Willingness to Participate in Agricultural Water Conservation Programs: Choice Experiment Evidence from the Upper Colorado River Basin

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Abstract

Amid ongoing policy discussions around water scarcity in the Colorado River Basin, we examine producer willingness to participate in agricultural water conservation programs (AWCPs). Specifically, we assess preferences for hypothetical AWCP attributes in Colorado's West Slope region using a discrete choice experiment. Participation rates increase with higher compensation, shared conservation responsibility, and water shepherding, but decline with water conservation intensity and land area commitment. Participation rates and willingness-to-accept values furthermore vary by operation and producer characteristics, including farm or ranch size, income, age, and ideological alignment. We discuss how these findings can inform AWCP design and regional water conservation modeling.

Keywords: choice experiment, economics, irrigation, technology adoption, U.S. West, water policy

JEL Codes: Q12, Q15, Q25, C55

Introduction

The Colorado River Basin faces a growing water scarcity crisis driven by declining snowpack, long-term aridification, and increasing water demand (Richter et al., 2024; Bass et al., 2023; Salehabadi et al., 2022). In response, a range of stakeholders—including water users, conservation organizations, scientists and universities, and government agencies, among others—have intensified efforts to address these challenges (Nemati & Dinar, 2024; Booker, 2022; Taylor et al., 2019). Agricultural Water Conservation Programs (AWCPs) represent an emerging policy tool that is currently under consideration by Upper Basin states (Colorado, New Mexico, Utah, and Wyoming) (Mooney & Hansen, 2024). The voluntary programs aim to achieve temporary reductions in crop consumptive use (CU) (i.e., crop evapotranspiration) on irrigated land by incentivizing producer adoption of reduced-irrigation water conservation practices. The conserved water would remain in the river, be stored in a downstream reservoir, and be released as needed to support Upper Basin compliance with the 1922 Colorado River Compact (Asgari & Hansen, 2024).

In this study, we examine producer willingness to participate in AWCPs with particular attention given to the role of program-and policy-relevant design features. Our focus is on agricultural operations in the Upper Colorado River Basin (UCRB), which is a region of interest due to its large geographic area and economic dependence on irrigated forage crops (Crespo et al., 2024; Hansen et al., 2024; Frisvold & Duval, 2023). Variation in production systems, operational sizes, and producer demographics shapes agricultural decision-making in the region and is likely to drive heterogeneity in AWCP preferences (Bennett et al., 2023; Hung et al, 2022; Pritchett, 2011). Using results from a discrete choice experiment (DCE) (Mason, 2025), we elicit preferences for three reduced-irrigation water conservation practices—full-season curtailment, split-season curtailment, and full-season limited irrigation—and several program attributes. The attributes evaluated include the choice of reduced irrigation practice (i.e., water conservation intensity), compensation level, land area commitment, shared conservation responsibility (with Colorado's East Slope), and water shepherding assurances. A random utility framework enables estimation of AWCP participation likelihood and willingness-to-accept (WTA) values using Multinomial Logit (MNL) and Mixed Multinomial Logit (MIXL) regression methods.

We address two research questions. First, how do AWCP practice type and program attributes influence producers' willingness to participate? Second, how do WTA values for AWCP participation and associated program attributes vary according to operation and producer characteristics? Rather than directly asking respondents whether they would enroll in an AWCP, the DCE presented hypothetical AWCP scenarios to assess tradeoffs among conservation practices, compensation levels, and policy features. We find that participation decisions and WTA values are significantly influenced by the AWCP attributes considered in our study as well as by operation and producer characteristics, including size, income, age, and ideological views. The results carry implications for AWCP design and regional modeling of water conservation outcomes, which we discuss later in the article.

Our findings contribute to a growing body of literature on policy responses to water scarcity in the Colorado River Basin in several ways. Past studies have examined the technical feasibility of water conservation practices for reducing CU at the field level (e.g., temporary fallowing, limited irrigation) (e.g., Perry et al., 2020; Smeal et al., 2005); however, relatively few have examined the potential economic, demographic, and behavioral dimensions of producer willingness to implement these practices (Colby et al., 2025; Bennett et al., 2023; Hung et al., 2022). Yet, understanding producer decision-making is crucial to the design and success of AWCPs, particularly in contexts where participation is voluntary and outcomes depend on the engagement of agricultural water users (Paige et al., 2021). Current policy discussions and pilot programs also frequently focus on full season fallowing or land retirement, which disallow crop production on the affected parcels (Mooney & Hansen, 2024). Our analysis expands this scope by also evaluating split-season curtailment and full-season limited irrigation—approaches that offer the potential to conserve CU while sustaining some forage or other crop production. By examining producer tradeoffs among conservation practices and program attributes, our study identifies design features that can enhance AWCP participation, thereby supporting more effective and targeted policy implementation. For example, policymakers could investigate the potential cost of conserving some water on many farms compared to restricting irrigation fully on a few.

The remainder of the article is organized as follows. In the next section, we present a conceptual framework for modeling AWCP participation decisions. We then describe the DCE and our empirical strategy, report our empirical results, and discuss the policy and research implications of our findings. The final section provides a summary and conclusions.

Producer Decision Framework

We elicit producer preferences for alternative AWCP practices and design attributes in a DCE framework. DCEs are widely used in applied economics research to evaluate individual preferences for hypothetical alternatives—such as new products, practices, or technology—particularly in contexts where respondents' real-world experience is limited (Louviere et al., 2000). In DCEs, respondents choose their preferred option from a set of alternatives, known as a choice set, each defined by varying attribute levels. Unlike revealed preference methods, which are based on observed behavior, DCEs rely on stated preferences to assess choices and estimate welfare measures like WTA (Hoyos, 2010; Hanley et al., 1998). DCEs have been utilized across a wide range of topics, including recent applications to agricultural production and resource conservation

(Hoag et al., 2023; Zemo & Termansen, 2018; Espinosa-Goded et al., 2010).

