Natural Gas Price Impact on Irrigated Agricultural Water Demands in the Texas Panhandle Region

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ABSTRACT

Rising natural gas prices led to a noticeable decrease in irrigation; however, the magnitude of the reduction in water pumped is unknown. The objective of this study was to estimate reduction in irrigation water pumped resulting from high natural gas prices in the Northern Texas High Plains.

Farm Service Agency irrigated acreage data were utilized to analyze eight major crop categories. The years having a January natural gas price below $3.00 were grouped as "low price years" and years above $3.00 were designated "high price years". These groups were evaluated for changes in crop composition and abandonment. In addition, four years of Agri-Partner demonstration data with comparable variance in natural gas prices and rainfall totals during the summer crop growing season were used to estimate change in water use by crop.

Overall, water pumped for irrigation in the Northern Texas High Plains was estimated to decrease 17.8 percent from low to high natural gas price years. Of this total decrease, changes in crop composition accounted for 2.3 percent, crop abandonment for 4.1 percent and the remaining 11.4 percent attributed to lower water use by crop. Reduction in water pumped over a 60-year planning horizon was computed at 13.9 million acre-feet.

KEYWORDS: economics, natural gas, irrigation water demand

INTRODUCTION

Population in the United States has increased from 23 million to over 221 million since 1870. Coupled with industrial growth, we are now more dependent upon energy than ever before. Natural gas is a very important component of the energy mix, is a driving force in our economy, heats American homes, and plays a vital part in U.S. agriculture. Natural gas meets one-fourth of the United States' total energy needs (AGA, 2004). In agriculture, natural gas represented four percent of the total energy consumed on U.S. farms in 2002 (Miranowski, 2004). Natural gas powered approximately 30 percent of irrigated acres in Texas in 2000 (Figure 1) (Marek et al., 2004). However, in

Region A, natural gas is far more important in the energy mix. According to Leon New, Texas Cooperative Extension engineer (New - personal communication, 2005), it is estimated that 60 percent of the irrigation wells are powered by natural gas and these groundwater wells account for 80 percent of all irrigation water pumped. Thus, water pumped using natural gas accounts for about 48 percent of the total irrigation water pumped in Region A. This study quantifies the change in irrigation demand due to high natural gas prices from this effective percentage of irrigation water pumped using natural gas.

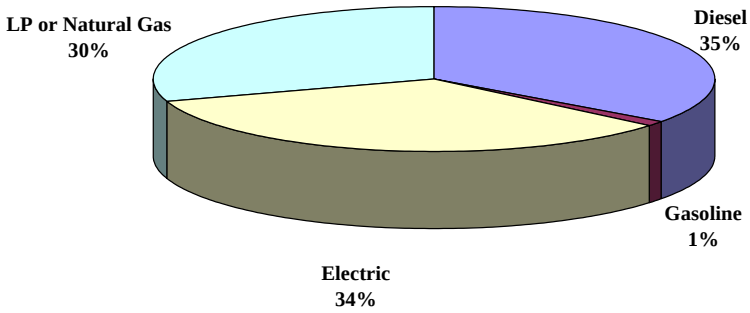

Figure 1. Percent of irrigated acres by utilized power unit source, Texas, 2000.
Source: Marek et al., 2004.

Volatility of natural gas prices has had a noticeable impact on agriculture. Former Agriculture Secretary Ann Veneman stated, "Price volatility in natural gas and liquid petroleum gases such as propane impacts farmers who rely heavily on heating, drying and irrigation, and affects the cost of other energy intensive inputs such as fertilizers and pesticides" (Veneman, 2004). In today's dynamic environment, farmers must be willing to adapt to changes in order to thrive. Due to the increase in natural gas prices, many farmers have adapted by limiting irrigation or changing their cropping patterns and practices.

Sixteen Water Planning Regions were formed in the state of Texas pursuant to the Senate Bill 1 planning effort, which required all areas of the state of Texas to conduct a comprehensive water planning program. The plans that were created as a result of this legislation are the most detailed, encompassing regional level water plans created to date. The Panhandle Water Planning Region (Region A) is comprised of 21 counties in the Texas Panhandle. In the Senate Bill 1 effort (2001), it was determined that 89 percent of current and 86 percent of projected water use was by irrigated crop production in Region A. Several of the heavily irrigated counties were not projected to meet the current maximum 1.25 percent annual depletion rate recommended by the water planning group. However, fluctuating natural gas prices have changed these conditions and had a noticeable impact on agricultural irrigation water demands. Natural gas price spikes starting in 2000 led to changes in crop composition, water use, and therefore, future water supplies in the region.

