OPPORTUNITY COSTS OF WATER LEASING: IRRIGATION, INSTREAM FLOW, AND WETLAND CONSIDERATIONS IN THE LARAMIE BASIN, WYOMING

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Abstract

Agricultural production in the Laramie Basin of southeast Wyoming is dominated by cow/calf operations. Operators flood irrigate hay fields and pastures from spring to fall to support livestock through the year. Flood irrigation has created many wetlands that rely directly on spring irrigation runoff and indirectly on groundwater table enhancement by irrigation inputs for water. The low profitability of hay production in this high-altitude basin, to date, has precluded measures to increase irrigation efficiency. However, the Laramie Basin, a subbasin of the North Platte River, which is a tributary of the Platte River, is a proposed water supply source for instream flow enhancement. There is urgent need to increase instream flows in the Platte River to benefit endangered cranes, terns, plovers, and sturgeons.

Improving Platte River instream and riverine habitat by increasing irrigation efficiency through subsidies, or retiring irrigated lands would transform Laramie Basin agriculture and cause a high fraction of the Basin's wetlands to be lost. This study explores the limitations of traditional water transfer tools when regional instream-flow requirements compete with local irrigation-dependent wetlands for agriculture's water. We propose an alternative water transfer program, short-term water leasing, designed specifically to meet the needs of Laramie Basin wetlands, considering the area's complex hydrology, and the challenge of moving water between agriculture and environmental uses. Short-term water leasing provides water for instream flow by utilizing nonconsecutive, seasonal water contributions by many agricultural producers. This avoids large changes in the Laramie Basin's agricultural economy, allowing an economically feasible contribution to instream flows without long-term injury to other irrigators or water delivery to wetlands. Short-term water leasing programs could meet regional environmental water needs without sacrificing local ecological resources. An estimate of minimum water costs, and advantages and disadvantages of short-term water rights leasing are discussed.

Irrigated agriculture: the wetland connection

Irrigated agriculture has created many wetlands in western North America, since the early 1900s (Szymczak; Lovvorn and Hart). Water collecting in natural depressions in the landscape has created and sustained valuable wetland complexes that otherwise would not exist. Irrigation water reaches wetlands as surface flow through irrigation ditches, and as ground water and interflow via percolation from irrigated fields and unlined ditches (e.g., Harmon). These wetlands have become productive habitats that support numerous species, particularly migrating waterfowl and shorebirds, and provide valuable recreational opportunities. Three notable examples of productive irrigation-dependent wetlands include the Salton Sea of California, the Klamath refuges of southern Oregon, and areas of the Platte River Basin in Wyoming, Colorado and Nebraska. The Laramie Basin of Wyoming, a sub-basin of the Platte River, was the focus of this study. The events unfolding in this basin demonstrate the difficulties that arise when multiple demands are placed on limited water supplies, and illustrate the need for creative solutions in order to preserve both local and regional ecological resources.

Urban growth, demand for instream flow to support threatened and endangered species, and more frequent and severe drought in the West are placing larger demands on scarce water resources. Agriculture, as the largest consumer of water in the United States (National Research Council), faces increased pressure to improve water use efficiency (technological efficiency, not necessarily economic efficiency). Flood irrigation systems are a target, in particular, due to their technological inefficiency. Seepage from ditches, and evaporation from flooded fields increase consumptive water use and decrease the volume of downstream flows (although much seepage returns to streams). Irrigators are encouraged to prevent seepage by lining ditches, and to reduce evaporative losses by installing sprinklers (National Research Council; Wallace). Such

efficiency improvements strongly impact irrigation-dependent wetlands, but these effects are seldom considered in water management decisions (Sando et al.; Gates and Grismer).

The Laramie Basin of southeast Wyoming offers a rich opportunity to study the complex relationships that must be considered if irrigation-dependent wetlands are to survive regional efforts to preserve endangered species. This study explores the limitations of traditional water transfer tools when regional instream-flow requirements compete with local irrigation-dependent wetlands for agriculture's water. We propose an alternative water transfer program designed specifically to meet the biological needs of the Laramie Basin's wetlands, taking into consideration the area's complex and poorly understood hydrology, and the political challenge of moving water out of agriculture and into environmental uses.

