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Public Opinion on Colorado Water Rights Transfers: Are Policy Preferences Consistent with Concerns over Impacts?

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We evaluate Coloradans' preferences for policies decreasing the need for agricultural water transfers using two choice experiments with different frames—one highlighting policy choices and one emphasizing *ex post* impacts on prices, urban landscaping, and base charges. We find that a majority of users state a willingness to face private costs to reduce agricultural water transfers. Latent-class analysis is used to describe heterogeneity in opinion groups, showing that a minority of urban, lower-income participants would prefer to fallow agricultural land than to pay for alternative policies. This opinion group increases in size in the impact-framed survey.

Key words: agriculture; best–worst scaling; choice experiment; latent-class model; municipal water demand

Introduction

Utility companies throughout the United States must balance available water supplies with the long-run water needs of rapidly growing population bases. Over the last 20 years, water providers have increasingly relied on purchasing water rights from agricultural producers to meet demand in urban areas (Keenan, Krannich, and Walker, 1999; Brewer et al., 2008). For water providers, transfers provide a permanent, low-risk supply of water; for farmers, the prices that municipalities pay for water rights often far exceed the value of using water rights to grow crops (Ward, 2002). Furthermore, because utilities frequently require developers to donate water rights (or cash-in-lieu) for new housing projects, agricultural water transfers provide a simple mechanism to pass the costs of new water supply on to developers and (ultimately) residents. In this way, utilities may minimize the need for new water infrastructure or water-management policies.

In the state of Colorado, population growth is forecasted to increase water demand by roughly 50% by 2050, swelling the state's water needs by more than 700,000 acre-feet of water per year (Colorado Water Conservation Board, 2010). Absent policy changes, up to 25% of currently irrigated agricultural land will be fallowed to meet these demands, even after accounting for adoption of water-efficient appliances and changes in private and public landscaping (Colorado Water Conservation Board, 2010). Population growth is not unique to Colorado or the western United States; policy makers in arid and semi-arid areas throughout the world are struggling to respond to the growing demands of municipal and industrial water users.

While market transfers of water rights from agricultural production appear to be a simple solution, concerns regarding the consequences of transfers on rural communities led the state of

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Colorado to develop a series of grant programs incentivizing alternatives to permanent transfers (Colorado Water Conservation Board, 2010). The state supports mitigating transfers because sales of agricultural water rights may result in significant negative impacts to rural economies (Howe, Lazo, and Weber, 1990; Howe and Goemans, 2003). For this reason, politicians and policy makers may be wary of how urban and rural communities perceive agricultural land fallowing (see Keenan, Krannich, and Walker, 1999), especially given that the popular press often depicts water transfers as a "rural versus urban" conflict, where greedy developers and speculators seize water from poor, naÃŕve farmers (see Knudson, 1987; Libecap, 2005). In sum, the issue of allocating and managing the scarce water resources of the American West is both economic and political, but the two perspectives may suggest different solutions.

In this article, we investigate Coloradans' preferences for addressing the problem of water scarcity, analyzing the public perceptions surrounding the fallowing of agricultural land and the development of new diversion projects. These perceptions, we argue, will play an important role in shaping the future political debate. To this end, we surveyed a sample of 2,000 Coloradans stratified to match the income, gender, and geographic distributions of the state's population in two separate choice experiments related to water policies and (separately) their associated impacts. We also made a concerted effort to calibrate the policy options presented to remain within ranges consistent with the projections made by state water authorities (the Colorado Water Conservation Board).

The survey method of choice is best–worst scaling (Marley and Pihlens, 2012), a discrete choice experiment technique that, fittingly, was introduced by Finn and Louviere (1992) to study public concern over hotly debated food policy topics (e.g., pesticides, irradiation, etc.) in a contextual (i.e., relative to other issues) manner. While the method has been widely adopted in the agricultural marketing literature (e.g., Lusk and Briggeman, 2009; Costanigro, Appleby, and Menke, 2014, and many others), its use in resource allocation problems has been more limited (one example is Scarpa et al., 2011), especially in water economics.

To insure our results against possible framing effects, we implement an innovative experimental plan, conducting two distinct surveys using a between-subject design. The first survey attempts to simulate the information environment typical of a ballot initiative, where citizens are asked to support specific policies (e.g., new supply projects, agricultural transfers) with limited information about costs or implications. The second survey is framed more heavily on the household-level impacts of such policies (e.g., increases in base charges in the utility bills, fallowing of agricultural land). The dual approach not only serves as a robustness check but also allows to us to gauge public opinions from two different perspectives. Table 1 presents a schematization of water policies and associated impacts.

While we do not postulate that either survey is more truth-revealing than the other, understanding how responses may change depending on framing is important for a number of reasons. On one hand, households may be inclined to support specific policies due to "feel good" factors (social desirability bias, see Fisher, 1993), or a lack of information/misperception of policy impacts (Malone and Lusk, 2016; Jeffrey and Seaton, 2004). For example, few households understand that even non-price conservation programs are generally funded through increased fixed costs on residents' water bills. Conversely, households may reject certain policies because of a status quo bias (Kahneman, Knetsch, and Thaler, 1991), or uncertainty aversion (Etner, Jeleva, and Tallon, 2012), leading to the possibility that useful policies may be discarded *a priori* (see Tisdell and Ward, 2003, on water market reforms in Australia).

Perceptions may change when the framing is centered on the household-level impacts of water policies. In the case of water, preference studies have generally focused on particular characteristics of the water service, such as reliability (e.g., Griffin and Mjelde, 2000) or water quality (Jakus et al., 2009); other work has addressed specific policies (e.g., Thorvaldson, Pritchett, and Goemans, 2010) without confronting consumers with the wide range of opportunity costs associated with alternatives. While some work quantified preferences for transfers and other methods of water provision (Blamey,

Table 1. Policies and Associated Impacts

	Policies			
Associated Impacts	**Supply Projects**	**Non-Price Conservation Programs**	**Price Increases**	**Agricultural Transfer**
Price increases	Yes	No	Yes	No
Base charge increases	Yes	Yes	No	No
Decreases in private landscaping	No	Likely (depends on conservation program participation)	Likely (depends on responsiveness to price)	No
Decreases in public landscaping	No	Likely (depends on conservation program participation)	Likely (depends on responsiveness to price)	No
Fallowing and dry-up agricultural land	No	No	No	Yes

Gordon, and Chapman, 1999; Haider and Rasid, 2002; Hensher, Shore, and Train, 2006), we are not aware of any study examining consumer attitudes from multiple perspectives, as we do here.

The analysis of heterogeneity in opinions—as opposed to measuring the typical (average) preference within a given community/population (e.g., Blamey, Gordon, and Chapman, 1999)—is another central contribution of this study. Since public debate is often shaped by polarized groups with strong preferences (see Hukkinen, Roe, and Rochlin, 1990, on the controversy over irrigation-related salinity in the San Joaquin Valley), identifying and comparing the characteristics of each camp is fundamental. To this end, the best–worst choice data is analyzed via a latent-class model (Swait, 1994; Ben-Akiva et al., 1997), and groups of households with similar opinions are identified and characterized according to sociodemographic descriptors.