Following the DCE elicitation approach in Champ et al. (2003), we assume producer choices follow a random utility model. Respondents are presented with multiple irrigation curtailment program options, along with a “neither” opt-out alternative, and asked to select the option that maximizes their utility. The utility that respondent i derives from alternative j in choice set t is specified as:

$$U_{ijt} = \beta_i' X_{ijt} + \varepsilon_{ijt} \tag{1}$$

where $\beta_i' X_{ijt}$ represents the deterministic component of utility and ε_{ijt} is a stochastic error term. A respondent chooses alternative j if it yields higher utility than any other option in the choice set. For example, the probability of choosing alternative $j = 1$ is,

$$\pi_{i1} = \Pr\big(\beta_i' X_{i1t} + \varepsilon_{i1t} > \beta_i' X_{ijt} + \varepsilon_{ijt},\ \forall\, j \neq 1\big) \tag{2}$$

Assuming ε_{ijt} follows an independently and identically distributed type I extreme value distribution, the choice probabilities can be represented using a logit model,

$$\pi_{i1} = \frac{\exp\big(\boldsymbol{\beta}_i' \mathbf{X}_{i1t}\big)}{\sum_{t=1}^{T} \exp\big(\boldsymbol{\beta}_i' \mathbf{X}_{ijt}\big)} \tag{3}$$

We calculate the willingness-to-accept (WTA) for AWCP attributes using the ratio of the attribute coefficient to the negative of the compensation coefficient:

$$\text{WTA} = \frac{\beta_k}{-\beta_c} \tag{4}$$

where β_k is the coefficient for attribute k and β_c is the estimated coefficient for compensation. To estimate the standard error of WTA, we use the Delta method, which is widely applied in DCE studies (Greene, 2017; Espinosa-Goded et al., 2010).

Data and Empirical Approach

We utilize study data from a mixed-mode survey administered using the Qualtrics platform, targeting agricultural water users in Colorado’s West Slope region (Mason, 2025). The survey ran from summer 2023 to spring 2024 and gathered data on producer preferences for AWCP attributes.

Survey Design and Administration

The survey included a DCE along with questions on operation and producer characteristics. Its design was informed by previous DCE studies, publicly available reports on AWCPs, and stakeholder input through focus groups and personal interactions. Pretesting with selected water users and professionals helped refine question clarity and content. The final survey instrument received Institutional Review Board exemption from Colorado State University.

Participant recruitment followed a multi-channel strategy. Email invitations were sent through the mailing lists of conservation districts and other regional organizations. A paper version was also mailed to nearly 4,500 agricultural addresses in the West Slope region. Digital outreach to raise awareness about the study used targeted ads on Facebook and Twitter. Public notices of survey availability were also provided at meetings of Basin Roundtables, soil and water conservation districts, and regional water conferences. The survey generated a total of 573 responses, of which 350 participants completed the DCE and provided details on farm or ranch operations and demographic characteristics used to construct our study variables. Our primary results, presented below, use this sample of N = 350 observations. We additionally present results for a larger sample of N = 433 observations in the Supplementary Materials (SM) file as a robustness check. The larger sample includes respondents who completed the DCE but skipped one or more questions regarding operation characteristics or producer demographics.

Choice Experiment Attributes

The DCE included five AWCP attributes: conservation practice, compensation level, conserved acreage, East Slope match, and water shepherding (Table 1). Attribute levels were informed by expert input and the academic literature to reflect plausible AWCP scenarios. The conservation action attribute included three reduced irrigation practices that vary by water conservation intensity and reflect viable options for AWCPs in the U.S. West (Mooney & Hansen, 2024). As defined in the questionnaire, the reduced irrigation practices included were split-season curtailment (no irrigation Jul 1–Oct 31), full-season limited irrigation (50% reduction in irrigation Apr 1–Oct 31), and full-season curtailment (no irrigation Apr 1–Oct 31). [1]. Earlier shutoffs yield greater expected water conservation but may limit production flexibility and potentially reduce willingness to participate. Therefore, we expect willingness to participate to decrease as conservation intensity (amount of irrigation that is limited) increases. A fourth, baseline, opt-out alternative was also included. This reflected a choice to maintain standard irrigation during the Apr 1–Oct 31 period.

The compensation attribute included six levels and ranged from $0 to $1,600 per acre, capturing values

[1] The irrigation season in western Colorado runs from April 1 to October 31

from recent AWCP pilot studies (e.g., SCPP's benchmark of $509 per acre-foot of conserved CU in 2024) (Mooney & Hansen, 2024).[2] We expect higher compensation to increase the likelihood of participation. Producers may have heterogeneous preferences regarding the share of irrigated land enrolled. The DCE included five levels for irrigated land under conservation, ranging from 0% to 100%. The technology adoption literature suggests that producers prefer to pilot new technologies or practices in small areas to reduce agronomic and financial risk (Pannell et al., 2006); therefore, we posit that larger land area commitments may deter participation.

The two remaining DCE attributes, East Slope match and water shepherding, were specified as binary. The East Slope match indicated the inclusion of a provision in the AWCP for volumetric curtailment of transmountain water diversions, matched at a 1:1 ratio for any water conserved on Colorado's West Slope. In this context, transmountain diversions are engineered systems that transfer water across the Continental Divide, from Colorado's West Slope, where water is historically more abundant, to the East Slope, where demand is historically highest (Jirak & Cotton, 2006). We expect producers to favor AWCPs with a match provision as a commitment to shared responsibility around water conservation. The water shepherding attribute specified whether conserved water would be legally protected and delivered downstream past other junior water users, supporting Upper Basin responsibilities under the Compact's 10-year, 7.5 million acre-feet per year delivery requirement (USBR, 1992).

Choice Sets and Regression Methods

We use a Bayesian Multinomial Logit (MNL) D-efficient design to construct the final DCEs, using the idefix package (version 1.0.3) in R (Traets et al., 2020). This approach enhances statistical efficiency and improves estimation accuracy by selecting the optimal subset of possible choice alternatives that minimizes the determinant of the model parameter estimates' variance–covariance matrix and has been used in previous studies (Scarpa et al., 2007; Nian et al., 2025). As a result, the final DCE design comprises twelve choice sets, each containing three alternatives. This approach balanced the need to estimate preference heterogeneity in a mixed logit framework with concerns about respondent burden and complexity (Bahrampour et al., 2020; De Bekker-Grob et al., 2012). DCE studies commonly use 8 to 16 choice sets, so the design used in Mason (2025) aligns with established practice. Figure 1 shows an example choice set. For instance, Option 1 featured full season limited irrigation, $300 per acre in compensation, 50% of the irrigated area under

[2]For example, crop water use for grass pasture in western Colorado ranges from 19 to 30 inches per acre per season (Schneekloth and Andales, 2017). This implies an upper bound on per-acre compensation of up to $1,275 (i.e., 2.5 acre-feet CU per acre at $509 per acre-foot CU) if the land were fallowed without any vegetative growth.

conservation, no East Slope match, and no water shepherding. The third option in every set was a status quo alternative (i.e., neither Option 1 nor Option 2).