The New York Mercantile Exchange nearby monthly futures indicates that during the 1990s, the price of natural gas was quite stable at around $2 per thousand cubic feet. Since the summer of 2000, however, prices have been relatively volatile and have averaged about $4.75 per thousand cubic feet (mcf), with a high of $9.78 in

December 2000 and a low of $2.01 in January 2002. The current trend in natural gas prices is increasing as the average price in 2003 was $5.51, whereas, the average price in 2004 was 15 percent higher at $6.31 (Figure 2).

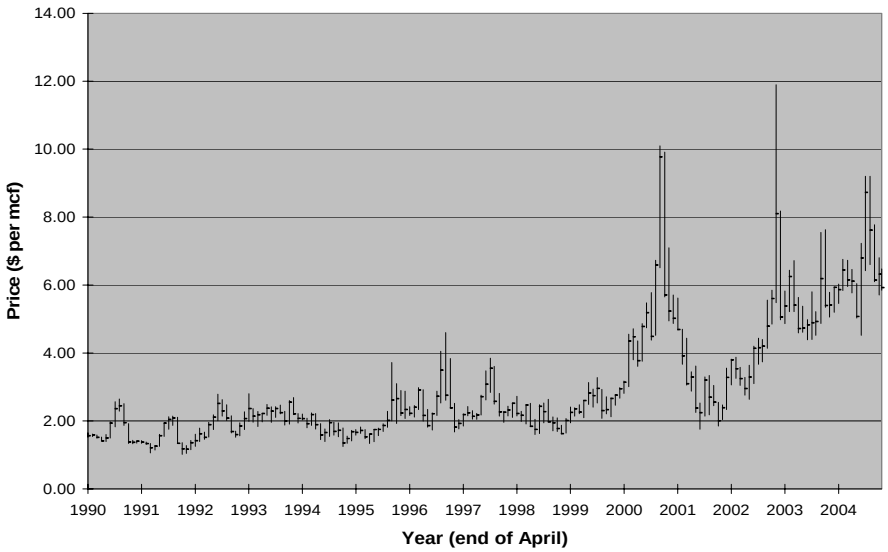

Figure 2. Natural Gas Futures Price (Nearby Monthly, 04/1990 – 02/2005).
Source: New York Mercantile Exchange

Natural gas is the major source of energy used to power irrigation pumps in Region A and is an important factor in determining irrigation costs. Escalating natural gas prices are having an adverse affect on irrigated producer profitability. For example, the estimated cost of natural gas used for irrigating corn in the region rose from $78.40/acre to $140.00/acre from 2003 to 2005 (Amosson et al., 2004). Similarly, the projected cost of anhydrous fertilizer used in corn production increased from $20.80/acre to $38.00/acre while the price for corn remained unchanged.

While it is widely recognized that a change in water use is occurring, the magnitude of the change is unknown. The primary objective of this project is to estimate the reduction in irrigation water pumped resulting from high natural gas prices in Region A in an effort to determine whether a more rigorous study is warranted in the future to refine projected water use estimates for future water planning efforts. Results of this study could have significant implications to current as well as future water planning efforts in the region. Specific objectives of this regional study are to evaluate changes in crop composition, abandonment scenarios and water use reductions by crop due to increasing natural gas prices and project the change in water use due to higher natural gas prices.

MATERIALS AND METHODS

This analysis evaluates the potential impact of rising natural gas prices on irrigation water use demand in Region A. Farm Service Agency (FSA) was utilized as

the source for irrigated acreage data in this study. Crops were grouped into eight major categories: corn, wheat, sorghum, cotton, soybeans, peanuts, hay, and pasture and other. The New York Mercantile Exchange was the source used for nearby monthly natural gas futures prices. Annually, the majority of producers within Region A make their planting decisions in January. Accordingly, years having a January natural gas price below $3.00 were grouped together as the "low price years" and include 1998, 1999, 2000, and 2002. Conversely, years with a January price above $3.00 were grouped together as the "high price years" and include 2001, 2003, and 2004. These two groups were then compared and contrasted for changes in crop composition and abandonment due to rising natural gas price.

