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We appreciate the counsel and assistance of Dr. James Osborn of Texas Tech University and are indebted to Larry Canion and Eric Boltinghouse of the Texas Crop and Livestock Reporting Service for their assistance in providing data regarding planted crop acreages.

Of course, any errors, omissions or limitations of the report are the sole responsibility of the authors.

Introduction

Agriculture is a major income-producing sector in the Texas economy and a large part of this economic activity originates in irrigated crop production. For example, in 1973, 50% of all grain sorghum and 46% of all cotton in Texas were produced on irrigated acreage [Texas Crop and Livestock Reporting Service]. These two crops alone produced 26% of the cash receipts from the sale of Texas farm commodities in 1973 [Texas Crop and Livestock Reporting Service]. There are several other crops in Texas including vegetables which generate significant levels of income and rely heavily on irrigation. Further there are several associated industries which rely on production from irrigated agriculture, such as the cattle feeding industry in the Texas Panhandle. It is evident from this rather cursory examination of statistics that irrigation plays a large role in Texas agriculture.

Both producers and policy-makers have found themselves faced in the past two years with many uncertainties. The U.S., plagued in the past with surplus production and supply control problems, now finds itself in a world shortage of food products. The long range signals seem to call for increased production, yet the policy-maker faces decisions concerning not only how to increase production, but more basically, how to maintain current levels of production. Groundwater resources in many areas are being diminished and annual irrigation water supplies fully committed in other areas. Long run planning for Texas agriculture requires that interbasin transfers of water be evaluated. Texas holds a position of prominence in the production of U.S. food and fiber products, and the evaluation of these alternatives has implications not only for Texas, but for the U.S. and possibly the world. To objectively evaluate water transfer proposals, it is necessary that the value of irrigation water in different regions of Texas be established.

The producer faces the same call for maintaining or increasing production as the policy-maker, but he does so with many uncertainties which often have not disturbed the policy-maker in evaluating alternatives. Product prices have risen and fallen at an unprecedented rate while input prices have steadily risen at rates which preclude realistic budgeting. For example, during the recent energy crisis, the prices of fuel and fertilizer have more than doubled. These variable input and product prices weigh heavily upon production decisions by the producer, and likewise must receive serious consideration in evaluation of resource allocation alternatives by policy-makers. The demand for irrigation water is derived from the production of crops and any change in production patterns, input prices or availability, and product prices directly affects this demand.

Current and future water resources planning requires an estimate of the various quantities of water which will be used for irrigation under differing assumptions concerning price of water, other input prices, and product prices. Of particular importance are shifts in cropping patterns, changes in level of agricultural production and net effect on producers income. Since many policy decisions are made in relatively short periods of time, there is an urgent need for a capability to evaluate alternative policies and change input or product prices in a timely fashion.

Objectives

The general purpose of this study was to satisfy the need to have rapid evaluation capability as to effects on irrigated agriculture of selected policies or changes in prices. Specific objectives of the study were as follows:

(1) Develop a model of the Southern High Plains of Texas with the capability of estimating cropping pattern changes, changes in agricultural output, adjustments in net producer income and quantity of inputs used (i.e., water, natural gas, diesel, fertilizer, etc.) given alternative policies and input and product prices.

(2) Develop an analogous model for a second region in Texas.

(3) Link the two models together and test validity of results produced by the models.