We estimated MIXL and MNL models on the DCE data with fully correlated random parameters using the gmnl package in R (Sarrias & Daziano, 2017). The dependent variable was formulated as a vector of binary indicators, one for each of the three choices presented in each choice set, where non-selection was indicated as a zero value and choice selection was set to a value of one. The MIXL model also estimated standard deviations for random parameters, allowing us to assess preference heterogeneity. We used the MNL model results as a benchmark to check the consistency of results. To estimate errors around WTA, we applied the delta method using the msm package in R.

We then estimated individual-level coefficients for each attribute from the MIXL model and used the individual-level coefficients to calculate individual-level WTA values for all 350 respondents. These were then regressed on operation and producer characteristics using OLS as:

$$y_i^l = Z_i^l \gamma^l + \varepsilon_i^l \tag{5}$$

where y_i^l are the WTA values of individual i for attribute l, Z_i^l is a vector of explanatory variables, and γ^l is a vector of coefficients for outcome l. The variables in Z_i^l are defined in Table 2.To assess multicollinearity, we calculated Variance Inflation Factors (VIF) and Condition Indices. Values below 10 and 20, respectively, indicate no concern (Mela Kopalle, 2002).

Results

Operation and Producer Characteristics

Table 2 summarizes operation and producer characteristics of the survey respondents. The average age was approximately 63 years, and nearly three-quarters were male. Approximately 20% identified as Democrats, nearly one-third identified as independents, and the remainder identified as Republicans or with other parties. On average, over three-quarters of annual farm water use was allocated to grass hay or alfalfa production, reflecting the region's emphasis on irrigated forage crops. Additionally, over one-third operated a farm larger than 200 acres, and farm income accounted for just over 25% of total household income. Most respondents (almost 75%) received irrigation from a shared ditch or similar conveyance structure. The sample characteristics are similar to statewide population data but lean slightly older with a greater proportion of males. According to the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS, 2023), the average age of agricultural producers in Colorado is 57 years, over 58% are male, and about one-third operate farms larger than 180 acres.

Regression Results

Table 3 presents the results for the MIXL and MNL models. The AIC value of the MIXL model (4445.5) is smaller than that of the MNL model (6858.7), indicating that the MIXL model provides a better fit to the data. We can interpret the coefficients as a one-unit change in the variable of interest associated with a beta change in the log-odds ratio of picking something other than the status quo. For instance, full-season limited irrigation is associated with a –3.503 change in the log-odds ratio of participating in some form of agricultural water conservation other than the status quo (selecting "neither") [3]. The negative and statistically significant coefficients on the three reduced irrigation practices show respondents' negative preferences for implementing any water conservation practice, relative to maintaining their standard practice. The strongest negative preference is for full-season curtailment (–4.565), followed by split-season curtailment (–3.552) and full-season limited irrigation (–3.503), which is as expected due to the more intensive irrigation restriction under full-season curtailment. The standard deviation results for the MIXL model (Column 2b of Table 3) are also statistically significant for split-season curtailment ($p < 0.01$) and full-season limited irrigation ($p < 0.01$), indicating heterogeneity in preferences across respondents. [4] Respondents also showed a negative preference for the share of land under conservation, and the standard deviation for this attribute is significant, indicating heterogeneity.

As expected, respondents had positive preferences for larger compensation, an East Slope match, and water shepherding. A one dollar increase in compensation increases the log odds of participating in an AWCP, relative to the status quo, by 0.002 units. Additional regression results are reported in the SM file. They include Table S1 (results for larger sample of N = 433 observations that includes respondents who completed DCE but not one or more operation or producer characteristic questions), Table S2 (results for a restricted sample of N = 214, derived from the main sample of N = 350 but who responded yes to at least one AWCP scenario in the DCE) and Table S3 (results for a restricted sample of N = 258, derived from the sample of N = 433 but who responded yes to at least one AWCP scenario in the DCE). The model results are highly consistent across these specifications.

[3] Note this interpretation is due to the status-quo values all set to zero.

[4] The mixed logit enables the estimation of the standard deviations of the random coefficients, providing evidence of the presence and extent of preference heterogeneity among respondents.

Willingness-to-Accept (WTA) values

Table 4 shows the estimated WTA for both regression models. Comparable coefficients are similar in magnitude, indicating that the results are robust to the choice of model. Among the different water conservation programs, respondents had the highest WTA of approximately $3,000 per acre for full-season curtailment, the lowest WTA of about $2,300 per acre for full-season limited irrigation, and an intermediate WTA of about $2,350 per acre for split-season curtailment. The WTA estimates for different conservation programs are consistent with the relative restriction in agricultural production; completely curtailing irrigation will have a larger impact on agricultural production than partial curtailment (i.e., split season curtailment or limited irrigation).

In terms of compensation, respondents are willing to accept approximately an additional $8 per 1% increase in land under conservation per acre (Table 4). Adding the policy-relevant program attributes reduced WTA estimates. For example, the East Slope match and water shepherding program attributes yielded a reduction in the WTA to participation in a conservation program of $908/acre and $156/acre, respectively. When combined, respondents had a WTA of $1,445 per acre for split-season curtailment with an East Slope match, $1,412 per acre for full-season limited irrigation with an East Slope match, and $2,116 per acre for full-season curtailment with an East Slope match. Similarly, respondents had a WTA of $2,197 per acre for split-season curtailment with water shepherding, $2,164 per acre for full-season limited irrigation with water shepherding, and $2,868 per acre for full-season curtailment with water shepherding.