Methods: Experimental Design, Best–Worst Scaling, and Latent-Class Models

Experimental Design

Creating a preference-revealing choice experiment requires calibrating attributes and levels so that the tradeoffs in a choice set are realistic and intelligible. Here, it was important to include all relevant water policy options and impacts without overwhelming respondents with information (Flynn et al., 2007). For this reason, we chose a between-subject design in which participants completed only one of the two choice experiments. Unlike other consumer preference studies, in which the choice of attributes and levels is somewhat ad hoc, we strive, to the extent possible, to constrain the design to policies and associated impacts currently under consideration in Colorado at technologically feasible levels. The intent is to simulate policy choices and their tradeoffs under probable scenarios and to obtain results of interests for academics and policy makers alike.

Water policies can be categorized as either aiming to augment current supplies or decrease household water demands. Demand-side management approaches include changes in pricing (price increases, use of block-rate pricing structures) and non-price conservation (watering restrictions, utility incentive programs and messaging). Alternatively, water supplies are augmented through new development (i.e., new reservoirs) and/or purchases of water rights from agricultural users. Each management approach has different direct and indirect impacts on the population (Table 1).

Connecting water policies to their likely impacts in a quantitative way is quite complex and required some approximations. Fortunately, the task was facilitated by a spreadsheet-based

Table 2. Experimental Design: Attributes and Levels

Survey	Polices/Impacts[a]	Levels 0	1
Policies	Supply projects	0%	30%
	Non-price conservation	0%	30%
	Price increases	0%	30%
	Agricultural transfers[b]	*	*
Impacts	Agricultural land dry-up	15%	30%
	Price increase	25%	50%
	Base charge increase	$15	$30
	Reduction in public landscaping	30%	70%
	Reduction in private landscaping	15%	30%

Notes: [a] Percentages in the policies survey represent the portion of the gap that could be met via specific policies. In the impacts survey, included percentages represent a range of plausible percent changes in acres fallowed, costs, and landscaping that could result from combinations of policies used to meet future demands.
[b] Agricultural transfers are calculated as the complement to 100% within each portfolio (e.g., 40% for levels 1–1–0).

calculator designed by the Colorado Water Conservation Board (CWCB).[1] The instrument allows users to develop scenarios for various levels of household conservation, supply development, and agricultural water transfers that could be used to satisfy the future water needs of the state. CWCB has determined that no single active policy intervention (e.g., new supply projects) could reasonably be expected to provide for more than 30% of the water shortage projected for 2050. Market transactions from agricultural to urban use, on the other hand, could potentially fill a larger portion of the water gap (according to the U.S. Geological Survey, approximately 88% of total water withdrawals in Colorado were used for irrigated agriculture in 2010. See Maupin et al. (2014). Table 2 presents the levels of each attribute included in the surveys.

In the policy-framed survey, attributes included supply projects, non-price conservation, and price increases, each with two levels (0% or 30%) specifying how much of the water gap was met by a specific policy. Residual demand, the percentage of the water gap not fulfilled by the three policy options, determined the level of agricultural water transfers, so that each policy scenario would sum to 100%. This design adds realism and fits the real-world tradeoffs faced by policy makers. However, for any given choice set, the full set of four policies are perfectly collinear, implying that only three out of the four preference parameters can be identified. In an attempt to reproduce the information environment citizens face when voting in a ballot initiative (where policies are often presented with some information about implementation costs), projected increases in base charges (the flat fee paid regardless of the volume of water consumed) and the marginal (per unit) price of water relative to each portfolio were also included (Figure 1).

In the impact-framed survey, attributes included changes in private landscaping (15% or 30% decreases), changes in public landscaping (30% or 70% decreases), increases in base charges ($15 or $30), increases in per unit water prices (25% or 50%), and decreases in irrigated farmland (15% or 30%). Percentages in the policies survey represent the portion of the gap that could be met via specific policies; in contrast, impact percentages represent the range of plausible changes in acres fallowed, costs, and landscaping related to potential combinations of policies used to meet future demands. For instance, in the policies survey, meeting 30% of the water supply gap through water transfers is not the direct equivalent of (the impact of) fallowing 30% of agricultural land. These levels were calibrated to remain within the plausible range of the effects of a 30% increase in each of the policies. Levels for changes in base charges and in prices were calculated using CWCB's estimates of the average cost (dollars/acre-foot of water) of conservation programs and

[1] *Colorado's Water Supply Future Portfolio and Trade-Off Tool*, http://cwcb.state.co.us/technical-resources/portfolio-tool/Pages/main.aspx

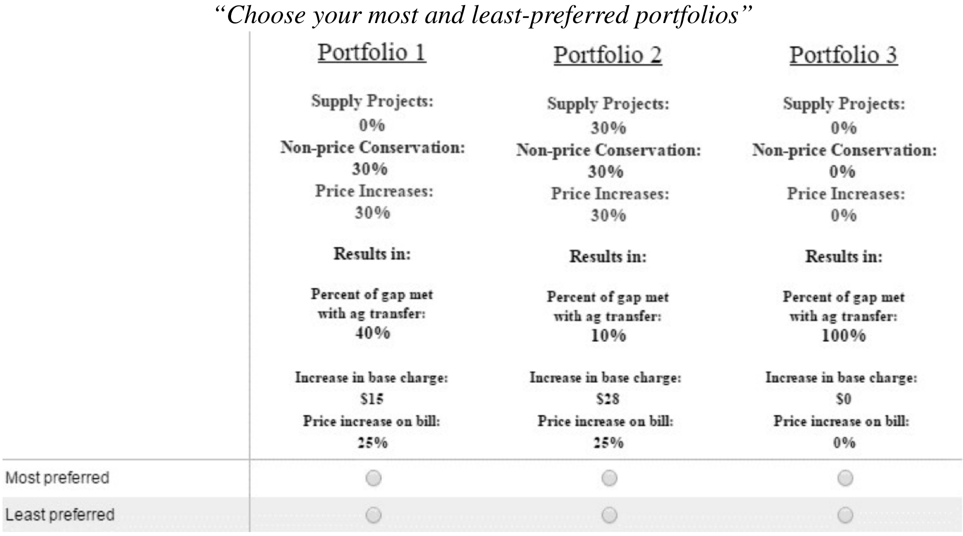

Figure 1. Sample Choice Set for Policies Survey

supply development.[2] Potential changes in landscaping were based on planning documents from the state's largest water utility, Denver Water, which identify viable landscaping options for low- and high-conservation scenarios (Pacetti and Keammerer, 2011).