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,

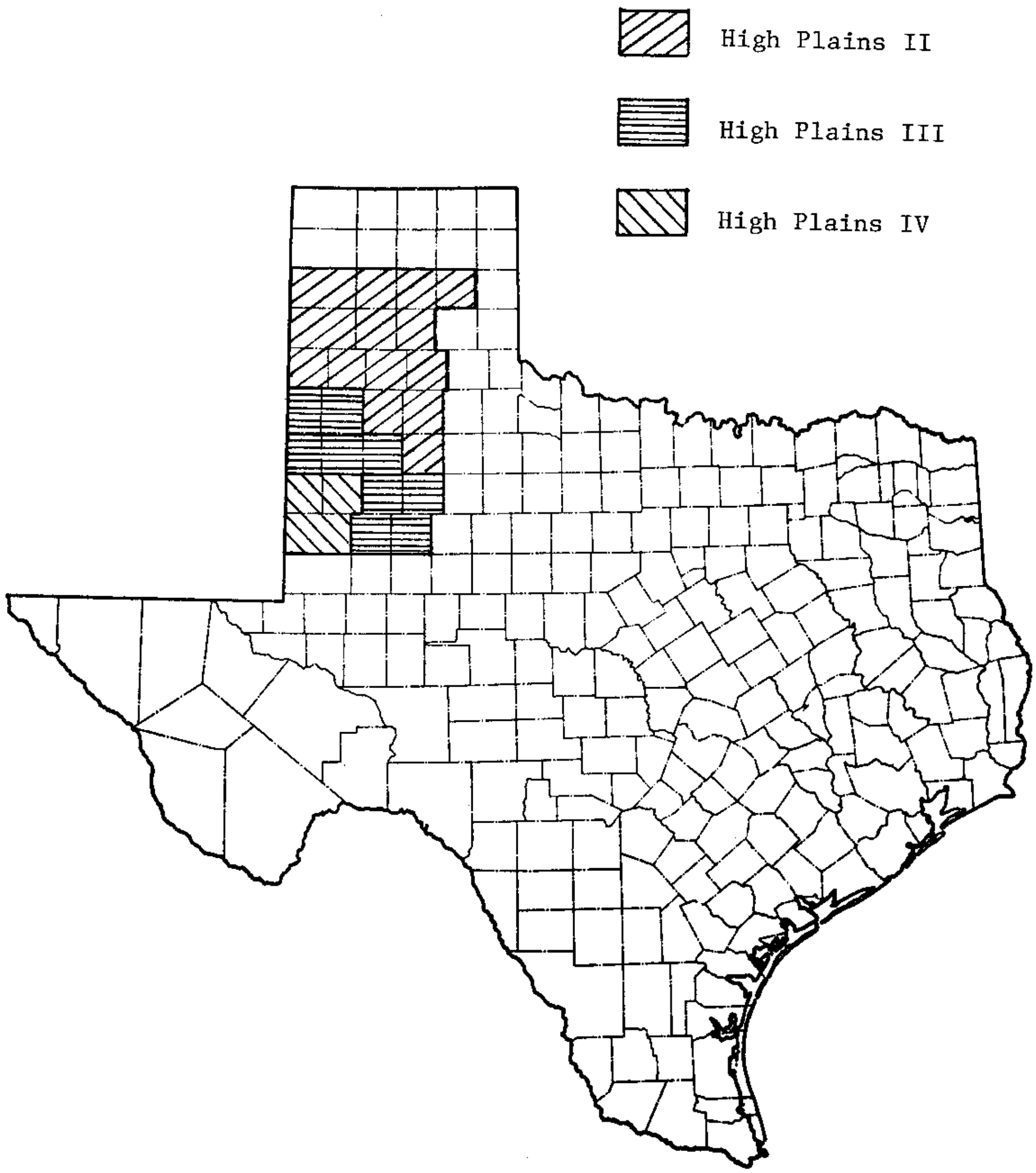

Figure 1. The study area with designated subregions

Source: Extension Economists - Management

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 (Texas Almanac). 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 (Texas Almanac). 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 (Texas Almanac).

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. 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. 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.

Procedure

Only a brief description of the methodology is provided in the report. For specific details of the model and input data refer to Condra, Lacewell, Sprott and Adams or Adams.

Linear programming (LP) was selected as the analytical technique since it provides an effective tool for allocating land, water, and other inputs. Basically the LP model developed in this study maximizes producer net returns subject to resource restraints.

The major crops of the area (corn, cotton, grain sorghum, soybeans, and wheat) were incorporated into the model. These crop enterprises were restrained by upper and lower flexibility restraints. These restraints reflect the maximum "expected" increase or decrease in the acreage of a particular crop in a given year. The level of a given restraint was jointly determined by base acreage and the flexibility coefficient of increase or decrease.

Crop acreage flexibility coefficients were estimated from historical planted acreages (Texas Crop and Livestock Reporting Service) using linear regression analysis (Condra and Lacewell, 1976). Base acreages were specified as the past three years' average acreage for each crop except corn and soybeans.[1] The base was established as a three year average to minimize distortion of results due to the effects of typical weather conditions and product prices in 1973 and 1974.

To obtain model flexibility, purchasing activities were included for natural gas, nitrogen fertilizer, diesel fuel, herbicide, direct water charges, and nonfuel groundwater pumping costs. This means prices for these items can be specified at alternative levels or varied parametrically.

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[1]Insufficient data were available for statistical analysis using averages for corn and soybeans.

Similarly, a selling activity for each crop was incorporated to allow efficient analysis of the effects of alternative product price levels on the demand for water and other inputs.

All resources were assumed to be unrestricted in supply except irrigated and total cropland, which were restricted to current levels. Groundwater supplies were not explicitly limited except through the irrigated land restriction.

Per acre production input-output coefficients for crop enterprises were taken from the Texas Crop Budgets (Extension Economists - Mangement). Only single-level irrigated enterprises were considered for corn and soybeans, however, alternatives for the other three crops include dryland production and different levels of irrigation (Sartin). It has been assumed that typical management applies too all crop enterprises.

Input prices prevailing in 1975 were used (Sartin; Osborn; Grubb) unless specified otherwise in the particular application. Several alternative sets of product prices were used including (1) lowest price for each product (crop) from 1971-74, (2) average price from 1971-74, (3) highest price from 1971-74 and (4) product prices existing in early 1976.

Results

Models developed in this study have been applied to estimate impacts of energy price increases and derive demand schedules for irrigation water. Results of these applications are presented in detail in publications evolving directly from this project.[2] Therefore, this report will provide summary results with a reference to the appropriate publication.

