Bargaining in the Shadow of Prior Appropriation: Concessions and Trade-Offs in Native American Water Settlement Negotiations*

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Abstract

Water use in the western United States remains highly concentrated in irrigated agriculture, in part because the "first in time, first in right" tenets of appropriative water law have insulated irrigators, as senior appropriators, from legal challenges to their water use. However, the relatively recent recognition of Native American tribes' senior water rights poses a rare legal threat to irrigators, drawing them into negotiations that potentially diminish their water entitlements. This study examines the effects of bargaining power asymmetries on tribal water settlement outcomes to 61 irrigation districts participating in 11 negotiations. An irrigation district's bargaining power is assessed as its relative risk of experiencing shortage under prior appropriation law, or, its fallback option if tribal water claims were resolved in court. I find that as relative shortage risk increases, irrigation districts relinquish larger shares of their water rights, presumably to avoid litigation. Financial compensation secured in exchange is increasing with the political influence of a settlement act's congressional sponsor. Results show that the legal threat of unresolved tribal water claims is an important mechanism that incentivizes water reallocation to meet new and growing water needs.

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1 Introduction

Laws governing natural resource rights define allocations, shape resource use decisions, stipulate how shortages are shared, and provide a foundation for resolving competing resource claims (Libecap, 1989; Ostrom et al., 2003; Coase, 1960). Competing claims can be resolved in court according to existing law. Judicial rulings, however, can result in economically inefficient resource allocations while legal ambiguities and untested case law expose litigants to risks of potentially unfavorable but binding decisions (Cooter et al., 1982). Alternatively, parties can negotiate to reach mutually beneficial agreements that avoid court-imposed solution, returning to court only if negotiations fail (Mnookin and Kornhauser, 1979).

Analyses of air and water quality markets, land and water allocations, and conflicts over minerals and hunting rights find that legal rules provide the backdrop against which parties bargain to reach agreements that, relative to litigation, yield a surplus of benefits (Madani and Dinar, 2012; Reeling et al., 2018; Byun, 2015; Hanley and Summer, 1995). While all parties benefit, those with more bargaining power capture larger shares of the surplus. Parties expecting more favorable court outcomes wield greater bargaining power in a negotiation, make fewer concessions, and secure better outcomes for themselves while those with worse fallback options may cede more to avoid a return to court (Nash, 1950; Harsanyi, 1959; Cooter et al., 1982; Choi and Triantis, 2012).

Bargaining costs also factor into parties' decisions to settle. Hence, those with a greater capacity to absorb bargaining costs or raise costs to others can secure better outcomes for themselves (Libecap, 1989). Parties benefiting from status quo resource allocations wield a unique influence over negotiations: even if their legal position is weak, they can resist change by delaying settlement (Hubbard, 2018). Uncertainty about the costs and benefits of altering resource allocations tends to make parties more pessimistic about potential changes, can delay settlement, and raises costs and opportunity costs to all water users (Libecap, 2008). In the context of scarce natural resources, delays deprive others from benefiting from their resource rights, perpetuate inefficiencies, and deplete resource stores (Ayres et al., 2018; Edwards, 2016; Sanchez et al., 2020). As such, reducing uncertainty about bargaining outcomes to status quo beneficiaries is especially important. However, there are few empirical *ex post facto* analyses of the factors that impede and incentivize settlement from the perspective of status quo beneficiaries.

This study examines a complex bargaining problem - the contentious process of restoring Native American water rights in the western United States - from the perspective of irrigation districts (ID)[1] as the parties most likely to benefit from status quo water allocations. Despite regional water scarcity, a combination of

[1]Here, irrigation district broadly encapsulates public and private irrigation organizations such as irrigation districts, mutual ditch companies, canal companies, and agricultural water users associations operated as corporations or cooperatives that deliver water to farms.

water law and policy insulates irrigators from legal challenges to their water use. Surface water rights in the West are governed by the prior appropriation doctrine, under which water rights are established based on the chronological priority of the initial claim. The earliest established water rights are filled first, while junior rights are curtailed first during times of shortage. The earliest water rights were established for irrigated agriculture in the mid-1800s. Since then, federal investments in irrigation infrastructure helped irrigators expand and maintain their beneficial use (Benson, 1998).

Native American reservations across the West have unresolved claims to potentially large volumes of water that supersede most appropriative rights in priority. A 1908 Supreme Court ruling Winters v. United States affirmed that reservation treaties signed with the federal government entitle tribes to enough water to fulfill the homeland needs of the reservation. The ruling, however, did not establish water rights, referred to as *Winters* rights, for tribes, so they remained unenforceable as surface water was fully appropriated for off-reservation use. Fifty years later, the Arizona v. California (1963) Supreme Court decision clarified that tribes have rights to enough water to cultivate every irrigable acre on a reservation (the Practicably Irrigable Acreage, or PIA, standard). By affirming tribal water rights would be upheld through state and federal courts, even if their adjudication displaced existing water users, these rulings established the legal pathway for tribes to adjudicate their water rights. They also establish a backdrop against which tribes, IDs, and other appropriative rights holders can bargain over how to meet tribal water needs while also minimizing other parties' exposure to shortages.