There are potentially other impacts—most prominently environmental and recreational uses of water—that might result from the policies we consider. Unfortunately, CWCB was not able to quantify such impacts, as they tend to be project- as opposed to policy-specific. The choice was therefore between including some qualitative or typical impacts with ad hoc levels or excluding such impacts from the survey. While both approaches have pros and cons, our preference was to limit the impacts survey to the effects we could quantify.[3]

We employed a main-effects fractional factorial sequential design (see Scarpa and Rose, 2008) for both surveys. The chosen design maximizes the variation in attributes in each choice set while ensuring that no options are strictly dominated. We refer readers to Street, Burgess, and Louviere (2005) for more information on optimal designs. The final design for the policy-framed survey included eight choice sets, each containing three alternative policy portfolios, and participants were asked to choose the most and least preferred options (Figure 1 shows a sample policy choice set). The impact-framed survey also consisted of eight choice sets, each of which included five alternative impacts,[4] which participants ranked on a scale from "most concerning" to "least concerning." Respondents made two rounds of choices: most and least concerning impacts were selected in the first round, and the remaining three options were ranked in the second round, allowing for a full ranking of the alternatives. A sample choice set appears in Figure 2. Last, each choice set in the impact survey presents outcomes associated with some feasible water policy combination,

[2] The tool allows the user to identify potential water savings (in acre-feet/year) from conservation, supply projects, and agricultural water transfers. State estimates of the average cost/acre-foot for each of these categories of water savings were multiplied by estimated savings to obtain a range of potential total costs of each option. These costs were divided by estimates of Colorado's 2050 population to obtain household-level costs of each policy. For supply projects, it was then assumed that new residents of the state would pay 40% of the costs of new supply (per conversations with the CWCB and local water utilities), with additional costs passed on to new residents. Potential price increases were determined by assuming that water savings from price increases would be similar to those from conservation and by assuming an elasticity of demand of −0.6.

[3] However, we collected information about each participant's environmental preferences and motivations and used it as conditioning controls in the latent-class models. The idea is that, if some subjects rate some policies/impacts higher or lower because of their perceived environmental effect, we will be able to segregate such behavior.

[4] The pictures portraying the effects of reduction in private and public landscaping were taken from a water conservation planning document prepared for the water utility Denver Water (Pacetti and Keammerer, 2011), while the effect of land dry-up in the Colorado plains was taken by the authors.

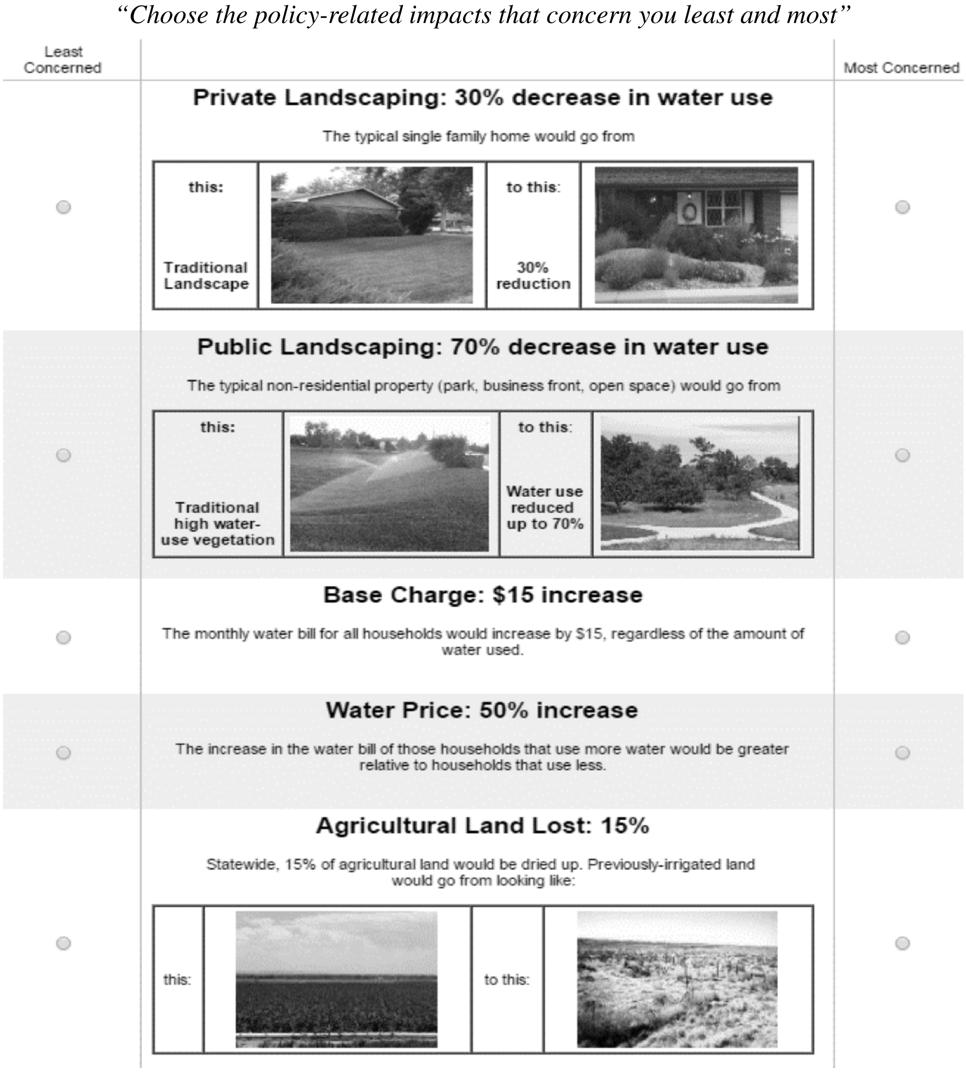

Figure 2. Sample Choice Set for Impact Survey

but no single choice set directly corresponds with the impacts of a specific policy. Unfortunately, imposing orthogonality in the policy experiment (so that preferences for policies are identified) and deriving the impacts from this design for the second survey does not guarantee the identification of the preferences parameters for impacts in the second survey, because the effects of the policies are correlated.

Before beginning the choice experiment, respondents received information regarding motivations for the study and potential policies that could be used to meet future water demands (policies survey) or potential impacts of water-provision alternatives (impacts survey). We refer the reader to the online supplement (available at www.jareonline.org) to see the pretext for each survey. Finally, both surveys included a "cheap talk" script (Carlsson, Frykblom, and Lagerkvist, 2005) to remind participants that choices, though hypothetical, might impact them in the future if water policies were implemented. That is, truth-revealing behavior in the survey was incentive-compatible (Carson and Groves, 2007).

Best–Worst Scaling

Best–worst (B–W) scaling, a variant of discrete choice experiments, requires respondents to pick their most and least preferred options in a choice set, which can contain either individual attributes or attribute bundles. The impacts survey used here asked participants to rank water policy impacts (attributes), allowing for evaluation of their relative importance (Batsell and Louviere, 1991). For the policy framing, choices were made across attribute bundles (policy combinations). Use of a balanced experimental design allowed the choice data for both surveys to be summarized at the aggregate level by giving each attribute (or attribute bundle) a "score" calculated based on the difference between the number of times the attribute/bundle is ranked as best and the number of times it is ranked as worst. The attribute level scores can be standardized (relative to a chosen attribute and level or policy combination) and interpreted directly in terms of relative importance,[5] providing a measure of the aggregate preferences manifested by the participants in the sample (Flynn et al., 2007).

To study heterogeneity in preferences, we develop a model in which a respondent's best and worst choices are analyzed and conditioned on choice attributes and the characteristics of the decision maker. The assumptions underlying B–W scaling models are based on random utility theory, which assumes that the overall utility, U_{ij}, that individual i receives from good j can be broken down into a sum of deterministic and random components. In each choice set, utility is often assumed to be a linear function of the attributes ($\boldsymbol{x}_{ij}$) of good j, a conforming vector of preference parameters ($\boldsymbol{\beta}$), and a random error term (ε_{ij}), yielding $U_{ij} = \boldsymbol{x}'_{ij}\boldsymbol{\beta} + \varepsilon_{ij}$. An individual chooses a good j as preferred over another good, k, in the choice set if the utility from good j is larger than the utility from k (i.e., $U_{ij} = \boldsymbol{x}'_{ij}\boldsymbol{\beta} + \varepsilon_{ij} > U_{ik} = \boldsymbol{x}'_{ik}\boldsymbol{\beta} + \varepsilon_{ik}$).With best–worst (also called maximum difference) scaling, the choice of an option j as most preferred and k as least preferred means the difference in utility provided by this attribute/bundle pair is larger than it would be for any other combination in the choice set (Lee, Soutar, and Louviere, 2007).