Multiple Regions

Models were developed for the three regions of the Southern High Plains of Texas (HP-I, HP-II, HP-III). The three regional models were linked. Application of this regional model emphasized implications of increasing costs for energy. Inputs considered were diesel, natural gas, nitrogen fertilizer and irrigation water. Three levels of crop prices were used. The results included cropping pattern shifts, changes in agricultural output, effect on producer net revenue and associated demand for the specific input. Detailed results are available in Adams and in Lacewell.

For this particular analysis, a shortrun perspective was used. This means only "out of pocket" or variable costs of production were considered. Thus, these results are applicable over only a shortrun period such as several months. This characteristic of the study should be kept in mind. Also commodity prices used were the high, low and average over the 1971-74 period.

Application of the model results in large quantities of data. For presentation, a synthesis was necessary. Therefore, the study results

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[2]Publications directly associated with this project are Adams; Condra and Lacewell; Condra, Lacewell, Sprott and Adams; Lacewell; Lacewell, Condra and Fish, 1976a; and Lacewell, Condra and Fish, 1976b.

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 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 has 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 shifting from 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, regional net revenue is $531 million; if he pays $1.66 per Mcf, net revenue falls 16 percent to $446 million; and if he pays $2.54 per Mcf, 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 impact less on cropping patterns than 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 acresgea. 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 most 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 tend 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.

Conclusion: In summary, the energy price increases that are probably imminent in the near future will have only a minimal impact in the short run 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 shortcoming of these results is not considering possible related 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.

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.

Model Update and Application

After completion of the rather comprehensive study by Adams, it became apparent that there was a need to consider the long run situation where fixed and variable costs are considered. In addition, updating and sophistication of the model was needed. This was accomplished by restricting the model to one region (High Plains II). This is the largest region of the three. For High Plains II, the modifications were made and the revised model applied to several problem areas.

Demand for Irrigation Water: One of these areas was an investigation of demand for irrigation water. Research details are presented in Condra and Lacewell (1975) and in Condra, Lacewell, Sprott and Adams.

The model was applied using alternative crop prices and input prices. Assuming 1971-74 average crop prices, 1975 input prices and only variable costs of production, as the price of water was increased wheat shifted from irrigated to dryland production, then grain sorhgum, cotton, corn and soybeans, in that order. The price of water was \$80.15 per acre foot when all land shifted to dryland production.

The same analysis, except variable and fixed costs both included, gave similar results relative to the sequence of crops that shift to dryland production as the price of water was increased. However, the shifts occurred at much lower water prices; i.e., at \$55.47 per acre foot, all land had shifted to dryland production. This suggests that over the long run, irrigation in the Texas High Plains is quite sensitive to the price of energy used in pumping water. Further, there are strong implications relative to farmer's "abiltiy to pay" for water imported to the High Plains from other regions.

In this report, several scenarios including low, high and average crop prices and variable input prices were evaluated. Figures 2, 3 and 4 graphically represent some of these results. In all cases, the water value (price) includes cost of pumping water. This means to get the value per acre foot of water from surface sources, the values in the table need to be increased $8.40 for short run demand schedules and $21.00 for long run demand schedules.

Figure 2 shows an estimated long run and short run demand schedule for irrigation water, figure 3 is long run demand schedule for irrigation water given alternative sets of crop prices and figure 4 indicates effect of natural gas price on demand for irrigation water drawn from the underground aquifer.

<u>Natural Gas Pricing Effects</u>: A last major emphasis of this project was model application to evaluate the expected effect of natural gas price increases on irrigated agriculture in the region High Plains II of the Southern High Plains. In these studies crop prices were set at the 1971-74 average and at levels prevailing in early 1976. The analysis involved systematically increasing the price of natural gas and establishing cropping pattern changes, agricultural output adjustments and changes in producer net returns. Details of these studies are presented in Lacewell, Condra and Fish (1976a and 1976b).