To date, 48 of 226 reservations across the West have secured legal titles to water through 38 settlement agreements. The high concentration of relatively low-value, low-efficiency water use in irrigated agriculture has meant that IDs are the most likely sources of water that can be reallocated and used more efficiently to meet tribal and other non-agricultural needs (Garrick et al., 2019). In exchange, IDs can secure financial compensation from cities and government entities who also want to avoid a court ruling. Settlements have resulted in a patchwork of changes to ID water rights, but there is little systematic research exploring why some IDs relinquish large volumes of water while others preserve the status quo. This study tests for the effects of an ID's relative bargaining power in a negotiation on the share of water entitlements that it reallocates to other parties in a negotiation, and funding it secures in return.

Negotiations often include multiple IDs. The *ad hoc* nature of establishing water rights has meant that IDs' are exposed to heterogeneous risks of water shortage under prior appropriation rules that curtail the junior-most rights first. This study examines changes to ID water entitlements as a function of their risk of exposure, relative to other IDs in the negotiation, to shortage under prior appropriation rules that would be imposed if Winters rights were defined in court. Next, it assesses the relationship between bargaining power stemming from an ID's wealth, risk aversion, and political influence and the level of funding that it secures in exchange for relinquishing water rights. By examining the relative importance of an ID's fallback option as a determinant of settlement outcomes, this study provides new insight into the importance of pairing a credible legal threat that incentivizes water right reallocations in a negotiation with side payments that facilitate settlement. Understanding the bargaining processes and outcomes to IDs as parties most likely to benefit from status quo water allocations will be key to adapting water use to meet evolving needs.

2 Institutional Setting

2.1 Appropriative Water Rights

Under the prior appropriation doctrine governing surface water in the West, irrigators hold large volumes of high priority water rights. Appropriative water rights are quantified and assigned a priority date based on the initial claim and are maintained through continuous beneficial use. During times of shortage, earliest ("senior") rights are filled before later established ("junior") rights. That the first appropriative rights were established for irrigated agriculture between 1850 and 1920, has meant that irrigators typically receive their full entitlements before later established non-agricultural water rights are filled. By protecting early claimants against reductions in streamflow caused by later diversions, appropriative water rights facilitated capital investments in water conveyance and storage infrastructure (Leonard and Libecap, 2019). This prioritization and quantification of water rights enabled individual irrigators to pool infrastructure costs, and establish rights to relatively large volumes of water (Benson, 1982).

Federal investments in irrigation infrastructure under the Reclamation Act of 1902 further concentrated water use in agriculture. Nearly 20 percent of irrigators across the West receive water from Reclamation projects (U.S. Bureau of Reclamation, 1977). IDs' federal project water rights arise from long-term service contracts that provide them with large volumes of highly subsidized water. Legally, IDs can forfeit contracts if they divert more water than is permitted, or when the federal government is obligated to use project water to uphold federal laws, like the Endangered Species Act (Benson, 1997). In practice, however federally subsidized water has led to inefficient use, and Reclamation has not enforced overuse violations within project areas (Benson, 1998).

By the mid-1900s, surface water in most basins had been fully appropriated. Cities with relatively inelastic, high-value water demand tend to hold junior water rights. Cities increasingly look to neighboring irrigators as potential water sources as scarcity increases. However, high transaction costs associated with water marketing have limited market-based reallocations of water agriculture to non-agricultural uses (Leonard et al., 2020; Womble and Hanemann, 2020). Today, irrigated agriculture accounts for nearly 90 percent of consumptive water use in western states, much like it did 100 years ago (Deiter et al., 2018; Libecap, 2007). Despite growing demand from non-agricultural sectors and diminishing supply, the limited legal mechanisms and viable water marketing opportunities provide incentive for IDs to conserve or reallocate water to other users in a system.

2.2 Winters Rights

Winters v. United States (1908) affirmed that reservation treaties signed with the federal government implicitly entitle tribes to enough water to support reservations as permanent homelands for tribes. With a priority date of when the reservation was established, Winters rights supersede almost all appropriative rights in priority. Unlike appropriative rights, they are held in reserve for tribes by the federal government and cannot be forfeited through nonuse. While the ruling did not establish water rights for tribes, it affirmed that the federal government's treaty obligations give it a legal fiduciary duty to protect tribal water interests (Stern, 2019).

Tribes must quantify their water rights through an adjudication process if those rights are to be legally enforceable. Arizona v. California (1963) established PIA as a "homeland" standard to quantify tribal water rights in a ruling that established rights to Colorado River water for five tribes based on the standard. Although the ruling did not precisely define what constitutes a "practicably" irrigable acre, a 1983 study estimated that the potential magnitude of PIA-based Winters claims exceeds natural water availability in many basins (Johnson, 1983). Successive court rulings have expanded Winters quantification metrics to include non-agricultural uses (Cordalis and Cordalis, 2014). Many reservations, however, continue to assert PIA-based claims to maximize their potential settlement outcomes (Sanchez et al., 2020). The limited legal precedent and ambiguous quantification metrics generate uncertainty about potential court outcomes and expose all litigants to a certain degree of risk of an unfavorable ruling.

Arizona v. California (1963) established a legal pathway for tribes to adjudicate their water rights. When adjudicated in court, a tribes' water rights are quantified according to a "homeland", assigned a priority date of when the reservation was established, and inserted into the existing priority order ahead of nearly all appropriative rights. Because prior appropriation rules determine the order in which water rights are curtailed during times of shortage, court decreed Winters rights pose heterogeneous shortage risks to appropriators. Relatively junior appropriators are more likely to be curtailed as Winters rights are added into the priority order.