The Laramie Basin

The Laramie Basin of southeast Wyoming contains many wetlands created by flood irrigation (Lovvorn and Hart). Peck and Lovvorn found that for 74 wetlands, 65% of inflows were directly from flood irrigation. This high-altitude intermountain basin is one of the major areas for breeding and migrating waterfowl in the state (Prenzlow and Lovvorn), and contains the only remaining habitat for the endangered Wyoming toad (*Bufo hemiophrys baxteri*). Laramie Basin agriculture is dominated by beef cattle production. Flood irrigation is used to produce hay and pasture to feed and over-winter cattle. Low profitability of hay production, and stable water demand in this high-altitude basin has historically precluded measures to increase irrigation efficiency. The Laramie Basin is, however, a sub-basin of the North Platte River, a tributary of the Platte River (Figure 1), where there is urgent need to increase instream flows in the mainstem Platte River, to benefit threatened or endangered cranes, terns, plovers, and sturgeon (Hadley et al.; Jenkins).

The Platte River Endangered Species Partnership is a collaborative agreement between Wyoming, Colorado, Nebraska, and the United States Department of the Interior to save threatened and endangered species that inhabit the Platte River in Nebraska. The Partnership is working to increase instream flows through the Platte River in Central Nebraska by 130,000-150,000 acre-feet per year (Boyle Engineering Corporation). With supply-side solutions exhausted, an estimated 60,000 acre-feet will be acquired through incentive-based water conservation projects throughout the Platte River Basin (Boyle Engineering Corporation). Conservation efforts may include improving irrigation efficiency in agricultural areas upstream of the target stretch of river, like the Laramie Basin. If increased irrigation efficiency were encouraged, or if irrigated lands were retired through easements to improve Platte River instream flows, a high fraction of the Laramie Basin's wetlands and wetland-dependent species would be lost.

Finding a solution

The hydrological and biological framework of the Laramie Basin renders several common reallocation techniques infeasible, if the conservation of local wetlands is a priority. For example, the hydrology of flood-irrigated basins, like the Laramie Basin, is complex, and not well documented. Large or long-term changes in irrigation patterns will generate negative consequences of uncertain magnitude to wetlands, due to the intricate biological relationships of wetland communities and hydrology. Until the Laramie Basin's hydrology is better understood, programs that cause large reductions in irrigation levels, or shift irrigation patterns are a major threat to the existence and productivity of the Basin's wetlands. Improved irrigation efficiency, through canal lining or sprinkler irrigation technology, for example, would disrupt irrigation patterns that supply wetlands with water. Wetland salinity would increase and habitat composition would shift, or wetlands could disappear completely. Water rights purchases or

long-term leases would also permanently remove water from the agricultural landscape, resulting in wetland loss. Several traditional water transfer approaches are thus ruled out by wetlands' hydrological dependence on irrigated agriculture.

The political atmosphere surrounding water transfers also makes some traditional approaches less attractive. Water transfer proposals are often met with resistance from the agricultural community. Water transfers threaten injury to remaining irrigators through hydrologic changes. And although the appropriation doctrine, known widely by the slogan, "first in time, first in right," prohibits injury to other water users from proposed water transfers, such transfers symbolize a much larger threat, the irreversible deterioration of agricultural infrastructure and community. Skeptical agricultural communities thus sometimes discourage participation in many traditional transfer programs, particularly those that permanently move large volumes of water away from agriculture.

Several traditional water transfer programs were filtered through the hydrological, biological and political framework of the Laramie Basin. The following were overarching requirements for a successful program: minimal wetland hydrology disruption, minimal disruption of the agricultural community, and economic feasibility. Several programs were eliminated by major shortcomings within this framework. With a clearer vision of the barriers a transfer program must overcome, a short-term water-leasing program was designed to address the Laramie Basin's needs. The program objective was to allow Laramie Basin irrigators to contribute to instream flow for endangered species, without causing significant negative impacts on local wetlands. Several additional variables were considered for the program to successfully address hydrological and biological circumstances, including the following: the drought tolerance of perennial irrigated grass species, the uncertain impact of irrigation changes on groundwater and interflow deliveries to wetlands, the impact of water transfers on other

irrigators (due to the appropriation doctrine's no-injury rule), and the operational details of Laramie Basin agricultural production.