Many of the WTA estimates exceed the highest compensation value offered in the survey (with the maximum being $1,600 per acre), particularly for scenarios involving full-season curtailment. This may be attributable to a substantial number of respondents selecting the "neither" option across all choice sets—over 38% of respondents (136 out of 350) chose to maintain their standard irrigation practices in every scenario. This pattern suggests that many respondents are unwilling to relinquish irrigation, even at relatively high compensation levels. Like the low adoption of agricultural conservation practices (e.g., no-till, cover cropping, and nutrient management) despite widespread awareness, this is also observed in other conservation programs in the United States (Thompson et al., 2021; Wade et al., 2015). For example, while incentive payments may promote some adoption, their impact appears to diminish. Wade et al. (2015) also similarly report that adoption often occurs on only part of the available acreage.

When we excluded respondents who selected "neither" for all choice sets—approximately 38.9% of those who completed the survey—our WTA estimates were reduced (as shown in Table 4). In the restricted sample, the estimated WTAs for split-season curtailment, full-season limited irrigation, and full-season curtailment were approximately $1,146, $1,065, and $1,926 per acre, respectively (Table 4). For example, the split-sample

WTA results suggest that if the payment is approximately \$1000 per acre, around 62% of the sampled respondents might participate in the AWCPs. The interpretation of WTA in the restricted sample analysis can be viewed as the WTA for those who are at least willing to consider participating at reasonable compensation levels, which in this case is about 62%. This also explains, at least in part, the relatively low participation rate observed under the 2024 benchmark payment of \$509 per acre-foot of CU from Colorado's experience in the SCPP, where CU rates between 1.5 - 2.0 acre feet per acre are commonly expected in Colorado and vary according to elevation, soil type, crop type, and other environmental factors. Conversely, some producers were willing to participate at relatively low WTA values, consistent with adoption literature showing that non-monetary motivations—such as amenity values, stewardship ethics, and social leadership—can drive participation even in the absence of clear financial returns (Mooney & Barham, 2023; Fitzsimmons et al., 2025).

Determinants of WTA

Table 5 present the determinants of WTA for different conservation practices (split-season curtailment, full-season limited irrigation, and full-season curtailment) and other program attributes. These determinants were statistically significant and positively related to age ($P < 0.05$) and farm income ($P < 0.01$ for split-season curtailment, full-season limited irrigation, and full-season curtailment). The results of the multicollinearity diagnostics show that the VIF values and condition indices for all variables included in the models are below 10 and 20, respectively. Therefore, our model is free from serious multicollinearity. The results are intuitive, but it is important to note that we interpret these estimates as a correlation, rather than a causal relationship. Older respondents and those whose income is primarily derived from farming had a positive WTA for three conservation programs. With an increase in the respondent's age by one year, the marginal willingness to accept the split-season curtailment, full-season limited irrigation, and full-season curtailment increased by \$29, \$27, and \$27 per acre, respectively. The positive relationship between age and WTA is consistent with previous studies, which show that younger respondents are more concerned about water conservation and are more willing to pay for it (Groothuis et al., 2015). A one-unit increase in the share of farm income increased WTA for split-season curtailment, full-season limited irrigation, and full-season curtailment by \$17, \$17, and \$16 per acre, respectively. The positive relationship suggests that producers may exhibit stronger aversion toward conservation as farm income becomes a larger share of total income.

Respondents who identified as Democrats or Independents had a lower WTA for participation, suggesting they will participate in greater numbers, ceteris paribus, than Republicans (Table 5). Specifically, Democratic respondents ($P < 0.01$) had a lower WTA for all three conservation programs by \$2,000 per acre for split-season curtailment, $1,800 per acre for full-season limited irrigation, and $1,880 per acre for full-season curtailment compared to respondents with different ideological alignments. Similarly, Independent respondents had a lower WTA by $625 per acre for split-season curtailment ($P < 0.1$), $560 per acre for full-season curtailment ($P < 0.1$), and $602 per acre for full-season limited irrigation ($P < 0.1$) compared to other politically affiliated respondents (Table 5). The lower WTA among Democrats could be associated with more pronounced support for conservation within the party generally (Hoag et al., 2023; Walker, 2017). Respondents with large farm sizes had a lower WTA for participation. Specifically, they reported lower values for split-season curtailment, full-season limited irrigation, and full-season curtailment by $806, $739, and $735 per acre, respectively, compared to respondents with smaller farm sizes. The negative relationship between farm size and WTA is consistent with previous findings, for instance Amsalu and De Graaff (2007) found that farmers with larger farms are more likely to invest in water conservation in Ethiopia, and Lambert et al. (2007) found that farm size is positively related to participation in agricultural conservation programs in the United States. This could be associated with the coinciding reduction in the relative size of any specific level of participation, e.g. 50 acres is less of a loss to a big farm than a small one. Tables S5 and S6 present additional regression results for the determinants of WTA as robustness checks.

Policy Implications

The success of voluntary AWCPs in the Upper Colorado River Basin, if implemented, will depend on producers' willingness to participate in water conservation programs. Understanding the policy implications of our study is particularly timely, given the region's intensifying water scarcity challenges and ongoing negotiations to revise interstate water-sharing arrangements under the 1922 Colorado River Compact (Hansen & Ashgari, 2024). We discuss three policy insights related to the design of AWCPs and the academic modeling of regional water conservation outcomes.

First, compensation expectations are likely to pose an economic barrier to participation for a significant share of producers. The estimated WTA for full-season irrigation curtailment among all respondents ranged from $2,320 to $3,024 per acre, well above the approximately $1,600 per acre maximum offered under Colorado's recent SCPP experience. However, these WTA values were influenced by the approximately 40% of respondents who consistently opted out of participation across DCE scenarios. Among producers open to participating (defined as respondents who selected at least one hypothetical AWCP program across the 12 DCE tasks) average WTA fell within a more policy-feasible range of $860-$1,600 per acre, depending on the degree of curtailment. This suggests that while some AWCP participation is indeed likely, overall participation rates are likely to face an adoption ceiling. Many producers may never participate regardless of payment levels, while others will enroll if offered compensation that meets their operational and economic thresholds (Pannell et al., 2006). For example, if our participants were the producers offered a chance to participate, we would expect only 33.4% to participate in at least one of the conservation program at the maximum offer of $1,600 (choosing 28% for full season limited, 22% for full season curtailment, and 31% for split season curtailment).

This observation aligns with broader findings in the agricultural economics literature, which demonstrate how cultural, ideological, or operational constraints can limit participation, even when financial incentives are present (e.g., Ma et al., 2012; Barham, 1996). To improve estimates of potential conservation outcomes, future modeling efforts could incorporate AWCP participation as a two-step process: first, consider the share of producers who might consider participating, and second, consider the terms or intensity under which they would participate. This approach can more accurately reflect heterogeneity in producer decision-making and help place more realistic bounds on program scale.

