FARMER ADOPTION OF IRRIGATION WATER CONSERVATION MEASURES IN THE SOUTH PLATTE RIVER BASIN

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ABSTRACT

The potential of demand management as a water management tool in the South Platte River basin is limited by a lack of information regarding existing irrigation practices. A study was conducted to obtain information regarding irrigation water use practices in the basin, to determine the frequency of adoption of water conservation practices, and to relate the frequency of adoption of water conserving measures to various demographic factors. The results were based on 285 responses to a voluntary survey sent to a random sample of 1000 irrigators in eight counties within the basin during the winter of 1995. The survey sought information on farming practices, the adoption of water conservation practices, and grower characteristics.

Although disincentives for irrigation water conservation appeared to be significant, the results indicated a high rate of adoption. Seventy-four percent of the survey respondents had adopted some type of water conservation measure on their farms. Adoption of various irrigation water conservation practices was associated most frequently with farm size, but factors such as method of irrigation, water source, knowledge of water law, and level of education were also associated with adoption of one or more conservation measures. Respondents indicated that the primary incentive for adopting water conservation measures was "water conservation." The typical reason for conserving water was to improve existing operations. This suggests that in many instances conservation is being used as a method of extending existing supplies on farms operating under water-short decrees.

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INTRODUCTION

Competition for limited water supplies in the South Platte River basin is becoming more pronounced because of greater demand caused by increasing population. This competition will likely intensify in the future with increased demands for recreation and enhancement of wildlife habitat. Given the difficulties associated with developing new sources of water, nonagricultural users in the basin are looking toward agricultural water as a potential source of future water supplies. Many have suggested that the necessary supplies could be obtained through water conservation resulting from increases in irrigation efficiency.

Agricultural water is an attractive source of water because of the relative magnitude of irrigation water use in the South Platte River basin. Irrigation accounts for more than 80% of the total surface water diversions and consumptive use in the basin (Litke and Appel, 1989). The water is used by 5,100 irrigators farming approximately 904,000 acres of irrigated cropland (U.S. Department of Commerce, 1994). More than 540 ditches divert water for irrigation purposes, while there are over 4,500 direct flow and 1,300 storage rights operative (Caulfield et al., 1987). The economic value of total agricultural production in the basin in 1992 was approximately $278 million (Colorado Department of Agriculture, 1994). The vast majority of irrigation diversions and acreage within the basin occur along the main stem and its major tributaries on the plains of eastern Colorado at elevations in the approximate range of 3,500 to 6,000 ft.

Both sprinkler and surface irrigation systems are used in the basin. The exact distribution between the two classes of methods is unknown, but estimates indicate that surface irrigation, including flood and furrow types, is used for 80 to 85% of the total irrigated acreage. The results from a limited number of controlled studies indicate that on-farm irrigation efficiencies are highly variable, with surface methods being less efficient than sprinklers. Typical values for surface systems are in the range of 20 to 50% (Emond, 1993; Hoffner and Crookston, 1994). Emond (1993) found an average efficiency value of 60% for sprinklers.

Institutional and economic issues play a large role in determining the potential for greater irrigation water conservation in the South Platte basin. The basic law under which all water rights are administered in Colorado, the prior appropriation doctrine, is frequently viewed as a major barrier to improved irrigation efficiency at the farm level (Wilkinson, 1989). Because the value of a water right is based on historic beneficial consumptive use, any effort to maximize historic consumptive use will, in turn, increase the inherent value of the right. In addition, water saved through improvements in on-farm application or conveyance efficiencies can not be transferred, sold, or used on land other than that specified in the original decree. Because many farms in the basin experience supply shortages, the incentive exists to implement measures that increase the efficiency of diversion for the purpose of

extending supplies for the existing decreed acreage. Other economic factors acting as disincentives for conservation include the low cost of water in relation to other inputs and the cost of improvements that will enhance application efficiency.

Legitimate concern exists about the potential effects of widespread changes in irrigation practices on basin hydrology (Smith et al., 1996). The amount of surface and tributary ground water diverted for irrigation in the basin greatly exceeds the sum of imports and native water yield of the basin (Caulfield et al., 1987). Thus, many irrigation water rights in the basin are dependent on return flows. Changes in irrigation practices at the basin level that would significantly increase diversion efficiencies could negatively impact water users dependent on these flows.