2.3 Bargaining in the Shadow

Winters rights are adjudicated either in court or through settlements negotiated between tribes and adjacent water users. Both pathways result in legally enforceable water rights for tribes, but negotiation provides parties with more control over potential outcomes. Court adjudications expose all parties to some degree of risk. Adjudications occur in the context of water scarcity, as water in most basins has been fully appropriated for off-reservation uses and growing water scarcity drives parties to pursue adjudications (Sanchez et al., 2020). This, combined with tribes' potentially vast claims means that a favorable ruling for tribes potentially divests even senior appropriators of some water use (Sanchez et al., 2020).

In court, appropriators provide evidence of their water rights and historical beneficial use. An ID's declining water demand, which, for example, can coincide with urbanization in its service area, diminishes its legal justification for retaining large water entitlements under beneficial use rules (Aylward, 2006). Protracted litigation is costly, and parties are not entitled to compensation for financial losses from an unfavorable ruling (Baley v. United States, 2019). Further, court rulings resolve uncertainty about the volume and priority of a tribe's water rights on paper, but they do not resolve uncertainty about potential changes to water use. Tribes risk being unable to divert or access their water rights for on-reservation use. Winters rights cannot be lost through nonuse, so uncertainty about whether future tribal use will displace appropriative uses persists.

Uncertainty about litigation has meant that most ($\approx$ 80%) Winters claims are resolved through negotiated settlements that are ultimately enacted by Congress. Negotiations typically include tribes, the federal government on behalf of tribes, state and federal government agencies, IDs, and cities. Parties bargain to reach mutually beneficial agreements that improve their water security while also resolving broader water conflicts in a basin. This can involve reallocating existing rights or generating conserved water so that more water needs can be met without displacing existing use (Colby and Young, 2018). The high concentration of water use in irrigated agriculture has meant that IDs are the most likely parties to cede portions of their water entitlements in a negotiation. As such, they are uniquely positioned to prevent a return to court. In exchange, IDs can bargain for settlement terms that quiet future claims against their water rights, result in long-term water security, and provide financial compensation.

Settlements typically rely on federal funding and market mechanisms to generate conserved water that can be reallocated to tribes and, in some cases, relatively junior urban and environmental interests (Colby and Young, 2018). The government's competing legal obligations to protect tribal water rights, uphold Reclamation project contracts, and enforce environmental laws expose it to significant legal and financial risks if broader water disputes are not resolved efficiently through negotiation (Department of the Interior, 1990). Inefficiently used Reclamation project water presents a relatively low-cost option for the government to reallocate contract water to tribes and other parties to meet its legal obligations. For example, by leveraging IDs' federal water project debt obligations, the government has been able to renegotiate contracts with IDs to reallocate project water to tribes and to maintain streamflow for endangered fish (Arizona Water Settlements Act, 2004; Wolfley, 2016).

Heterogeneity in the marginal value of water across bargaining parties and within ID service areas generates opportunities for market-based reallocation (Griffin, 2012; Colby and Young, 2018). IDs can maximize potential gains from a settlement by reallocating water and removing the most marginal farmland from production (Griffin, 2012). Cities and states represent relatively high-value water users that provide the financial resources necessary to acquire agricultural water that would otherwise be unavailable in a court adjudication. For instance, cities seeking reliable, long-term water supplies have financed infrastructure improvements to generate conserved water that can be reallocated away from IOs (Arizona Water Settlements Act, 2004). As water demand decreases with urbanization, IOs can reallocate water more efficiently within their service areas and sell conserved water to satisfy competing demand. Irrigators who previously opposed water marketing may be more willing to partake when they anticipate a loss in court.

The federal government is legally and financially responsible for protecting tribal water interests, and therefore prefers settlements over protracted and risky court adjudications. In the context of a settlement, federal funding has supported water infrastructure projects for tribes, water buy-backs from irrigation districts, and investments in more efficient off-reservation water infrastructure. The government does not reveal the estimated costs of its own legal exposure, its legal liability is likely increasing with the strength and volume of tribal water claims as well as its contract obligations to appropriate rights holders (Yashoda, 2020). The government maintains that its contributions should not exceed the costs of its legal liability to provide water to tribes (Department of the Interior, 1990). Compensating irrigation districts for relinquishing water rights therefore enables the federal government to meet its legal obligations at a lower cost than if Winters rights were resolved in court. Anderson (2006) notes that in practice, Congress's willingness to enact a settlement with substantial federal funding is often a question of political will, the influence of the affected state's congressional representatives, and broad public support rather than economic calculation.

3 Methods

3.1 Bargaining Framework

Winters settlement negotiations represent a multilateral bargaining problem, where coalitions of multiple parties (i.e., tribes, cities, IDs, government agencies) bargain with one another to resolve tribal water claims. This study analyzes the bargaining process and outcomes within coalitions of IDs, as the beneficiaries of status quo water allocations and the parties most likely to cede water in a negotiation. To avoid litigation, IDs can bargain with one another over whether and how to reallocate portions of their water rights to other bargaining parties.

Bargaining theory posits that parties with greater bargaining power in a negotiation secure larger shares of the settlement benefits and that bargaining power is primarily a function of a party's fallback option in court relative to other bargaining parties (Muthoo, 2001; Cooter et al., 1982; Cooter and Rubinfeld, 1989). Accordingly, an ID's bargaining power is assessed here as a function of its relative risk of exposure to water shortage under prior appropriation rules, which would be applied in a court adjudication.