Similar year groupings were made of Agri-Partner data (New, 1998-2004) to estimate the impact on water use by crop resulting from high natural gas prices. (Agri-Partner is an Extension irrigation production monitoring program.) However, only years of similar rainfall data for the growing season were used. Rainfall data were taken from the National Climatic Data Center's annual climatological summaries for the Amarillo International Airport Station. As a result, the 2000 and 2002 Agri-Partner water use by crop data were grouped together for the low price years, whereas, 2001 and 2003 data were used for the high price years. Due to the differing growing season for wheat, 2003 and 2004 data were utilized for the high price years due to similar rainfall amounts received for the September through May period. Since there was no Agri-Partner data available for water use by crop for hay and pasture and other, the water use for these crops were decreased by the same amount as corn, which was a modest decrease.

The Region A Water Use Demand Model (TAMA model, Marek et al., 2004) developed in Senate Bill 2 – Task 2 was the projection source used in this analysis to determine the change in total irrigation water use from the low price base years to the high price base years. It was also used to project the change in future irrigation water demand due to higher natural gas prices.

The TAMA model is a deterministic simulation model utilizing acreage and crop evapotranspiration (ET) based approach to calculate by crop, county estimations of irrigation demand. The model additionally uses average rainfall and soil profile extraction potential on a county basis. The respective model crop ET per county is derived from a proportional ET matrix based on meteorological station data of the North Plains ET network. Finally, a grower or application factor derived from county demonstration data is included to reflect actual producer application practices (expressed as a percentage of ET) by crop and on a county basis.

To determine the change in total irrigation water use, four scenarios were analyzed. First, total water use during the low price base years was determined using the low price acreage and crop composition. Then, the low price acreage was combined with the high price crop composition to establish the effect of the change in crop composition on total water use. Next, high price acreage and crop composition were used to determine the impact of abandonment on water use. Finally, the high price base was combined with the Agri-Partner data to identify the effect of change in water use by crop on total irrigation water use.

RESULTS

Total irrigation water use was evaluated for the baseline years of 1998, 1999, 2000, and 2002, which experienced relatively low natural gas prices. These years were

compared to the years of 2001, 2003, and 2004, which had relatively high natural gas prices. The components that make up the change in water use were analyzed and presented on an individual basis and include change in crop composition, abandonment, and change in irrigation water use by crop. Finally, the potential impact on projected irrigation water use is presented over a 60-year planning horizon.

Crop Composition

The FSA planted irrigated acres by crop for the 21 counties in Region A are shown below (Figure 3) for the years of 1998 through 2004. Initial price spikes in 2000 did appear to alter producer crop composition somewhat. The most significant change, as a result of higher natural gas prices, was that corn acreage decreased 28 percent (163,543 acres) from 2000 to 2001. In that same time period, wheat acreage increased 7 percent and sorghum acreage increased 35 percent.

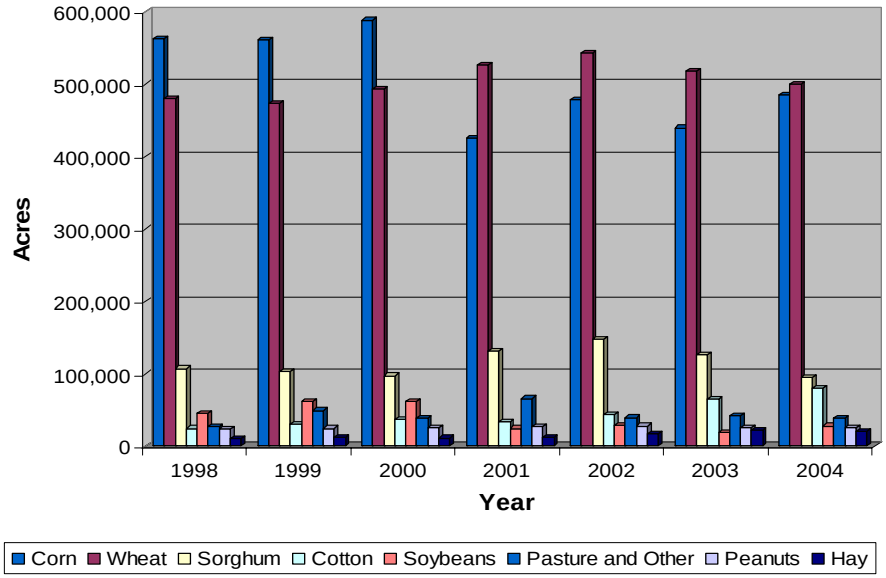

Figure 3. FSA planted irrigated acres by crop in Region A, 1998-2004.
Source: Farm Service Agency