The proposed short-term water-leasing program would involve the voluntary leasing of water from irrigators to a neutral party on behalf of Platte River interests. Producers holding water rights with desirable combinations of location, wetland-association, priority date, quantity, and ease of transfer would be recruited into a 10-year agreement. The irrigator, upon advanced notice, and in exchange for compensation, would transfer a portion of their water right to instream flow for the irrigation season. The water would proceed to Lake McConaughy, Nebraska, and be stored for beneficial release to the Platte River. Each participant would contribute water during two or three non-consecutive irrigation seasons over a 10-year contract period, depending upon the drought tolerance of hay fields and wetlands.

Short-term leasing would meet our overarching objectives by disrupting irrigation patterns and water delivery to any particular wetland only in the short-term. Rotating water contribution will disperse annual impacts throughout the area, minimizing long run impacts to particular producers and wetlands. Producers, we suspect, would be more willing to participate in this program versus others, because they maintain their valuable water rights for future use. They are also able to continue operating under nearly normal conditions, and are compensated their opportunity cost of participation. Finally, they can resume normal production following participation.

Impacts to other water right holders should be small, short-lived, and negotiable if necessary. This is because the consumptive use rule would be enforced, annual contribution would be widely dispersed and rotated through time, and impacts would last only a single season at a time. The agricultural community as a whole should see few long-term impacts overall, thus making the program more widely accepted. Finally, as discussed later, short-term water leasing

would be economically comparable to other programs. In summary, drawing water from a rotating pattern of irrigated lands would allow an economically feasible contribution to instream flows without long-term injury to other irrigators or water delivery to wetlands.

Feasibility of short-term leasing

Short-term leasing was designed to address the uncertain hydrological impacts of water transfers, the biological requirements of wetlands, the technological demands of the agricultural production process, and the strained political atmosphere surrounding water transfers. The next step was to determine the program's economic feasibility. Research questions included the following: 1) what economic provisions would induce voluntary participation by agricultural community, and 2) would program costs compare with other water transfer proposals?

The cost of leasing an acre-foot of water from Laramie Basin producers was estimated as the producer's opportunity cost of leasing their water. To resume normal production after a season of water leasing, participants must be able to maintain their normal cattle operation during the contribution year, including over-wintering the base-herd. A producer's operating costs and revenue are modified when water is leased away from hay production. The largest opportunity cost of not producing hay is the need to purchase replacement forage.

An enterprise budget simulating a normal Laramie Basin agricultural operation was built and manipulated to determine potential changes in the production process in response to participation in a water lease program. A producer, as an alternative to irrigating and harvesting a full hay crop, could lease their water to instream flow and either harvest a smaller hay crop during an above average precipitation year, or graze hay fields during an average precipitation year, or fallow all fields during a below average precipitation year. Budget outcomes for several of these alternative production scenarios were compared to generate a range of costs incurred by

operators when irrigation water is leased away from hay fields, but their livestock operation continues.

An operator's opportunity cost (change in net revenue) ranges from $30 to $90 per acre-foot of water leased, depending upon the production alternative chosen and the cost of replacement hay (Figure 2). An expected cost of $45 to $80 per acre-foot was estimated, based on the number of wet, average and dry years occurring in the area (for January) from 1961 to 1990 (NOAA 2002) and the production alternatives likely to occur under each precipitation category.

The cost of water leased from Laramie Basin agriculture seemed reasonable thus far. However, Wyoming water law limits the portion of a water right that can be transferred in order to protect downstream users that rely on return flows. Only the portion of the water right that is consumptively used can be transferred (Wolfe). A 50% consumptive use rate was used as an estimate for flood irrigation (Negri and Hanchar); the remaining 50% is assumed to return to the river system, for use by downstream water right owners. Thus, for each acre-foot leased from a producer, only one-half of an acre-foot is legally transferable; the other half must remain available for downstream users. Although producers are paid, for example, $50 to leave an acre-foot of water instream, only one-half of that water is actually protected for instream use. Thus to protect one acre-foot of water, two acre-feet must be leased. Therefore, the cost of protecting an acre-foot of water for instream use is double the lease cost, $100 in this example.