Under the assumption that errors are Gumbel distributed, the probability of an overall ranking of alternatives (A, B, C) based on a series of best–worst choices may be expressed via a sequential best–worst multinomial logit (Collins and Rose, 2013; Lanscar et al., 2013). This model has an advantage over a rank-ordered logit in that it reflects the actual choice task faced by respondents, where a best and then worst option is chosen in order to achieve an overall ranking of options. If we let $\boldsymbol{x}_{ij}$ represent the vector or policy options observed by participant i for the three portfolios $j = A, B, C$, the multinomial probability that A is most preferred and C is least preferred can be represented as

$$(1) \qquad P(A, B, C) = \frac{\exp(\boldsymbol{x}'_{ij=A}\boldsymbol{\beta})}{\sum_{j=A,B,C} \exp(\boldsymbol{x}'_{ij}\boldsymbol{\beta})} \times \frac{\exp(-\boldsymbol{x}'_{ij=C}\boldsymbol{\beta})}{\sum_{j=B,C} \exp(\boldsymbol{x}'_{ij}\boldsymbol{\beta})},$$

where utility is positive for best and negative for worst choices.[6] For the case of the impact-framed survey, the set of possible impacts, M, associated with policies was used to create the experimental design for the choice task. In this case, we assume utility is a function of the impacts $\boldsymbol{z}_i = [z_{i1}, \ldots z_{im}, \ldots z_{iM}]$ included in each best–worst scaling choice task, such that $U_i = \boldsymbol{z}'_i\boldsymbol{\theta} + \varepsilon_i$. Participants ranked five attributes (i.e., impacts), as opposed to bundles of attributes, in two iterations of best–worst choices. If we indicate each impact as z_{im} and let θ_m represent the associated marginal utility, the probability of observing the sequence (a, b, c, d, e) becomes

$$(2) \quad P(a,b,c,d,e) = \frac{\exp(z_{ia}\theta_a)}{\sum_{m=a,b,c,d,e} \exp(z_{im}\theta_m)} \frac{\exp(-z_{ie}\theta_e)}{\sum_{m=b,c,d,e} \exp(-z_{im}\theta_m)} \frac{\exp(z_{ib}\theta_b)}{\sum_{m=b,c,d} \exp(z_{im}\theta_m)} \frac{\exp(-z_{id}\theta_d)}{\sum_{m=c,d} \exp(-z_{im}\theta_m)}.$$

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[5] This method has been shown to give results identical to those found in maximum-likelihood estimation for an aggregate-level data "max-diff" multinomial model (Finn and Louviere, 1992).

[6] The scale parameter, directly related to the variance of the Gumbel distribution, is implicit in this equation but normalized to unity because it is not estimable from choice data (for an example, see Train, 2009, p. 48).

Latent-Class Models

Latent-class models (Swait, 1994; Ben-Akiva et al., 1997) have the advantage of allowing the estimation of preference parameters specific to different types of consumers (i.e., consumer classes), while modeling the sociodemographic determinants of heterogeneity in a separate, ad hoc process. The approach is fully parametric, requiring a detailed specification of the data-generating process, and estimation is implemented via maximum likelihood. Here, we use an estimation routine developed by Pacifico and Yoo (2013) and based on Greene and Hensher's (2003) likelihood function for latent-class discrete choice models.

Considering the case of choosing over a set of policy portfolios, the likelihood function is represented as

$$\ln(L) = \sum_{i=1}^{N} \ln \left[\sum_{q=1}^{Q} \pi_{iq} \left(\sum_{t=1}^{T} \sum_{j=1}^{J} \left(\frac{\exp(\boldsymbol{x}'_{ijt}\boldsymbol{\beta}_q)}{\sum_{J=1}^{J} \exp(\boldsymbol{x}'_{ijt}\boldsymbol{\beta}_q)} \right)^{d_{ijt}} \right) \right], \tag{3}$$

where Q is the total number of consumer classes, N is the total sample size, T is the total number of choices, J is the number of choice set options, and d_{ijt} is an indicator variable for the alternative chosen as most (or least) preferred by individual i on choice occasion t. The expression

$$\frac{\exp(\boldsymbol{x}'_{ijt}\boldsymbol{\beta}_q)}{\sum_{J=1}^{J} \exp(\boldsymbol{x}'_{ijt}\boldsymbol{\beta}_q)}$$

corresponds with each individual best or worst choice made in the series of sequential choices in equations (1) and (2). The probability that individual i belongs to class q, π_{iq}, is the process that determines heterogeneity and is typically parameterized as a logit function of exogenous individual descriptors $\boldsymbol{w}_i$ and class membership parameters $\boldsymbol{\delta}_q$ according to

$$\pi_{iq} = \frac{\exp(\boldsymbol{w}'_i\boldsymbol{\delta}_q)}{\sum_{q=1}^{Q} \exp(\boldsymbol{x}'_i\boldsymbol{\delta}_q)}, \tag{4}$$

where $\boldsymbol{\delta}_q$ is normalized to 0 for identification purposes. The likelihood function for the case of choosing policy impacts, instead of bundles, is built from the choice probabilities in equation (2), but it is otherwise analogous. An EM algorithm is used to iteratively estimate class membership parameters, $\boldsymbol{\delta}_q$, and attribute coefficients, $\boldsymbol{\beta}_q$, for each class. For a detailed explanation of the derivation of the log-likelihood function and maximization routine see Pacifico and Yoo (2013) and Train (2008).

Data, Sample Characteristics, and Empirical Model Specification:

Data and Sample Characteristics

Each survey was administered to 1,000 Colorado residents using the Internet-based survey company Qualtrics and with funding provided by the Colorado Water Conservation Board. Participation was limited to those at least 21 years and older, as younger individuals are less likely to pay for their water consumption. To ensure that our results would be representative of the preferences of all Coloradoans, each sample was stratified to match the income, gender, and geographic distributions of Colorado's population. The sample demographics presented in Table 3 show minimal, statistically insignificant differences between the two samples and a reasonable matching with the state's demographics (though the Eastern Plains population is somewhat overrepresented).