A comparison was made regarding the crop composition during the low price years versus the high price years (Figures 4 & 5). Corn and soybean acreage, as a percentage of total crop composition, decreased by five and two percent, respectively. Corn is considered a high water use crop, and it appears that most of the corn acreage was replaced with either wheat or cotton of which both can utilize considerably less water per irrigated acre. In effect, wheat acreage increased four percent, cotton acreage increased two percent, and pasture and other acreage increased one percent. Sorghum, peanuts, and hay acreages remained unchanged relative to their percentage of total crop composition.

The estimated change in total irrigation water applied due to the change in crop composition was determined by comparing two scenarios. In the first scenario, the total water use during the low price base years was determined with the TAMA model using

the low price acreage and crop composition. Then, another scenario was completed with the TAMA model keeping the low price total acreage constant while changing to the high price crop composition. The net change between these two scenarios resulted in a decrease in total irrigation water use of 36,316 acre-feet or 2.3 percent.

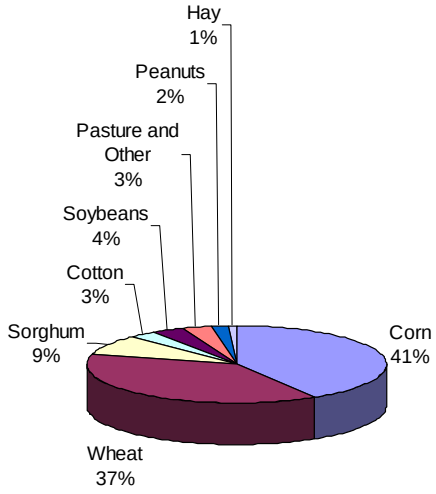

Figure 4. Crop composition during low natural gas price years, Region A.

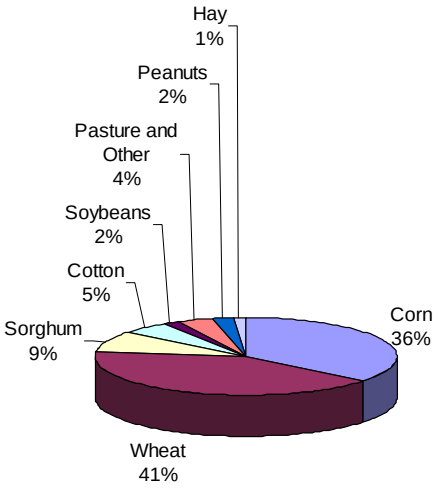

Figure 5. Crop composition during high natural gas price years, Region A.

Abandonment

The amount of irrigated crop acreage was compared between low and high natural gas price years to determine the level of abandonment in irrigated acreage (Figure 6). Total average irrigated acreage decreased 4.6 percent from 1,319,861 acres during the low price years to 1,259,165 acres during the high price years. This resulted in a total loss of about 60,696 irrigated acres during high natural gas price years.

The reduction in irrigation water applied due to abandonment was estimated by the difference in the water pumped between the low natural gas price crop acreage and the high natural gas price acreage assuming the same crop composition. The impact of acreage abandonment on total water use was an additional decrease of 63,876 acre-feet or 4.1 percent.

Water Use by Crop

Four years of Agri-Partner data (2000-2003) were used to estimate the impact on water use by crop resulting from high natural gas prices (New, 1998-2004). These four years were selected because of the similar variance in natural gas prices and similar rainfall totals that occurred during the respective summer cropping seasons. For wheat, the 2001 data was dropped from the analysis and replaced with 2004 data which experienced similar natural gas prices as that of 2001 but received nominal rainfall during the growing season more consistent with the other three years.

Agri-Partner water use by crop data were grouped together with the years 2000 and 2002 representing the low price years, and 2001 and 2003 as the high price years.

The results indicate that irrigation water applied to each crop decreased during the high natural gas price years. However, the reduction in water pumped was more significant in some crops than in others. For example, water applied to peanuts, corn and cotton decreased 4.7 percent, 8.1 percent and 8.6 percent, respectively; whereas, soybean, wheat and grain sorghum irrigation was reduced 18.2 percent, 18.7 percent and 22 percent, respectively (Table 1).

