A FARM-LEVEL ECONOMIC ANALYSIS PARTICIPATION IN WATER MARKETS BY COMMERCIAL FARMERS IN CENTRAL OREGON

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Abstract

Low flows due to irrigation diversions in the Deschutes River of central Oregon impact water quality between Bend, Oregon and Lake Billy Chinook. The development of a water market to reallocate water among irrigators and instream uses is one alternative to help alleviate this problem. Important questions include how much water could be supplied, the price irrigators would demand, and how irrigators could change their on-farm operations to free water for transfer. This research addressed these issues in relation to commercial agriculture (usually full-time) operations in the North Unit Irrigation District and Central Oregon Irrigation District. On-farm practices considered included fallowing land, adopting water-conserving irrigation technologies, changing crop rotations, deficit irrigation, and involvement in Oregon's water conservation program. Water supply curves indicating the quantity of water irrigators would be willing to supply to a lease market at various lease prices were generated assuming expected and alternative water availability levels. Results were compared to the cost-effectiveness of lining and piping the district canals that supply these districts. Results indicated that all on-farm alternatives considered were utilized to make water available for lease on the representative, profit maximizing farm in each district. However, the results depended on the market price for water and the annual water availability. Canal lining was generally a more cost-effective means of providing water to enhance flows in the middle Deschutes River than purchasing water directly from irrigators.

Introduction

A recent study of the upper Deschutes River quality revealed that temperature and pH levels were high during summer months. Poor water quality is believed to be the result of low river flows, high ambient air temperatures, lack of riparian vegetation, the existence of agricultural return flow, and excessive growth of aquatic vegetation during summer. Reservoir releases keep flows high for river portions above the city of Bend, which helps alleviate some of the problems on the Deschutes River. But beyond the irrigation district diversions in Bend, the reservoir releases are not enough to meet environmental needs of the middle Deschutes River. It is the area between Bend, Oregon and Lake Billy Chinook that typically experiences critically low flows during the irrigation season.

The development of a water market to reallocate 'water among irrigators and instream uses is one alternative to help alleviate the water quality problems. To research this water market, we assumed that water would be supplied by irrigators for instream use when it becomes more profitable to lease than retain the water for agricultural production. The 220 cubic feet per second (cfs) needed to raise the middle Deschutes River flow to the Department of Fish and Wildlife recommendation of 250 cfs is equal to about 79,200 acre-feet of water over the irrigation season. Water supplied by commercial agriculture through a water market could potentially meet this requirement. This study focused on water markets for commercial farm and ranch operations

in the North Unit Irrigation District (NUID) and Central Oregon Irrigation District (COID), and instream water users.

Methods

Farm budget analysis and mathematical programming were used. Enterprise budgets were generated for major crops based on information from irrigators, local agribusinesses, and existing research. They outline the costs and returns of crop production for traditional and alternate irrigation management practices and technologies (those which demonstrate potential for water conservation and feasibility on major central Oregon crops).

The budgets formed the basis of the mathematical programming models. Several alternative management practices and technologies were considered for leasing water. Water could be freed either by 1) fallowing land with and without involvement in the government wheat program, 2) producing less water intensive crops, 3) conserving water by increasing production and(or) delivery efficiency, 4) deficit irrigation, or 5) complying with Oregon's allocation of the conserved water program. The conserved water program allows up to 75 percent of conserved water, water saved by adopting a conserving irrigation technology or practice, to be leased in addition to water tied to fallowed land. The remaining water permanently reverts to the state for instream flows.

The mathematical programming models were constructed based on the activities of a single hypothetical farm operating in each district. Farm-level leasing results were calculated based on a 300 acre hay producing farm in COID. These results are considered representative of the approximately 10,000 acres of full-time commercial farms located the district. Likewise, NUM results based on a 500 acre specialty seed crop farm are considered representative of the 50,000 acres of Deschutes River water rights in that district. Crops used to represent farm production on the NUID included carrot seed, garlic seed, peppermint, wheat, and bluegrass seed. The crop mix for COID commercial irrigators included alfalfa hay, grass hay, grain hay, pasture, and peppermint.

The models were used to determine the water management practices and crop rotations that would maximize profit, given various assumptions about water allotments. Water production functions were generated to show a direct relationship between irrigation levels and crop yield. Agrimet evapotranspiration estimates for the central Oregon region were used to represent crop water requirements necessary to achieve a maximum crop yield.

Three variations of each district model were constructed. The first assumed that the current irrigation technologies - sprinklers, furrow, flood, and center pivots - were used. This is the Base option. The second option, called Alltech, assumed that either the current or alternate water-conserving practices and technologies could be used. Both of these options required fallowing land to lease water. The last alternative assumed that irrigators could participate in the conserved water program (the Conserve option). This option eliminated the requirement that land must be fallowed to lease water.

