00000       1.00000       1.00000        .             .             .          R4COTACR
R4GSOACR       .             .             .             .            1.00000       1.00000       1.00000     R4GSOACR
R9COTACR      1.00000       1.00000       1.00000       1.00000        .             .             .          R9COTACR
R9GSOACR       .             .             .             .            1.00000       1.00000       1.00000     R9GSOACR
R9LIRRIG      1.00000       1.00000       1.00000       1.00000        .            1.00000       1.00000     R9LIRRIG
R9LTOTAL      1.00000       1.00000       1.00000       1.00000       1.00000       1.00000       1.00000     R9LTOTAL
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                EXECUTOR.    MPS/360 V2-M11                                              PAGE    25  -  75/307

              C4GSOCP3     C4GSOCP4     C4WHTDPY     C4WHTSP3     CXBUYDSL     CXBUYNGS     CXBUYNIT                 7....1

OBJF1         37.03000-    40.21000-    13.47000-    28.64000-      .40000-      .88000-      .20000-   OBJF1
OBJPARA       37.03000-    40.21000-    13.47000-    28.64000-      .40000-      .88000-      .20000-   OBJPARA
OBJF2        113.34000-   124.02000-    33.96000-    77.52000-      .40000-      .88000-      .20000-   OBJF2
RXDIESEL      12.55000     12.71000      6.08000      8.25000      1.00000-      .            .         RXDIESEL
RXCHGDSL        .            .            .            .           1.00000-      .            .         RXCHGDSL
RXNATGAS      15.84000     19.49000       .          11.82000       .           1.00000-      .         RXNATGAS
RXCHGNGS        .            .            .            .            .           1.00000-      .         RXCHGNGS
RXNITROF     100.00000    100.00000       .          40.00000       .            .           1.00000-   RXNITROF
RXCHGNIT        .            .            .            .            .            .           1.00000-   RXCHGNIT
RXHERBCD        .           3.50000       .            .            .            .            .         RXHERBCD
RXWATERQ       1.08000      1.33000       .           1.08000       .            .            .         RXWATERQ
RXWTRXNG       4.38000      5.88000       .           6.59000       .            .            .         RXWTRXNG
R4LSROLL        .            .            .           1.00000       .            .            .         R4LSROLL
R4LCNPVT       1.00000      1.00000       .            .            .            .            .         R4LCNPVT
R4LIRRIG       1.00000      1.00000       .           1.00000       .            .            .         R4LIRRIG
R4LTOTAL       1.00000      1.00000      1.00000      1.00000       .            .            .         R4LTOTAL
R4LGSOMX       1.00000      1.00000       .            .            .            .            .         R4LGSOMX
R4LGSCMN       1.00000      1.00000       .            .            .            .            .         R4LGSCMN
R4LWHTMX        .            .           1.00000      1.00000       .            .            .         R4LWHTMX
R4LWHTMN        .            .           1.00000      1.00000       .            .            .         R4LWHTMN
RXSELGSO      47.00000     51.00000       .            .            .            .            .         RXSELGSO
RXSELWHT        .            .          12.00000     30.00000       .            .            .         RXSELWHT
RXSELREF        .            .            .50000      1.20000       .            .            .         RXSELREF
R4GSOACR       1.00000      1.00000       .            .            .            .            .         R4GSOACR
R4WHTACR        .            .           1.00000      1.00000       .            .            .         R4WHTACR
R9GSOACR       1.00000      1.00000       .            .            .            .            .         R9GSOACR
R9WHTACR        .            .           1.00000      1.00000       .            .            .         R9WHTACR
R9LIRRIG       1.00000      1.00000       .           1.00000       .            .            .         R9LIRRIG
R9LTOTAL       1.00000      1.00000      1.00000      1.00000       .            .            .         R9LTOTAL
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            EXECUTOR.    MPS/360 V2-M11                                                        PAGE    26  -  75/307