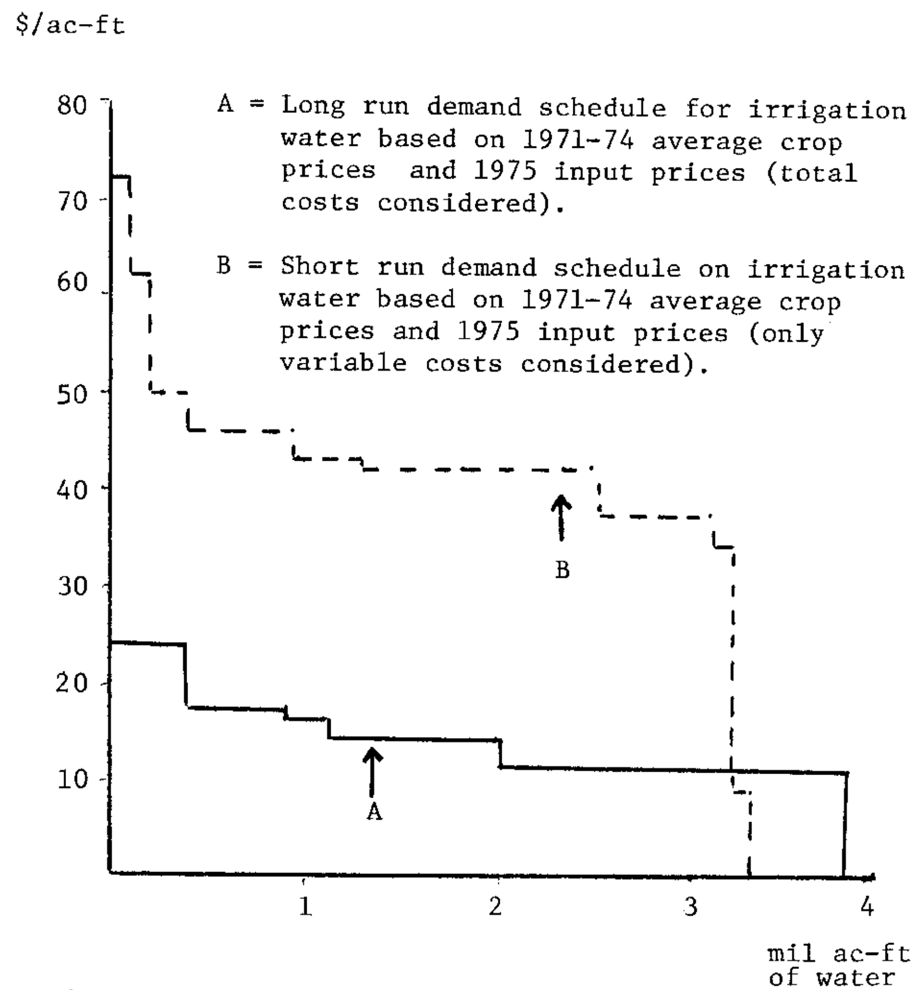

Figure 2. Long Run and Short Run Derived Demand for Irrigation Water, Texas High Plains, Subregion II.

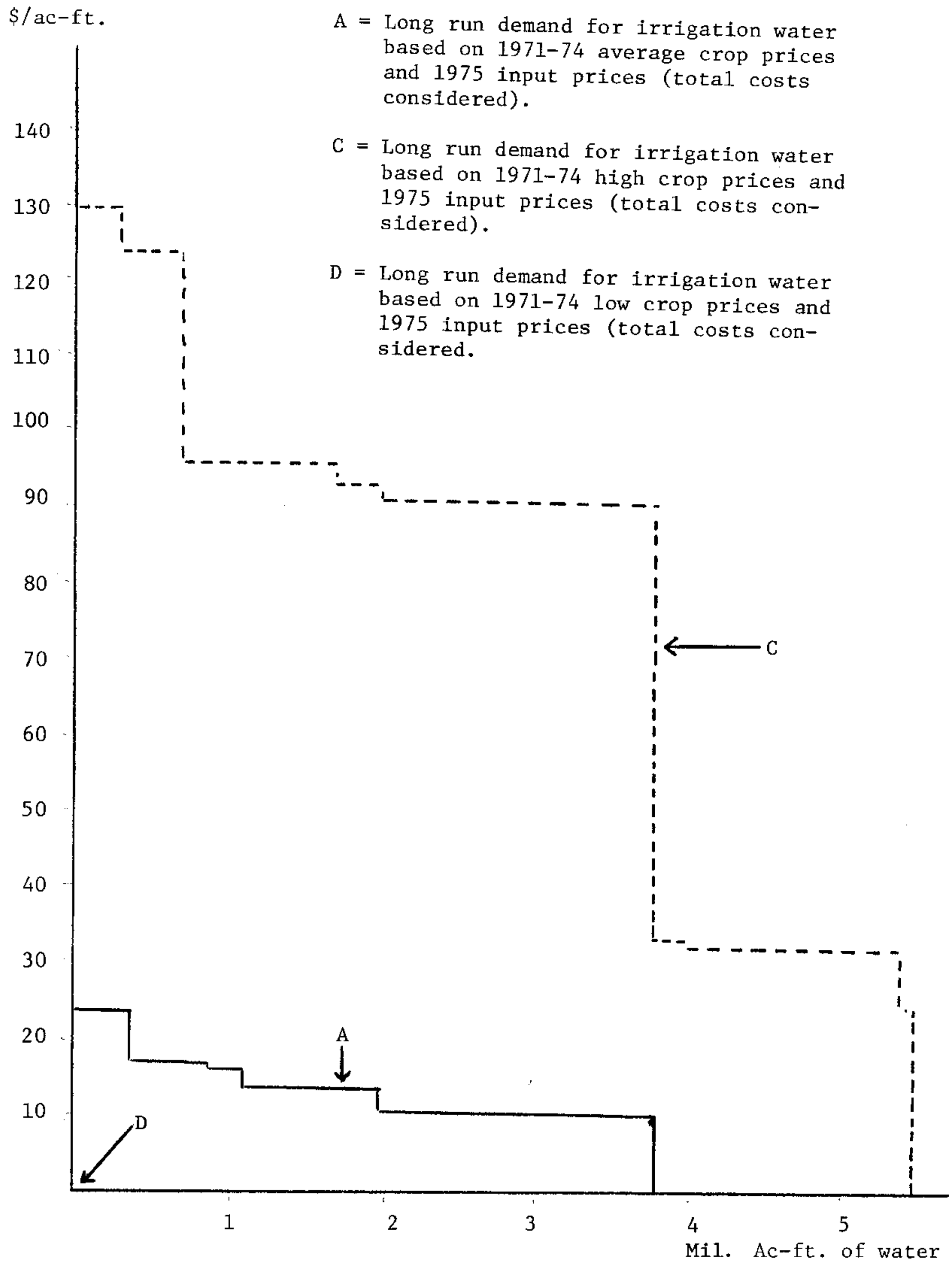

Figure 3. Long Run Derived Demand for Irrigation Water With Alternative Assumptions Concerning Crop Prices, Texas High Plains, Subregion II.

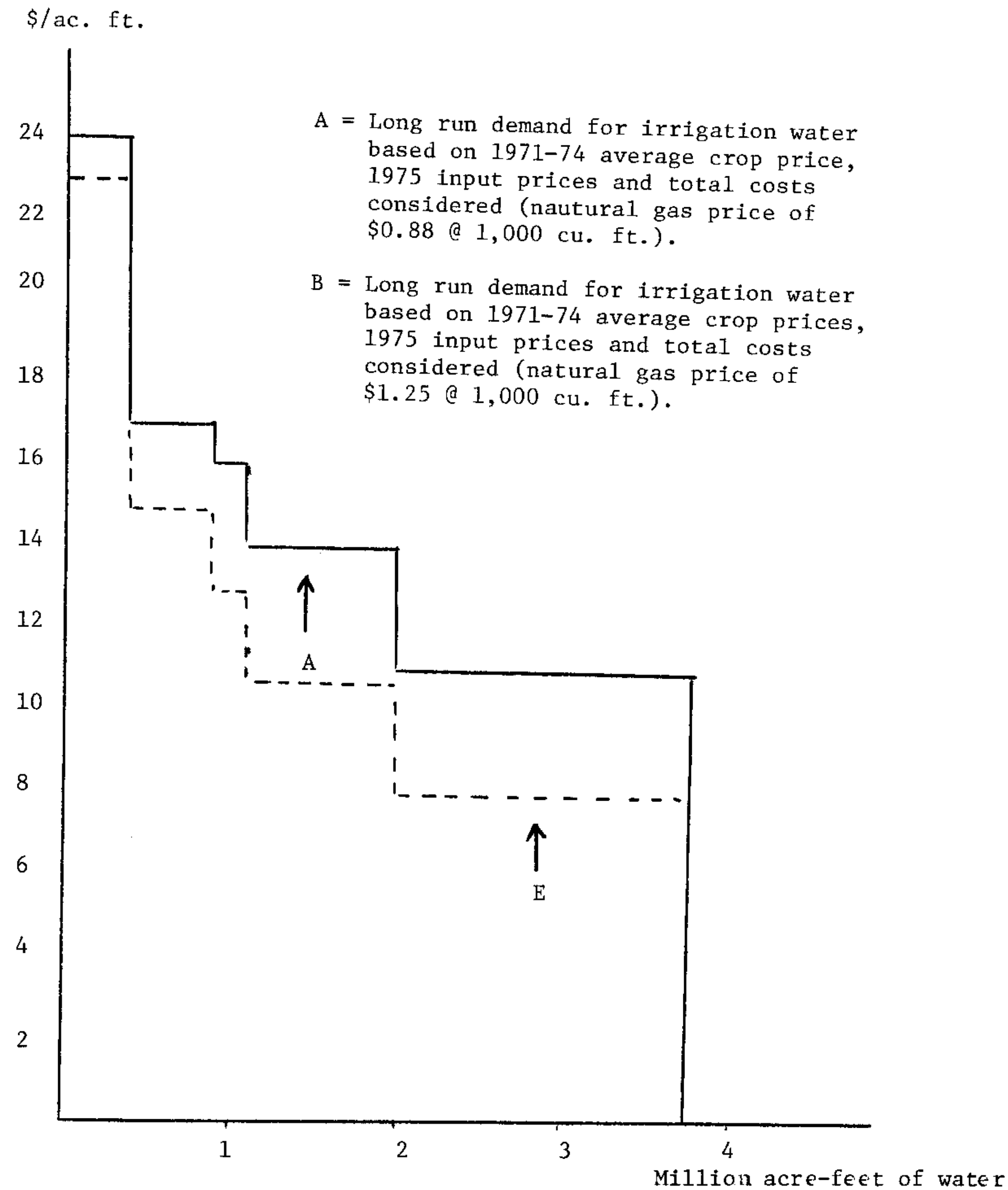

Figure 4. Long Run Derived Demand for Irrigation Water with Alternative Assumptions Concerning natural Gas Prices, Texas High Plains, Subregion II.