The Alltech and Conserve options included six alternate practices selected for their water

conservation potential. Employment of these alternatives was assumed to reduce the water application required to meet crop needs by reducing deep percolation and runoff. Though not widely implemented in central Oregon, these alternatives have been shown in previous research to conserve water with minimal yield impacts. The first water-conserving technology is alternate furrow irrigation. This system involves irrigating every other furrow throughout the season, resulting in water never flowing down half the furrows. When irrigating with alternating furrow, every other furrow is irrigated during an irrigation set; those furrows not irrigated in the current set are irrigated in the following set. Surge furrow involves use of an automated valve to apply water intermittently in surges. Center pivots distribute water through a linear overhead sprinkler system that rotates in a large circle. Variations of some of these irrigation schemes were also considered including the use of either gated pipe or syphon tubes and the development of pumpback systems for furrow irrigation techniques.
The last two basic alternatives are not irrigation technologies, but a means of improving the efficiency of existing irrigation systems. The first involves leveling fields to reduce the chance of uneven water distribution and the need to over-water parts of a field to gain a minimum application over the entire field. Gross irrigation applications can also be reduced by monitoring the soil water content and crop evapotranspiration to schedule irrigation sets. One means of monitoring soil water content involves placing soil probes in an irrigated field and using a meter to read the water content of the soil.

The models were solved for a $0 per acre foot lease price (assuming no water market), then re-solved with the water lease price increasing at $5 per acre foot increments. Varying the lease rate illustrated how irrigators might change their crop rotations and irrigation management in response to a range of lease prices if they were to maximize their profit.

Lining and piping irrigation district canals was also considered. Lining and piping would reduce deep percolation losses between the Deschutes River and the farm diversions. The Bureau of Reclamation has estimated the annualized cost of lining district canals and the potential water savings. The Bureau divided the canal systems into sections and estimated the cost-effectiveness of each canal segment. The results of the on-farm analysis were compared to the Bureau's cost and water savings estimates. When comparing these on-farm results to canal lining costs it must be noted that if canals are lined, payment for construction costs must be made regardless of the water availability whereas leasing water can be performed on a year-to-year basis.

Results

Results are presented in the form of water supply curves in Figures 1, 2, and 3, for low, average and above-average water years, respectively. A supply curve was generated for each of the lease options - Base, Alltech, and Conserve - at each level of water availability. The supply curves illustrate the estimated quantity of water that would be leased by commercial farmers in NUID and COlD at various lease price levels, assuming that irrigators would intend to maximize their profits. At each $5 lease price increment, a particular profit maximizing crop rotation, irrigation technology, and irrigation water application combination was identified for each district. As the lease price increased, both NUID and COlD production practices were altered to free water for

the market while still maximizing profit. Garlic and carrot seed were produced in all options and water years while pasture production was never a profit maximizing activity in COID.

Low Water Year

The representative allotment for a low water year was one acre-foot for the North Unit and two acre-feet for COID. In general, Figure 1 illustrates that if irrigators are operating under the Base option, they would be more willing to lease their water than if they were to adopt water-conserving practices under the Alltech and Conserve options. This occurs because the Base technologies are generally more costly and always more water intensive than the alternate water-conserving practices. The results of the Base option show that fallowing land occurred with all lease prices.

NUID-only results with the Base option show that peppermint and wheat did not enter the profit maximizing rotation. Involvement in the government wheat program generated two sources of revenue; one from the program and the other through lease of the water tied to the fallowed program acreage. As water became more valuable in the lease market, bluegrass production ceased leaving only the high valued specialty seed crops in production at lease prices above $125 per acre foot. The results for the Alltech and Conserve options for NUID are identical because the profit maximizing set of activities did not include participation in the conservation program in a low water year. Wheat was produced at low water prices when water-conserving irrigation technologies were introduced but no mint production occurred. The wheat was deficit irrigated and the government wheat program was utilized. The dominant irrigation technology was surge furrow combined with irrigation scheduling.

Alfalfa, pasture, and grass hay never entered the crop mix for the COLD-only Base option. Grain hay, peppermint, and fallow land made up the crop rotation. Crops were irrigated to their maximum yield with sprinklers. Most COlD land was utilized for crop production at lease prices of $0 to $30 per acre foot. At $30, only 50 of the 300 acres produced crops, and at $90 per acre foot no crops were produced. The water conservation realized by using center pivot irrigation in the Alltech and Conserve options merited alfalfa production but not grass hay or pasture. Alfalfa was the first crop to drop out of production as lease price increased. The water-conserving center pivot system was used to irrigate grain hay and alfalfa. Participation in the conserved water program increased profits slightly for COID irrigators. At $95 per acre foot, all water in COID was leased for farmers to maximize their profits.