Second, AWCP design features can influence both participation and cost-effectiveness. Two attributes tested in our DCE (East Slope match, water shepherding) significantly reduced WTA. Specifically, the East Slope match reduced average WTA by $908 per acre, while water shepherding decreased WTA by $156 per acre. This suggests producers are more willing to participate when they perceive the program as fair and as achieving meaningful outcomes. That is, when AWCPs view water conservation as a shared responsibility and ensure that their actions will yield downstream benefits, producers are more likely to perceive participation as legitimate and worthwhile. This observation is consistent with prior research that identifies equity and institutional credibility as critical drivers of voluntary conservation in the UCRB (Bennett et al., 2023; Paige et al., 2021). Importantly, it also implies that policymakers have modifiable program levers that they can employ to shape participation without simply increasing compensation.

Third, farm and producer characteristics were also strong predictors of WTA. Older producers were less likely to participate, demanding higher compensation, with each additional year of age associated with a $30 per acre increase in WTA. Political affiliation was another significant factor: Independents and Democrats required $550–$1,900 less per acre in compensation than Republicans, reflecting potential ideological differences in attitudes toward government-supported conservation. Higher farm income was associated with higher WTA—likely due to higher opportunity costs—whereas larger operations required $730–$805 less per acre, possibly reflecting scale economies or greater management flexibility. These findings suggest both constraints and opportunities. For example, targeting larger farms may yield greater conservation benefits at a lower cost, although this approach may raise equity concerns. Conversely, tailoring outreach and messaging to politically diverse or older producers could help expand the pool of potential participants, especially when coupled with trusted intermediaries.

Several limitations and caveats should also be considered when applying these findings to the design of the AWCP program and policy. First, reductions in field-level water use may not yield basin-scale conservation benefits due to the complex hydrological and institutional water governance structures of the UCRB (e.g., patterns of return flows, transit losses, and administration of downstream water rights). Conservation outcomes in the absence of water shepherding are also impacted by the irrigation paradox, where field-level conservation or efficiency gains can encourage crop intensification by other downstream water users, undermining regional savings (Grafton et al., 2018). Future research could assess the extent to which localized irrigation reductions under AWCPs might yield measurable reductions in net water consumption across a region or basin.

Second, while producer preferences favor policy features such as an East Slope water conservation match or water shepherding, these potential AWCP components remain largely aspirational under the current legal, institutional, and technological constraints prevailing in the U.S. West. The ability to quantify, track, and transfer conserved water remains limited under present frameworks. As a result, policymakers and stakeholders should interpret stated preferences for these attributes as expressions of producer interest rather than as a recommendation for immediate enactment. That said, other studies in the UCRB have found similar producer sentiments about the importance of shared conservation burdens and program effectiveness in their potential willingness to participate (Bennett et al., 2023; Paige et al., 2021).

Last, our study relied on stated preference data collected through a DCE conducted in one region of the UCRB. While this allowed us to isolate key tradeoffs and consider diverse policy scenarios, actual producer behavior may differ due to market conditions, policy uncertainty, or shifting social norms. Moreover, participation decisions are often shaped by additional factors beyond the DCE attributes included in this study, such as peer behavior and networks, community norms, or outreach from trusted sources, including conservation districts or extension agencies (Bennett et al., 2023; Holm, 2022). To better account for this complexity, future research should integrate these behavioral considerations into modeling frameworks such as agent-based models or integrated assessment models (Berger & Troost, 2001; Kiesling et al., 2012). Extending the scope of future studies to include producers throughout the UCRB or across basins facing water scarcity could lead to more realistic estimates of participation and net water conservation at scale.

Summary and Conclusions

This research advances our understanding of producers' willingness to participate in AWCPs by examining how program attributes and policy features influence enrollment decisions. Policy makers increasingly view AWCPs as a tool for addressing water scarcity challenges in arid and semi-arid regions, including the western

United States. For instance, recent pilot programs in the UCRB aimed to incentivize the adoption of voluntary and temporary irrigation reduction practices, which can conserve CU at the field-level (Mooney & Hansen, 2024). However, the effectiveness of AWCPs in achieving regional water conservation goals will rely not only on agronomic and hydrological factors but also on participation rates (Bennett et al., 2023).

To investigate this issue, we analyzed DCE data gathered from 350 agricultural producers on Colorado's Western Slope. The DCE included three reduced irrigation practices that varied by water conservation intensity—split-season curtailment, full-season limited irrigation, and full-season curtailment—relative to a status quo opt-out option. Additional DCE attributes included compensation level, land are commitment, and policy features (i.e., East Slope match, water shepherding). We estimated MIXL and MNL regression models to determine the compensation levels required to induce participation (i.e., WTA) and identified the influence of the program attributes and policy features. Higher payments, East Slope water-sharing, and water shepherding significantly increased the likelihood of adoption. At the same time, more intensive conservation practices (i.e., full-season curtailment) and larger acreage requirements reduced participation. We also assessed the determinants of WTA using variables representing farm and producer characteristics and found that WTA varied by farm size, income, age, and ideological alignment.

The findings can help inform economic, agricultural, water, and other stakeholders about designing AWCPs to achieve alignment between program or policy attributes and producer preferences. The positive relationship between compensation and the likelihood of participation highlights the importance of adequate financial incentives, particularly for operations that are economically dependent on irrigation. The greater willingness of larger farms to participate at lower compensation suggests opportunities for potentially improving the cost-effectiveness of AWCPs through targeted approaches. Positive responses to policy attributes—East Slope water conservation matching and water shepherding—highlight the importance of sharing conservation burdens and ensuring that conserved water reaches intended users, respectively. Incorporating these factors into AWCPs could improve program legitimacy and participant buy-in. However, we also recognize that implementing these design elements into AWCPs would be a long-term process, likely requiring institutional reforms and legal innovations.