In addition to demographic information, data regarding individuals' water consumption habits were collected (Table 4). Respondents were asked to report how they paid for their water

Table 3. Demographic Characteristics

Characteristic	Range	Share of Residents in 2012 (percentage)[a]	Policies Survey (percentage)	Outcomes Survey (percentage)
Income	<$25,000	20.7	12.91	12.56
	$25,001–$50,000	23.4	22.07	21.07
	$50,001–$75,000	18.6	22.86	21.66
	$75,001–$100,000	13.1	22.46	22.55
	$100,001–$200,000	19.3	15.86	17.41
	>$200,000	5.0	3.84	4.75
Gender	Male	51.1	49.66	50.74
	Female	49.9	50.34	49.26
Region	Front Range	82.0	75.07	72.30
	West Slope and Mountains	13.1	10.74	10.68
	Eastern Plains	3.0	14.19	17.01
Age	21–30	14.4	9.06	10.48
	31–40	14.1	13.30	12.76
	41–50	14.3	13.99	14.84
	51–60	11.9	26.6	27.50
	61–70	9.1	29.26	25.32
	>71	7.4	7.78	9.10
Education	High school	22.4	7.49	6.33
	Some college	22.8	33.69	36.20
	Bachelors	23.4	22.96	21.56
	Graduate or professional degree	13.2	32.02	31.85
	Vocational or technical degree	8.1	3.84	4.06
Type of home	Single family home	74.2	75.85	75.87
	Multiple family home	25.8	1.08	1.68
	Condominium or townhouse	N/A	12.61	13.25
	Apartment	N/A	9.46	9.20
Owner or Renter	Own	65.9	79.01	79.72
	Rent	34.1	20.99	20.28

Notes: [a] 2012 American Community Survey 5-year estimates.

consumption (per unit, flat monthly rates, no payment), their average water bill in the winter and summer months, and their relative average summer versus winter bills, indicative of water used for basic household activities (winter use) or outdoor irrigation and landscaping (summer). Finally, we recorded perceptions regarding what water uses should receive priority in times of scarcity. Participants selected their three top priorities among a number of possible private (e.g., household, farmland, industrial) and public uses (e.g., preserving the natural environment, municipal landscaping).

Empirical Model Specification

We assume that, within a latent class, preferences are determined by the experimental treatments; therefore, in the policies survey, the systematic part of utility is made to be a function of the policy

Table 4. Water Use Descriptors

Characteristic	Range	Policies Survey (percentage)	Impact Survey (percentage)
Billing	Pay a monthly or bi-monthly water bill based on amount used	73.40	76.36
	Pay a fixed charge (monthly or bi-monthly) regardless of use	2.66	2.77
	Water included in HOA payment	16.35	14.84
	Do not pay for water	7.59	6.03
Average winter bill (Nov. to Feb.)	\$0–\$24.99	22.56	22.75
	\$25–\$49.99	35.47	34.82
	\$50–\$74.99	15.86	16.42
	\$75–\$99.99	4.73	6.53
	$\geq$ \$100	1.38	1.98
	Do not pay for water	20.00	17.51
Average summer bill (May to Aug.)	\$0–\$24.99	7.98	7.72
	\$25–\$49.99	20.10	18.00
	\$50–\$74.99	19.31	21.56
	\$75–\$99.99	15.57	15.43
	$\geq$ \$100	17.04	19.78
	Do not pay for water	20.00	17.51
Summer use	Avg. summer use does not differ from avg. winter use	38.82	35.11
	Avg. summer use up to 2× avg. winter water use	46.21	48.07
	Avg. summer use more than 3× avg. winter use	14.98	16.82
First priority in times of scarcity attributed to:	Household use	63.07	55.26
	Irrigated farmland	13.26	22.47
	For preserving the natural environment	16.22	13.98
	For natural resource management	6.49	6.08
	Industrial use	0.29	0.87
	For private landscaping	0.38	0.48
	Recreation	0.19	0.47
	Municipal landscaping	0.10	0.39

levels in each option j. In the impacts survey, utility is function of the impact levels (two potential levels for each impact, see Table 2) included in each choice set. Estimating preferences with impact levels coded as binary variables for inclusion/exclusion in each choice set allows for a complete relative ranking of the impacts, relative to one omitted impact and level. Thus, the empirical model specifications for the two surveys are

$$(5) \quad \mathbf{x}'_j\boldsymbol{\beta} = \beta_1 Supply30_j + \beta_2 Conservation30_j + \beta_3 Price30_j \text{ and}$$

$$(6) \quad \begin{aligned} \mathbf{z}'\boldsymbol{\theta} = {} & \theta_1 DryLand30 + \theta_2 Price25 + \theta_3 Price50 \\ & + \theta_4 BaseCharge15 + \theta_5 BaseCharge30 + \theta_6 PrivLandsc15 \\ & + \theta_7 PrivLandsc30 + \theta_8 PubLandsc30 + \theta_9 PubLandsc70. \end{aligned}$$

Table 5. Predictors of Class Membership

Variable	Description	PCA Policy		PCA Impacts	
		Irrigated Use	High Total Use	Irrigated Use	High Total Use
MargPrice	= 1 if individual pays a per-unit price for water	0.651	−0.119	0.656	−0.096
OutdoorUse	= 1 if summer use at least double winter use	0.484	0.826	0.484	0.815
WinterBill	Ordinal variable based on 1–5 winter bill categories[a]	−0.585	0.551	−0.579	0.572
Income	Ordinal variable based on 1–6 income categories[a]	–	–	–	–
EnvFirst	= 1 if environmental/natural resource-based uses of water in times of scarcity is in top 3 priority list	–	–	–	–
Age	Ordinal variable based on 1–6 age categories[a]	–	–	–	–
Urban	= 1 if zipcode is in a census-defined urbanized area	–	–	–	–

Notes: [a] See Table 3.

For the class membership process (equation 4), we assume that differences in preferences between classes are driven by an individual's typical pattern of water use, personal priorities in time of scarcity, and demographic controls. These variables are defined in Table 5. Preliminary models and correlation analysis revealed high collinearity between the water-use variables (*MargPrice*, *OutdoorUse*, *WinterBill*), resulting in inflated variance of the model coefficients. The collinearity problem is common, given the observational nature of an individual's characteristics. To address the problem, two out of the three orthogonal principal components of this sub-data matrix were extracted and used as regressors.[7] Principal components were derived from the polychoric correlation matrix (Olsson, 1979), which accounts for the presence of dichotomous and ordinal variables. Results for the PCA are presented on the right side of Table 5.

Principal components are essentially identical for the policy and impact surveys, providing further evidence of the equivalence of the two stratified samples. The first component presents a contrast between *OutdoorUse* (0.48) and *WinterBill* (−0.58), plus a positive coefficient (0.65) for *MargPrice*. This component explains a large portion of variation (67%) in the data and captures the correlation structure for households that irrigate in the summer, pay marginal prices, and therefore have significant differences between winter and summer bills. We label this component *IrrigatedUse*. The second component (capturing 25% of variation in the data) loads on both *OutdoorUse* (0.82) and *WinterBill* (0.55), capturing the patterns of households with higher year-round consumption, perhaps indicative of larger families. We label this component *HighTotalUse*.

In additional to the typical demographic controls (*Income*, *Age*), we also include a binary variable for urban versus rural resident (*Urban*) and another to indicate participants with strong environmental concerns (*EnvFirst*). Thus, π_{iq}, the probability that an individual i belongs to class q (equation 4), was parameterized as follows:

$$\mathbf{w}_i'\boldsymbol{\delta}_q = \delta_0 + \delta_1 IrrigatedUse_i + \delta_2 HighTotalUse_i + \delta_3 Age_i + \delta_4 Income_i + \delta_5 EnvFirst_i + \delta_6 Urban_i. \tag{7}$$

[7] An alternative approach is to include all class membership predictors in the PCA analysis. We chose to follow Ashok, Dillon, and Yuan (2002) and include only the most collinear variables, as this allows obtaining variable-specific marginal effects for all other variables and facilitates the interpretation of results.