A canal-lining supply curve is also shown in Figure 1. This curve would be the cost to instream water buyers for water leased as a result of lining district canals if the water saved was leased at the cost needed to line the canals. In years when the irrigation district allotments are low, results indicate that irrigators were not very willing to give up their water unless canals could be lined. A quantity of only about 15,000 acre-feet (100 percent from COID) could be leased from irrigators operating with the baseline systems at a price slightly higher than the cost to line canals. Quantities greater than 15,000 acre-feet, however, would be obtained least expensively through canal lining.

Average Water Year

The per-acre allotments that were considered average in recent years were two acre-feet for NUID and three acre-feet for COID. The sum of the district supply curves for an average year is shown in Figure 2.

The results of the Base option show all crops entering the profit maximizing crop rotation except peppermint in NUID. Bluegrass, wheat, and garlic were deficit irrigated. With the exception of a mixture of sprinklers and furrow irrigation of carrot seed, every-furrow irrigation was the only irrigation technology utilized at lease prices below $65 per acre foot. Sprinklers were adopted for garlic and carrot seed at higher lease prices. The government wheat program entered the profit maximizing solutions. As lease price increased, deficit irrigation of bluegrass, garlic, and wheat continued. Wheat and bluegrass dropped out of the rotation at $110 per acre foot and $130 per acre foot respectively. The most profitable water-conserving irrigation technology was surge furrow with irrigation scheduling in both Alltech and Conserve. Model results for these options show peppermint production, no deficit irrigation, and no fallowing of land without leasing water.

Crops produced under the COID Base option included mint and grain hay. Pasture, grass hay, and alfalfa did not enter the rotations. Both crops produced were irrigated to reach maximum potential yield. Because only baseline practices were allowed in Base, and because the baseline irrigation systems for the crops produced used sprinklers, sprinkler irrigation was the only technology. When center pivots and irrigation scheduling were included in the irrigator's technology choice set (Alltech), the crop rotations included peppermint, grain hay, alfalfa, and grass hay. Center pivots were used to produce grass hay, alfalfa, and grain hay at low lease prices. Grass hay and alfalfa dropped from the rotation at $5 per acre foot and $40 per acre foot respectively. All water was leased at $85 per acre foot. The conservation program was utilized with an average allotment with center pivots as the conserving system. In an average water year the cost per acre-foot to lease water from commercial irrigators exceeded the cost per acre-foot of water saved by lining canals if greater than 25,000 acre feet of water was supplied to the market. If water availability was similar to that depicted here as an average water year in the long run, canal lining appears to be the most cost effective way to free water for instream use regardless of whether Alltech, Base or Conserve exists.

High Water Year

An above-average water year was depicted with a three acre-foot allotment for the NUID and a four acre-foot allotment for COID. The supply curves in Figure 3 are notably shifted down to the right indicating that more water was supplied to the lease market at lower prices. The 79,000 acre feet needed to meet the recommended minimum flow could be obtained at significantly lower prices in high water years. Generally the profit-maximizing activities in a high water year were similar to those in an average year. In both COD and NUID, all crops were produced at lower lease prices except pasture. The most marginal crops left the rotation first as in the low and average water year scenarios. Less efficient systems were utilized more because of the abundance of water. Fallowing land was not necessary to be able to apply adequate water to achieve maximum crop yields. Also, deficit irrigation was not practiced.

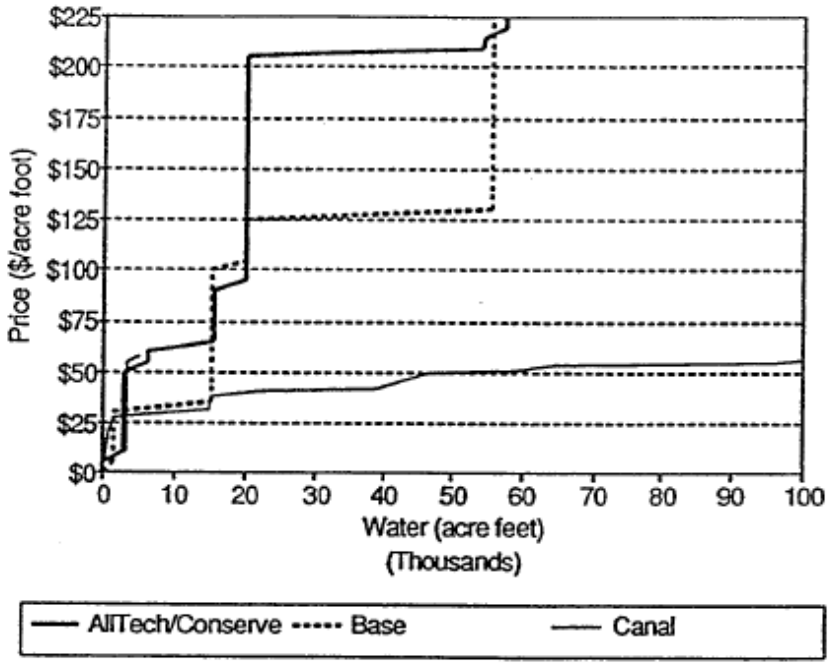

Figure 1. Total Estimated Water Supply in a Low Water Year from Commercial Agriculture in the North Unit Irrigation District and Central Oregon Irrigation District, Central Oregon, 1995.