Specifically, this study tests the hypothesis that an ID, i, participating in negotiation, s, relinquishes a larger share of its pre-settlement water entitlements as its risk of having its water rights curtailed under prior appropriation rules increases relative to that of other IDs in the negotiation. A key assumption is that water is already fully allocated, so tribal water needs must be met through changes to existing water rights. As such, IDs participating in a negotiation must bargain over changes to the fixed volume of their collective pre-settlement water rights, ΣAFY_{is}. A second key assumption is that each ID bargains to minimize reductions to its water entitlements, while still avoiding a return to court.

The Harsanyi (1959) game model offers a framework for understanding how multiple parties, n, bargain to reach a binding, pareto optimal agreement against the backdrop of a non-cooperative court ruling. Parties bargain to maximize their respective shares of the total negotiation surplus, π, where $\pi > 0$. A Winters negotiation surplus, π, can be characterized as avoided losses had the dispute been resolved in court, with IDs opting to relinquish smaller shares of their water in a settlement than they would have expected to lose through litigation. In the context of a Winters negotiation, an ID's maximization of the "surplus" benefits generated in a settlement is the minimization of water that it reallocates to other parties. Because IDs are unlikely to acquire more water in a negotiation than they started with prior to settlement, the model relies on an implicit assumption of non-satiation.

Negotiation offers a set of possible agreements, $X = \{(x_1, x_2, \ldots, x_i)\} : 0 \leq x_1 \leq \pi, x_2 = \pi - x_1$, and $x_i = \pi - x_2$ where x_i is the share of π to party $i(i = 1, 2, 3)$. For each $x_i \in [0, \pi]$, a party $i's$ utility function from obtaining a share of π is $(U_i(x_i))$. If IDs fail to reach an agreement, then ID i obtains a utility of d_i, the default utility obtained in court, where $d_i \geq U_i(0)$. Under the Nash-Harsanyi bargaining solution, parties can reach a unique, pareto optimal division of π that maximizes their joint utility of x_i:

$$\max_{x \in X} \prod_{i=1}^{n} (u_i - d_i)^{\partial_i} \tag{1.1}$$

Where ∂_i is the bargaining weight for party, i, defined as:

$$\sum_{i-1}^{n} \partial_i = 1 \tag{1.2}$$

Assuming equal bargaining weights, the party with the smallest fallback utility function, d_i, is set to receive a smaller share of the surplus. Thus, bargaining power is primarily a function of having the best alternative option to a negotiation, which reduces a party's dependency on others to achieve a favorable outcome (Cooter and Rubinfeld, 1989). An ID's fallback utility, d_{is}, is its relative risk of water curtailment under prior appropriation rules. As relative curtailment risk increases, so do opportunity costs of litigating, so IDs may give up more to avoid a negotiation breakdown.

IDs that cede water can bargain for financial compensation from cities and government agencies paying to acquire water for themselves and tribes. Most funding decisions are made at the congressional level. As such, relatively powerful congressional sponsors may be better able to secure spending packages that result in more funding for bargaining parties (Anderson, 2006). Additionally, prior research indicates that relatively large, wealthy, homogeneous IDs wield greater political influence, are better equipped to endure a protracted settlement process, and therefore may be able to exact higher levels of funding in a negotiation (Esteban et al., 2019; Libecap, 2009). As such, this study tests the hypotheses that funding outcomes to IDs are increasing with congressional influence and measures of its wealth and patience.

The bargaining solution is weighted by the bargaining weight, ∂_i, which captures such measures of political influence. As an ID's relative ability (i.e., its share of the bargaining weight) to influence outcomes and exact concessions from others increases, so does its utility function, u_i, and the likelihood that it will secure a larger share of the surplus, π.

Relatedly, an ID's aversion to risk shapes its utility function. For example, a risk-neutral ID's utility function is $u_1(x_1) = x_1$, while a risk-averse ID, anticipating diminishing returns to x_2, has a utility function of $u_2(x_2) = \sqrt{x_2}$. Thus, risk aversion diminishes a party's expected utility relative to less risk-averse parties. Risk-averse IDs, such as those whose water demand is diminishing with urbanization, may accept less funding to resolve Winters rights more quickly.

3.2 Data

This study tests for the heterogeneous effects of Winters right settlements on changes to water entitlements and funding outcomes to 61 IDs that were parties to 11 settlements as a function of IDs' relative bargaining power in a negotiation. The analysis relies on two novel and complete datasets: 1) an ID-level dataset containing pre and post-settlement water rights and measures of bargaining power, and 2) a water right-level dataset containing pre and post-settlement water entitlement volumes and priority dates of 524 water rights belonging to the 61 IDs.

Dependent Variable Construction:

The primary outcome of interest is the percent change to the pre-settlement water entitlement volume ($\%\Delta AFY_{is}$) of an ID, i, participating in settlement negotiation, s. This measure is constructed using i) data on the total volume of an ID's pre-settlement water rights, collected from the statement of claimants (SOC) filed in state court proceedings, and ii) data on the volume of water that an ID relinquishes in a settlement collected from individual settlement texts.