Conveyance loss of water between Laramie and Lake McConaughy is another variable that impacts the cost of an acre-foot of water. As water moves downstream a portion is lost through evaporation, transpiration by riparian plants, and deep percolation. Conveyance loss estimates from Laramie to Lake McConaughy have not yet been measured, so a range of values was used to investigate the sensitivity of cost to conveyance loss rates. Table 1 summarizes the

rise of expected cost per acre-foot as conveyance loss increases. With no conveyance loss, expected cost is $86 and $160 per acre-foot received at Lake McConaughy, for average and drought-year hay costs respectively. A 50% conveyance loss rate results in costs of $172 and $321 per acre-foot received. A conveyance loss of 75% generates costs of $344 and $641 per acre-foot received. Figure 3 illustrates how the expected cost per acre-foot rises when the consumptive use rule and a 50% conveyance loss rate are included. The cost per acre-foot of water leased from agriculture is compared to the cost per acre-foot legally protected for instream flow, and the cost per acre-foot received at Lake McConaughy in Nebraska.

Assuming a 50% consumptive use rate, and a 50% conveyance loss rate, up to 13,500 acre-feet of water could be delivered to Lake McConaughy in an average water year if all producers participated and 30% of participants contributed water each year, [based on average flow records for the Laramie Basin, (Pugh and Spranger)]. Figure 4 illustrates the variation in water delivery during an average water year, as participation and contribution rates change. 1,125 acre-feet of water would be delivered if 25% of producers participated and 10% of this pool contributed water each year. Water received at Lake McConaughy during a drought year could vary from 940 to 11,250 acre-feet with minimum and maximum participation and contribution levels respectively. An above average water year could generate from 1,688 to 20,250 acre-feet received at Lake McConaughy.

Short-term leasing of water from the Laramie Basin is less expensive per acre-foot than deficit irrigation in Nebraska, on-farm irrigation technique changes in Nebraska, and water leasing in south-central Nebraska (Boyle). The program is also comparable in cost to conservation cropping in Nebraska and passively lowering groundwater tables in Nebraska (Boyle). Boyle used the annual economic value of irrigation on farmlands to estimate a cost of $22 to $38 per acre-foot of consumptive water use for a similar temporary lease program from

farmlands along Wyoming's North Platte River. Detailed methodology was not reported, so the discrepancies between Boyle's estimates and this study's estimates remain unclear. The approach of this study, in comparison, was to simulate Laramie Basin producer behavior in detail, and model production and net revenue changes that might result from the program.

Conclusions

The short-term water-lease program designed, in this study, for the Laramie Basin is comparable in cost to other proposed programs, and could therefore be a realistic target for Platte River conservation efforts. More importantly, however, is the program's ability to meet regional environmental water needs with minimal negative impact on local wetland resources, and minimal disruption to the agricultural community.

Irrigated agriculture will no doubt face increasing pressures to transfer water to nonagricultural uses, including instream flows for endangered species management. Wetlands will be lost if irrigation water is transferred to other uses without careful design. This study suggests that short-term water leasing programs designed with an understanding of a region's unique ecological and agricultural needs could meet regional environmental water needs without sacrificing local ecological resources.