Results from the analysis using a $15 per acre land charge and no charge to the water resource beyond non-fuel pumping costs indicates expected regional agricultural production adjustments due to natural gas price increases. Table 1 shows producer returns to water, management and risk; irrigated acres; and crop output for the 1971-74 average crop prices. These crop prices are relatively low compared to current prices, hence they represent a lower boundary.

As the natural gas price rises from $0.80 to $2.12 per thousand cubic feet, net returns to the producer for water, management and risk decline 40 percent, but no major changes occur in output or irrigated acres. However, it is critical to emphasize that with a 40 percent reduction in net returns to producers, there are most serious economic implications concerning the viability of existing farm firms.

As the natural gas price increases from $2.12 to $2.47 per thousand cubic feet, there is an additional 10 percent reduction in producer net returns compared to those at the $0.80 natural gas price. In addition irrigated acres decline 15 percent with cotton going completely out of production.

As natural gas price reaches approximately $3.00 per thousand cubic feet, irrigated acreage declines to 80 percent of the 2.6 million acres available for irrigation and net returns decline another 10 percent. At approximately this natural gas price, grain sorghum shifts from irrigated to dryland production.

Shifts continue to occur up to a natural gas price of $4.67 per thousand cubic feet where all production is dryland and net returns

Table 1. Expected Crop Output, Irrigated Acreage and Producer Net Returns for Alternative Natural Gas Prices, Texas High Plains[a]

Item	Unit	Price of Natural Gas per 1000 cubic feet								
		0.00	0.80	2.12	2.47	2.80	3.00	3.37	3.82	4.67
		- - - - 1,000,000 - - - -								
Net Returns[b]	dol.	129.9	99.0	59.5	49.0	40.7	38.0	35.8	33.3	32.4
Irrigated Acres[c]	ac	2.6	2.6	2.6	2.2	1.3	0.5	0.5	0.3	0.0
Crop Output										
Corn	bu.	180.8	148.9	115.2	115.2	23.3	23.3	23.3	0.0	0.0
Cotton	lb.	203.5	203.5	203.5	0.0	0.0	0.0	0.0	0.0	0.0
Grain Sorghum	cwt.	29.3	29.3	40.0	40.0	40.0	12.0	12.0	12.0	15.3
Soybeans	bu.	0.9	11.1	11.1	11.1	11.1	11.1	8.7	8.7	0.0
Wheat	bu.	12.1	12.1	16.7	16.7	29.3	29.3	30.3	30.3	30.3

[a] Based on a per acre $15 charge for land and no charge for water on acres irrigated. Crop prices are 1971-74 average and are cotton $0.31/lb., cottonseed $100/ton, wheat $2.60/bu., corn $1.95/bu., soybeans $4.27/bu., and grain sorghum $3.10/cwt.

[b] Net returns are returns to management, water and risk.

[c] Total land available is 3.7 million acres of which 2.6 million are irrigable.

are $32.4 million. This is compared to net returns of $99 million at an $0.80 natural gas price.

This analysis indicates that at a natural gas price of about $2.50 per thousand cubic feet, important shifts begin occurring rapidly in irrigated acreage, producer net returns, and agricultural output, given the 1971-74 average crop prices.

To consider the effect of crop price, a set of prices were used that represent late 1975 and early 1976 levels. The results using the 1976 planning price levels for crops are presented in Table 2. With the higher crop prices, a much different picture evolves. Using a natural gas price of $1.30 per thousand cubic feet as a base (since it is the approximate current price in the area), producer returns to water, management and risk are $289.6 million with 2.6 million acres irrigated.

At a natural gas price of $5.46, net returns decline 45 percent, and irrigated acreage declines slightly as soybeans go out of production. The next major adjustment is near a natural gas price of $7.00 where irrigated acreage declines to 2 million and net returns decline to $116 million (a 60 percent reduction compared to a $1.30 natural gas price). Grain sorghum and cotton production are also declining.

At about an $8.00 natural gas price, irrigated acreage is only 15 percent of the 2.6 million acre potential, net returns to producers in the region are less than $100 million with cotton, grain sorghum and wheat produced dryland; corn irrigated; and soybeans deleted from production.

Table 2. Expected Crop Output, Irrigated Acreage and Producer Net Returns for Alternative Natural Gas Prices, Texas High Plains[a]

Item	Unit	Price of Natural Gas per 1000 cubic feet										
		0.00	0.38	1.25	1.30	5.46	6.09	6.94	7.63	7.79	8.40	10.12
		1,000,000										
Net Returns[b]	dol.	331.8	319.0	291.0	289.6	160.5	141.1	116.2	99.3	95.9	92.4	87.6
Irrigated Acres[c]	ac.	2.6	2.6	2.6	2.6	2.5	2.5	2.1	1.6	0.4	0.2	0.0
Crop Output												
Corn	bu.	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	47.7	23.3	0.0
Cotton	lb.	96.1	203.5	203.5	203.5	203.5	173.0	173.0	61.1	61.1	61.1	61.1
Grain Sorghum	cwt.	45.6	32.7	29.3	29.3	29.3	29.3	12.0	12.0	12.0	15.3	15.3
Soybeans	bu.	0.9	0.9	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheat	bu.	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	30.3	30.3	30.3

[a] Based on a per acre $15 charge for land and no charge for water on acres irrigated. Crop prices are set at levels that seem most reasonable with current information. These prices are cotton $0.42/lb., cottonseed $100/ton, wheat $3.75/bu., soybeans $4.50/bu., corn $2.70/bu., and grain sorghum $4.25/cwt.