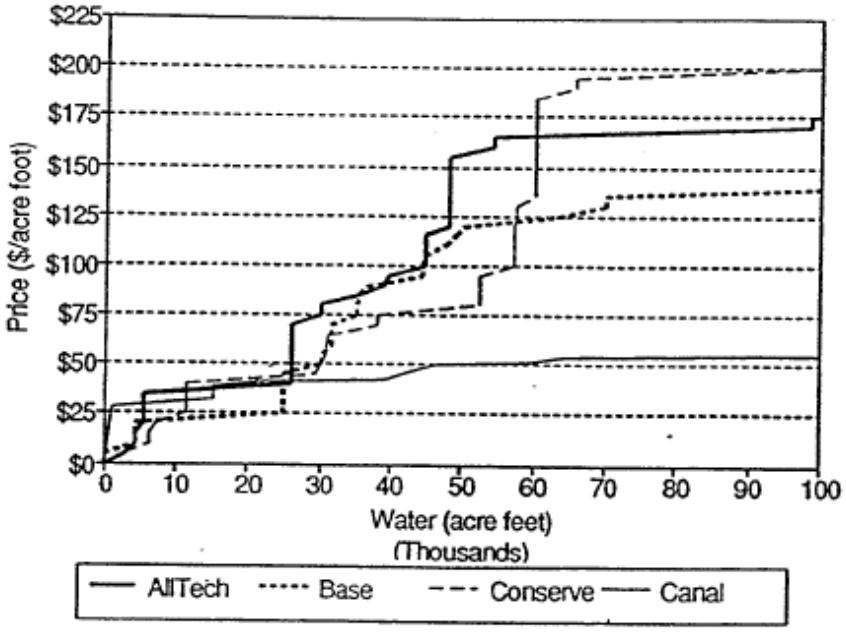

Figure 2. Total Estimated Water Supply in an Average Water Year from Commercial Agriculture in the North Unit Irrigation District and Central Oregon Irrigation District, Central Oregon, 1995.

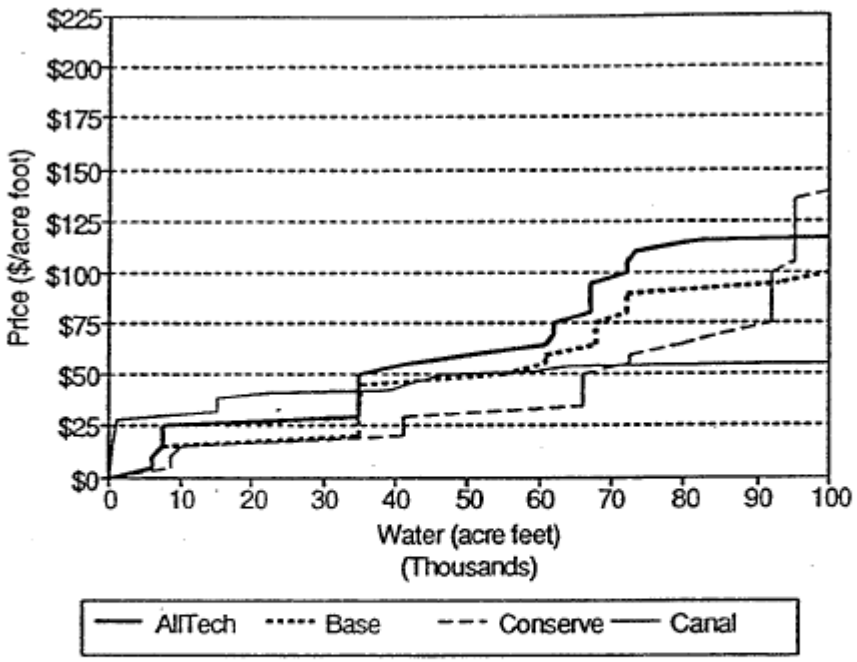

Figure 3. Total Estimated Water Supply in a High Water Year from Commercial Agriculture in the North Unit Irrigation District and Central Oregon Irrigation District, Central Oregon, 1995.