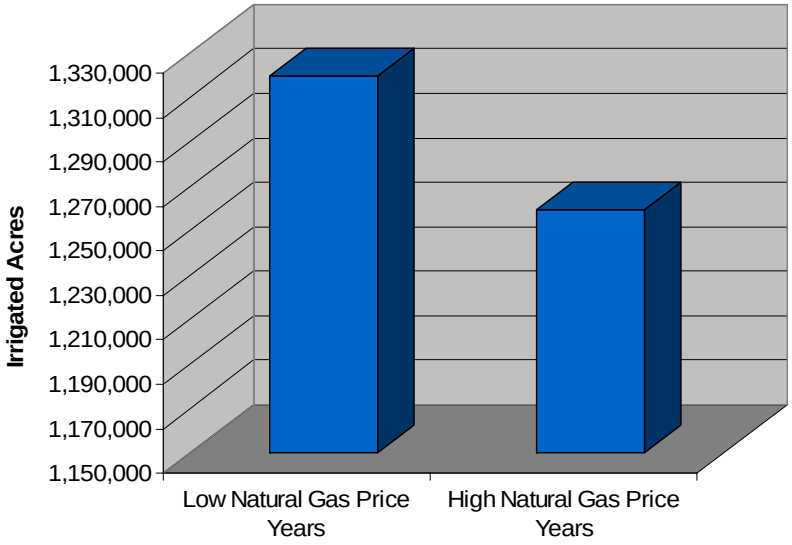

Figure 6. Average Total Irrigated Acreage during Low and High Natural Gas Price Years, Region A.

Table 1. Water applied by crop through center pivot irrigation during low and high natural gas price years.

Crop	**Low Natural Gas Price Years** Average Ac-In (2000, 2002)	**High Natural Gas Price Years** Average Ac-In (2001, 2003)*	% Change
Corn	20.45	18.81	-8.05
Grain Sorghum	12.84	10.02	-21.99
Cotton	12.22	11.17	-8.62
Peanuts	19.89	18.96	-4.66
Soybeans	16.82	13.76	-18.16
Wheat	10.61	8.63	-18.71

*High natural gas price years used for wheat were 2003 and 2004 due to similar rainfall amounts for the Sept – May period.
Source: Agri-Partner Demonstration Results (New, 1998-2004)

While the magnitude of the irrigation decrease is unknown, the relative results between crops are consistent with expectations. Producers reduced irrigation less on the higher marginal value crops and more on the lower marginal value crops, where marginal value is defined as the price of the crop multiplied by the change in production level due to the application of an additional inch of irrigation water.

The estimated reduction in total irrigation water applied due to the change in water use by crop was determined utilizing the high price base acreage and crop composition. The long-term average irrigation water pumped by crop in the TAMA model was reduced by a similar percentage as was observed between low and high natural gas price years (Table 1) to estimate the reduction in irrigation. The largest decreases in irrigation water applied by crop occurred in wheat, corn, and sorghum with reductions of 82,260 acre-feet, 55,968 acre-feet, and 20,658 acre-feet, respectively. The remaining crops exhibited only slight decreases due to the limited amount of acreage of these crops within the region. The estimated total effect of change in water use by crop on irrigation water applied was a considerable decrease of 180,019 acre-feet or 11.4 percent.

Summary

The total effect on irrigation water applied considering the change in crop composition, abandonment, and water use by crop during high natural gas price years is a total annual decrease of 280,211 acre-feet or 17.8 percent (Figure 7). Of this total decrease, changing crop composition accounts for 2.3 percent (36,316 acre-feet), crop abandonment 4.1 percent (63,876 acre-feet), and the remaining 11.4 percent (180,019 acre-feet) is attributed to the lower water use by crop.