[b] Net returns are returns to management, water and risk.

[c] Total land available is 3.7 million acres of which 2.6 million are irrigable.

Irrigated production ceases at $10 natural gas. Returns to management and risk are $87.6 million and cotton, grain sorghum and wheat are produced dryland. It is at this point that returns to water have been reduced to zero.

This analysis suggests that at the 1976 planning price level for crops, the Texas High Plains will continue to be a major irrigated region even with rather dramatic increases in the price of natural gas. This is a regional conclusion, however, and a defiency of this analysis is the lack of consideration of the previously mentioned internal adjustments that have little immediate effect on output but have significant implications for local farmers, financial institutions, suppliers and communities.

Since the regional analysis glosses over important issues facing the individual farmer, an average farm firm was studied. For this analysis, an abundant water supply is assumed, all acres are irrigated and farm size is 700 acres.

The abundant water supply and location in High Plains II indicates this analysis applies to the most favorable irrigation situation on the Texas High Plains. Other areas have shallower wells, but well yields are less due to a very limited saturated thickness. Alternatively, other areas have relatively more abundant groundwater supplies but pumping depth is much greater, hence, energy required for pumping is relatively larger. Therefore, it is expected for other resource situations on the Texas High Plains, returns to water would be less than for the following situation; i.e., adjustments occur at lower natural gas prices including reverting to dryland production.

For this average farm situation, there was no charge included for land, water, management or risk. Further, the two sets of crop prices were identical to those used for the region.

Figure 5 shows total farm and per acre returns to land, water, management and risk for the average 700 acre farm. For the 1971-74 average crop prices, returns to land, water, management and risk are about $36,000 for the farm or just over $50 per acre at a zero natural gas price. At a natural gas price of $1.30, these returns decline to about $27,000 or just under $40 per acre. These data suggest that at $4.25 per thousand cubic feet for natural gas, all land will be farmed dryland since the fuel costs more than the water is worth in producing crops given the 1971-74 average prices for crops.

Compared to the 1976 planning crop prices, returns to land, water, management and risk are increased some two to threefold; i.e., at a natural gas price of $8.30, all production is under dryland conditions.

Figure 5 can be used to estimate the maximum price for natural gas a particular producer can afford given his lease or land payment and household expense requirements (returns to management). For example, assume a producer is purchasing the 700 acre farm and his annual principal and interest payment is $50,000. In addition, the producer requires a return for management (to cover household expenses) of $15,000. This means this producer requires $65,000 returns to land, water, management and risk. Therefore, going to $65,000 returns on the vertical axis and moving horizontally to the intercept with the solid line