Lastly, future research on AWCP participation could enhance regional or basin-scale water conservation modeling efforts by addressing the limitations identified in our current study. Integrating behavioral analyses of participation into hydrological modeling would refine estimates for the overall potential of AWCPs in terms of net conservation. For instance, the support for program and policy features that we identified (e.g., East Slope match, water shepherding) suggests that producer sentiment around those features could limit the share who participate or the intensity of their participation. These factors could be incorporated into models as bounds to provide grounded estimates of net conservation potential. Additionally, investigations into the role of social networks, trusted information sources, and local intermediaries could help document whether these factors increase participation rates or the speed of participation decisions. Addressing these aspects will help create AWCPs that are economically viable, institutionally sound, and behaviorally grounded, in addition to being hydrologically and agronomically feasible.

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Table 1. Choice experiment attributes and attribute levels

Attribute	Attribute description	Attribute levels
Conservation action	The irrigation reduction activity that will be contracted and enacted for a single irrigation season	Full season curtailment (April 1 to Oct 31 dry up) Full season limited (50% water reduction) Split season curtailment (July 1 to Oct 31 dry up) Opt-out (maintain normal irrigation practice)
Compensation	Payment per acre for land placed under water conservation	\$0 \$150 \$300 \$600 \$1,200 \$1,600
Conservation intensity	Portion of typically irrigated area placed under water conservation	0 0.25 0.50 0.75 1
East Slope match	Whether water conservation will be matched in volume by curtailment of transmountain water diversions to the Front Range	Yes No
Water shepherding	Whether the conserved water will be shepherded downstream past all other water users and controlled by the Upper Basin states to reduce risks of a Compact Call on the Colorado River	Yes No

Note: All options assume that water rights will not be at risk of diminishment or abandonment. Source: Mason (2025).

Table 2.Summary statistics of operation and producer characteristics

Variable	Definition	Full sample (N=350)	Restricted sample (N=214)	Protest sample (N=136)
Age	Age of the respondents in years	62.9 (13.5)	61.7 (13.3)	64.8 (13.5)
Male	1 if the respondent is male, 0 otherwise	0.743 (0.438)	0.738 (0.441)	0.750 (0.435)
Democrat	1 if the respondent is affiliated with the Democratic Party, 0 otherwise	0.194 (0.369)	0.248 (0.433)	0.110 (0.314)
Independent	1 if the respondent is independent of party affiliation, 0 otherwise	0.325 (0.469)	0.308 (0.463)	0.353 (0.480)
Hay/alfalfa	Percentage of annual water use by grass hay or alfalfa on the farm	75.4 (23.6)	76.1 (22.3)	74.3 (25.6)
Large farm	1 if the farm size is larger than 200 acres, 0 otherwise	0.377 (0.485)	0.379 (0.486)	0.375 (0.486)
Farm income	Percentage of total income derived from farm income	28.8 (30.3)	28.3 (29.7)	29.6 (31.3)
Shared ditch	Percentage of water that comes from shared ditch or similar arrangement	73.1 (27.3)	72.2 (27.3)	74.6 (27.4)

Note: The full sample (N = 350) includes respondents who completed the Discrete Choice Experiment (DCE). The restricted sample (N = 214) includes those who also chose to participate in at least one conservation practice. The protest sample (N = 136) includes those who chose the opt-out option for all choice sets. Data source: Mason (2025).

Table 3.Multinomial (MNL) and Mixed Multinomial Logit (MIXL) regression results

Variables	**MNL** Coef. (1)	**MIXL** Coef. (2a)	**MIXL** Std. dev (2b)
Split season curtailment	–1.958***	–3.552***	–5.354***
	(0.107)	(0.280)	(0.390)
Full season limited irrigation	–2.002***	–3.503***	–1.568***
	(0.105)	(0.260)	(0.144)
Full season curtailment	–2.505***	–4.565***	–0.306
	(0.120)	(0.283)	(0.234)
Compensation	0.001***	0.002***	–0.0004
	(0.0001)	(0.0002)	(0.003)
Percent under conservation	–0.007***	–0.012***	0.002***
	(0.001)	(0.002)	(0.0002)
East Slope match	0.730***	1.371***	0.612***
	(0.061)	(0.165)	(0.131)
Water shepherding	0.254***	0.236*	0.480***
	(0.059)	(0.137)	(0.128)
N observations (respondents)	4200 (350)	4200 (350)	4200 (350)
AIC	6858.688	4445.533	4445.533
Log Likelihood	–3422.3	–2187.8	–2187.8

Note: The first column presents the estimated coefficients for the MNL model. The second (2a) and third (2b) columns present the estimated coefficients and from the MIXL model. Values in parentheses indicate standard errors. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Willingness-to-Accept (WTA) to participate in agricultural water conservation programs (AWCPs) ($/acre)

Variable	WTA (MNL)	WTA (MIXL)
Full sample (N = 350)		
Split season curtailment	$2,440 (0.107)	$2,353 (0.280)
Full season limited irrigation	$2,495 (0.105)	$2,320 (0.260)
Full season curtailment	$3,122 (0.120)	$3,024 (0.283)
Percent under conservation	$9 (0.001)	$8 (0.002)
East Slope match	–$910 (0.061)	–$908 (0.165)
Water shepherding	–$317 (0.059)	–$156 (0.137)
Restricted sample (N = 214)		
Split season curtailment	$1,217 (0.119)	$1,146 (0.237)
Full season limited irrigation	$1,200 (0.116)	$1,065 (0.221)
Full season curtailment	$1,884 (0.134)	$1,926 (0.256)
Percent under conservation	$8 (0.001)	$8 (0.002)
East Slope match	–$785 (0.065)	–$916 (0.157)
Water shepherding	–$288 (0.064)	–$232 (0.114)

Note: The full sample (N = 350) includes all respondents who completed the DCE. The restricted sample (N = 214) includes those who responded to the DCE and opted into at least one AWCP option. Values in parentheses indicate standard errors calculated using the Delta Method.

Table 5.Determinants of WTA for AWCP attributes

	Estimated coefficients for determinants of WTA					
Variables	**Full season limited**	**Full season curtailment**	**Split season curtailment**	**Percent conservation**	**East Slope match**	**Water shepherding**
Age	27.033**	26.579**	28.819**	–0.018	–2.124	2.114
	(10.632)	(10.295)	(11.161)	(0.015)	(2.885)	(1.884)
Male	–161.008	–175.243	–212.464	0.169	0.976	–71.127
	(331.137)	(320.653)	(347.622)	(0.46)	(89.856)	(58.664)
Democrats	–1887.06***	–1822.69***	–2005.203***	2.179***	–1.899	–26.041
	(389.486)	(377.154)	(408.876)	(0.541)	(105.69)	(69.001)
Independent	–602.517*	–562.11*	–625.334*	1.027**	–72.125	61.271
	(323.365)	(313.127)	(339.463)	(0.449)	(87.748)	(57.287)
Hay/alfalfa	–1.22	1.977	–2.664	–0.002	1.208	0.138
	(6.126)	(5.932)	(6.431)	(0.009)	(1.662)	(1.085)
Large farm	–739.191*	–734.762**	–805.622**	0.472	55.422	–55.679
	(384.734)	(372.553)	(403.888)	(0.535)	(104.401)	(68.159)
Farm income	16.633***	15.763***	17.347***	–0.022**	1.729	1.752
	(6.21)	(6.013)	(6.519)	(0.009)	(1.685)	(1.1)
Shared ditch	7.443	7.509	7.414	0.005	–2.268	0.034
	(5.298)	(5.13)	(5.562)	(0.007)	(1.438)	(0.939)
Constant	1138.328	1971.665**	1385.882	7.614***	–771.844***	–265.313
	(1012.705)	(980.641)	(1063.121)	(1.407)	(274.805)	(179.411)
No. Obs.	350	350	350	350	350	350

Note: Values in parentheses indicate standard errors. Each column represents the determinants of WTA for AWCP attributes, calculated based on individual WTA. The condition index and VIF for the estimates are less than 30 and 5, respectively, indicating that our models are free from serious multicollinearity. *** p<0.01, ** p<0.05, * p<0.1.

Choice set 1 of 12:

Option 1 ○

Option 2 ○

Neither ○

	Option 1	Option 2	Neither of these
Conservation Action	Full Season Limited Irrigation (50% water reduction)	Full Season Limited Irrigation (50% water reduction)	Maintain normal irrigation practices
Compensation Per Participating Acre	$300	$150	
Irrigated Acreage Under Conservation	50%	25%	
East Slope Match	No	Yes	
Water Shepherding/Protection	No	No	

Figure 1. Example of a choice set provided to participants. Note: Each participant was provided with 12 sets of choices, with each set offering three choices and containing attributes varied in an orthogonal design. Source: Mason (2025).

Supplementary Materials (SM) File

Willingness to Participate in Agricultural Water Conservation Programs: Choice Experiment Evidence from the Upper Colorado River Basin

Table S1. Multinomial (MNL) and Mixed Multinomial Logit (MIXL) analysis results for those who completed DCE

Variables	**MNL** Coef. (1)	**MIXL** Coef. (2a)	**MIXL** Std. dev (2b)
Split season curtailment	–2.075***	–3.512***	–4.596***
	(0.098)	(0.268)	(0.296)
Full season limited irrigation	–2.089***	–3.455***	1.719***
	(0.095)	(0.247)	(0.158)
Full season curtailment	–2.616***	–4.686***	0.155
	(0.109)	(0.275)	(0.166)
Compensation	0.0008***	0.002***	–0.006**
	(0.0001)	(0.0001)	(0.002)
Percent under conservation	–0.007***	–0.012**	0.0003*
	(0.001)	(0.002)	(0.0002)
East Slope match	0.761***	1.623***	1.338***
	(0.056)	(0.160)	(0.110)
Water shepherding	0.220***	0.231*	–0.049
	(0.054)	(0.115)	(0.177)
N observations (respondents)	15588 (433)	15588 (433)	15588 (433)
AIC	8316.912	5418.065	5418.065
Log Likelihood	–4151.5	–2674	–2674

Note: This sample includes all respondents who completed the DCE, including those who skipped one or more questions regarding operation characteristics or producer demographics. The first column represents the estimated coefficients for the Multinomial Logit (MNL) model. The second (2a) and third (2b) columns represent the estimated coefficients and estimated standard deviation from the Mixed Logit (MIXL) model, respectively. Values in parentheses indicate standard errors. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table S2. Multinomial (MNL) and Mixed Multinomial Logit (MIXL) analysis results for the restricted sample

Variables	**MNL** Coef. (1)	**MIXL** Coef. (2a)	**MIXL** Std. dev (2b)
Split season curtailment	–1.225***	–1.847***	–2.942***
	(0.119)	(0.237)	(0.241)
Full season limited irrigation	–1.207***	–1.717***	–0.516***
	(0.116)	(0.221)	(0.181)
Full season curtailment	–1.896***	–3.105***	–0.588***
	(0.134)	(0.256)	(0.195)
Compensation	0.001***	0.002***	0.002
	(0.0001)	(0.0001)	(0.002)
Percent under conservation	–0.008***	–0.013***	–0.0001
	(0.001)	(0.002)	(0.0002)
East Slope match	0.791***	1.477***	–0.130
	(0.065)	(0.157)	(0.198)
Water shepherding	0.289***	0.373***	0.200
	(0.064)	(0.114)	(0.148)
N observations (respondents)	2568 (214)	2568 (214)	2568 (214)
AIC	4978.457	4089.755	4089.755
Log Likelihood	–2482.2	–2009.9	–2009.9

Note: This sample includes respondents who completed the DCE and opted into at least one AWCP option. The first column represents the estimated coefficients for the Multinomial Logit (MNL) model. The second (2a) and third (2b) columns represent the estimated coefficients and estimated standard deviation from the Mixed Logit (MIXL) model, respectively. Values in parentheses indicate standard errors. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table S3. Multinomial (MNL) and Mixed Multinomial Logit (MIXL) analysis results for respondents who completed DCE and participated in at least one conservation program

Variables	**MNL** Coef. (1)	**MIXL** Coef. (2a)	**MIXL** Std. dev (2b)
Split season curtailment	–1.332***	–1.661***	–3.686***
	(0.109)	(0.224)	(0.287)
Full season limited irrigation	–1.252***	–1.523***	–1.442***
	(0.106)	(0.208)	(0.128)
Full season curtailment	–2.005***	–2.835***	0.422*
	(0.123)	(0.228)	(0.168)
Compensation	0.001***	0.002***	0.0002
	(0.00006)	(0.0001)	(0.003)
Percent under conservation	–0.007***	–0.012***	–0.001***
	(0.001)	(0.002)	(0.0001)
East Slope match	0.840***	1.561***	1.189***
	(0.060)	(0.137)	(0.140)
Water shepherding	0.249***	0.349***	–0.635***
	(0.059)	(0.101)	(0.126)
N observations (respondents)	3096 (258)	3096 (258)	3096 (258)
AIC	5957.347	4817.186	4817.186
Log Likelihood	–2971.7	–2373.6	–2373.6

Note: The result is based on the respondents who completed DCE but not all operation and producer characteristics and participated in at least one conservation program. The first column represents the estimated coefficients for the Multinomial Logit (MNL) model. The second (2a) and third (2b) columns represent the estimated coefficients and estimated standard deviation from the Mixed Logit (MIXL) model, respectively.