Each SOC corresponds to an ID's individual pre-settlement water right, denoted as $AFY_{WR,is}^{pre}$, and specifies the priority date of when the water right was established, the entitlement volume, water source, and any evidence of historical beneficial use. Settlement texts, available from the University of New Mexico's Water Settlement Database, specify the volume of individual entitlements that changed as the result of a settlement, $AFY_{WR,is}^{\Delta}$. The percent change to an ID's water entitlements is calculated as:

$$\%\Delta AFY_{is} = \frac{\Sigma AFY_{WR,is}^{\Delta}}{\Sigma AFY_{WR,is}^{pre}} \times 100 \tag{1.3}$$

Because legal rights to water may exist beyond natural water availability in a basin, the cession of a junior water right in a negotiation may not result in a meaningful change to water access. To gain additional insight into the effects of a settlement on water access, volumetric changes to an ID's water rights, $\Delta AFY_{WR,is}$, are assessed as a function of the water right's priority rank, relative to other water rights in an ID's pre-settlement water right portfolio. A standardized measure of a water right's relative priority in the ID's water right portfolio – its priority rank – is constructed by 1) listing the pre-settlement water rights ($AFY_{WR,\ is}^{pre}$) belonging to each ID, i, within a settlement, s, in descending chronological priority order (from junior to senior), 2) assigning each water right a value, $p_{WR,is}$, from 1 (assigned to the lowest priority water right in the ID's pre-settlement portfolio) to the highest return value (assigned to the highest priority right), and 3) calculating the percentile rank as:

$$rank_{WR,is} = \frac{(p_{WR,is} - 1)}{(n_{WR,\ is} - 1)} \times 100 \tag{1.4}$$

Here, $rank_{WR,is}$ is the percentile rank of individual pre-settlement water rights (WR) in an ID's portfolio. The highest rank return value (i.e., the total number of water rights in an ID's pre-settlement portfolio) is $n_{WR,is}$. An ID's most senior right receives a value of 100 percent, while the most junior receives a value of 0 percent. Where an ID only has one water right in its portfolio, that right is assigned a percentile rank of 50.

Finally, settlement funding is measured as the total adjusted (2020$) dollar per acre-foot allocated to each ID, i, that forfeited water rights through settlement, s. Settlement funding includes a) direct payments to IDs, such as where water and/or land with appurtenant water rights is purchased from an ID at market price; b) funding allocated for infrastructure improvements that generate conserved water, which can be transferred to another party; c) forbearance agreements where an ID is compensated for permanently reducing its water use; d) and the monetary value of debt reduction/forgiveness on federal water project contracts. Data are collected from settlement texts, federal agency budget reports, contracts signed between federal government agencies and individual IDs, and federal records detailing debt forgiveness and/or restructuring agreements. The variable, $\$/AFY_{is}$, is the total funding received by ID, i, in settlement, s, divided by the total volume of relinquished water, AFY^{Δ}_{is}.

Independent Variable Construction:

An ID's, i, bargaining power is assessed primarily as a function of its risk, relative to other IDs participating in negotiation, s, of having its water rights curtailed under prior appropriation rules. Using data on the volumes and priority dates of an ID's pre-settlement water rights, WR^{pre}_{is}, a measure of an ID's relative shortage risk ($risk_{is}$) is constructed according to the following steps. First, individual water rights belonging to IDs participating in a negotiation are ranked in order of ascending priority (senior to junior) (Table A2). It is assumed that IDs in a negotiation are bargaining over changes to a fixed volume of water. Total water availability in a settlement is therefore assessed as the sum of the negotiating IDs' collective pre-settlement water entitlement volumes, $\sum AFY_{is}$. The percentage of an ID's pre-settlement water entitlement volume that would be curtailed under prior appropriation rules ($PctCurtailment_{is}$) is modeled as a function of total water availability, which is decreasing in ten percent increments.

An ID's relative risk of exposure to water shortage in court is calculated as the least-squares curve, denoted by β^{risk}_{is}, that measures the linear relationship between the percentage of incrementally larger reductions to total water availability and the corresponding percentage of its water rights that would be curtailed:

$$PctCurtailment_{is} = \alpha_0 + \beta^{risk}_{is}(\sum AFY_{is} \times \gamma) \tag{1.5}$$

Where α_0, the y-intercept, equals zero following the assumption that all IDs receive their full entitlements when there are no water shortages, and γ is the simulated level of water shortage system shortage, where $\gamma = 0, .1, .2, .3, \ldots, .9$. β^{risk}_{is} is calculated as the linear best fit line:

$$\beta^{risk}_{is} = \frac{n_{is} \sum(x_s y_{is}) - \sum(x_s) \sum(y_{is})}{n_{is} \sum({x_s}^2) - (\sum x_s)^2} \times 100 \tag{1.6}$$

Where n_{is} is the number of observations for each ID in a settlement. Relative shortage risk is assessed as a percentage where $risk_{is} = \beta_{is}^{risk} \times 100$. (See Figure A1 for an example of a graphical depiction of β_{is}^{risk}).

ID-level covariates include measures of the number of unique pre-settlement water rights in an ID's water right portfolio, total acreage, pre-settlement AF/acre water entitlement, and the percentage of pre-settlement water right volume held under Reclamation contract. The number of ID water rights and their water duty reflect their adaptive capacities to water shortages. Mean precipitation within ID boundaries is a measure of natural water availability. Decadal urbanization rate and crop and hay/pasture land cover within ID boundaries prior to negotiation start reflect heterogeneity in water demand and the marginal value of water. The percentage of water rights provided via Reclamation contract captures the federal role in the bargaining process.

Water right level controls include a dummy variable where the pre-settlement water right is assigned a value of 1 if it is delivered via Reclamation contract, and a value of zero if it is not. Additionally, models control for the number of years that a tribal water right predates the individual water right as a measure of bargaining power.

Settlement-level controls include prime reservation acreage as a proxy for magnitude of tribes' water right claims, the year when the reservation was established as a measure if the tribe's water right priority, and population growth rate in cities participating in negotiations as measures of water scarcity and competing demand. The political influence of the congressperson sponsoring the settlement act is assessed according to the Dirksen Congressional Power Index (CPI) (Table A4). To maintain exogeneity, independent variables are either time-invariant or measure ID characteristics before a negotiation start. Table A5 describes variable construction, and Table A6 presents summary statistics.