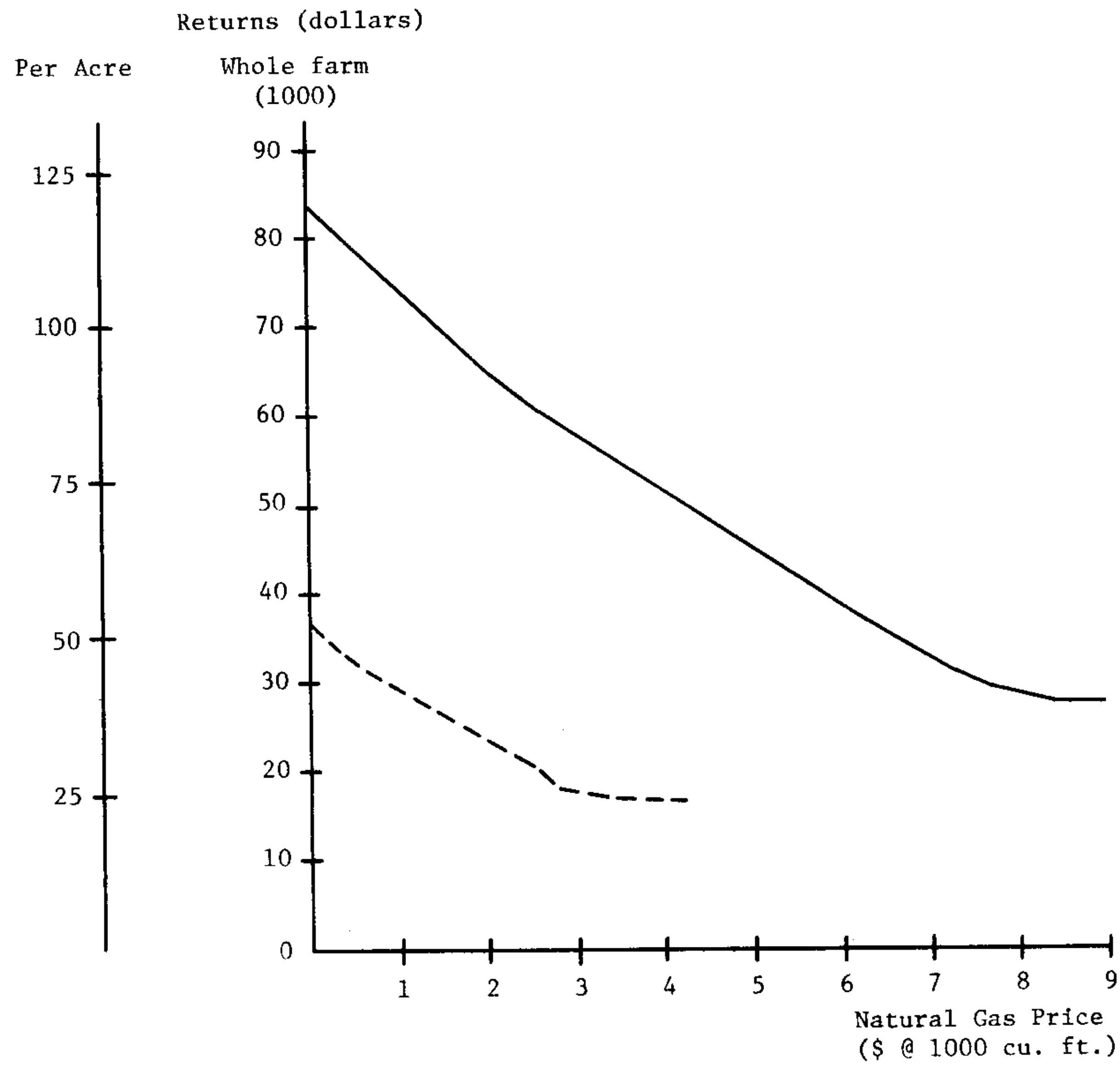

Figure 5. Returns to Land, Water, Management and Risk for a 700 Acre Irrigated Farm; Strong Water Supply in Texas High Plains[a]

[a]Assumptions Underlying the Relationships

Land and Water Charge (dol. per acre)		Crop Prices	
	Cotton @ lb.	$0.31	$0.42
	Grain Sorghum @ cwt.	3.10	4.25
	Soybeans @ bu.	4.27	4.50
	Corn @ bu.	1.95	2.70
	Wheat @ bu.	2.60	3.75
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indicates the producer can pay up to $2.00 per thousand cubic feet for natural gas given the 1976 planning prices for crops. If natural gas price exceeds $2.00 the producer must either acquire more land at a lower price, reduce his returns to management (standard of living) or default on the land payment.

A similar example can be shown for the producer with a cash lease. Assume a cash lease of $70 per acre and required returns to management of $14,000 or $20 per acre. In this case, required returns to land, water, management and risk are $90 per acre. Moving up the per acre vertical axis to $90 and then across horizontally to the returns solid line again gives an upper permissible natural gas price of $2.00 per thousand cubic feet.

Other situations can be similarily analyzed. The analysis for the High Plains indicates the difficulties of addressing the adjustments expected with an increasing natural gas price. Agriculture is in a most dynamic era of changing crop prices, uncertainty relative to government policy, and varying input prices. One point that can be made is that natural gas price increases elevate the cost of pumping water and hence decrease the value of the groundwater. This effect can be expected to be reflected in land prices in the area. The average farm example serves to show the level of natural gas price at which a specified payment as annual purchase payment or cash lease as well as a given return to management can no longer be maintained. The cash lease must be reduced to keep land in irrigation. The farmer making land payments is in a particularly sensitive position; i.e., the net returns from the farm can fall below that sufficient to make payments on land and meet household expenses.

Producers have traditionally invested a majority of their savings in land. As the residual returns to land decrease, land values will decline and producers' savings will be eroded. Thus, both the income generating and equity position of the producer is destroyed.

Conclusions

With rapid changes in product and input prices, many policies at the state and national level relative to agriculture are being proposed, discussed and enacted, and with the need for a viable, productive irrigated agricultural sector, it is critical that meaningful planning be done. This requires a systematic evaluation technique. This study developed a model for the Southern High Plains of Texas which has the capability of addressing many of the problems facing farmers and policymakers today.

This model has been applied to energy issues, water resource planning and policy implications. Requests from federal and state agencies, farmers and policymakers for additional results are incurred regularly. This emphasizes the need for such evaluation capabilities.

Although models of this type are powerful evaluation techniques, there are many limitations. Many of these were listed in the results of the energy application to the three regions. In addition to technique limitations, it is essential that current reliable data be incorporated into these models and periodically updated.

The experience with this project indicates the value of such models and as such sets the stage for extending and further updating of the model.

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