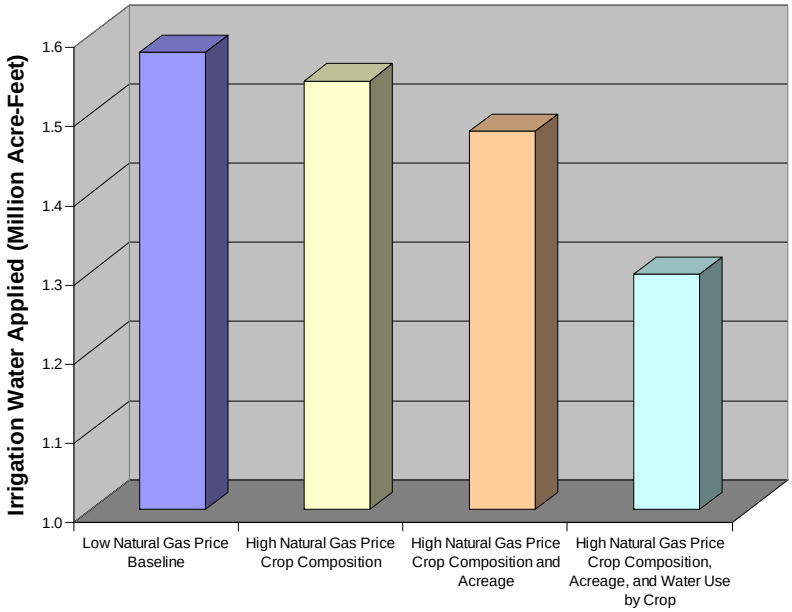

Figure 7. Estimated change in annual irrigation water applied due to change in crop composition, abandonment, and water use by crop during high natural gas price years, Region A.

Potential Impact on Future Irrigation Demand

It is clear that high natural gas prices do, in fact, have an effect on water use in Region A. As a result, persistent high prices will likely cause future water demand to also be lower. To measure this effect, the acreage, crop composition, and water use by crop from the high natural gas price base years were projected in terms of annual irrigation water applied through 2060. The total water use resulting from the low natural gas price baseline over the planning horizon is 78,515,801 acre-feet, whereas, the total water use from the high natural gas price baseline is 64,575,291 acre-feet. The reduction in water pumped consists of 1,806,714 acre-feet from the change in crop composition, 3,177,852 acre-feet from abandonment, and 8,955,944 acre-feet from the change in water use by crop. Therefore, the total water savings generated over a 60-year planning horizon is estimated to be 13,940,510 acre-feet or 17.8% of the total projected irrigation water applied during the low natural gas price baseline (Table 2).

DISCUSSION

Rising natural gas price has lead to a noticeable decrease in irrigation; however, the magnitude of the reduction in water pumped is unknown. The primary objective of this project was to estimate the reduction in irrigation water pumped resulting from high natural gas prices in Region A. Specific objectives of the project were to evaluate the change in crop composition, abandonment and water use by crop due to rising natural gas prices and estimate and project the change in irrigation water use due to higher natural gas prices.

Table 2. Estimated water savings (acre-feet) generated with persistent high natural gas prices.

	2010	2020	2030	2040	2050	2060	Total
Low Natural Gas Price Baseline Water Applied	15,387,518	14,992,967	14,203,863	12,625,656	11,047,451	10,258,346	78,515,801
Reduced Water Pumped:							
Crop Composition	354,079	345,001	326,843	290,527	254,211	236,053	1,806,714
Abandonment	622,795	606,826	574,888	511,011	447,135	415,197	3,177,852
Water Use by Crop	1,755,185	1,710,180	1,620,171	1,440,152	1,260,133	1,170,123	8,955,944
Total Water Savings	2,732,059	2,662,007	2,521,902	2,241,690	1,961,479	1,821,373	13,940,510
High Natural Gas Price Baseline Water Applied	12,655,459	12,330,960	11,681,962	10,383,966	9,085,972	8,436,972	64,575,291

Overall, water pumped for irrigation in Region A was estimated to decrease 17.8 percent from the low natural gas price years to the high natural gas price years. Of this total decrease, changing crop composition accounted for 2.3 percent, crop abandonment 4.1 percent with the remaining 11.4 percent being attributed to lower water use by crop. The reduction in water pumped on irrigated crops over the 60-year planning horizon is expected to total 13.9 million acre-feet. Realistically, these estimates understate what the

total reduction in irrigation would be over time. High natural gas prices will reduce the number of producers able to cover their fixed cost associated with irrigated production. As crop specific and irrigation equipment gets older and begins to wear out, they may consider producing lower water use crops or may not be able to economically justify replacing irrigation equipment increasing the level of abandonment from what is estimated.

The change in water pumped in high natural gas years is significant enough to warrant additional study. Failure to account for the affects of higher natural gas prices may lead to inaccurate projections of future water use resulting in the adoption of errant policies. A more sophisticated study that includes additional years of data, more data on water use by crop, factors in rainfall, identifies/evaluates fixed and variable costs associated with irrigation, and takes into account the impact of crop prices on irrigation water use is necessary for a better projection of how natural gas prices will affect crop composition, abandonment, and water use.

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