            CXBUYHBC      CXBUYWTR      CXBUYWXG      CXSELCOT      CXSELCOS      CXSELGSO      CXSELSOY                    9....1

OBJF1        1.20000-         .          1.00000-    154.70000    100.00000      3.10000      4.27000     OBJF1
OBJPARA      1.20000-         .          1.00000-    154.70000    100.00000      3.10000      4.27000     OBJPARA
OBJF2        1.20000-         .          1.00000-    154.70000    100.00000      3.10000      4.27000     OBJF2
RXCHGDSL     3.00000-         .              .            .            .            .            .        RXCHGDSL
RXHERBCD     1.00000-         .              .            .            .            .            .        RXHERBCD
RXWATERQ         .        1.00000-           .            .            .            .            .        RXWATERQ
RXCHGWTR         .        1.00000-           .            .            .            .            .        RXCHGWTR
RXWTRXNG         .            .          1.00000-         .            .            .            .        RXWTRXNG
RXSELCOT         .            .              .        1.00000-         .            .            .        RXSELCOT
RXSELCOS         .            .              .            .        1.00000-         .            .        RXSELCOS
RXSELGSO         .            .              .            .            .        1.00000-         .        RXSELGSO
RXSELSOY         .            .              .            .            .            .        1.00000-    RXSELSOY
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           EXECUTOR.   MPS/360 V2-M11                                                                         PAGE    27  -  75/307

          CXSELWHT      CXSELBEF      CXSELCRN      QTR                                                                     9....1

OBJF1      2.60000      20.00000      1.94000       .          OBJF1
OBJPARA    2.60000      20.00000      1.94000       .          OBJPARA
OBJF2      2.60000      20.00000      1.94000       .          OBJF2
R2LIRRIG    .            .             .         2570000.0     R2LIRRIG
R2LTOTAL    .            .             .         3686000.0     R2LTOTAL
R2LCOTMX    .            .             .         684000.00     R2LCOTMX
R2LCOTMN    .            .             .         544000.00     R2LCOTMN
R2LGSOMX    .            .             .         1315000.0     R2LGSOMX
R2LGSOMN    .            .             .         1028000.0     R2LGSOMN
R2LSOYMX    .            .             .         120000.00     R2LSOYMX
R2LWHTMX    .            .             .         1529000.0     R2LWHTMX
R2LWHTMN    .            .             .         1127000.0     R2LWHTMN
R2LCRNMX    .            .             .         730000.00     R2LCRNMX
R3LSPRKL    .            .             .         535000.00     R3LSPRKL
R3LFURRW    .            .             .         786000.00     R3LFURRW
R3LIRRIG    .            .             .         1321000.0     R3LIRRIG
R3LTOTAL    .            .             .         2792000.0     R3LTOTAL
R3LCOTMX    .            .             .         1439000.0     R3LCOTMX
R3LCOTMN    .            .             .         1184000.0     R3LCOTMN
R3LGSOMX    .            .             .         983000.00     R3LGSOMX
R3LGSOMN    .            .             .         674000.00     R3LGSOMN
P3LSOYMX    .            .             .         17000.000     R3LSOYMX
R3LWHTMX    .            .             .         291000.00     R3LWHTMX
R3LWHTMN    .            .             .         118000.00     R3LWHTMN
R4LSROLL    .            .             .         439000.00     R4LSROLL
R4LCNPVT    .            .             .         74000.000     R4LCNPVT
R4LIRRIG    .            .             .         513000.00     R4LIRRIG
R4LTOTAL    .            .             .         1072000.0     R4LTOTAL
R4LCOTMX    .            .             .         598000.00     R4LCOTMX
R4LCOTMN    .            .             .         427000.00     R4LCOTMN
R4LGSOMX    .            .             .         426000.00     R4LGSOMX
R4LGSOMN    .            .             .         329000.00     R4LGSOMN
R4LWHTMX    .            .             .         335000.00     R4LWHTMX
R4LWHTMN    .            .             .         48000.000     R4LWHTMN
RXSELWHT   1.00000-      .             .            .          RXSELWHT
RXSELBEF    .           1.00000-       .            .          RXSELBEF
RXSELCRN    .            .            1.00000-      .          PXSELCRN
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