3.3 Empirical Strategy

First, the study uses multiple linear regression (MLR) to estimate the effects of an ID's relative bargaining power on changes to its water entitlements:

$$\%\Delta AFY_{is} = \beta_0 + \beta_1 risk_{is} + \beta_2 X_{is} + \xi_s + u_{is} \tag{1.7}$$

Where X_{is} is a vector of ID-level controls, and u_{is} is an error term. The magnitude of coefficients, $\hat{\beta}_n$, indicate the extent to which an independent variable is associated with a change to an ID's water entitlement. A negative sign on the coefficient β_1 indicates that a higher shortage risk is correlated with a reduction in water right volume. Models include settlement fixed effects, ξ_s, to account for unobserved factors that may systematically vary across settlements.

Next, a multilinear regression models the relationship between measures of bargaining power and the relative seniority of an individual water right in an ID's water right portfolio:

$$ {}_{WR,is} = \beta_0 + \beta_1 X_{is} + \beta_2 \gamma_s + \zeta_{state} + u_{is} \tag{1.8} $$

Here, ${}_{WR,is}$ is the percentile rank of a water right, WR, owned by ID, i, participating in negotiation, s. To ascertain determinants of the relative seniority of individual water rights changed in a negotiation, the sample of water rights excludes water rights that did not change as the result of a settlement. X_{is} is a vector of ID-level measures of bargaining power. It is expected that those in weaker bargaining positions will cede higher priority water rights. γ_s includes measures of settlement-level characteristics, such as the magnitude of a tribe's water right claim, expected to influence bargaining positions.

Because ${}_{WR,is}$ is increasing with the seniority of a water right, a negative coefficient on $\hat{\beta}_n$ indicates that the independent variable is correlated with the cession of a relatively junior water right. Models include state-level fixed effects, ζ_{state}, control for unobserved factors, such as state policies regarding water right enforcement and priorities for settling Winters rights. As a robustness check, additional models include settlement-level fixed effects and ID-level controls. Standard errors are clustered at the ID level.

Finally, a MLR estimates determinants of settlement funding ($\$AFY_{is}$) on a subset of 28 IDs that relinquished water rights in a negotiation:

$$ \$AFY_{is} = \beta_0 + \beta_1 X_{is} + \beta_2 Z_s + \gamma_{state} + u_{is} \tag{1.9} $$

Where X_{is}, is a vector of ID-level explanatory variables, and Z_s is a vector of settlement-level explanatory variables that include measures of an ID's bargaining position and political will, respectively. The magnitude of the coefficients, $\hat{\beta}_n$, indicates the extent to which independent variables are correlated with funding outcomes. Models include state-level fixed effects, γ_{state}, to account for unobserved state-level factors (e.g., budgetary constraints and priorities; political sentiment) that may influence funding decisions.

To identify a parsimonious model that accommodates the small sample size, explanatory variables are selected using a backward elimination procedure. Beginning with a full model that includes ID- and settlement-level controls, variables that reduce the R^2 the least when omitted from the model are dropped in a step-wise process. The significance threshold is set at $\alpha = .05$. Additional models include explicit tests of federal-level political influence, ID-level bargaining power measures, and measures of competing water demand from non-agricultural water users.

4 Results

4.1 IDs Cede Larger Shares of their Water Rights as Legal Risk Increases

Table 1.1 presents estimates of the effects of shortage risk on ID water entitlements. Increased risk of water shortage is consistently and significantly correlated with reductions to water entitlements across all models. The relationship between prior appropriation shortage risk and changes to water entitlements remains relatively consistent as additional measures of bargaining power and the bargaining environment are introduced. That shortage risk is the main significant predictor of diminishing water entitlements supports the intuition that those with the lowest priority water rights, and thus the worst fallback option in court, are more willing to give up water to avoid litigation. Table A8, which includes a quadratic function of relative shortage risk, corroborates these findings.

Tables A7 and A9 present robustness checks containing state fixed effects and measures of tribes' water claims. On average, IDs cede larger shares of their water entitlements as the magnitude of a tribe's water right claims increases. This further indicates that a strong legal threat incentivizes water right reallocations.

Table 1.1: MLR Estimated effects of relative water shortage risk on changes to water entitlements

	% Δ Pre-Settlement Entitlement (AFY)					
	(1)	(2)	(3)	(4)	(5)	(6)
Shortage Risk (%)	-0.228***	-0.227***	-0.228***	-0.198***	-0.181**	-0.156**
	(0.0744)	(0.0714)	(0.0726)	(0.0691)	(0.0776)	(0.0736)
Water Rights (#)		0.341	0.357	0.455	0.407	0.377
		(0.509)	(0.501)	(0.467)	(0.525)	(0.519)
Pre-Settlement AFY/Acre			-0.0907	-0.154	-0.0815	-0.142
			(0.418)	(0.429)	(0.377)	(0.391)
Precip. (mm)				0.471	0.449	0.547
				(0.328)	(0.351)	(0.438)
IO Acreage				-2.13e-05	-2.07e-05	-8.57e-07
				(3.30e-05)	(3.53e-05)	(3.59e-05)
USBR Contract Rights (%)					-7.171	-8.458
					(11.66)	(11.89)
IO Urbanization Rate (%)						0.0673
						(0.0719)
Hay/Pasture (%)						-0.584*
						(0.306)
Constant	8.746	5.587	6.453	-4.808	-4.946	-5.577
	(5.416)	(5.293)	(6.942)	(10.51)	(11.11)	(13.61)
Settlement FE	x	x	x	x	x	x
Observations	61	61	61	61	61	59
R-squared	0.388	0.398	0.399	0.419	0.429	0.460

