Projections of Net Income & Water Use in Pinal County, Arizona

*by William E. Martin, Thomas G. Burdak and Robert A. Young**

Problem Setting

Large-scale pumpage of underground water for crop irrigation in Pinal County has been followed by a rapid decline in the underground water level. Public concern has been expressed as to the future of agriculture and other water-using industries in the face of this falling water table and the consequent rise in water costs.

In order to provide criteria for selecting between alternative private and public policies to combat this falling water table, it is necessary to project the consequences of each such alternative. Previous empirical projections of either hydrologic or economic activity have taken the other activity as largely given. A complete analysis, however, requires that the interactions between the irrigated farming sector of the economy and the physical state of the underlying aquifer be estimated.

We had previously made economic projections of agricultural activity in Pinal County over the next 40 years, using a technique involving linear programming on a digital computer. About the same time, projections of groundwater table decline were being made by the U. S. Geological Survey, using an electric-analog model of the aquifer developed by Thomas Anderson of their Phoenix office. By combining the two analyses we were able to obtain projections that recognize the interrelated nature of agricultural activity and the state of the aquifer.

** The authors are Professor, Research Assistant, and Associate Professor, respectively, in the Department of Agricultural Economics, The University of Arizona.*

Interrelated System

The interrelated nature of the agricultural-aquifer system should be emphasized. It is obvious that as irrigation water pumping costs increase, farmers will change both the way in which they grow crops and the num-

(Turn to Page 24)

Table 1. Acreage of Field Crops, Net Revenue Over Variable Costs and Water Use, Pinal County, 1966-2006.[a]

Year	*American-Egyptian Cotton*	*Upland Cotton*	*Grain Sorghum*	*Alfalfa*	*Barley Wheat & Other*[b]	*Total Cropped Acres*	*Water Use*	*Net Revenue Over Variable Costs*
	1,000 acres						*(1,000 acre-feet)*	*(Million Dollars)*
				Actual Reported[c]				
1966	7	84	32	21	54	198	—	—
1967	6	81	40	21	59	207	—	—
1968	6	95	38	18	68	225	—	—
				Model Projections				
1966	7	84	65	10	68	234	945	29.7
1976	7	84	63	6	65	225	889	29.1
1986	7	84	57	8	58	214	841	28.3
1996	7	84	46	3	44	184	730	27.2
2006	7	84	40	3	38	172	688	26.8

[a] *The first three rows are reported acreage in 1966, 1967 and 1968. Data in all other rows are projections of the integrated linear programming — aquifer analog model.*

[b] *Barley, wheat and miscellaneous other field crops are treated as a single activity since net returns and resource requirements are practically identical at present. Barley is the more significant; in 1968, barley acreage was 47,800; wheat, 12,400; and other crops, 6,350.*

[c] *Source: Arizona Crop and Livestock Reporting Service and Arizona Agriculture.*

Pinal County

(From Page 3)

ber of acres of each crop grown. Acreage of low-valued crops such as barley and alfalfa will be greatly influenced by rising water costs, while high-valued crops such as cotton and vegetables will be affected hardly at all. When crop acreage is changed, the quantity of water pumped changes. When the quantity pumped changes the rate of decline in the water table changes. A different rate of decline implies a different rate of adjustment by farmers to changing water cost.

Our analysis begins with estimates of the number of acres of each crop grown, and the water use of each. We can then estimate the quantity of water pumped in each subarea of the county for a given time period. These estimates are developed using linear programming analysis — a mathematical procedure solved on the digital computer. The quantities of water pumped during the time period are the inputs into the electric-analog model.

Anderson describes this model as follows:

> *An electric-analog model is an electric system that is analogous to the groundwater system. Resistors simulate the ability of the sediments to transmit water, and capacitors simulate the storage of water within the soil pores.*
>
> *The response of the model to the simulated pumping stress is shown on an oscilloscope in the form of a hydrograph. By measuring with the oscilloscope at different points, it is possible to prepare a contour map of water level changes caused by a specific stress applied for any specific length of time.*

These estimates of changes in depth to water allow new water cost estimates to be entered into the new linear programming model of the next time period. This cyclical procedure is continued until the end of the planning horizon is reached.

Empirical Results

Table 1 presents the agricultural projections for Pinal County for ten-year intervals from 1966 to 2006. Rows one through three give the actual reported acreages planted for the years 1966 and 1968, thus serving as a test of the predictive ability of the model.

The model was constructed in terms of the cotton program in effect in 1966 with a lower allotment than in 1965. In 1966, the upland cotton allotment was cut to 84,000 acres. Our projections for 1966 overestimated total cropped acres because, while in the model all readjustment occurred instantly, in actuality farmers take some time to adjust to a new equilibrium. The 1966 projections should be thought of as representative of the period 1966-1976. By 1968, readjustment is close to that projected. Alfalfa is adjusting downward, grain sorghum is adjusting upward, and barley, wheat and miscellaneous field crops are equal to the projection. Since by 1968 the actual cotton allotment was raised above the constraints dictated by the 1966 program, upland cotton acreage in 1968 was higher than projected. It is doubtful that allotments can remain this high over time, however. Downward adjustments in the cotton allotment would be reflected by increased grain sorghum acres. We submit that the model is closely reflecting actual farm adjustments.

Projected total cropped acres fall by 26.5 percent over the 40-year period. This is entirely because of rising water costs rather than from a physical shortage of water. Less acres of the low-valued crops will be grown. Acreage of high-valued crops, including cotton, vegetables and citrus, will not be affected.

Vegetables and citrus presently use only four percent of the county's irrigated acreage. They are mostly grown on specialty-type farms rather than the general crop farms used in our model. Since they can better afford high-priced water than can cotton, and cotton acreage is not affected by the price of water, acreage of these crops also will be independent of the falling water table.

Water use will fall by 27.2 percent during this period. Use falls slightly faster than acreage because less water is used per acre as water costs rise and as the larger, more efficient farms grow a larger percent of total cropped acres.

Projected net income over variable cost drops by only 9.8 percent during the same period. There are several reasons. Adjustments in total acreage are entirely of low-valued crops which are even presently contributing little to net income. In 2006, a much larger proportion of the farms are large farms with lower costs of production. Finally, a larger proportion of total water use is from the small surface supply in the area.

Implications

Our projections imply that while the water table will continue to fall, the water-cost-increasing aspect of this decline will slow down the rate of future decline. Net farm income in Pinal County will also decline in future years, but this decline will be gradual and of a relatively small magnitude. Smaller farms will bear most of the economic burden. These projections suggest that so long as current cotton programs continue, the economic impacts of continuing groundwater withdrawal may not have as serious an impact as some have predicted.

PROGRESSIVE AGRICULTURE IN ARIZONA

Official Publication of the College of Agriculture and School of Home Economics The University of Arizona

Harold E. Myers Dean

to: