Key Points:
- An economic survey quantified how legal changes impact transaction costs, completion times, and third-party effects for water marketing
- Some legal changes project decreases in transaction costs and report less probable increases in third-party effects, while others do not
- Modifying water law to reduce transaction costs involves trade-offs between these reductions and potential increases in third-party effects

Legal Change and Water Market Transaction Costs in Colorado

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Abstract Water markets are commonly described as failing to achieve efficient water management because of transaction cost barriers to trade. In the western United States, two sources of legal conflict frequently drive transaction costs: (1) negative externalities of trading and (2) uncertain property rights. Conflicts arise because water law applies a no-injury rule that prevents water transfers from modifying water available to third-party water rights and defines water rights by historical water use, among other reasons. Existing literature suggests many legal changes to reduce transaction costs, but no studies in the western United States quantify transaction costs under proposed future changes. Here we developed statistical models of transaction costs for water transfer proponents under four specific legal changes in the state of Colorado. Two legal changes would modify the no-injury rule, and two aim to clarify property rights. Colorado hosts active markets and has recently experienced debate over such legal changes. By surveying 100 legal and hydrologic experts, we elicited transaction cost estimates and rankings of which legal changes were most likely to increase third-party injury. The legal changes that aim to clarify property rights had significantly lower likelihoods of increasing injury. One of these legal changes, which would not limit transferable water to historical use in certain circumstances, also had the greatest reductions in proponents' transaction costs. Meanwhile, the legal changes that directly modify the no-injury rule project substantial transaction cost savings but much higher likelihoods of increased injury. The results demonstrate trade-offs between reducing transaction costs and increasing third-party effects.

1. Introduction: Third-Party Effects and Uncertain Property Rights in Western U.S. Water Markets

Water supplies in the western United States are increasingly overallocated. Agriculture uses most water in the western United States, with 72% of freshwater withdrawals in the 17 western states going to irrigation in 2015 (Dieter et al., 2015). However, growing demands, largely driven by population growth as well as industrial and environmental uses, are increasing competition for scarce water resources (Brewer et al., 2008; Brown, 2006; Tidwell et al., 2014). Population in the 17 western states is projected to grow by 38% from 2010 to 2040, yet western states have historically experienced the most drought vulnerability in the United States, and scientists expect climate change to alter the region's precipitation and evapotranspiration (Barnett et al., 2008; Kearney et al., 2014; Seager et al., 2013; University of Virginia Weldon Cooper Center Demographics Research Group, 2018). By 2030, models project that increases in consumptive water demand will exceed legally available surface water and groundwater in 61% of watersheds in the 17 western states (Tidwell et al., 2014).

Around the world, water markets have been proposed and implemented as institutional mechanisms for efficiently managing water scarcity (Grafton et al., 2011). Existing markets in the western United States have helped adapt water use to new demands, most often transferring water from agricultural use to use by cities, industry, and freshwater ecosystems (Brewer et al., 2008; Brown, 2006; Garrick & Aylward, 2012; Payne et al., 2014). Yet markets in the western United States have been described as failing to achieve their theoretical promise, in part because the region's water law imposes high transaction cost barriers that yield expensive, lengthy, and uncertain legal approvals for proponents of water rights transfers (Garrick & Aylward, 2012; Squillace, 2012; Squillace & McLeod, 2016). Two sources of legal conflict frequently drive these transaction costs: (1) negative externalities of trading and (2) uncertainty in the definition of property rights.

An important policy concern for water markets involves balancing social benefits of water transfers against their negative externalities, or social costs (Colby, 1990). Water transfers generate social benefits when they reallocate water from economically lower- to higher-valued uses, but transfers may also impose negative externalities on other water users and society (Howe & Goemans, 2003). Transaction costs impede socially beneficial transfers, but at the same time they may limit negative externalities (Colby, 1990). The U.S. National Research Council (1992) has recognized the importance of balancing these competing interests, noting that "[t]he challenge for water regulators and providers is to devise processes that encourage transfers with real benefits and restrain or condition those that impose high costs on legitimate third party interests."

However, prior appropriation water law, the dominant legal regime for water allocation across the 17 western U.S. states, does not apply a balancing test of social benefits versus social costs for water transfers (Gould, 1988; Thompson et al., 2012; Trout et al., 2011; Womble et al., 2018). Instead, prior appropriation applies a no-injury rule that requires water transfers to avoid causing *any* alteration to the timing, location, or amount of water used by third-party water rights holders, whether now or in the future (Banks & Nichols, 2015; Thompson et al., 2012; Trout et al., 2011). Any transfer (formally, a "change") of water rights that modifies an existing water right's type, time, or place of use requires government approval, and injury to other water rights holders is grounds for disapproval (Thompson et al., 2012; Trout et al., 2011).

Prior appropriation water law also commonly generates uncertain definitions of property rights that can raise water market transaction costs (Culp et al., 2014; Garrick, 2015; Thompson et al., 2012). One important reason for this uncertainty in property rights is prior appropriation's "use it or lose it" principle. In water rights transfers, this principle generally limits the amount of water that may be transferred with a water right to its lawful historical use (Trout et al., 2011). This limitation means that the amount of water that may be transferred can change over time with changes in the actual use of the water right. It also means that usage beyond explicit or implied legal restrictions on a water right, such as use beyond what was contemplated when the right was initially granted, may not be eligible for transfer (Trout et al., 2011). Like the no-injury rule, this limitation protects against third-party effects by preventing enlargement of a water right via a transfer. However, where a water right's historical use has not been determined by a court adjudication, or where a water right's historical use has changed following a previous court adjudication, legal disputes over such limits on water rights can generate substantial transaction costs (Nichols & Kenney, 2003; Taussig, 2014; Trout et al., 2011).

In this paper, we quantify how several proposed changes to prior appropriation water law could reduce expected transaction costs in the context of the state of Colorado's water markets. Each of the proposed legal changes that we study aims to reduce legal conflict over either negative externalities of water transfers or the definition of property rights. We evaluate these projected reductions in transaction costs alongside quantitative and qualitative analyses of the legal changes' third-party effects. Because opportunities to adapt water rights law for markets are constrained by existing laws and institutions (Kanazawa, 1998), our analysis focuses on legal changes that work within the overarching structure of prior appropriation. This analysis builds on our companion article, which analyzed determinants and magnitudes of transaction costs in Colorado under existing water law (Womble & Hanemann, 2020).

Colorado provides a valuable venue to study such legal changes to prior appropriation. Among the western states, Colorado has some of the region's most developed water law, and it also has particularly active water markets (Brewer et al., 2008; Trout et al., 2011). Brewer et al. (2008) report that Colorado's water markets accounted for over half the number of water transfers recorded from 1987 to 2005 in the 12 western states they studied and had the highest percentage of permanent transfers. Colorado is also the only state with a permanent, specialized water court system that performs initial legal review of water rights transfers. Although disputes over issues like lawful historical use still add substantial uncertainty to water rights in Colorado, the water courts establish a continuous adjudication process that affords Colorado perhaps the most clearly defined water rights of any state in the western United States (Trout et al., 2011; Womble & Hanemann, 2020). In this system, one water court exists in each of the state's seven water divisions, where divisions roughly follow major river basin boundaries (Figure 1a). The Colorado Supreme Court appoints an existing district court judge as the water judge in each water court, and a water referee assists each judge. The water courts review and approve transfers of rights to both surface water and hydrologically connected
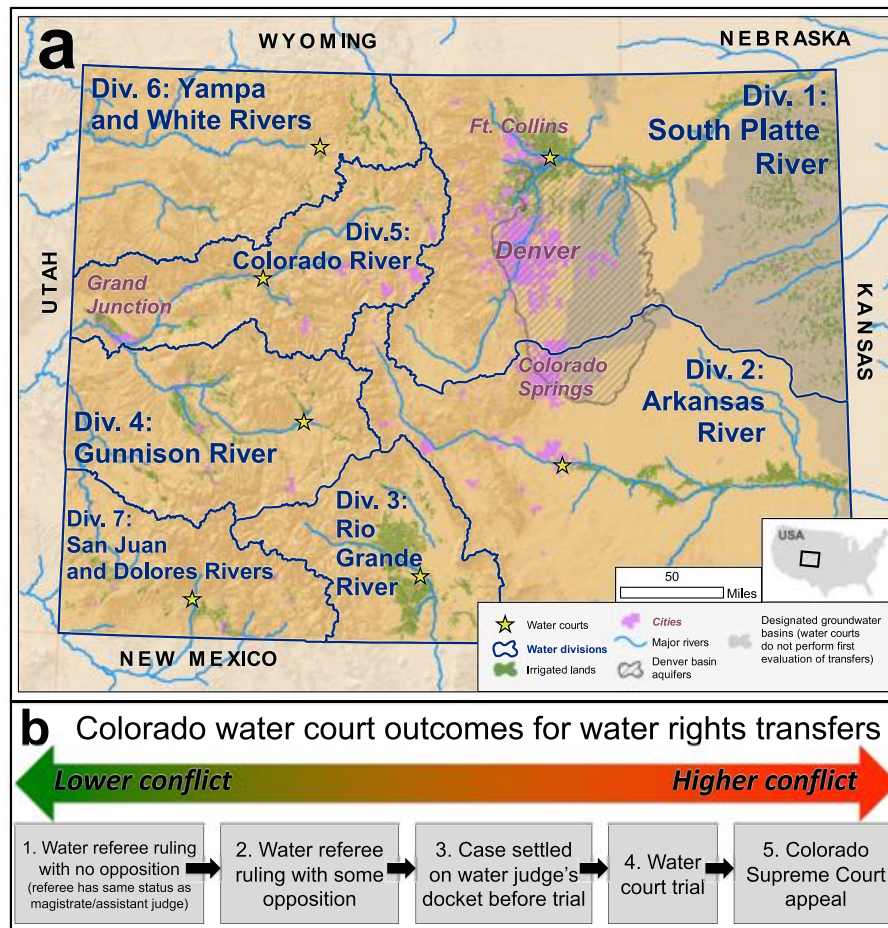
Figure 1. (a) Colorado law administratively separates the state into seven water divisions, which largely track major river basin boundaries. Each water division has a water court. Water courts approve long-term water rights transfers of surface water and tributary groundwater, while agencies approve transfers in designated groundwater basins in eastern Colorado and certain temporary water rights transfers. (b) Legal outcomes for water rights transfers in Colorado's water courts.

groundwater, in addition to handling other water disputes (Trout et al., 2011). In other western states, government agencies initially review and approve of water transfers, but the agency decision may subsequently be appealed to a court (Colby et al., 1989). In most other states, the courts that handle water rights lawsuits are generalist courts that hear diverse legal matters (Thorson, 2016).

In all western U.S. states, third parties may legally object to proposed water transfers. Because all water transfers in Colorado are first referred to the water referee, low-conflict cases without opposition may be resolved before the referee or, where opposition exists, via settlement. Otherwise, referees refer higher-conflict cases that face more opposition back to the water judge. Some such cases may be settled before trial, while others proceed to a water court trial. Finally, in especially contested cases, Colorado allows direct appeals of water court decisions to the Colorado Supreme Court, which must hear these appeals (Trout et al., 2011; Figure 1b).

The result is that while attorneys and hydrologic experts are a fixture of water transfers across the western United States (Colby et al., 1989), Colorado's system prompts nearly all participants in water transfers to retain attorneys and hydrologists at an early stage (Colby, 1990). Consequently, water market transaction costs are high in Colorado. Colby (1990), for example, compared transaction costs across 19 transfers and found that they averaged 12% of total water and non-water costs in Colorado but 6% across Arizona, Colorado, New Mexico, and Utah. Our own recent investigation, a companion to this paper, found that expected transaction costs in Colorado under existing law averaged 35.7% of total costs across 523 transactions (Womble & Hanemann, 2020).

In our companion analysis, we found that legal conflict due to objections to water transfers, along with other legal and physical features of transferred water rights, are significant determinants of transaction costs in Colorado. For instance, for a transfer of 100 acre-feet per year (AFY; 1 AF equals 1,233 m^3) of senior rights in Colorado's South Platte River Water Division (Division 1) (Figure 1a), the division with the most water scarcity and transfer activity and the highest market prices for water rights, the range of expected legal plus hydrologist fees to complete a water transfer is $800/AFY under the lowest-conflict court outcome (a referee's ruling with no opposition) but $3,417/AFY under the highest-conflict outcome (an appeal to the Colorado Supreme Court). For this 100 AFY transfer, ex ante expected probabilities of the legal outcomes ranged from, at lowest, 1.52% for a referee's ruling without opposition to, at highest, 53.6% for a settlement of the transfer on the water judge's docket before trial; other legal outcomes had intermediate probabilities. Considering all possible legal outcomes, the expected value of legal plus hydrologist fees for this transfer amounted to $2,208/AFY. For a 100 AFY transfer of junior rights with a lower legal priority to water in the South Platte River Division, the expected value of fees decreased to $1,770/AFY. Also, these transaction costs contain substantial fixed costs, generating significant economies of scale; for example, expected transaction costs for a very large 40,000 AFY transfer of senior rights in the South Platte River Division were just $20/AFY. Expected transaction costs and probabilities of different legal outcomes also vary substantially across Colorado's water divisions, with higher-conflict legal outcomes more probable and transaction costs for each outcome higher in divisions with greater water scarcity, water market prices, and complexity of water rights operations. The South Platte River Division (Division 1) has the highest expected transaction costs, while several rural divisions (Divisions 4/6/7) have the lowest transaction costs. A transfer of 100 AFY of senior rights in Divisions 4/6/7 had expected transaction costs of just $787/AFY (Womble & Hanemann, 2020).

The legal objections that drive transaction costs in Colorado commonly allege at least two deficiencies in proposed transfers: (1) that the transfer will cause legal injury to third parties or (2) that the transfer will enlarge water rights beyond their lawful historical use (Trout et al., 2011). Prior appropriation law entitles all water rights holders to continuation of the stream conditions that existed when their water right was initially appropriated (Gould, 1988; Thompson et al., 2012). Because downstream water users commonly rely on water diverted but not consumed upstream, transfers that change the timing, location, or type of use upstream may modify streamflow available to downstream users. Where these modifications reduce the volume or timing of return flows available to a downstream water right, they constitute legal injury prohibited by the no-injury rule (Gould, 1988). The no-injury rule and related legal requirements are a major source of transaction costs for water transfers in Colorado (Banks & Nichols, 2015; Squillace, 2012).

Unlike other western states, Colorado's water markets primarily consist of permanent water rights sales as opposed to temporary leases (WestWater Research, 2017). There are various types of temporary lease in Colorado, and the legal requirements and procedures for approving leases varies by type of lease and differ from those for permanent transfers (Trout et al., 2011). A recent set of legal changes in Colorado authorized an administrative agency, the State Engineer's Office, to approve certain temporary water leases in an expedited fashion instead of Colorado's water courts, which historically approved those transfers (McLane & Dingess, 2014; Nichols & Kenney, 2003). However, standalone leases are not very common in Colorado, and in general, third-party effects are less of an issue with temporary leases because of their short time duration. Because of the importance of permanent transfers in Colorado, we focus here on transaction costs for that type of transfer. Permanent transfers are likely to become the main mechanism for achieving long-run reallocation of water to urban, industrial, and ecosystem uses and long-run adaptation to climate change.

In our companion article, nearly all survey participants reported that during their careers, water court transaction costs to complete permanent water transfers in Colorado have increased faster than the rate of inflation (Womble & Hanemann, 2020). The high transaction costs for these transfers and their growth over time have generated discussion of changing Colorado water law to lower transaction costs (Banks & Nichols, 2015). That ongoing discussion prompts the question at the core of this paper: to what extent could changes to water law reduce transaction costs for water transfers in Colorado? Though existing legal and economics literature qualitatively suggests many changes to water law intended to reduce water market transaction costs, few studies quantitatively estimate how future legal change could impact transaction costs (cf. Crase et al., 2001; Speelman et al., 2010).

As part of the same survey that we used to measure transaction costs under existing water law in Womble and Hanemann (2020), we also asked respondents to assess how transaction costs might change with several modifications to prior appropriation water law in Colorado. This paper analyzes those particular survey responses and develops a statistical model of the impact of legal changes on transaction costs for water transfers in Colorado. Because these legal changes might modify legal protections against negative externalities, we also explore perceived third-party impacts of the legal changes through the stated preference survey and also qualitative interview data.

2. Market-Oriented Changes to Colorado Water Law Examined in Our Survey

Our survey explored four specific changes to Colorado water law, shown in Table 1. The first two legal changes modify the no-injury rule, while the next two legal changes aim to clarify the definition of water rights. These legal changes could be implemented in any prior appropriation state in the western United States. For each legal change, we estimated the impact on expected transaction costs for water transfers, and we assessed the potential increases in third-party injury relative to status quo law. The first three legal changes emerged during a workshop in Colorado attended by approximately 20 judicial officers, state officials, attorneys, hydrologists, and engineers, hosted by the University of Colorado School of Law in 2014 (Banks & Nichols, 2015). The fourth change drew upon legislation enacted by the Colorado State Legislature in 2015. Although these legal changes pertain to western U.S. water law, they confront general dilemmas faced by water markets across the world: management of third-party impacts of trading, whether and how to allow third parties to object to transfers, standardizing and increasing the fungibility of water market commodities, and treatment of unexercised "sleeper rights" (i.e., "paper water") (Carey & Sunding, 2001; Chang & Griffin, 1992; Crase et al., 2004; Etchells et al., 2004; Hadjigeorgalis & Lillywhite, 2004; Howe et al., 1986; Michelsen et al., 2000; Nieuwoudt & Armitage, 2004; Turral et al., 2005; Young et al., 2000; Young et al., 2015).

2.1. Legal changes #1A and #1B: Apply a de minimis injury standard that sets a minimum threshold for injury

While Colorado and many other states acknowledge no de minimis or minimum threshold for injury, in a recent case on Idaho's Snake River, the state's Department of Water Resources chose not to curtail junior groundwater rights that fell within a 10% margin of error in its groundwater model, effectively implementing a 10% de minimis injury standard. The Idaho Supreme Court upheld this decision (*Clear Spring Foods, Inc. v. Spackman*, 2011). Our pretest survey participants in Colorado suggested that a 10% de minimis injury standard was too large. However, when the Colorado Water Conservation Board decides whether or not to file legal objections to transfers, it applies a 1% standard (2 Colo. Code Regs. § 408-2:8e (2019)). We therefore evaluated a de minimis injury standard that excludes consideration of third-party injury less than 1% of average streamflow over a representative time period. In one version of this change, #1A, we told participants that the transfer occurred on a major river, while in #1B we told participants that the transfer occurred on a smaller tributary with a smaller minimum threshold.

2.2. Legal change #2: Shift the initial burden of proof for injury from applicants to objectors

Because under the no-injury rule, transfer applicants bear the initial burden of proving a negative—that no real or imagined injury will occur—several analysts have suggested shifting the initial legal burden of proof for injury from applicants to objectors (Banks & Nichols, 2015; Squillace & McLeod, 2016; Thompson et al., 2012). Under existing law, applicants first bear this burden of proof, and only after they have satisfied it with adequate evidence (legally, a "prima facie case") of no injury is this burden shifted to objectors (Banks & Nichols, 2015; Womble, 2017). This burden of proof has been reported as problematic for applicants in other western states (e.g., Montana) (Szeptycki et al., 2015).

2.3. Legal change #3: Attach a rebuttable presumption to use of a standardized tool for calculating the amount of transferable water associated with a water right (i.e., consumptive use)

Consumptive use is one common metric of transferable water for water transfers in the western United States (Thompson et al., 2012). In Colorado, transferable water is quantified as historical consumptive use (Trout et al., 2011). Substantial transaction costs in western U.S. water markets are attributed to disputes over parameters, equations, and data used to calculate consumptive use. To reduce these costs,

Table 1
Legal Changes for Which Expected Transaction Costs and Potential Increases in Third-Party Injury Were Quantified

Objective of the legal change	Legal change number	Legal change[a]
Modify management of third-party impacts under the no-injury rule	**#1**	De minimis injury threshold for transfers (1% of average annual streamflow over a representative time period) • **#1A:** Standard implemented on a major river • **#1B:** Standard implemented on a smaller tributary
	#2	Shift the initial burden of proof for injury to objectors
Clarify the definition of property rights	**#3**	Rebuttable presumption for transferable water calculated with a standardized tool developed by the Colorado State Engineer's Office
	#4	Abolish or restrict requirement that transferable water be limited to a water right's historical use (e.g., where a prior transfer has already quantified the water right's transferable water, adopt that value instead of relitigating transferable water)

[a]Complete descriptions of the legal changes that we presented to participants during our survey are available in the supporting information.

commentators have suggested establishing presumptive or standardized tools for calculating consumptive use (Banks & Nichols, 2015; Podolak & Doyle, 2014; Squillace, 2012; Thompson et al., 2012). Montana, for example, has promulgated standard assumptions for calculating historical consumptive use (Mont. Admin. R. 36.12.1902, 2019). For legal change #3, we instructed survey participants to evaluate transfers as if the Colorado State Engineer's Office had promulgated a regulation that established how to calculate historical consumptive use, including parameters and equations for consumptive use, return flows, and irrigation efficiency. This regulation would serve as a rebuttable presumption in Colorado's water courts. To provide survey participants with examples of such tools, we highlighted two standardized tools that have been piloted in Colorado's Arkansas River Basin without a rebuttable presumption (Banks & Nichols, 2015).

2.4. Legal change #4: Abolish (or restrict) historical use analysis

Many western U.S. states, including Arizona, Colorado, Idaho, Montana, Wyoming, and Washington, limit transfers to the amount historically used under the water right (Szeptycki et al., 2015; Thompson et al., 2012; Text S21). This restriction means that transfer proponents must credibly document the water right's past use. Such historical use analysis raises legal and hydrology costs (Szeptycki et al., 2015; Taussig, 2014). Some other states do not apply the historical use limitation; for example, Texas law allows transfers of "paper water" by directing that water rights transfers be evaluated "based upon the full amount of water authorized by the existing permit irrespective of the amount that the permit holder has actually used" (*City of Marshall v. City of Uncertain*, 2006). Moreover, while Colorado law typically requires historical use analysis, in two situations it may not. First, 2015 Colorado legislation established that where a prior water court case determined the historical consumptive use of a water right, that determination controls in subsequent cases, effectively removing historical use analysis from subsequent cases (Colo. Rev. Stat. § 37-92-305(d)-(e) (2018)). Second, where a prior transfer moved water out of a mutual ditch company and a ditchwide analysis determined the historical consumptive use per share of stock in that company, subsequent transfers often adopt this prior determination (Payne et al., 2014; Taussig, 2014). In our survey, we instructed participants to evaluate transfers with legal change #4 as if at least one of these two situations applied more generally.

3. Methods

In our companion article, we estimated a hedonic cost function for procedural transaction costs for water rights transfers under existing law in Colorado (Womble & Hanemann, 2020). Hedonic cost functions represent the unit price of a commodity as a function of its various attributes. Data on transaction costs for water market transfers are usually not publicly available under existing water law, and limited or no empirical experience exists with the four changes to water law. Accordingly, we employed stated preference survey methodologies to elicit transaction costs associated with water transfers having various specific characteristics. We identified relevant water rights transfer characteristics by reviewing prior literature and then conducting pretest interviews with five attorneys and five hydrologic experts. We identified three

characteristics of water rights that might influence transaction costs: the transfer's (1) volume of average annual consumptive use; (2) water right seniority; and (3) Colorado water division. Rather than providing specific priority dates for water right seniority, we qualitatively described water rights as "senior" or "junior" because the priority dates that delineate senior versus junior rights vary across Colorado. To elicit responses without and with legal change, we included the four legal changes listed in Table 1 as a fourth characteristic of the water rights transfer.

The fifth characteristic of the transfer is its water court outcome, ranging from low- to high-conflict resolutions (Figure 1b). Because water court outcomes are unknown ex ante (e.g., whether a case is settled or goes to trial), we elicited responses in two steps: we elicited (1) respondents' expectations of the legal outcome and then (2) their estimate of transaction costs conditional on a given legal outcome. We performed each of these steps twice: once under status quo water law (analyzed in Womble & Hanemann, 2020) and once with the legal change (analyzed in this paper). Our final estimate of expected transaction costs combines the two elicitation steps; the expected value is given by

$$E(\text{cost}) = \sum_{j=1}^{J} P(\text{outcome}_j) * \text{cost}_j \tag{1}$$

where j represents alternative water court outcomes.

In addition to this transaction cost elicitation, we explored potential third-party effects of the legal changes. We did this by asking participants to (1) indicate the percent change, if any, in a third party's transaction costs to legally oppose the transfer under the legal change and (2) rank the four legal changes from most to least likely to increase the likelihood of injury to other water rights.

3.1. Survey Structure

The survey consisted of an in-person interview followed by an online survey. The in-person interview introduced the four legal changes and asked respondents to rank them based on injury. Then, the survey moved into a hedonic cost elicitation (Table S2 and Figures S1–S8 in the supporting information). We first presented respondents with a particular water transfer characterized in terms of its volume of consumptive use, seniority, and water division and asked them to assess probabilities of the five legal outcomes for that transfer under existing Colorado law. Possible options were 0%, <1%, 1–5%, 5–10%, 10–20%, 20–40%, 40–60%, 60–80%, 80–90%, 90–95%, 95–99%, >99%, and 100% (Figures S1 and S2). Then, we told the respondent which water court outcome had occurred, and we asked them to consider two versions of that transfer with that outcome under existing Colorado water law—a simple version and a complex version. For each version of the transfers, we asked respondents to provide an estimate of the applicant's legal fees, hydrologist fees, and water court completion times (in months) under existing law (Figures S3 and S4). We asked survey participants to estimate fees and completion times under conditions that existed when we administered the survey in 2017. We instructed participants to estimate fees and times from when a client first asked them to work on a transfer until the water court issued a decree. We also asked them to report typical costs based on reasonable market rates that they and their colleagues would charge.

Next, we introduced the specific legal change, and we repeated the assessment of probabilities of water court outcomes, fees, and completion times under the legal change (Figures S5–S8). For this assessment, we reminded respondents of their prior estimates of these variables, and we asked them by what percentage fees and completion times would change, if at all (Figures S7 and S8).

After the in-person interview, we invited respondents to take the online survey. The online survey presented five more water transfer scenarios like the one scenario in the in-person survey, again requesting probabilities of alternative water court outcomes and then, for a given outcome, the applicant's legal fees, hydrologist fees, and water court completion times under existing law and then with a specific legal change.

For the in-person and online water transfer scenarios, we varied the five characteristics using a fractional factorial *D*-efficient experimental design (Sawtooth Software, 2017) (Table S2). However, we began the in-person and online surveys by asking respondents to indicate water divisions and volumes of water that they felt comfortable evaluating, and where the experimental design assigned a different division or volume, we randomly replaced the value with one that fell within their experience or comfort. Moreover, on a final

card or webpage for each transfer scenario, we asked participants to indicate whether they thought that the legal change would increase, decrease, or not change legal fees or hydrologist fees for a leading objector to the transfer, and we asked participants to supply interval data (low and high estimates) of this percent change.

After the choice experiment was completed, we concluded the in-person interview by briefly asking respondents how recent changes to Colorado law—expedited review for temporary leases and recent water court rule changes adopted by the Colorado Supreme Court—have affected transaction costs.

3.2. Survey Sample

Including the 10 pretest participants, 100 respondents completed the in-person survey. Of these, 71 completed the online survey. Initial participants were identified through email and phone notifications to subscription lists maintained by Colorado's water courts, the State Engineer's Office, the Colorado Bar Association, the Colorado Water Congress, and the American Water Resources Association. Additional interviewees were identified through references from earlier participants. Because there is no database of water lawyers and engineers in Colorado and the population is small, we interviewed as many participants as possible rather than a representative sample. A sampling approach combining convenience and snowball sampling is common in expert surveys (Fink, 2003).

The sample is described in Table S1. Of the respondents, 63 were lawyers, and 35 were hydrologic experts. The other two were a water planner and an administrator. In our analysis below, for simplicity, we refer to the group of all non-lawyers as hydrologists. Overall averages for respondents were 26.2 years of experience, 15.3 transfers per year, and a lifetime experience of 159 transfers. On average, respondents reported that 40.7% of the transfers they worked on were for applicants; 23 respondents reported working more than half of their transfers for applicants, 53 reported working more than half for objectors, and 21 reported working half for applicants and half for objectors.

We surveyed legal and hydrologic experts with repeat water court experience across diverse types of water transfers because they are probably best informed about potential impacts of the legal changes. Because the legal changes analyzed in this paper are proposed or nascent, the respondents lack direct experience with these changes (with the exception of ditchwide decrees under #4). Accordingly, the survey results measure experts' expectations regarding the impacts of legal changes rather than actual experience. Where our models below depict statistically significant impacts, they can be interpreted as consensus expert opinion.

Issues that sometimes arise in stated preference surveys are hypothetical bias or strategic behavior by respondents. Conventional stated preference surveys elicit respondents' maximum willingness to pay for an item, and empirical evidence suggests that respondents tend to understate willingness to pay and instead offer estimates anchored on what they think the item would cost (Brown, 2005). In this study, however, we elicited assessments of cost, not willingness to pay, from informed respondents for whom such assessments are a daily reality. However, because the specific legal changes may be novel to them, we made elicitation scenarios more realistic by referencing similar specific technical tools or legal provisions that already exist in Colorado accompanying each legal change. Likewise, we emphasized early in our in-person interviews that other Colorado water professionals (not us) suggested the legal changes. Also, the survey was administered by a fellow professional—a lawyer with experience in Colorado water law. Consequently, we believe that conventional issues of incentive compatibility that can arise in a stated preference surveys are unlikely here.

Obviously, some of our respondents may favor or disfavor particular legal changes. That is a matter of their preference; whether it also led them to misrepresent the impact on legal and hydrologist fees, as opposed to offering their unvarnished assessment, is unclear. We endeavored to mitigate strategic response behavior by asking questions about third-party impacts before we asked about the impact on transaction costs, since pretest respondents seemed particularly concerned about the effect of legal changes on third-party impacts. As described in our results, we also investigated whether systematic differences of opinion existed in transaction costs elicited from different types of respondents by exploring two-way interaction terms between respondent characteristics and legal changes. Most of these interaction terms were not statistically significant.

3.3. Econometric Methods

As depicted in equation (1), our model for predicting water market transaction costs in Colorado has two components: predictions of probabilities of water court outcomes and then estimation of transaction costs conditional on court outcomes. Responses to the survey questions about water court outcomes take the form of five probabilities, with one for each water court outcome. Except for the case where the assessed probability is 0 or 1, the response is a range of probability values. A Dirichlet distribution can be used to model a set of proportions, and there are several methods to elicit Dirichlet proportion estimates (Zapata-Vázquez et al., 2014). One approach elicits a point estimate for each probability. However, that approach is problematic when there is significant uncertainty about the probabilities. Accordingly, another practice is to elicit respondents' confidence intervals around their point probabilities (Chaloner & Duncan, 1987), or, more simply, to elicit an interval in which they believe the probability falls (Garthwaite et al., 2005), known as the variable interval method. Because we observed uncertainty in the elicitation of probabilities in pretest interviews, we elicited ranges rather than point estimates for probabilities of court outcomes.

Because some combinations of probability values within ranges offered by participants did not sum to 1 across the five outcomes, we restricted these to a feasible range of the lowest to highest probabilities that allowed possible combinations that sum to 1 when combined with probability ranges for other legal outcomes (equations (S8) and (S9) in the supporting information). Then, we converted feasible probability ranges to single-valued probabilities using three approaches. The main approach uses a middle value from the feasible range, while a low-conflict version maximizes the probability of low-conflict court outcomes and a high-conflict version maximizes the probability of high-conflict outcomes (equations (S10) and (S11)). The low- and high-conflict versions offer a form of bounds for the main estimate. We present the main estimate below and the low- and high-conflict estimates in Tables S3 and S4.

The main approach, which is calculated with equation (2), selects middle values between the bounds of the feasible ranges that ensure all probabilities sum to 1.

Main approach $_j$ = lower bound of feasible range $_j$ +

$$+\left(\frac{\text{upper bound of feasible range}_j - \text{lower bound of feasible range}_j}{\sum_{j=1}^{J}\left(\text{upper bound of feasible range}_j - \text{lower bound of feasible range}_j\right)}\right) \tag{2}$$

$$*\left(1 - \sum_{j=1}^{J}\text{lower bound of feasible range}_j\right)$$

where j are the alternative legal outcomes

The five outcome probabilities were modeled as a function of the transfer characteristics, including legal changes, using fractional multinomial logit (FMNL) estimation. FMNL proceeds by assuming that the expected value of the y_{ijk} is given by

$$E\left(y_{ijk}|X_{ik}\right) = \frac{\exp\left(X_{ik}\beta_j\right)}{\sum_{j=1}^{J}\exp\left(X_{ik}\beta_j\right)} \quad j = 1, ..., J \tag{3}$$

where y_{ijk} is the ith respondent's assessment of the probability of water court outcome j under water transfer scenario k; X_{ik} are explanatory variables pertaining to respondent i and the attributes of transfer scenario k, including the legal changes; and β_j holds the coefficients for X_{ik} in the case of court outcome j (Ramalho et al., 2011).

Second, we estimate hedonic cost functions for legal fees, hydrologist fees, and water court completion times. The survey elicited simple and complex estimates for fees and completion times, which we took as interval data. We used interval regression for the hedonic cost functions, which works similarly to ordinary least squares (OLS) regression of the log-linear model

$$\ln W_{ik} = X_{ik}\beta + \upsilon_k \tag{4}$$

where explanatory variables are denoted by $\mathbf{X}_{ik}$ (identical to those in the FMNL model but also including legal outcome); their coefficient vector is $\boldsymbol{\beta}$; and υ_k are normally distributed error terms. Unlike in OLS, in interval regression, bounded variables W_{ik} are given by

$$\mathrm{P}(\text{lower bound} \leq W_{ik} \leq \text{upper bound}) = \mathrm{P}\big(e^{X_{ik}\beta+\upsilon_k} \leq \text{upper bound}\big) - \mathrm{P}\big(e^{X_{ik}\beta+\upsilon_k} \leq \text{lower bound}\big) \tag{5}$$

Separately from the estimation of transaction costs, we used rank-ordered logistic regression to assess data from the ranking exercise that compared third-party impacts. As shown in equation (6), rank-ordered logistic regression models are fitted by estimating β values that maximize the likelihood of the observed rank orders from survey responses (Long & Freese, 2006). The probability that legal change a is ranked first, change b second, and change c third is

$$\mathrm{P}(y_1 = \mathrm{a}|\mathbf{x}) \ \ x \ \ \mathrm{P}(y_2 = \mathrm{b}|\mathbf{x}, y_1 = \mathrm{a}) \ \ x \ \ \mathrm{P}(y_3 = \mathrm{c}|\mathbf{x}, y_1 = \mathrm{a}, y_2 = \mathrm{b})$$

$$= \left(\frac{\exp\big(\mathbf{x}\beta_{a|z}\big)}{\sum_{j=1}^J \exp\big(\mathbf{x}\beta_{j|z}\big)}\right) x \left(\frac{\exp\big(\mathbf{x}\beta_{b|z}\big)}{\big(\sum_{j=1}^J \exp\big(\mathbf{x}\beta_{j|z}\big)\big) - \exp\big(\mathbf{x}\beta_{a|z}\big)}\right) x \left(\frac{\exp\big(\mathbf{x}\beta_{c|z}\big)}{\big(\sum_{j=1}^J \exp\big(\mathbf{x}\beta_{j|z}\big)\big) - \exp\big(\mathbf{x}\beta_{a|z}\big) - \exp\big(\mathbf{x}\beta_{b|z}\big)}\right) \tag{6}$$

where $y_r = m$ is the rank given to alternative m; $\mathbf{x}$ includes case-specific variables; z is the baseline (excluded) legal change; $\beta_{k,m\,|\,b}$ is the effect of x_k on log odds of choosing alternative m over alternative b, with $\beta_{k,b\,|\,b} = 0$ for all k; and $j = 1, \dots, J$ are the legal changes.

4. Estimation Results

4.1. Influence of Legal Changes on Water Court Outcomes

As described above, possible water court outcomes are, from least to most conflict, (i) referee ruling with no opposition, (ii) referee ruling with some opposition, (iii) settlement on the judge's docket before trial, (iv) trial, and (v) appeal to the Colorado Supreme Court. Both (ii) and (iii) involve a legal settlement among the parties. Potential determinants of the outcome include volume transferred, water right seniority, and the water division(s) where the transfer occurs, along with the legal change. To understand the relationship between legal changes and water court outcomes, we now present the main FMNL model (3). Because the $\boldsymbol{\beta}_j$ coefficients in the FMNL model lack a simple interpretation, we instead show partial effects evaluated at the mean (Table 2). Partial effects of the $\mathbf{X}_{ik}$ variables, or $PE_{ik} \equiv \frac{\partial E\big(y_{ijk}|X_{ik}\big)}{\partial X_{ik}}$, may be interpreted like coefficients in standard linear regression.

With regard to non-legal change variables, the pattern of results is the same as in Womble and Hanemann (2020). A larger transfer volume raises the probability of higher-conflict outcomes and reduces that of lower-conflict ones. In Divisions 1 and 2, which have the most transfer activity and water scarcity, the most expensive water rights, and complex water rights operations, outcomes before the water referee are less likely and settlements before the water judge or trials are more likely.

The most significant legal change impact involves abolishing or restricting historical use analysis for water rights whose consumptive use has previously been quantified (legal change #4). This raises the probability of low-conflict outcomes and decreases that of high-conflict ones. Legal change #1A, a 1% de minimis injury standard on a major river, raises the probability of the lowest-conflict outcome, a referee's ruling with no opposition, and concomitantly reduces the probability of a higher-conflict outcome, a settlement on the water judge's docket awaiting trial. Main effects for other legal changes are statistically insignificant, but some interactions are significant. In the Rio Grande and Colorado River Divisions, shifting the initial burden of proof for injury to objectors (legal change #2) lowers the probability of the two highest-conflict outcomes. Using a presumptive standardized tool to calculate consumptive use (legal change #3) for a larger transfer volume lowers the probabilities of two higher-conflict outcomes, settlement before the water judge and appeals to the Colorado Supreme Court. Applying the de minimis injury threshold on a small tributary (legal change #1B) for transfers of senior rights raises the probability of a lower-conflict outcome (referee's ruling

Table 2
Fractional Multinomial Logistic (FMNL) Regression Results for Probabilities of Five Water Court Outcomes With Changes to Colorado Water Law

Determinant	Outcome 1[a]: Referee ruling with no opposition	Outcome 2[a]: Referee ruling with some opposition	Outcome 3[a]: Case settled while on judge's docket awaiting trial	Outcome 4[a]: Water court trial	Outcome 5[a]: Colorado Supreme Court appeal
Legal change 1A[b]	0.0357 (0.0142)*	0.0292 (0.0259)	−0.0645 (0.0291)*	0.00641 (0.0119)	−0.00672 (0.00481)
Legal change 1B[b]	−0.0120 (0.0361)	−0.0804 (0.0437)˙	0.0664 (0.0478)	0.00735 (0.0331)	0.0187 (0.0219)
Legal change 2[b]	0.0213 (0.0301)	−0.0220 (0.0382)	−0.0425 (0.0435)	0.0305 (0.0249)	0.0128 (0.0105)
Legal change 3[b]	−0.0101 (0.0441)	−0.0729 (0.0731)	0.113 (0.0779)	−0.0396 (0.0557)	0.00928 (0.0121)
Legal change 4[b]	0.0396 (0.00724)***	0.128 (0.0231)***	−0.0860 (0.0247)***	−0.0613 (0.00761)***	−0.0201 (0.00224)***
Interaction term 1: Division 3 or 5—Rio Grande or Colorado × legal change 2[b]	−0.00495 (0.0112)	0.0498 (0.0332)	0.0381 (0.0439)	−0.0605 (0.00822)***	−0.0224 (0.00396)***
Interaction term 2: ln (consumptive use) × legal change 3[c]	0.0110 (0.00838)	0.0280 (0.0175)	−0.0407 (0.0153)**	0.00554 (0.00758)	−0.00386 (0.00157)*
Interaction term 3: seniority × legal change 1B[b]	0.0297 (0.0228)	0.139 (0.0524)**	−0.135 (0.0484)**	−0.0225 (0.0206)	−0.0115 (0.0100)
Volume traded: ln (consumptive use)[c]	−0.0297 (0.00664)***	−0.0428 (0.00117)***	0.0410 (0.00412)***	0.0224 (0.00643)***	0.00917 (0.00207)***
Seniority: Senior rights[b]	−0.0170 (0.0151)	−0.0500 (0.0189)**	0.0144 (0.0237)	0.0394 (0.0121)**	0.0132 (0.00480)**
Location: Division 1—South Platte[b]	−0.109 (0.0351)**	−0.241 (0.0281)***	0.218 (0.0358)***	0.113 (0.0189)***	0.0190 (0.00910)*
Location: Division 2—Arkansas[b]	−0.0831 (0.0214)***	−0.100 (0.0280)***	0.102 (0.0373)**	0.0688 (0.0202)***	0.0127 (0.00968)
Location: Division 3—Rio Grande[b]	−0.0572 (0.0310)˙	−0.0692 (0.0352)*	0.0366 (0.0495)	0.0643 (0.0332)˙	0.0255 (0.0135)˙
Location: Division 5—Colorado[b]	−0.0264 (0.0167)	−0.0337 (0.0275)	−0.0191 (0.0385)	0.0719 (0.0190)***	0.00728 (0.00913)
Respondent characteristic: lawyer[b,d]	0.0359 (0.0173)*	0.000754 (0.0204)	−0.0857 (0.0225)***	0.0271 (0.0167)	0.0220 (0.00651)***
Respondent characteristic: years of work experience[c]	0.000653 (0.000657)	−0.00381 (0.000698)***	0.000361 (0.000881)	0.00229 (0.000515)***	0.000501 (0.000250)*
Observations			816		
Initial log likelihood			−1,118		
Model log likelihood			−999		
LR chi²			238		
Prob > chi²			0.00		

Note. Excluded categories are Seniority: junior rights; Location: Division 4, 6, or 7—Gunnison, Yampa/White, or San Juan/Dolores; Respondent characteristic: non-lawyer; and Legal change scenario: status quo.
[a]Krinsky-Robb robust standard errors for partial effects against the mean provided in parentheses. We used the post-estimation procedure in the fmlogit package in R (Ji, 2016), which derived partial effects against the mean and standard errors for these partial effects from an underlying FMNL model with standard errors for the β_{jk} coefficients clustered by respondent for odds ratios against the baseline choice; see equations (S6) and (S7) for bootstrapping procedure applied for clustering. [b]For dummy variables in X_{ik}, partial effects at the mean depicted in Table 2 are the effect of raising that dummy variable X_{ik} from 0 to 1 on the choice variable y_{ijk} (i.e., the probability of a given legal outcome) at the mean of all other X_{ik} covariates (Ji, 2016). [c]For continuous variables in X_{ik}, the partial effects at the mean depicted in Table 2 represent the effect of a marginal change of one continuous variable X_{ik} on the choice variable y_{ijk} (i.e., the probability of a given legal outcome) at the mean of all X_{ik} covariates (Ji, 2016). [d]The "hydrologist" category groups all non-lawyers interviewed (35 hydrologists, 1 water planner, and 1 water resources administrator). ***Significant at 0.1%. **Significant at 1%. *Significant at 5%. ˙Significant at 10%.

with some opposition) and reduces the probability of a higher-conflict outcome (cases settled before the water judge).

4.2. Transaction Costs and Completion Times

As noted, we used interval regression to evaluate legal fees, hydrologist fees, and completion times. Table 3 shows these results.

The pattern of results for non-legal change variables is again the same as in Womble and Hanemann (2020). Larger transfer volumes require longer total completion times but have lower unit fees due to scale economies. Higher-conflict legal outcomes generate higher fees and longer completion times. Fees are higher in Divisions 1, 2, and 5 and for transfers of senior rights.

Among the legal changes, only a de minimis injury threshold on a smaller tributary (legal change #1B) has no significant impact on fees or completion time. Change #1B likely lacks a significant impact because 1% of average annual streamflow on a smaller tributary establishes a smaller de minimis injury standard. All other legal changes have some impact on fees, with particularly large reductions in hydrologist fees.

In reducing hydrologist fees, abolishing/restricting historical use analysis (legal change #4) has the largest main effect, followed by a de minimis injury threshold on a major river (legal change #1A), and then shifting the initial burden of proof for injury to objectors (legal change #2). However, reductions in hydrologist fees dissipate under legal change #1A for larger-volume transfers. They probably dissipate because larger-volume transfers would be less likely to escape scrutiny under the de minimis injury standard on a major river. Also, reductions in hydrologist fees from change #4 lessened for respondents with more years of work experience.

Lawyers and hydrologists held different opinions about the impact of legal change #3 on hydrologist fees. Hydrologists as a group did not think change #3 would affect these fees (the main effect is insignificant), while lawyers thought that it would reduce them (the interaction term between lawyers and change #3 is negative and significant). While this result might reflect strategic bias, another explanation is that it reflects particular events brought up by some respondents. The State Engineer's Office had recently raised more strident objections to some proposed transfers, which triggered higher transaction costs, and it recently expressed a preference for a particular irrigation efficiency tool (the Natural Resources Conservation Service Farm Irrigation Rating Index) that met strong opposition from water users. Since legal change #3 directs the State Engineer to develop a presumptive tool for calculating consumptive use, these past experiences could explain why hydrologists did not think giving the State Engineer more legal authority would lower their workload or their fees.

With regard to legal fees, the view was that changes #4, #2, #1A, and, marginally, #3 would lower them, though the reductions are generally smaller than those for hydrologist fees. Completion times would be reduced under legal change #4 and, very marginally, under #1A, but not under #1B or #2. The view of legal change #3 was mixed. In the case of senior rights, hydrologists felt that change #3 would lengthen completion times, while lawyers thought that it would shorten them. With junior rights, both lawyers and hydrologists felt completion times would decrease.

Given these findings, in the remainder of our analysis, we drop legal change #1B and focus on changes #1A, #2, #3, and #4.

5. Projected Impact of Legal Changes on Water Transfer Proponents

Here we examine the impact of these legal changes on the expected transaction cost borne by transfer proponents. We combine the impacts of the legal changes on the probability of alternative legal outcomes with their impacts on legal and hydrologist fees conditional on the legal outcome, using equation (1) to calculate the total expected transaction cost. We compare those projected expected costs to status quo projected transaction costs absent any legal change. We also compare the changes in expected transaction costs with market prices for water rights.

In order to project the expected legal and hydrologist fees under each legal change, we assume work experience equal to survey respondents' average of 26.2 years, we use lawyers' expectations of legal fees, and we use a value of 0.5 for the "lawyer" dummy variable to estimate probabilities of alternative legal outcomes and completion times. We use hydrologists' assessment of hydrologist fees for all legal changes with the exception of legal change #3, where we previously found a difference of opinion between hydrologists and lawyers about hydrologist fees: hydrologists thought that their fees would remain the same under legal change #3,

Table 3
Interval Regression Results for Legal Fees, Hydrologist Fees, and Completion Times With Changes to Colorado Water Law

Determinant	**Model 1**: Natural log of unit (legal fees + 1) ($/AFY consumptive use)[a]	**Model 2**: Natural log of unit (hydrologist fees + 1) ($/AFY consumptive use)[a]	**Model 3**: Natural log of (total completion time + 1) (months)[a]
Legal change 1A	−0.188 (0.0710)**	−0.590 (0.189)**	−0.0178 (0.00976)·
Legal change 1B	0.0817 (0.0849)	0.0262 (0.0786)	−0.0242 (0.0149)
Legal change 2	−0.191 (0.0712)**	−0.214 (0.0776)**	−0.0204 (0.0143)
Legal change 3	−0.135 (0.0797)·	0.0335 (0.106)	0.0631 (0.0274)*
Legal change 4	−0.216 (0.0758)**	−0.770 (0.162)***	−0.0474 (0.0134)***
Interaction term 1	N/A	**ln(consumptive use) x legal change 1A:** 0.0862 (0.0380)*	**Junior rights × legal change 3:** −0.0915 (0.0397)*
Interaction term 2	N/A	**Lawyer respondent[b]× legal change 3:** −0.374 (0.151)*	**Lawyer respondent[b]× legal change 3:** −0.0652 (0.0270)*
Interaction term 3	N/A	**Respondent years of work experience × legal change 4:** 0.0168 (0.00637)**	N/A
Volume traded: ln(consumptive use)	−0.815 (0.0186)***	−0.796 (0.0203)***	0.0107 (0.00310)***
Seniority: Senior rights	0.188 (0.0768)*	0.234 (0.0700)***	0.00685 (0.0121)
Location: Division 1—South Platte	0.769 (0.162)***	0.841 (0.150)***	0.0181 (0.0241)
Location: Division 2—Arkansas	0.741 (0.150)***	0.687 (0.126)***	0.0343 (0.0201)·
Location: Division 3—Rio Grande	0.337 (0.216)	0.289 (0.165)·	−0.0328 (0.0287)
Location: Division 5—Colorado	0.489 (0.143)***	0.365 (0.127)**	0.00271 (0.0256)
Water court outcome 2: Referee ruling with some opposition	0.624 (0.152)***	0.620 (0.134)***	0.160 (0.0243)***
Water court outcome 3: Case settled while on judge's docket awaiting trial	1.04 (0.151)***	1.03 (0.129)***	0.234 (0.0276)***
Water court outcome 4: Water court trial	1.30 (0.148)***	1.20 (0.129)***	0.261 (0.0277)***
Water court outcome 5: Colorado Supreme Court appeal	1.59 (0.130)***	1.30 (0.138)***	0.335 (0.0302)***
Respondent characteristic: lawyer[b]	N/A	−0.336 (0.141)*	−0.0122 (0.0224)
Respondent characteristic: years of work experience	N/A	−0.00749 (0.00576)	N/A
Constant	8.52 (0.181)***	8.53 (0.255)***	0.928 (0.0379)***
Observations	721	809	873
Initial log likelihood	−1,797	−1,950	−1,294
Model log likelihood	−1,050	−1,131	−1,081
LR chi^2	1,495	1,637	426
Prob > chi^2	0.00	0.00	0.00
Assumed distribution of dependent variable[c]	Normal	Normal	Lognormal

Note. Excluded categories are Seniority: junior rights; Location: Division 4, 6, or 7—Gunnison, Yampa/White, or San Juan/Dolores; Respondent characteristic: non-lawyer; Water court outcome: Referee ruling with no opposition; and Legal change scenario: status quo. Standard error is provided in parentheses (clustered by respondent).
[a]Box-Cox transformations for unit legal fee, unit hydrologist fee, and total completion time OLS regressions, using the midpoint of each interval-censored dependent variable, supported our chosen semi-log functional form (Tables S5–S7). [b]The "hydrologist" category groups all non-lawyers interviewed (35 hydrologists, 1 water planner, and 1 water resources administrator). [c]Assumed distribution of dependent variable selected based on examination of AIC (Table S8).
***Significant at 0.1%. **Significant at 1%. *Significant at 5%. ·Significant at 10%.

whereas lawyers thought those fees would be reduced. Reflecting this difference of opinion, we perform the analysis both ways, projecting both the hydrologists' assessment of their fees under change #3 and the lawyers' assessment of the reduction in these fees.
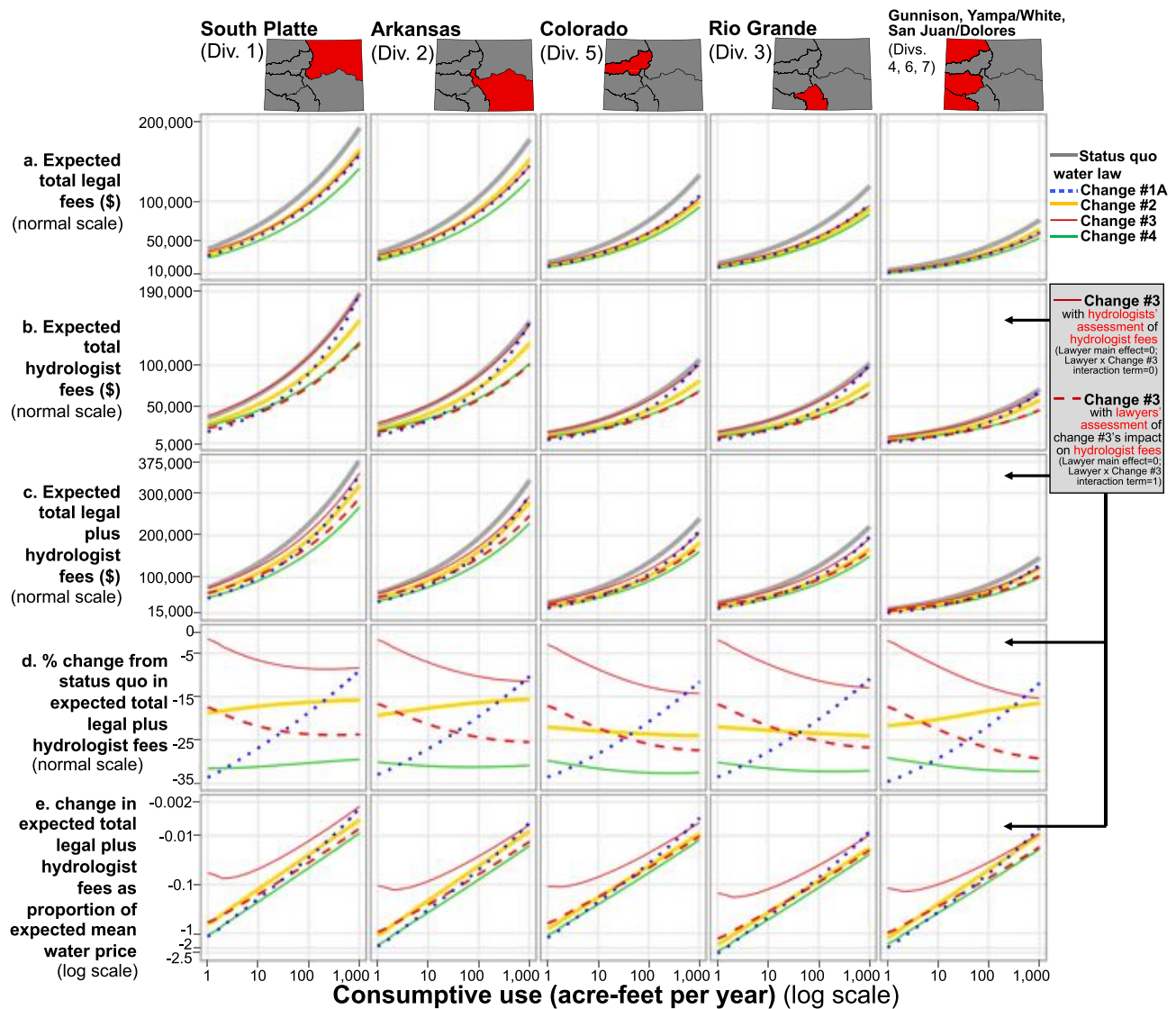
Figure 2. Expected value of applicant's (a) total legal fees; (b) total hydrologist fees; and (c) total legal plus hydrologist fees for water rights transfers, assuming senior rights. (d) The percent change in total expected fees relative to status quo water law. (e) The change in total expected fees as a proportion of the expected mean water price in each division. Figure S10 shows identical information but with expected transaction costs for junior rights.

Figures 2a and 2b show expected legal and hydrologist fees with and without legal change by water division across transfer volumes from 1 to 1,000 AFY for senior rights. Figure 2c plots the combined sum of expected legal plus hydrologist fees. Figure 2d shows the percentage change in total fees under the legal changes compared to the baseline of no legal change. Abolishing or restricting historical use analysis (legal change #4) provides the greatest reductions in expected legal plus hydrologist fees in all water divisions for all but the smallest-volume transfers. For example, for a 100 AFY transfer of senior rights in the South Platte River Division, legal change #4 reduces legal and hydrologist fees by $689/AFY, a 30.3% reduction. At the smallest volumes, the de minimis injury standard on a major river (legal change #1A) offers the greatest reductions in total fees. For example, for a very small 1 AFY transfer of senior rights in the South Platte River Division, #1A reduces total fees by $25,753, a reduction of 33.6%. At larger volumes, the fee reductions dissipate under #1A. For a transfer of 100 AFY of senior rights in the South Platte River Division, total fees decrease by $424/AFY, or 18.7%, and at 1,000 AFY of senior rights in this division, total fees decrease by $34/AFY, or just 8.99%. Shifting the initial burden of proof for injury to objectors (legal change #2) causes moderate reductions in total expected fees. For the 100 AFY transfer of senior rights in the South Platte River Division,
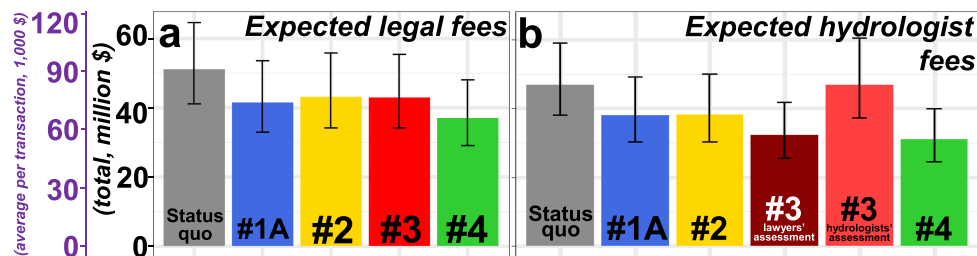
Figure 3. (a) Average and total expected legal fees with and without legal changes for water rights transactions in WestWater Research data whose transfer could require water court approval, assuming senior rights; and (b) average and total expected hydrologist fees with and without legal changes for water rights transactions in WestWater Research data whose transfer could require water court approval, assuming senior rights. In (b), we calculated lawyers' assessment of change #3 in the same way as in Figure 2b. Figure S11 shows identical information but with expected transaction costs for junior rights.

this legal change decreases total fees by $370/AFY, a 16.3% reduction. However, because shifting this burden of proof makes the highest-conflict outcomes less likely in the Rio Grande and Colorado River Divisions, expected legal and hydrologist fees show a greater percentage decrease in those divisions than elsewhere, increasingly so at larger volumes. In the Colorado River Division, for example, expected total fees for a 100 AFY transfer of senior rights decrease by 23.6%, and for a 1,000 AFY transfer of senior rights, they decrease by 24.0%. Finally, for the 100 AFY transfer in the South Platte River Division, hydrologists did not think the standardized tool for calculating historical consumptive use (legal change #3) would reduce their fees, but lawyers thought total fees would decrease by $538/AFY (23.6%).

Returning to Figures 2a and 2b, in most instances, hydrologist fees exhibit more pronounced reductions than legal fees. With restricted or abolished historical use analysis (legal change #4), expected legal fees decrease by $316/AFY (27.1%) for a 100 AFY transfer of senior rights in the South Platte River Division, while expected hydrologist fees decrease by $373/AFY (33.6%). The disparity between reductions in legal and hydrologist fees is greatest on a percentage basis for the de minimis injury standard on a major river (#1A) for small volumes traded because hydrologist fees under this legal change vary with volume. For instance, for a 1 AFY transfer of senior rights in the South Platte River Division, expected hydrologist fees decrease by $17,077 (47.3%), while legal fees decrease by $8,676 (21.4%). But at higher volumes traded, the change in hydrologist fees becomes comparable to or smaller than the change in legal fees under change #1A. Legal change #2, which shifts the initial burden of proof for injury to objectors, generates reductions in expected legal and hydrologist fees of a similar magnitude: for the 100 AFY senior rights transfer in the South Platte River Division, legal fees decrease by $173/AFY (14.8%), while hydrologist fees decrease by $197/AFY (17.8%). With regard to legal change #3, a rebuttable presumption for a standardized tool for calculating transferable water, the reduction in legal fees may be compared to the two different assessments of hydrologist fees under this legal change. Under change #3, legal fees decrease by $189/AFY (16.2%) for a 100 AFY transfer in the South Platte River Division. According to hydrologists, change #3 has no impact on hydrologist fees. But according to lawyers, change #3 decreases hydrologists fees for this transfer by $349/AFY (31.5%). Parallel results for expected completion times are in Figure S12.

To put these transaction cost changes in perspective, we compared them with market prices for water rights. In our companion article, we developed a statistical model of the expected market price for water rights in Colorado (Womble & Hanemann, 2020; the model is also available in Table S9). This OLS regression model predicts these prices as a function of characteristics of the water right being traded. We developed this regression based on price data for 523 permanent water market transactions that occurred in Colorado over the period 2008–2018. The price data were provided by WestWater Research, LLC, which maintains the most comprehensive modern data on water market transactions in Colorado. The prices are net of transaction costs; WestWater's market price data cover just the price paid by the buyer and exclude water court transaction costs, which the buyer in Colorado typically bears after the transaction closes (Author email with Brett Bovee, Intermountain Regional Director, WestWater Research, LLC, 15 August 2019). For purposes of comparing the changes in transaction costs with market prices for water rights, we assumed that any reduction in transaction costs had no effect on the water rights prices—we lack the means of making any other assumption.

Figure 2e displays the expected change in total legal and hydrologist fees as a proportion of the expected market price for water rights in Colorado calculated for each water division across volumes of 1 to 1,000 AFY. Across all legal changes, the reduction in transaction costs as a proportion of water price peaks at low transfer volumes and declines for higher volumes. In all water divisions, the greatest decreases in this proportion occur under the de minimis injury standard on a major river (legal change #1A) for a 1 AFY transfer of senior rights, with a maximum decrease of 2.56 for this transfer in the Rio Grande Division. At small volumes, legal change #1A is followed, from greatest to smallest decrease in the proportion, by changes #4, #2, #3 as perceived by lawyers, and #3 by hydrologists. At higher volumes, scale economies in transaction costs dominate, overwhelming decreased transaction costs from the legal changes. For 1,000 AFY transfers of senior rights across all divisions and all legal changes, the greatest decrease in the proportion is 0.0239 (legal change #4 in the Rio Grande Division), while the smallest is 0.00251 (legal change #3 by hydrologists in the South Platte Division).

In a second analysis based on the WestWater data, we also calculated transaction cost savings for each of the 523 individual transactions. For each of those transactions, we identified the change in expected transaction costs using the regression equations in Tables 2 and 3, using the volume and division of the transaction as our explanatory variables and also assuming senior rights and other parameters from Figure 2. In Figure 3, we present the average and total cost savings from each legal change. WestWater's data do not separate transactions on major rivers versus smaller tributaries, so Figure 3's estimates for legal change #1A (de minimis injury standard on a major river) assume all occurred on major rivers. Error bars in Figure 3 are 95% confidence intervals, which we computed via Monte Carlo simulation (Text S9).

Expected legal fees without legal change for senior rights, averaged across the 523 transactions, amounted to $97,655 per transaction, or $51.1 million when totaled across the transactions. Legal change #4 offers the largest reduction in these costs ($26,859 per transaction, or $14.0 million total), followed by legal change #1A ($18,542 per transaction/$9.70 million total), #3 ($15,652 per transaction/$8.19 million total), and #2 ($15,274 per transaction/$7.99 million total).

Meanwhile, hydrologist fees without legal change average $89,691 per transaction ($46.9 million total). Legal change #4 again generates the largest reduction ($30,485 per transaction/$15.9 million total), followed by lawyers' expectations for #3 ($28,057 per transaction/$14.7 million total), #1A ($17,065 per transaction/$8.92 million total), #2 ($16,487 per transaction/$8.62 million total), and hydrologists' expectations for #3 (where fees do not significantly change).

With regard to completion times, across the 523 transactions, the average expected completion time absent legal change is 2.29 years per transaction, assuming senior rights (Figure S13). Legal change #4 reduces this value by 5.51 months. Lawyers and hydrologists again held different opinions about the impact of legal change #3. Lawyers thought this change would decrease the average completion time by 0.855 months for senior rights, while hydrologists thought it would increase it by 6.13 months.

6. Projected Impact of Legal Changes on Third Parties

Changing water laws that govern water transfers may also impact third parties. First, because third-party objectors to transfers incur transaction costs to protect their water rights, changing water law may modify these costs. Legal changes that decrease objectors' water court expenses may or may not be favorable for objectors, because legal changes may reduce objectors' expenses by discouraging or precluding objectors from contesting issues they would like to contest. Second, changes to water law may reduce legal protections against injury. Our survey accounted for these two countervailing impacts of legal changes on third parties in separate analyses, detailed in sections 6.1–6.3.

6.1. Impacts of Legal Changes on Procedural Transaction Costs for Third-Party Objectors

After we requested estimates of applicants' transaction costs for a given water transfer scenario, we also asked survey participants about the potential impact of each legal change on a leading objector to that transfer. Specifically, we asked whether the objector's legal and hydrologist fees would be affected by the legal change. If the respondent indicated that an objector's fees would change, we asked for an estimate of the percentage change in the form of a range (i.e., interval data). Respondents estimated changes in objectors' fees ranging, across all of the legal changes, from a 95% reduction in legal fees with a presumptive standardized
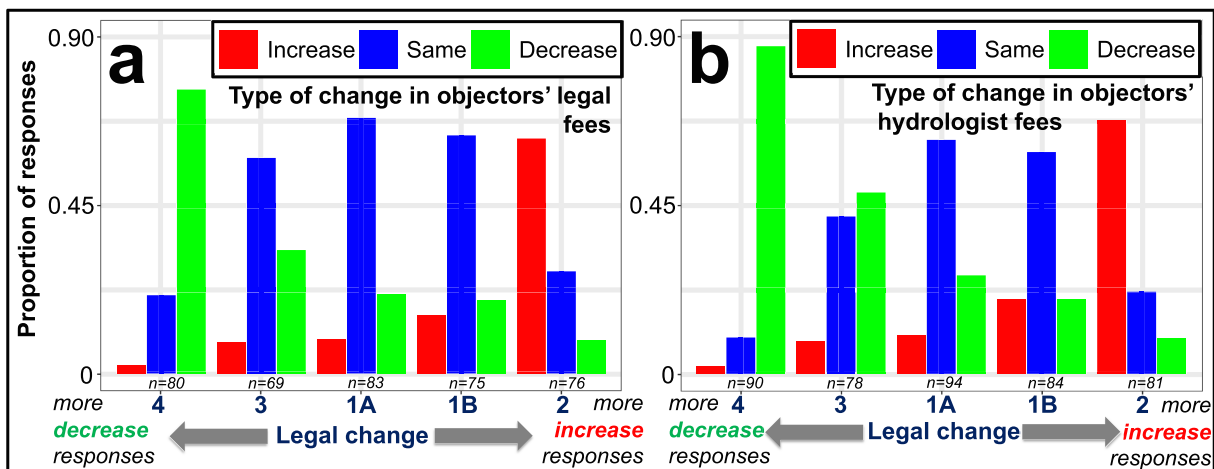
Figure 4. (a) Type of change in an objector's legal fees with each legal change. (b) Type of change in an objector's hydrologist fees with each legal change. Results in (a) and (b) are similar when grouped by respondent instead of response; see Figure S15.

tool for calculating transferable water (legal change #3) to a 400% increase in both legal and hydrologist fees after shifting the initial burden of proof for injury to objectors (change #2).

For each legal change, we first tallied the proportion of participants who indicated that an objector's fees would increase, stay the same, or decrease relative to status quo law. Those proportions are graphed in Figure 4. Then, we examined whether the different legal changes induced statistically significantly different percent changes in objectors' legal and hydrologist fees. For that evaluation, we fit a survival curve to interval response data for each legal change, and we used exact two-sample Wilcoxon-Mann-Whitney tests to compare each unique pairing of two legal changes (Fay & Shaw, 2014) (Table S12 and Figure S14).

In the case of the impact of legal changes on an objector's legal fees, most respondents indicated that under legal change #4 (abolish/restrict historical use analysis), these fees would decrease (Figure 4a). Of the elicited percent changes in an objector's legal fees, change #4 exhibited significantly more negative/less positive percent changes than other legal changes, with an average lower bound of −33.0% and an average upper bound of −13.5% (Table S12). Under legal changes #3, #1A, and #1B, most responses indicated that an objector's legal fees would decrease or remain the same (Figure 4a). Change #3 had average lower and upper bounds of −15.8% and −3.98% and significantly more negative/less positive percent changes than legal changes #1A, #1B, and #2 (Table S12). The de minimis injury standards reported average lower and upper bounds of −8.83% and +1.43% for the standard on a major river (#1A) and −3.91% and +3.52% for the standard on a smaller tributary (#1B), though the difference between these two standards was not significant (Table S12). At the other end of the spectrum, most responses indicated that shifting the initial burden of proof for injury to objectors (change #2) would increase an objector's legal fees. Change #2's percent changes were significantly more positive than those of the other legal changes (Table S12), with average bounds of +9.86% and +41.8%.

The pattern was similar for an objector's hydrologist fees. Most respondents indicated that objectors' hydrologist fees would decrease under legal change #4, decrease or remain the same under changes #3, #1A, and #1B, and increase under change #2 (Figure 4b). Under change #4, the average lower bound is −1.61% and the average upper bound is +22.5%. For the other legal changes, the average lower and upper bounds are −0.655% and +24.7% for change #3; −1.19% and +17.1% for #1A; +5.94% and +21.4% for #1B; and +13.3% and +52.7% for #2. Shifting the burden of proof for injury to objectors yields significantly greater percent increases in objectors' hydrologist fees than the other legal changes (Table S12).

6.2. Impacts of Legal Changes on Third-Party Injury

Near the beginning of each in-person interview, we conducted a ranking exercise to assess the possibility of increased legal injury to third-party water rights as a result of the four legal changes. In this exercise, we presented respondents with four cards, with one for each legal change. We asked participants to identify the

Table 4
Rank-Ordered Logistic Regression Results for Probability That Legal Changes Were Ranked Most Likely to Increase Injury

Rank-ordered logistic regression		Regression predictions	
Legal change explanatory variable (legal change #4 is the excluded/baseline dummy variable)	**Coefficient** (std. error)	**Legal change**	**Probability that legal change was ranked most likely to increase injury** (std. error)
#1	1.45 (0.250)***	#1	0.382 (0.0404)
#2	1.43 (0.258)***	#2	0.373 (0.0419)
#3	0.557 (0.260)*	#3	0.156 (0.0249)
Initial log likelihood	−226	#4	0.0893 (0.0184)
Model log likelihood	−197		
LR chi^2	56.0		
Prob > chi^2	0.00		
Observations	400		

***Significant at 0.1%. **Significant at 1%. *Significant at 5%. ˙Significant at 10%.

legal changes that, in their opinion, would raise the likelihood of third-party injury. Then, of the selected cards, we asked participants to rank them from most to least likely to increase injury, with ties allowed. We used rank-ordered logit to model these rankings, with the rankings as the dependent variables and the legal changes as the explanatory variables (Long & Freese, 2006).

Table 4 shows the regression results. It shows that abolishing/restricting historical use analysis (legal change #4) had a significantly lower probability of being ranked most likely to increase injury than the other three legal changes. Also, the presumptive standardized tool for calculating transferable water (legal change #3) had a significantly lower probability of being ranked most likely to increase injury than the de minimis injury standard (#1) and shifting the burden of proof (#2) (Table S14). The difference between changes #1 and #2 was not significant.

Using the regression, we predicted the probability that each legal change was ranked most likely to increase injury. These predictions show legal change #1 as most likely to increase injury, followed closely by legal change #2 and then #3 and #4 (Table 4).

6.3. Qualitative Analysis of Third-Party Impacts

During in-person interviews, we also asked respondents to explain why they thought that particular legal changes might or might not increase third-party injury. After reviewing transcripts of the interviews, we identified unique reasons offered, and we listed them in Table 5.

For the de minimis injury standard (legal change #1), many respondents shared concerns about cumulative third-party injury arising from transfers smaller than the minimum threshold. For legal change #2, respondents shared concerns about distributional impacts of shifting the initial burden of proof from applicants to objectors, noting that smaller water users with fewer resources would struggle to carry this burden, allowing injury to such users sometimes to go unchallenged. A common concern with standardized tools for calculating transferable water (legal change #3) was that a one-size-fits-all tool for quantifying consumptive use would inevitably miss important site-specific factors that could meaningfully affect a water right's transferable consumptive use, thereby increasing third-party injury. Finally, a common concern with abolishing/restricting historical use analysis (legal change #4) was the effect of trading "paper water": water rights that were not fully used before a transfer could grow in use afterward, potentially reducing the amount of water available to other water rights holders.