Although there is significant potential for increasing on-farm irrigation efficiencies in the South Platte basin, there is no consensus on the desirability of encouraging increased water use efficiency. Another factor affecting potential initiatives is the lack of information on current irrigation practices used in the basin. Our objectives were to obtain information on the practices currently being used, the frequency with which conservation methods have been adopted, and farmer interest and attitudes regarding adoption of measures to improve efficiency.

METHODOLOGY

A survey of irrigators in the South Platte River basin was conducted to obtain information on current irrigation practices and to assess interest in the adoption of various measures. The survey instrument was developed in consultation with the State Statistician of the Colorado Agricultural Statistics Service. The questionnaire was sent to approximately 1,000 randomly selected irrigation farmers residing in eight counties (Adams, Boulder, Larimer, Logan, Morgan, Sedgwick, Washington, and Weld) that comprise the South Platte River drainage basin (including tributaries) east of the front range.

The questionnaire contained inquiries about the county in which the operation was located, the number of irrigated acres and methods of irrigation used, the source of water (surface, river basin groundwater, or deep aquifer ground water), and the major crops grown under irrigation and acreage of each. Operators were then presented with a list of 23 different water conservation practices or strategies and asked to respond to each by indicating whether the practice was currently being used. The list was assembled from a similar survey of ground water users in the Ogallala region of the Great Plains conducted by Kromm and White (1990). Respondents who indicated that they had taken actions to reduce water use were asked to note which of several designated factors accounted for their actions. The list of factors included the common reasons for adoption of water conservation practices including conserving water, reducing labor, saving energy, improving

water quality, replacing equipment, increasing acreage, increasing income from rental of saved water, and acting in response to educational programs sponsored by either Cooperative Extension or water conservancy districts. These respondents were also asked to estimate the extent to which they had reduced their water use (expressed as a percentage of total irrigation water use) by adopting various conservation practices. Respondents who indicated that they had not adopted water conservation measures were also asked to give reasons for their decision.

Other survey questions asked for additional information about respondents to determine whether the adoption of various conservation practices was associated with specific demographic characteristics of the respondents or their operations. The questionnaire also contained space at the end to allow respondents to provide general comments on agricultural water use and conservation practices.

The questionnaire was mailed on 15 January 1995 by the Colorado Agricultural Statistics Service along with a return envelope addressed to the Department of Soil and Crop Sciences and a letter requesting a response by 31 January. The letter indicated the purpose of the survey and guaranteed the anonymity of respondents. Responses were accumulated until 1 March 1995.

The survey responses were compiled and tabulated using a spreadsheet format. Individual narrative comments were also recorded for analysis. Chi-square analysis was used to determine whether the frequency of adoption of the various conservation practices indicated on the questionnaire was associated with various demographic characteristics based on five different classification categories. The demographic categories used were the source of water (tributary or nontributary), type of irrigation system (furrow/flood or sprinkler), farm size (equal to and greater than 400 acres or less than 400 acres), knowledge of water rights (generally knowledgeable or not generally knowledgeable), and education level (through high school and less or college and above).

RESULTS AND DISCUSSION

Respondent Demographics

A total of 285 responses were received from a survey of 1000 irrigators in the South Platte River basin. Just over 72% of the respondents indicated the county in which their primary operation was located. Responses were received from each of the eight counties surveyed, and the distribution of questionnaires received among counties was similar to that for the distribution of irrigated acreage among these counties. Weld county, which contains approximately 46% of the total irrigated acreage in the eight counties, accounted for 44% of the respondents identifying the

location of their primary operation. The total amount of land owned by the respondents was 62,617 acres, with an additional 53,621 acres leased. While average farm size varied among counties, the average farm size of respondents indicating they owned their properties was 278 acres.

The total irrigated acreage reported was 84,681 acres, with 60% of this total (50,142 acres) devoted to flood or furrow irrigation. Sprinklers were used on 40% (33,870 acres) of the total irrigated acres reported. The average amount of irrigated land reported by the respondents was 297 acres.

For the purposes of this survey, the source of water was an extremely important factor. Our objective was to obtain information about irrigation practices and factors affecting conservation decisions from farmers using water within the alluvial basin. Some of the counties surveyed contained land irrigated not only with surface and tributary ground water, but also from deep ground water aquifers. Because of the method of selecting potential respondents, we could not identify and select against those in areas outside of the alluvial basin. Fortunately, only 9% of the respondents indicated that they used only deep aquifer wells. The majority of respondents, 39%, relied on surface water alone for irrigation, and another 17% relied on tributary ground water alone for irrigation. Seventy-one respondents, or 25% of the total, indicated that they used both surface and tributary groundwater sources. Ten percent indicated that they used a combination of tributary and nontributary ground water. In view of these survey responses, we felt the overall survey results would generally represent characteristics and attitudes of surface water and tributary ground water users.

Respondents indicated that the primary irrigated crop being grown was corn, which accounted for 46% of the irrigated acreage devoted to growers' three principle crops. Alfalfa and hay combined accounted for 25% of the total acreage, with the remaining 29% comprised of beans, sugar beets, wheat, barley, and vegetables. Beans made up the largest portion of the balance, accounting for 8% of the total.

The vast majority of the respondents (90%) indicated that they were at least somewhat knowledgeable about water laws. Nearly half of the respondents had received some level of high school education, but had not gone on to college. A large percentage had received some level of college education (44%), with twenty-two people (8%) possessing M.S. degrees. Twelve respondents (4% of the total) indicated that they had received Ph.D. degrees.

The most popular sources of information on irrigation technology were farm magazines and journals (32% of the respondents). Cooperative Extension was noted as a resource by 18% of the respondents, while 16% relied upon conservancy districts and ditch companies. Personal experience and the Natural

Resources Conservation Service were each cited by 14% of the respondents as sources of information, and consulting firms were used by 6%.

Water Conservation Measures

The results of the survey indicated that 74% of the respondents had adopted water-conserving irrigation practices. Of the 210 who had adopted measures, 169 (80%) indicated that they had done so to conserve water. The desire to reduce labor costs was noted by 56% of those who had adopted measures, while energy cost reduction and the desire to increase yields were also noted by 41%. Equipment replacement, increasing productive acreage, improving water quality, increasing income from rental water, and educational programs sponsored by conservancy districts and Cooperative Extension were reasons cited less frequently for changing operations. Reasons given for the 26% of respondents who had chosen not to adopt conservation methods were, in order of importance, cost or budget-related factors, leased land, availability of sufficient water supply, fear of water-right abandonment, and low water cost.

Irrigators who had employed water-saving measures were also asked to estimate the extent to which they had reduced their water use. Responses ranged from 0 to 100%, with many respondents leaving the question blank. Of those who responded, the average estimate of reduction of total water use was 20%.

The 23 individual water conservation practices provided for response on the questionnaire and a summary of responses are presented in Table 1. The survey results indicated that scheduling irrigation based on moisture need was the most popular water conserving practice, which was used by over 50% of the survey respondents. Half of the respondents also applied fertilizer at appropriate growth stages and monitored soil moisture. Reduced tillage, land leveling, replacing open ditches with underground pipe, planting drought tolerant crops, and converting from furrow to sprinkler irrigation were measures adopted by about one-third of the respondents. Of the top ten practices adopted, eight were management practices involving minimal capital expense to implement.

Demographic Factors Associated With Adoption

One of the objectives of this study was to identify factors associated with farmer decisions regarding adoption of water-saving practices. In looking at the entire array of water conservation practices, variation in frequency of adoption the different measures was dependent on four of the five demographic variables observed. The four variables were farm size, source of water, type of irrigation system, and knowledge of water rights.

Table 1. Water conservation measures adopted by survey respondents, South Platte River basin, Colorado.

Conservation measures	Number adopting	Percent adopting
Schedule irrigation	153	54
Practice timely fertilization	136	48
Monitor soil moisture	109	38
Use minimum tillage	98	34
Level land	98	34
Install underground pipe	96	34
Use drought tolerant crops	93	33
Convert to sprinkler irrigation	91	32
Replace underground pipe	79	28
Line ditches	77	27
Install low-pressure spray heads	69	24
Install tailwater recovery system	63	22
Use alternate furrow irrigation	59	21
Practice deficit irrigation	42	15
Meter water use	40	14
Use surge valves	35	12
Use LEPA systems	32	11
Reduce irrigated acreage	20	7
Use furrow diking	12	4
Use drip irrigation	11	4
Begin transition to dryland farming	10	4
Use cablegation systems	6	2
Build conservation bench terracing	6	2

To determine whether one or more of the demographic factors were associated with the adoption of specific conservation measures, the ten measures with the highest adoption frequency were analyzed independently. Results of these analyses are summarized in Table 2. Farm size was the characteristic most consistently associated with adoption of water conservation measures. Larger farms (those of 400 acres or more) had a higher frequency of adoption for nine of the 10 conservation practices. The method of irrigation used was not associated with any conservation practices other than those inherently linked to either surface methods (ditch lining) or sprinkler methods (conversion to sprinklers).

Table 2. Relationships between adoption frequency and demographic characteristics for survey respondents in the South Platte River Basin.

	Demographic characteristics				
Conservation measure	Farm[1] size	Irrig.[2] method	Water[3] source	Water[4] rights knowl.	Educ.[5] Level
Schedule irrigation	X[6]				
Timely fertilization	X		X		
Monitor soil moisture	X				
Use minimum tillage	X		X		
Level land					
Install underground pipe	X	X		X	
Use drought tol. crops	X				
Convert to sprinklers	X	X			
Replace underground pipe	X				
Line ditches	X	X			X

[1] Farm size: Equal to and greater than 400 acres or less than 400 acres.
[2] Irrigation method: Furrow/flood or sprinkler
[3] Water source: Tributary or nontributary
[4] Water Right Knowledge: Knowledgeable or not knowledgeable
[5] Education level: Through high school and less or college and above
[6] Indicates frequency of adoption of conservation measure is associated with variation in indicated demographic characteristic based on Chi-square test ($P = 0.05$).

We anticipated that knowledge of water rights would influence adoption rates for one or more of the most popular individual conservation practices. However, the analyses indicated that knowledge of water rights was only significant with regard to replacing ditches with underground pipe. Perhaps the most interesting finding was that the source of water was a factor associated with frequency of adoption for only two of the 10 most often used conservation measures, timing fertilization and using minimum tillage. These results indicate that surface water and tributary ground water users within the South Platte basin appear to respond to some of the same incentives as deep ground water users.

CONCLUSIONS

As with any survey, questions arise as to how representative the respondents were of the general target population. The 285 respondents comprised approximately 6% of the total number of irrigated farms in the basin and represented about 10% of the total irrigated acreage in the study area. Respondent characteristics such as farm size and crops grown were similar to actual census data for the eight counties in the target area. Average irrigated farm size of respondents was 297 acres, compared to an average irrigated farm size in the region of 200 acres (U.S. Department of Commerce, 1994). However, the majority of responses originated from Weld County, where the average acreage from questionnaire responses was 222 acres per farm. The federal census indicates that average irrigated farm size in Weld County was 224 acres in 1992 (U.S. Department of Commerce, 1994). From this cursory analysis, we concluded that the survey respondents were generally representative of the target population in this basin.

The results suggest that differences existed in some cases between the purpose of various questions on the survey instrument and the perceptions of respondents. The most popular conservation measure indicated by the respondents was scheduling irrigations based on moisture need. Unfortunately, a follow-up question to determine the actual methods used to accomplish scheduling was not included. It seems likely that there is considerable variation among the respondents in the magnitude of technical inputs used for scheduling. Thus, one would expect some variability among irrigators in the effectiveness of their irrigation scheduling efforts. Another example of problems with perception is observed in responses indicating that 33% of those surveyed used drought tolerant crops. This clearly conflicts with survey responses indicating corn and alfalfa as the major irrigated crops being grown.

Despite the problems of perception cited above, the overall indication of interest in water conservation is significant. A large fraction of irrigation farmers in the basin are implementing practices to improve their water use efficiency even though there are apparently few institutional or economic incentives for these actions. This suggests indirectly that some farmers are using conservation as a method of extending existing supplies because they have historically been operating under water shortages. Provided this occurs under the terms of the existing decree, it is permissible and potentially results in greater consumptive use per unit of water applied. More importantly, from a policy standpoint, these conservation efforts by individual farmers are likely producing little if any water for other uses in the basin. Thus, without significant changes in policy, it is doubtful that increased efforts to encourage irrigation water conservation in the South Platte basin will yield additional water for alternative uses.

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