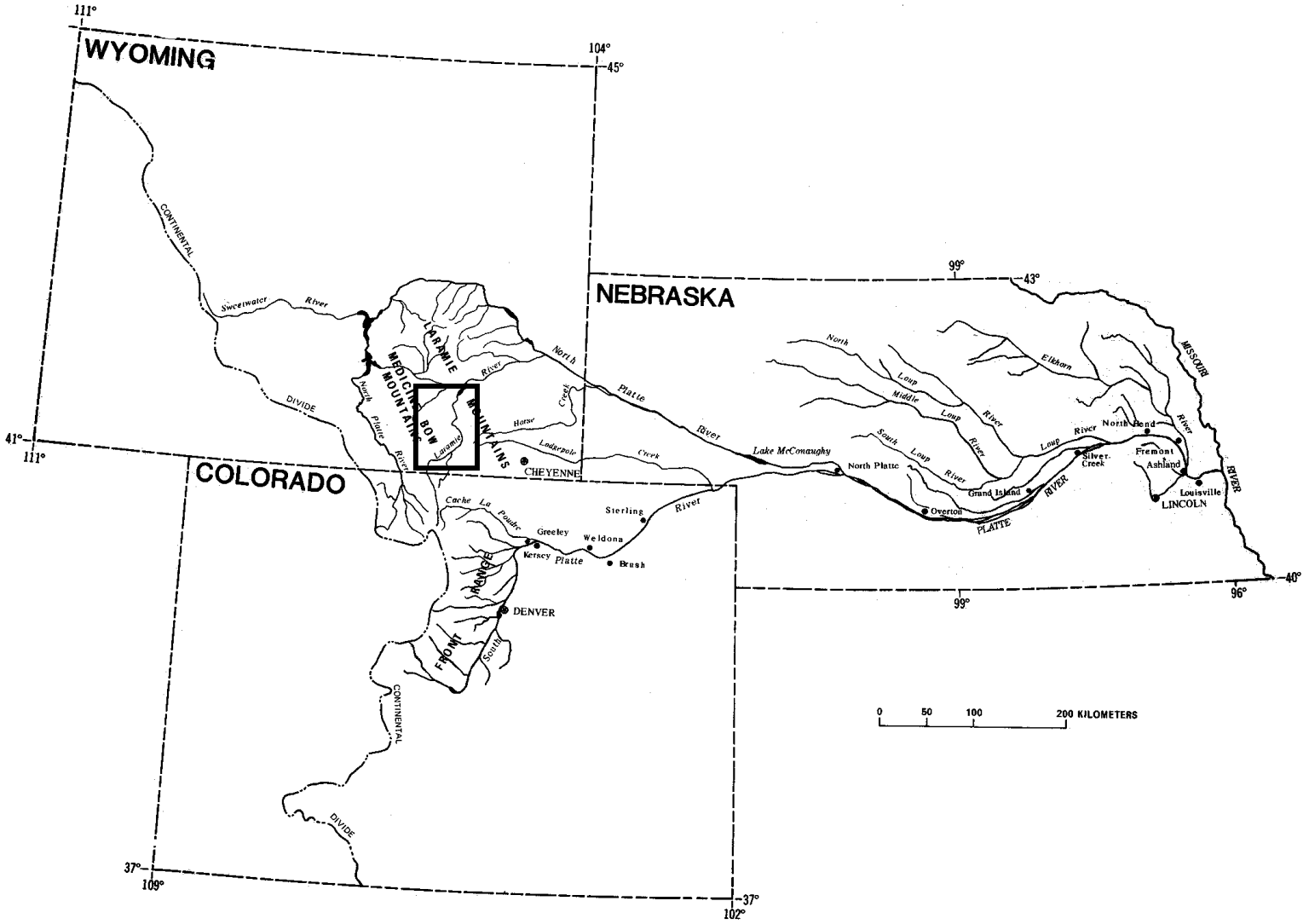


Figure 1. Platte River Basin in Wyoming, Colorado and Nebraska (Eschner et al.)

Figure 2. Cost ($) per acre-foot of water leased from production, using an average hay price of $70.64/ton and a drought-year hay price of $125.10/ton