7. Discussion of Colorado's Previous Legal Changes

We concluded our in-person interviews by asking respondents about their experience with two notable recent changes to Colorado water law. First, we asked about new water court rules that the Colorado Supreme Court adopted in 2009 "to increase the efficiency of the adjudication process [and] decrease

Table 5
Reasons Offered for Why Market-Oriented Legal Changes May or May Not Increase Third-Party Impacts (i.e., Legal Injury to Other Water Rights)

Legal change	Perceived reasons why legal change may increase injury	Perceived reasons why legal change may not increase injury
1. De minimis injury standard	•A de minimis injury standard would encourage applicants to submit many smaller transfers that fall under the minimum threshold for injury instead of fewer larger transfers. •Cumulative impacts of transfers under the de minimis injury threshold could yield substantial increases in injury. •Relatively small amounts of water can be very significant to some water users (e.g., smaller water rights holders).	
2. Shift initial burden of proof for injury from applicant to objectors	•Because applicants generally hold substantial information about the transfer they seek to accomplish—information objectors lack—it would be difficult for objectors to acquire that information, which could increase injury. •Some objectors (particularly smaller users) lack resources that applicants for transfers have, meaning that some injury could go unchallenged. •This legal change would increase injury in more rural parts of the state where fewer large, sophisticated water users exist with resources to scrutinize applicants' transfers, but it would not increase injury in regions like the South Platte River Water Division where many such water users exist.	•This legal change would not increase injury because, under current law, after an applicant satisfies their initial burden of proof for no injury, the burden shifts to objectors to show injury, so objectors already hold the burden of proof. This legal change would just change the sequencing of burden shifting. •This legal change would not increase injury because it is more difficult for an applicant to prove a negative (no injury) than for an objector to prove injury. •This legal change would not increase injury because the burden of proof is not a dispositive issue in transfers—some participants could recall no cases where applicants' and objectors' arguments were equally convincing.
3. Adopt standardized tools for calculating water rights' historical consumptive use with a rebuttable presumption in water court	•Consumptive use calculations vary tremendously across the state. A one-size-fits-all tool for computing historical consumptive use cannot accommodate site-specific differences. •If the tool was not well refined and constructed, it could increase injury. •Because someone besides the party potentially being injured determines what qualifies as injury with this tool, the tool could increase injury. •If the tool does not catch non-use of a water right (which would reduce the right's transferable water), this tool could increase injury.	•Because the presumptive calculation of historical consumptive use is rebuttable and can be overcome if successfully challenged in court, this legal change would not increase injury. •Because any such regulation would go through a formal legal rulemaking process, where all affected parties could raise their concerns with the tool and challenge it, this legal change would not increase injury.
4. Abolish or restrict historical use analysis (e.g., after a prior change case has already quantified historical use, do not relitigate it)	•Past transfers may have quantified much more water for water rights than they would receive under more stringent, modern standards for this quantification. •If law precludes reanalysis of a water right's historical use between a prior transfer and a subsequent transfer, if the water right was not consistently used after the initial transfer, then its larger, earlier quantified value (its "paper water" value) rather than its historical use (its "wet water" value) may be transferred, increasing injury. •Historical use analysis may be restricted in cases where a water court previously quantified historical consumptive use per share for many shareholders in a mutual ditch company in a "ditchwide decree"; these prior quantifications may be used in lieu of historical use analysis in subsequent transfers out of the ditch company. Some participants noted that different farmers within ditch companies have different circumstances (e.g., efficiencies, crops, sunlight, and historical use), meaning that application of the same consumptive use per share for all users in the ditch could yield injury.	•Even if past transfers generously or incorrectly quantified water rights, that injury is already occurring, so preventing reanalysis of this quantification would not increase injury.

costs" (Witwer & Jones, 2009). One important rule change required opposing hydrologic experts to meet without attorneys present to "identify undisputed matters ... [and] ... attempt to resolve disputed matters of fact and opinion" for cases on a trial track, and the rules also accelerated water court processing timelines (Witwer & Jones, 2009). A 2014 Colorado Supreme Court report found that these rules decreased the number of active water cases by >50% in the South Platte and Colorado River water courts; that cases after the rules took effect finished, on average, 6 months faster than those in the previous 3 years; but that the rules front-loaded casework (Colorado Supreme Court, 2014). Because this 2014 report did not assess transaction costs, we asked respondents whether, in their experience, these rules changed legal and hydrologist fees or completion times for water transfers. In our survey, the most common response (46 of 100 respondents) was that these rules increased legal and hydrologist fees. Few (10 of 100) respondents indicated that the rules decreased fees. Consistent with the 2014 report, for completion times, our most common survey response (47 of 99) was that these rules reduced completion times.

Second, for respondents who had experience with each of six types of temporary water leases that the Colorado State Engineer's Office may now approve instead of the water courts, we requested estimates of an applicant's legal and hydrologist fees as a percentage of those fees for a water court transfer of comparable water rights. The survey responses suggest that Colorado's efforts to create less expensive procedures for approving temporary leases have generally achieved that objective for applicants. As a percentage of an applicant's legal and hydrologist fees for a transfer of comparable water rights in water court, the highest median percentage for any of the six types of temporary leases was 25%, while the lowest was 10%.

The supporting information includes more details on these prior legal changes.

8. Conclusions

It is no secret that transaction costs are a barrier to efficient water markets in the western United States, and academic literature is replete with recommendations to reduce these barriers. Yet, to our knowledge, no past studies have estimated how much proposed future legal changes would reduce transaction costs in western U.S. water markets. Through an economic stated preference survey, we have demonstrated one methodological approach for quantifying how much prospective but untested legal changes could reduce water market transaction costs. Applying this approach, we investigated four legal changes that do not upend existing property rights systems and could be applied in any western U.S. state with prior appropriation water law. The legal changes that we investigated targeted two underlying sources of legal conflict for water transfers: (1) the no-injury rule and (2) uncertain definitions of property rights. The first two legal changes we investigated would modify the no-injury rule, with legal change #1 establishing a minimum threshold for third-party injury and legal change #2 shifting the initial burden of proof for injury to objectors. The next two legal changes aim to clarify the definition of water rights, with legal change #3 establishing presumptive, standardized calculations of transferable water and legal change #4 abolishing/restricting historical use analysis in certain circumstances and allowing transfers of "paper water" instead of requantifying "wet water" historically used every time a water right is transferred. Because economically optimal water policy would balance economic benefits of water trading against the costs of trading's third-party effects, we projected how various legal changes reduce transaction costs for proponents of water transfers, and we explored how those legal changes could impact third-party effects.

Legal change #4 combined the largest reduction in applicants' transaction costs and completion times with the lowest likelihood of increasing third-party injury. This change also offered the largest reduction in objectors' fees. This appears to be a win-win change. These advantages exist because the water rights to which legal change #4 applies have already been quantified in prior court decrees in terms of consumptive use. A legal change like #4 might be used in other states to give more staying power to water rights quantifications from expensive and sometimes decades-long general stream adjudications by precluding requantification of historical use after the adjudication. However, abolishing historical use analysis for water rights that have never been formally quantified or that were quantified in terms of a diversion flow rate but not a consumptive volume of water, which are common in other western states, could bring about more serious injury to third parties and be less likely to provide a win-win legal change.

The reduction in transaction costs under legal change #4 also provides a caution against the common academic suggestion that simply redefining water rights in terms of consumptive use should greatly lower

transaction costs (Culp et al., 2014; Johnson et al., 1981; Squillace, 2012). Colorado does define transferable water in terms of historical consumptive use, and legal change #4 further reduces transaction costs by making those consumptive rights even more fungible. However, transaction costs under legal change #4 are still very expensive (e.g., $1,586/AFY for a transfer of 100 AFY of senior rights in the South Platte River Division). Even with water rights defined in terms of consumptive use, transfers still face myriad legal and technical challenges to avoid third-party injury, including complex operational requirements to ensure that the pre-transfer pattern and timing of return flows are maintained. In Colorado, at least, defining rights in terms of consumptive use does not escape the burden of the no-injury rule.

The other legal change that aims to clarify property rights, legal change #3, shows the next lowest third-party effects. It has the second lowest chance of increasing third-party injury and the second greatest decrease in objectors' procedural transaction costs. Lawyers also expect that legal change #3 would substantially reduce a transfer proponent's hydrologist fees. However, legal change #3 projects smaller reductions in a proponent's legal fees than legal changes #1A and #2, and hydrologists expect that change #3 would not reduce a proponent's hydrologist fees.

Legal changes #1A and #2 modify the no-injury rule directly through a de minimis injury standard of 1% of streamflow on a major river (#1A) and by shifting the initial burden of proof for injury to objectors (#2). These changes are expected to produce substantial decreases in proponents' transaction costs. However, they had the greatest chances of increasing third-party injury and the highest percent increases in objectors' procedural transaction costs, and they evoked strong qualitative expressions of concern from respondents about third-party injury.

Another key finding is that impacts of legal changes on transaction costs can differ across different transfer volumes, types of water rights, regions, and hydrologic settings. We found that transaction cost savings for proponents' hydrologist fees from the de minimis injury standard on a major river declined with larger-volume transfers, likely because larger transfers would be less likely to fall under the minimum injury threshold. On smaller tributaries where 1% of streamflow would establish a lower minimum threshold for injury, we found that the de minimis injury standard reported no transaction cost savings for proponents. For larger-volume transfers, standardized tools for calculating consumptive use (legal change #3) decreased probabilities of higher-conflict legal outcomes; change #3 also shows different impacts on completion times for senior versus junior water rights. Moreover, shifting the initial burden of proof for injury decreased probabilities for the highest-conflict legal outcomes in two rural regions of Colorado, which matches our qualitative interview data indicating that smaller objectors in rural parts of the state would struggle more than larger objectors to carry this burden of proof. The broader point is that water rights transfers are highly heterogeneous, and the specific impact of a legal change will differ across transfers.

We also find that sometimes, legal changes intended to lower transaction costs may backfire and either not lower costs or raise them. For legal change #3, where the Colorado State Engineer's Office would develop standardized tools for calculating transferable water that serve as a rebuttable presumption in court, hydrologists reported that it would not decrease hydrologist fees and would increase completion times for senior rights. This surprising result may reflect a concern voiced by some survey participants—that because a standardized tool would be conservative in its calculations of consumptive use to pass muster in a legal rulemaking, some applicants might choose to conduct their own hydrologic analysis instead of accepting the conservative calculations. Indeed, one standardized tool piloted in Colorado's Arkansas River Basin employed conservative parameters that collectively underestimated historical consumptive use by at least 5–10% to reduce objections from potentially injured water rights holders. However, transfer proponents may not want to concede 5–10% of valuable water rights. Similarly, we found that the de minimis injury standard on a smaller tributary did not decrease legal fees, hydrologist fees, or completion times. Some survey participants suggested such a standard could increase, rather than decrease, transaction costs by adding another issue to litigate. And many survey participants reported that Colorado's recent water court rules, while intended to lower transaction costs, have actually raised them. These findings point to the value of thorough outreach to many practitioners before changing laws to anticipate unintended consequences.

Water Resources Research

In this paper, we have explored some legal changes that draw lessons from successful water markets and apply them within the constraints of prior appropriation law in Colorado. Several of the changes we explored offer significant projected reductions in static transaction costs. The changes considered in this paper may present achievable steps toward more active water markets in Colorado and other western states.

However, our results show that there are important trade-offs to consider in modifying water law to promote water marketing. Although legal changes that either aim to clarify the definition of property rights or modify the no-injury rule's protections for third parties can lower transaction costs for proponents of water transfers, these changes can increase the risk of injury for third parties and may also increase third parties' static transaction costs. Therefore, while legal changes that lower proponents' static transaction costs may be welfare enhancing by encouraging the reallocation of water to more economically valuable uses, they are probably not Pareto-improving absent compensation to third parties. The welfare improvements are achieved at some expense, whether in terms of injury to third-party water users or increased transaction costs for third parties. This dynamic underscores why any market-oriented change to western U.S. water law is a politically challenging task.

Among the legal changes we studied, we found that legal changes that aim to clarify property rights instead of directly modifying the no-injury rule offer some of the greatest reductions in proponents' transaction costs and also less negative externalities for third-party water users. These results suggest that legal changes that focus on clarifying property rights in water markets may be more politically palatable and economically beneficial than legal changes that directly modify legal protections for third parties.

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