Notes: Specifications include settlement-level fixed effects. ID urbanization rate prior to negotiation start and hay/pasture land cover are measures of IDs' water demand. Pre-settlement water duty is a measure of the volume of water with which it has to negotiate over. Standard errors clustered at the ID-level are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.2 IDs Cede Relatively Senior Rights as Legal Risk Increases

Because legal titles to water exceed natural water availability in many basins across the West, examining the relative seniority of specific water rights that change hands is key to understanding settlement effects on the functional water access. Figures A2 and A3, depicting the distribution of changes to individual rights by their priority rank, show the largest changes to the senior-most rights.

Table 1.2 presents estimates of the relationship between measures of bargaining power, and the relative priority of the individual water relinquished in a settlement. IDs exposed to disproportionately greater shortage risks in court relinquish relatively senior rights, as is indicated by positive signs on the coefficients. This suggests than when an ID risks greater losses in court, it may be more willing to relinquish relatively senior rights, despite those rights being most legally secure, in order to satisfy other water users in a negotiation.

Further, IDs tend to cede relatively high priority water rights when those rights are delivered through Reclamation contracts (cols. 2 and 3) and as the percentage of their total water rights under Reclamation contract increases (cols. 4 and 5). Reclamation contract water rights tend to be relatively senior, having been established primarily in the early 1900s. However, they are also subject to greater legal risk given the federal government's obligations to provide water to tribes.

Table 1.2: Relative Priority of Individual Rights Ceded in a Negotiation

	Y = Water Right Priority Rank (%)				
	(1)	(2)	(3)	(4)	(5)
Shortage Risk (%)	0.250***	0.226**	0.274***	0.193**	0.237***
	(0.0890)	(0.0859)	(0.0702)	(0.0900)	(0.0730)
ln(Prime Reservation Acres)	-8.990	-10.53	-11.69	-7.073	-8.027
	(9.709)	(10.60)	(12.98)	(10.30)	(12.70)
Winters Right Priority	-0.541	-0.954	-0.738	-0.158	0.121
	(2.326)	(2.561)	(2.854)	(2.470)	(2.765)
Winters Priority × ln(Prime Res. Acres)	-0.0224	0.00523	-0.0114	-0.0527	-0.0742
	(0.171)	(0.189)	(0.211)	(0.182)	(0.204)
WR under USBR Contract=1		9.417**	9.479*		
		(4.467)	(4.753)		
USBR Contract Rights (%)				16.06**	18.09**
				(6.151)	(6.866)
IO Urbanization Rate (%)			0.250***		0.268***
			(0.0776)		(0.0703)
IO Acreage			3.71e-05**		4.55e-05**
			(1.62e-05)		(1.68e-05)
Constant	202.2	225.0	230.3	180.1	182.2
	(130.4)	(142.6)	(174.7)	(138.3)	(170.8)
State FE	x	x	x	x	x
Observations	204	204	204	204	204
R-squared	0.506	0.523	0.555	0.535	0.574

Notes: Table depicts the relationship between various measures of ID bargaining power and the relative seniority of the water right relinquished/diminished in a settlement, as estimated by Equation 1.8. The dependent variable is the percentile rank of an ID's, i, individual water right priority, WR, (relative to other water rights in its portfolio) that changed as the result of the settlement, s. The relative priority of the water right, WR_{is} is increasing with its seniority. A positive coefficient on $\hat{\beta}_n$ indicates correlation with the cession of a relatively senior right. Robustness checks are included in Table A10. Standard errors clustered at the ID-level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Federal contract rights tend to be of mid-level priority (established for agriculture after many private canal companies emerge, but before growing cities established water right), tend to be inefficiently used, and the federal government's legal obligation to tribes often trumps its obligation to deliver contract water (Benson, 1997). While relatively senior rights may be targeted for reallocation, it is important to note the cession of even the most senior rights in a settlement represents a mutually beneficial outcome for all parties. Despite giving relatively senior rights, on average IDs relinquish nearly 12% of their total entitlements while still maintaining an average 8.7 acre-feet per acre water duty sufficient to meet most crop requirements (Johnson and Cody, 2015).

4.3 Political Influence Determines Funding Outcomes

Table 1.3 presents estimates of per acre-foot funding outcomes to IDs. Congressional Power Index (CPI), a measure of the settlement act sponsor's political influence, is significantly and positively correlated with average increases of between \$36 and \$45 per AF except for when controlling for a reservation's prime acreage as a measure of its potential water claim (col. 3). Overall, this indicates that political influence is an important determinant of funding outcomes. While the potential magnitude of a tribe's water right claim increases the federal government's legal liability if the tribe were unsuccessful in acquiring water rights in court, the mediating effect of prime reservation acreage on the role of CPI as a funding determinant suggests that the threat of a large Winters claim may motivate IDs to accept less funding to avoid litigation.