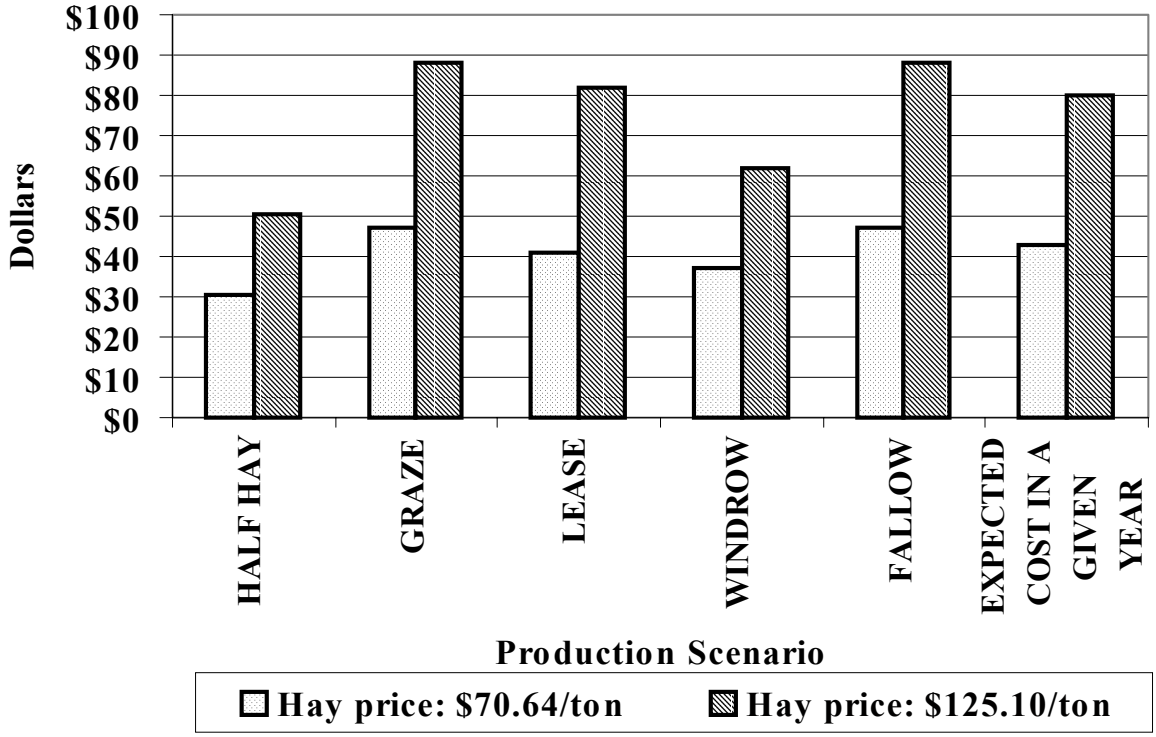


Table 1. Sensitivity to conveyance loss rates of expected cost per acre-foot of water received at Lake McConaughy, assuming a 50% consumptive use rate in irrigated agriculture

	Hay Price	
	$70.64/ton	$125.10/ton
Conveyance Loss Rate	Cost per acre-foot received ($)	
0%	86	160
25%	115	214
50%	172	321
75%	344	641
99.9%	86,015	160,353

Figure 3. Expected cost per acre-foot of water leased, transferred and received, assuming 50% conveyance loss rate