Table 6. Best–Worst Rankings of Policy Portfolios, Aggregate Results

Policy Portfolio				Number of Times	Number of Times	
Supply	Conservation	Price	Ag Transfer	Most Preferred	Least Preferred	Standardized
30%	30%	0%	40%	517	65	100.00
30%	30%	30%	10%	464	176	57.57
30%	0%	30%	40%	253	172	43.00
30%	0%	0%	70%	206	169	39.15
0%	30%	30%	40%	186	185	35.55
0%	30%	0%	70%	178	427	22.89
0%	0%	0%	100%	153	479	20.04
0%	0%	30%	70%	60	524	12.00

Table 7. Best–Worst Ranking of Impacts, Aggregate Results

Attributes and Levels	Most Concerning	Least Concerning	Standardized
Ag land dry-up, high (30%)	2,391	228	100.00
Ag land dry-up, low (15%)	1,965	320	76.54
Price increase, high (50%)	1,294	362	58.33
Base charge increase, high ($30)	752	247	53.70
Price increase, low (25%)	631	497	34.88
Base charge increase, low ($15)	331	668	21.60
Reduction in public landscaping, high (70%)	315	1,091	16.67
Reduction in public landscaping, low (30%)	153	1,192	11.11
Reduction in private landscaping, high (30%)	151	1,637	9.23
Reduction in private landscaping, low (15%)	104	1,846	7.41

Results

Aggregate Results: Preferences for Policies versus Impacts

Table 6 shows standardized scores for the policy portfolios, or each portfolio's score ranking as a percentage of the score for the highest-ranked alternative. The most preferred portfolio meets 30% of future demands via supply projects and 30% through non-price conservation, meaning 40% of demand would be met by agricultural water transfers. In the second-best portfolio, agricultural water transfers are further decreased to 10% through use of price increases. The least preferred portfolio would meet 30% of demand via price increases and 70% with water transfers. Overall, we find that Coloradoans generally support the use of supply and conservation-based portfolios, with a preference for supply projects. Participants also prefer an all-of-the-above type of approach, in which portfolios include a balanced mix of policies.

Table 7 shows the ordering (from most to least concerning) of the five impacts at their low and high levels, as well as standardized scores relative to the most concerning policy outcome. Drying up either 30% or 15% of agricultural land in Colorado are the two most concerning consequences of providing for the state's future water needs. The next most concerning impacts relate to costs: a 50% price increase and $30 increase in base charges are ranked similarly concerning. Changes in private and public landscaping are the least concerning impacts, by a significant margin. Perhaps surprisingly, reduction in public landscaping is, on average, more concerning than reductions in private landscaping.

Comparing the two surveys, it is clear that there is strong popular support for engaging in costly policies in order to avoid market transfers of agricultural water rights to urban use and the resulting fallowing of land. In the policies survey, households strongly support policy portfolios using supply projects as opposed to price increases. Some discrepancies, however, are visible even at this aggregate level. In the policy-framed survey, the four portfolios including a nonzero level of supply projects are all preferred to the four options without them. In the impact-framed survey, respondents show concern about base charges, which are used to fund supply projects—a result suggesting that households may not be aware that non-price water policies may also lead to large changes in water bills.

Latent-Class Results: Policies and Impacts

Estimation results of the aggregate (equation 1) and latent-class (equation 3) models relative to the policy-framed survey are presented side by side in Table 8. A positive/negative parameter estimate for a given policy implies the policy is more/less preferred to the omitted policy variable (meeting 30% of water needs through agricultural transfers). Results for the aggregate model suggest that, on average, a 30% increase in prices is considered slightly worse than fallowing 30% of the agricultural land in Colorado. On the other hand, new supply projects and conservation are much preferred. Three distinct classes of citizen preferences are identified in the latent-class estimation (Table 8).[8] Class membership parameters are identified as contrasts with a class whose full parameter vector is normalized to 0 (here, class 3) and should be interpreted accordingly. Coefficients for all preference parameters options are statistically significant at a 1% level of confidence, though this is not true for all variables included as predictors of class membership.[9]

The three classes of preferences are i) individuals with strong opposition to agricultural water transfers, ii) individuals who support use of all non-price policies to mitigate need for transfers, and iii) individuals who support use of transfers to meet demands. The first class, which we label the Anti-Transfer1 group (47.3% of participants), has positive coefficients for all available policies, indicating each policy is preferable to agricultural water transfers. Supply projects are the most preferred policies, followed by non-price conservation and price increases. Estimates for the class membership process show positive, significant coefficients for *HighTotalUse*, *Age*, *Income*, and *EnvFirst* and negative for *Urban*. Thus, compared with individuals in class 3, people strongly opposing water transfer policies tend to be older, higher-income individuals who are more likely to reside in rural areas, have higher total water consumption, and are concerned for the natural environment.

The third class is the polar opposite of the Anti-Transfer1 group and, thus, is named the Pro-Transfer group (23.2% of respondents). In Pro-Transfer, all policy coefficients are negative, implying that all policy alternatives to market-based water are worse options, with increases in the marginal price of water particularly disliked. The coefficients of the membership process for this class are normalized to 0, but, compared to the Anti-Transfer1 group, Pro-Transfer citizens tend to be lower-income individuals residing in urban areas, with lower relative water consumption.

Last, the second class (29.5% of observations) has preferences similar to the Anti-Transfer1 class, with positive coefficients for supply projects and non-price conservation. However, this coefficient for the variable Price is negative, indicating these respondents do not support using price increases to reduce the need for water transfers. The only (marginally) significant estimate in the class-membership process is the negative coefficient for *Urban*, implying that individuals in the Anti-Transfer2 class have similar characteristics to those in the Pro-Transfer class, but they are more likely to reside in a rural area.

Table 9 presents results for the aggregate (equation 2) and corresponding latent-class model for the impact-framed survey. Again, all coefficient estimates for impact variables are statistically significant. The coefficient associated with each potential impact is interpreted relative to the low

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[8] Bayesian criteria favored models with more than three classes, yet the estimated coefficients of many classes were quite similar, providing little additional economic insight and intuition. We therefore favored a more parsimonious three-class specification (see also Pacifico and Yoo, 2013).

[9] Standard errors were clustered around each individual subject to account for multiple choices from each participant.