Table S4. Willingness-to-Accept (WTA) to participate in agricultural water conservation programs (AWCPs) ($/acre)

Variables	WTA (MNL)	WTA (MIXL)
Respondents who completed the DCE (N=433)		
Split season curtailment	$2,447 (0.098)	$2,322 (0.268)
Full season limited irrigation	$2,463 (0.095)	$2,285 (0.247)
Full season curtailment	$3,086 (0.110)	$3,098 (0.275)
Percent under conservation	$8 (0.001)	$8 (0.002)
East Slope match	–$897 (0.056)	–$1,073 (0.160)
Water shepherding	–$259 (0.054)	–$153 (0.115)
Respondents who completed DCE and participated in at least one conservation program (N=258)		
Split season curtailment	$1,289 (0.109)	$943 (0.224)
Full season limited irrigation	$1,211 (0.106)	$865 (0.208)
Full season curtailment	$1,940 (0.123)	$1,610 (0.228)
Percent under conservation	$7 (0.001)	$7 (0.002)
East Slope match	–$813 (0.060)	–$886 (0.137)
Water shepherding	–$241 (0.059)	–$198 (0.101)

Note: Values in parentheses indicate standard errors calculated using the Delta Method.

Table S5. Determinants of WTA for AWCPs attributes for Restricted sample (N=214)

Variables	Full season limited	Full season curtail-ment	Split season cur-tailment	Percent conserva-tion	East Slope match	Water shepherd-ing
Age	11.949	12.048	12.535	–0.005	–1.557	–1.959
	(7.489)	(7.752)	(8.079)	(0.024)	(4.562)	(2.427)
Male	200.854	184.923	254.532	–0.388	–35.762	–97.582
	(233.328)	(241.537)	(251.725)	(0.738)	(142.141)	(75.609)
Democrats	–829.970***	–782.712***	–922.860***	1.012	3.848	18.774
	(254.619)	(263.577)	(274.694)	(0.805)	(155.111)	(82.508)
Independent	–602.336**	–484.582**	–672.270***	2.210***	–183.746	29.843
	(233.145)	(241.348)	(251.527)	(0.737)	(142.029)	(75.549)
Hay/Alfalfa	6.837	6.767	6.352	–0.004	–0.937	–1.459
	(4.558)	(4.719)	(4.918)	(0.014)	(2.777)	(1.477)
Large farm	–741.300***	–769.121***	–693.069**	–0.580	245.762	60.815
	(262.946)	(272.197)	(283.678)	(0.832)	(160.183)	(85.206)
Farm income	12.766***	12.132***	13.213***	–0.011	1.103	1.398
	(4.267)	(4.417)	(4.604)	(0.013)	(2.599)	(1.383)
Shared ditch	5.635	5.458	5.698	–0.001	–2.081	–0.021
	(3.790)	(3.923)	(4.089)	(0.012)	(2.309)	(1.228)
Constant	–429.401	430.604	–371.289	8.554***	–645.099	–36.735
	(723.482)	(748.935)	(780.525)	(2.288)	(440.736)	(234.440)
No. Obs.	214	214	214	214	214	214

Note: This sample includes respondents who completed the DCE and participated in at least one conservation program. Values in parentheses indicate standard errors. Each column represents the determinants of WTA for AWCP attributes, calculated based on individual WTA from the restricted sample. The condition index and VIF for the estimates are less than 30 and 5, respectively, indicating that our models are free from serious multicollinearity. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table S6. Determinants of WTA for AWCPs attributes among respondents who completed DCE

Variables	Full season limited	Full season curtailment	Split season curtailment	Percent conservation	East Slope match	Water shepherding
Age	29.690***	28.820***	28.720***	0.003	–3.512	0.794
	(9.861)	(9.654)	(9.710)	(0.026)	(3.086)	(1.477)
Male	5.074	7.334	–35.170	–0.982	–70.900	–51.750
	(307.100)	(300.700)	(302.400)	(0.802)	(96.130)	(45.990)
Democrats	–1932.000***	–1916.300***	–1910.200***	–0.042	190.300*	–92.560*
	(361.300)	(353.700)	(355.700)	(0.943)	(113.100)	(54.100)
Independent	–544.900*	–555.700*	–585.200**	0.973	–45.530	–16.540
	(299.900)	(293.600)	(295.300)	(0.783)	(93.870)	(44.910)
Hay/Alfalfa	2.939	2.044	–0.023	0.008	–1.171	–0.188
	(5.682)	(5.563)	(5.595)	(0.015)	(1.779)	(0.851)
Large farm	–873.200**	–825.800**	–790.200**	–0.501	188.700*	1.630
	(356.900)	(349.300)	(351.400)	(0.931)	(111.700)	(53.440)
Farm income	15.770***	14.970***	13.900**	0.009	–0.420	1.320
	(5.760)	(5.639)	(5.671)	(0.015)	(1.803)	(0.863)
Shared ditch	6.585	6.614	6.899	0.016	–2.585*	0.379
	(4.914)	(4.811)	(4.839)	(0.013)	(1.538)	(0.736)
Constant	673.300	1586.100*	989.700	6.834***	–659.900**	–165.900
	(939.300)	(919.600)	(924.900)	(2.452)	(294.000)	(140.700)
No. Obs.	350	350	350	350	350	350

Note: Values in parentheses indicate standard errors. Each column represents the determinants of WTA for AWCP attributes, calculated based on individual WTA obtained from respondents who completed DCE ($N = 433$). The condition index and VIF for the estimates are less than 30 and 5, respectively, indicating that our models are free from serious multicollinearity. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.