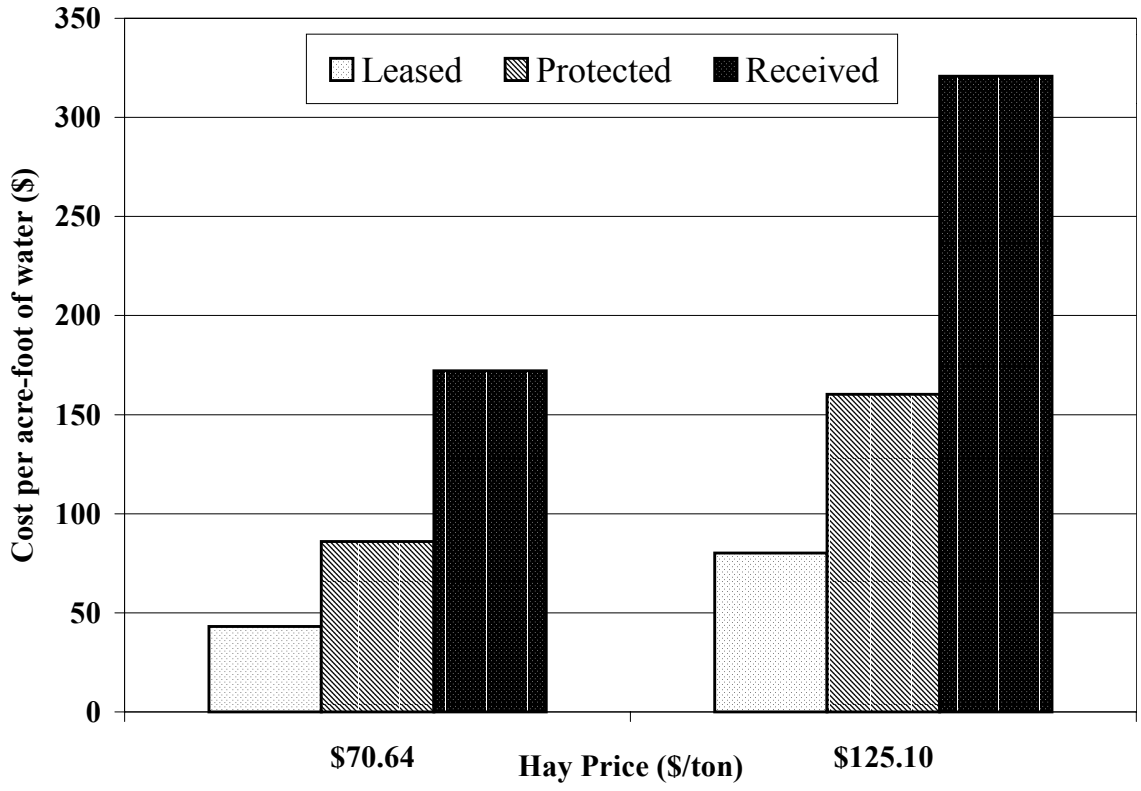
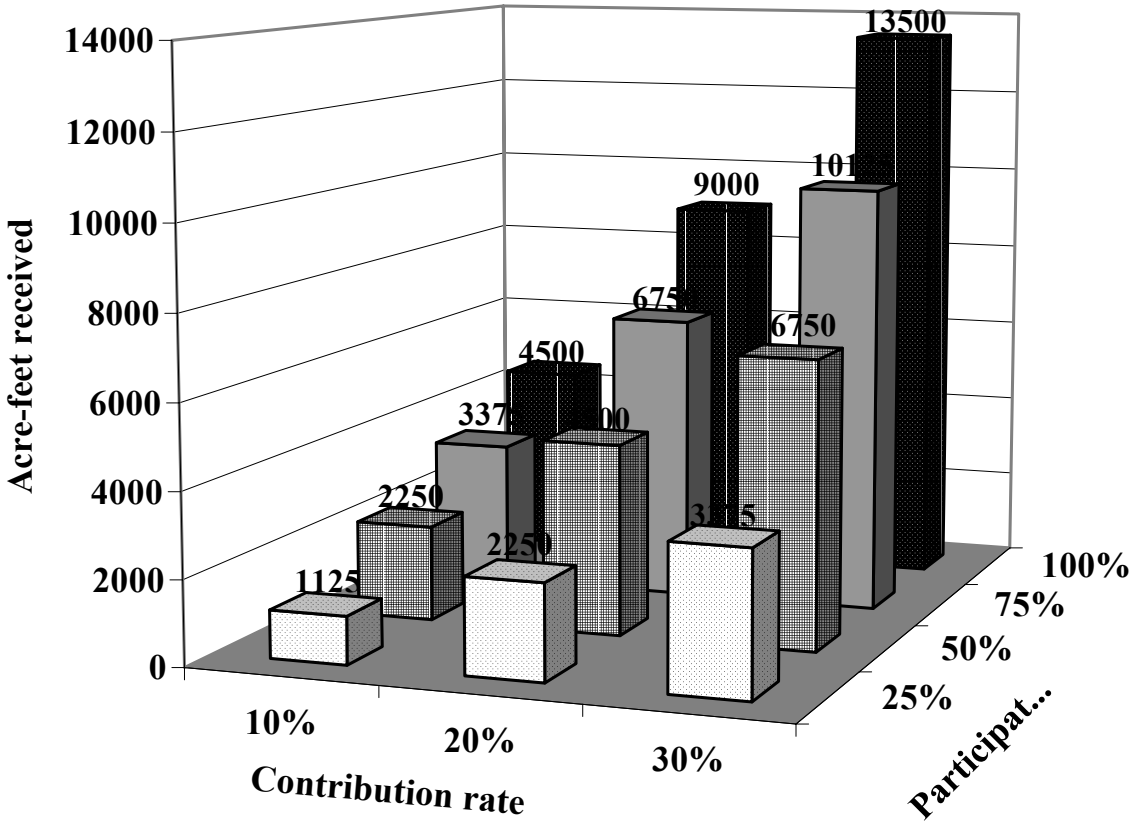


Figure 4. Water received in Nebraska by Producer Participation Rate and Annual Contribution Rate during an Average Water Year



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