Table 8. Sequential Best–Worst Multinomial and Latent-Class Results, Policies Survey

Aggregate Sequential Best–Worst Multinomial Logit Results			Latent-Class Results			
Regressor	**Coeff.**	**Std. Err.**	**Classes**	**Regressor**	**Coeff.**	**Std. Err.**
Supply	0.836***	0.039	Class 1: Anti-Transfer1 (47.3%)	Supply (30%)	3.224***	0.085
Conserve	0.748***	0.032		Conserve (30%)	2.980***	0.073
Price	−0.180***	0.040		Price	1.952***	0.067
N	40,598		Class 1 membership	*IrrigatedUse*	0.033	0.088
Log-pseudolikelihood	−12,888.51			*HighTotalUse*	0.264**	0.119
				Age	0.349***	0.064
				Income	0.211***	0.066
				EnvFirst	0.216*	0.125
				Urban	−0.331*	0.181
				Constant	−1.928***	0.445
			Class 2: Anti-Transfer2 (29.5%)	Supply (30%)	0.588***	0.044
				Conserve (30%)	0.467***	0.042
				Price (30%)	−0.413***	0.050
			Class2 membership	*IrrigatedUse*	0.105	0.098
				HighTotalUse	0.168	0.131
				Age	0.074	0.069
				Income	0.040	0.073
				EnvFirst	0.180	0.138
				Urban	−0.343*	0.202
				Constant	−0.454	0.471
			Class 3: Pro-Transfer (23.2%)	Supply (30%)	−0.659***	0.062
				Conserve (30%)	−0.730***	0.093
				Price (30%)	−2.641***	0.113
			n		40,598	
			Log-pseudolikelihood		−9,469.88	

Notes: Single, double, and triple asterisks (*, **, ***) indicate [statistical] significance at the 10%, 5%, and 1% level.

Table 9. Sequential Best–Worst Multinomial and Latent-Class Results, Impacts Survey

Aggregate Sequential Best–Worst Multinomial Logit Results

Regressor	Coeff.	Std. Err.
Dry land (30%)	0.393***	0.030
Price (50%)	−0.135***	0.062
Base charge ($30)	−0.382***	0.055
Price (25%)	−0.729***	0.057
Base charge ($15)	−1.008***	0.055
Pub. landsc. (30%)	−1.346***	0.057
Pub. landsc. (15%)	−1.657***	0.056
Private landsc. (15%)	−1.745***	0.063
Private landsc. (30%)	−1.944***	0.063
n	112,896	
Log-pseudolikelihood	−32,722.82	

Latent-Class Results

Classes	Regressor	Coeff.	Std. Err.
Class1: Anti-Fallow1 (38.7%)	Dry land (30%)	0.818***	0.089
	Price (50%)	−0.939***	0.084
	Base charge ($30)	−1.483***	0.080
	Price (25%)	−1.938***	0.085
	Base charge ($15)	−2.501***	0.083
	Pub. landsc. (70%)	−3.792***	0.105
	Pub. landsc. (30%)	−4.129***	0.095
	Priv. landsc. (30%)	−4.168***	0.095
	Priv. landsc. (15%)	−4.339***	0.094
Class1 Membership	*IrrigatedUse*	−0.220***	0.088
	HighTotalUse	−0.230**	0.110
	Age	0.198***	0.059
	Income	−0.016	0.062
	EnvFirst	0.154	0.128
	Urban	−0.285*	0.171
	Constant	0.395	0.413
Class2: Anti-Fallow2 33.8%	Dry land (30%)	0.694***	0.069
	Pub. landsc.(70%)	−0.729***	0.062
	Base charge ($30)	−1.115***	0.063
	Price (50%)	−1.226***	0.064
	Pub. landsc. (30%)	−1.257***	0.067
	Priv. landsc. (30%)	−1.627***	0.074
	Base charge ($15)	−1.789***	0.067
	Price (25%)	−1.811***	0.066
	Priv. landsc. (15%)	−1.916***	0.073
Class2 Membership	*IrrigatedUse*	−0.322***	0.089
	HighTotalUse	−0.262**	0.114
	Age	0.271***	0.061
	Income	0.118*	0.063
	EnvFirst	0.427***	0.127
	Urban	0.132	0.177
	Constant	−0.754	0.436
Class 3: Pro-Fallow (27.5%)	Price (50%)	2.541***	0.097
	Base charge ($30)	1.556***	0.079
	Price (25%)	1.399***	0.074
	Base charge ($15)	0.537***	0.070
	Dry land (30%)	0.309***	0.066
	Priv. landsc. (30%)	−0.708***	0.069
	Pub. landsc. (70%)	−0.720***	0.069
	Priv. landsc. (15%)	−0.899***	0.068
	Pub. landsc. (30%)	−1.024***	0.070
n		112,896	
Log-psuedolikelihood		−28,546.59	

Notes: Single, double, and triple asterisks (*, **, ***) indicate [statistical] significance at the 10%, 5%, and 1% level.

level (15%) of agricultural land fallowing, the impact omitted for identification purposes. Therefore, a positive coefficient means that an attribute is ranked more concerning than low-level dry-up, while a negative coefficient means it is less concerning. In the table, estimated coefficients are sorted in decreasing order, thereby providing a direct ranking of impacts from most to least concerning. The ranking of the coefficients in the aggregate model reproduces the results in Table 7, as expected.

Based on a qualitative assessment, each class from the impact survey may be matched to one of the preference classes described for the policy survey (Anti-Transfer1, Anti-Transfer2, or Pro-Transfer). This matching, while somewhat subjective, allows for interesting comparisons across the two surveys. Given the between-subject design, finding common threads between the policy and impact surveys also provides some model validation, as it suggests that the latent-class model applied to both surveys captures distinct preference groups with unique ways of thinking about water policies.

In the impacts survey, class 1 respondents (38.7% of the observations) consider the high level of agricultural land dry-up to be the most concerning water-policy impact, followed by the low level of dry-up and increases in base charges and marginal prices. These individuals, whom we will call Anti-Fallow1, are a good match for the Anti-Transfer1 group in the policy survey. This group believes the least concerning outcomes are reductions in the "greenness" of private and public landscaping. Class-membership coefficients are positive for *Age* and negative for *Urban*, *HighTotalUse*, and *IrrigatedUse*, meaning Anti-Fallow1 individuals tend to be older individuals from rural communities with lower water consumption than class 3 members. This last result stands in contrast to policy survey results, where the Anti-Transfer1 group comprised high water users.

The third class within the impact-framed survey (27.5% of participants, more than in the policy-framed survey) represents respondents who implicitly support water transfers, as evidenced by higher relative concern regarding increases in prices and base charges. We label these individuals Pro-Fallow. However, they are less concerned about the landscaping and greenness of the living environment. Again, class membership is simply the converse of the Anti-Fallow1 group, implying that these Pro-Fallow types—urban individuals with higher irrigated and total water consumption—were more likely to display Pro-Transfer preferences in the impact survey.

Class 2 members (33.8% of observations) in the impacts survey are labeled Anti-Fallow2 and are a reasonable match for the Anti-Transfer2 class of the policy survey. These individuals also consider transferring agricultural land water rights as the most concerning impact, though the magnitude of the coefficients is smaller relative to the Anti-Fallow1 class. The most visible difference between the Anti-Fallow1 and 2 classes in the impacts survey is the relative concern for the greenness of the living environment. For class 2, a 70% reduction in the water used in public landscaping is the most concerning outcome after the high and low level of agricultural land dry-up. The next most concerning impacts are high levels of base charge ($30) and unit price (50%) increases, followed by reducing water for public (30%) and private (30%) landscaping and the low-level base charges ($15) and prices (15%). These findings contrast the analogous class in the policy-framed survey, where non-price conservation policies (which cause reductions in private/public green spaces) are preferable to price-based approaches. Class-membership coefficients for *Age*, *Income*, and *EnvFirst* are positive and significant, whereas coefficients for *IrrigatedUse* and *HighTotalUse* are again negative. Thus, similarly to the Anti-Fallow1 members, Anti-Fallow2 types tend to be older individuals with higher income but lower water consumption than Pro-Transfer individuals. Anti-Fallow2 members also display stronger environmental preferences than type-1 individuals, which seems to correlate with a greater concern over landscaping changes dictated by water policies.

Discussion and Conclusions

The choice experiments we conducted show that most Coloradoans are hesitant to allow market-based water transfers to municipal use that would result in fallowing of significant acreage of agricultural land, despite the sizable costs required to keep agricultural land in production. This result is surprisingly (at least, to the authors) robust to changes in the framing of the survey and remains largely unaltered when the household-level impacts of the policy options are brought to the forefront. Results from the impact-framed survey also suggest that Coloradans prefer an all-of-the-above approach, in which a mix of solutions is adopted to address the water scarcity problem.

Even though a majority of Coloradans support avoiding water transfers from rural areas, latent-class models identify three distinct consumer groups with heterogeneous preferences and concerns. In the impact-framed survey, members of the Anti-Transfer1 class have the strongest willingness to protect agricultural land, endorsing the use of all available alternative policies or stating that dry-up of agricultural land is by far the most concerning possible impact. Anti-Transfer2 members support alternatives to transferring water from agricultural land, so long as increases in the marginal price of water are not required. A sizable (>20%) group of Pro-Transfer types, poorer and urban-based, is unwilling to face the impacts and out-of-pocket costs necessary to prevent extensive losses of irrigated land. The fault line in opinions is, as one may expect, along the rural–urban divide, but the Pro-Transfer group is surprisingly small if one considers that 86% of the population in Colorado is classified as residing in an urban area (U.S. Census Bureau, 2010).

While there are some strong similarities between the recorded choices in the policy and impact surveys, a comparison of the two surveys shows some interesting differences. First, we see a decrease in AntiTransfer1 class membership from 47.3% in the policies survey to 38.7% for the Anti-Fallow1 group in the impacts survey, while the corresponding Pro-Transfer and Pro-Fallow group increases from 23.2% to 27.5% of surveyed participants. Thus, support for use of agricultural water transfers increases somewhat when respondents are faced with the costs—in terms of increases in base charges, marginal prices, and landscaping changes—of meeting demand via alternatives policies. Furthermore, we find that in the impact-framed survey the stauncher opposition to water transfer comes from low water users (high users in the impact survey), who would be less impacted by the increased costs of policies that mitigate need for fallowing. The size of the middle-ground Anti-Tansfer2 and corresponding Anti-Fallow2 classes also increases from 29.5% to 33.8%.

As in any survey, the preferences described here are still hypothetical in nature, so choices may be influenced by the innate tendency to support socially desirable options when stating opinions in public (Andreoni, 1990). Here, we see eroding support for mitigating the volume of agricultural water transfers when participants face the consequences of required policies, even though respondents are not actually paying the increased water fixed costs, etc. presented in the impacts survey. Thus, an examination of how much the anti-transfer response is affected by social desirability bias (Fisher, 1993) is a hypothesis worthy of future investigation. Additionally, further work should incorporate environmental impacts as they become quantifiable, as some households, admittedly, might find environmental or recreational impacts even more concerning than those included here. However, the inclusion of *EnvFirst* allows us to condition strength of individual preferences on environmental attitudes, and results suggest that the inclusion of environmental or recreational impacts would not change the relative rankings of the impacts included in this study.

One may be tempted to conclude that preferences and choices over impacts should be the main and only object of study, for the simple fact that impacts provide more detailed information and choices made under more comprehensive information set can only increase consumer welfare. Our contention is that eliciting reactions to both policies and impacts creates a more realistic picture of the policy-making process, where the average household often has little realistic information on water policy impacts and where preferences are often influenced by a general aversion to water transfers, or what Libecap (2005) has called “the shadow of the Owens Valley.” However, while we believe the dual-survey approach adopted here is conceptually valid and insightful, the task of identifying and quantifying the impacts of a given policy is inevitably challenging and will always require some approximation. For example, we are unable to quantify the environmental impacts of building new supply projects and changes in instream flows or the social consequences of agricultural land dry-up on rural communities, and the comparisons we made between the policies and impact surveys were largely qualitative in nature. Further development of tools like the CWCB portfolio and trade-off tool would allow for a more detailed mapping of policies into their outcomes. This would facilitate research delving into the fascinating issue of determining what policies maximize consumer welfare over time for some criterion function, given that in many instances preferences for policies will vary throughout the stages of policy development and implementation.

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Online Supplement

Policies Survey Pretext

Colorado's population is projected to double over the next 40 years. The Colorado Water Conservation Board forecasts that, as a result of this growth, urban water demands in Colorado are likely to double by 2050.[10] If correct, this would mean a "gap" between current supplies and future demands of between 538,000 and 812,000 acre feet per year statewide (one acre-foot serves 2-3 households).

Options for closing this gap include a wide range of alternatives that roughly fall into four categories:

- **New water supply** projects (e.g., reservoirs)
- **Price-based conservation programs** (e.g., higher water prices)
- **Non-price based conservation programs (e.g., education programs, adoption of water-efficient technologies, etc.)**
- Market-based re-allocation of **water out of agricultural uses**

It is widely believed that water demands that cannot be met using conservation or supply projects will be met by transferring irrigation water rights to municipalities via market transactions that result in permanent "dry up" of agricultural lands. Many have voiced concern over the potential impacts to agriculture, the environment, and rural communities associated with such transfers. Regardless of the portfolio of policies adopted, all Coloradans will be impacted in some way.

Impacts Survey Pretext

Colorado's population is projected to double over the next 40 years. The Colorado Water Conservation Board forecasts that, as a result of this growth, urban water demands in Colorado are likely to double by 2050. If correct, this would mean a "gap" between current supplies and future demands of between 538,000 and 812,000 acre feet per year statewide (one acre-foot serves 2-3 households).

Options for closing this gap include a wide range of alternatives that roughly fall into four categories: (1) new water supply projects (e.g., reservoirs); (2) price-based conservation programs (e.g., higher water prices); (3) non-price based conservation programs (e.g., education programs, adoption of water efficient technologies, etc.); and (4) reallocating water out of agricultural use.

It is widely believed that water demands that cannot be met using conservation or supply projects will be met by "drying up" agriculture land and transferring irrigation water rights to municipalities. Many have voiced concern over the potential impacts to agriculture, the environment, and rural communities associated with such transfers.

Regardless of the portfolio of policies adopted, all Coloradans will be impacted in some way. This potentially includes impacts to the following:

- The **greenness** of individual properties and communities
- Household **water bills**
- **Dry-up** of agricultural lands.

The magnitude of the impacts in each of these areas will depend on the particular policies adopted. . .

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[10] Given concerns surrounding the possible impact of framing on the results, we created four alternative versions of the baseline introduction that is presented above. Each of the different versions was identical except for the inclusion of a single sentence offering a different motivation behind the need for evaluating alternatives to permanent transfers. For example, one of the versions modified the opening statement to read,

> Colorado's population if projected to double over the next 40 years. Close to 60% of this growth will come from "net migration," or from people moving to Colorado who currently do not reside here.

Contrary to our expectations, controlling for the information treatment did not impact the relative rankings of policies or impacts; therefore, we do not further discuss these results.