Table 1.3: MLR Estimates of bargaining power effects on funding outcomes

	Y = \$/AF (adj. 2020)					
	(1)	(2)	(3)	(4)	(5)	(6)
Congressional Power Index	45.39**	36.35**	37.12	35.80**	36.63**	41.14**
	(16.76)	(14.98)	(28.78)	(15.44)	(14.97)	(19.23)
IO Urbanization Rate (%)		-7.829**	-7.784*	-8.396**	-8.174**	-8.512**
		(3.449)	(3.898)	(3.365)	(3.395)	(4.012)
ln(Prime Reservation Acres)			-2.298			
			(49.61)			
IO Acreage				-0.00129		
				(0.000932)		
Shortage Risk (%)					-0.962	
					(2.131)	
USBR Contract Rights (%)						-231.3
						(340.6)
Constant	-253.5	22.75	36.97	134.2	115.6	17.51
	(195.3)	(170.8)	(245.1)	(191.9)	(313.5)	(176.9)
State FE						
Observations	28	28	28	28	28	28
R-squared	0.443	0.534	0.534	0.552	0.536	0.548

Notes: Sample restricted to IDs that ceded water in a negotiation. Congressional Power Index reflects the political nature of funding decisions. Urbanization rate is a measure of heterogeneous water demand within an ID service area. An ID's potential legal justification for maintaining water rights under beneficial use rules may be diminishing with an increasing urbanization rate. Estimates using explanatory variables identified through a step-wise elimination procedure are depicted in column 3. All specifications include state-level fixed effects. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

That an ID's urbanization rate is negatively correlated with funding outcomes across all specifications, suggests that as an ID's bargaining power is diminishing as heterogeneous water demand within its service area increases. As an ID's water demand decreases with a shift away from farming, it may not be able to justify maintaining a large water entitlement through beneficial use rules. A robustness check presented in Table A12 replaces measures of an ID's legal risk with measures of potential economic determinants of funding outcomes. Additional specifications corroborate the positive effects of CPI and negative effects of urbanization rates on funding outcomes. Measures of heterogeneity in the marginal value of water across bargaining parties are uncorrelated with funding outcomes. Together, this suggests that political influence and the legal framework eclipse market forces as a funding determinant.

4.4 Settlements Generate "Surplus" Benefits to Bargaining Parties

To better understand the extent to which settlements generate a "surplus" of benefits beyond what would be possible in court, this section examines differences between a) average per acre-foot funding achieved through settlement, b) the marginal value of water use had it remained in agriculture, and c) the unit price of water if it had been purchased in the open market.

IDs can maximize gains by removing marginal farmland from production. The USDA Farm and Ranch Irrigation Survey provides state- and year-specific data on the irrigation duty for hay/pasture and USDA Agricultural Marketing Service data on the market price of hay/pasture and alfalfa, which informs estimates of the average \$/AF generated from farming each crop. While both hay and alfalfa are considered to be relatively low-value crops, alfalfa represents the high \$/AF estimate of the two while hay, with a lower market value, represents a low \$/AF estimate of a return on relatively low-value farming. The estimated (adj. 2020\$) dollar per acre-foot, $\left(\frac{adj.2020\$_{ist}}{AF}\right)$, generated by each crop, i, in state, s, in year, t is:

$$\frac{adj.2020\$_{ist}}{AFY} = \frac{adj.2020\$_{ist}}{ton} \times \frac{tons_{ist}}{acre} \div \frac{AF_{ist}}{Acre} \tag{1.10}$$

Here, $\frac{AF_{ist}}{acre}$ is the acre-foot volume of water applied to each acre of crop annually, $\frac{tons_{ist}}{acre}$ is the per acre yield, and $\frac{adj.2020\$_{ist}}{ton}$ is the market price per ton adjusted for inflation. On average, IDs received \$468 acre-feet per acre in exchange for water in a settlement, while an acre-foot of water generated an average \$112 of hay/pasture or \$261 of alfalfa.

The federal government is legally liable to tribes for losses stemming from federal mismanagement of tribal resources, and therefore has an incentive to avoid litigation by acquiring water for tribes through negotiated settlements. Presumably, if no parties were willing to cede water in a settlement, the federal government could offer to purchase enough appropriative water rights to satisfy tribes' agreed upon water needs.

Water pricing data from the Water Transactions Dataset provides estimates the (adj. 2020\$) dollar per acre-foot price of water sold on the open market in state, s, in year, t is used to construct a hypothetical measure of what the federal government might pay for an acre-foot of water purchased outright to satisfy its trust responsibilities to tribes (Donohew and Libecap, 2010). While the market value of water varies across states ($2,110/AF in Arizona versus $386/AF in Idaho), the average adjusted (2020$) price per acre-foot was $1,049, or twice the unit price received through settlement. The discrepancy between $/AF generated through farming, secured via settlement, and available on the open market suggests that side payments in negotiations result in mutual benefits but that they are shaped by the legal setting.

While political will is the primary determinant of funding outcomes, that average settlement funding is 2.5 times that of $/AF generated from farming underscores the efficiency gains achieved by reallocating water away from relatively low-value uses in a negotiation. However, the market price of water is still double that of settlement funding. These estimates highlight that while funding outcomes are largely a function of political will, they still result in net benefits to both "buyers" and "sellers" of water rights in a negotiation. The federal government acquires water for tribes at below the market price while IDs potentially earn more than they would generate by using that water for relatively low-value crop production.

5 Discussion

Just as high-priority water rights protect IDs from legal challenges in court, they also insulate them from reductions to their water allocations within settlement negotiations. Findings demonstrate that water right seniority confers bargaining power within a negotiation, as IDs with the lowest risk of having their water rights curtailed under prior appropriation rules are less likely than those with higher shortage risk to relinquish water in a negotiation. That concessions are increasing with opportunity costs of litigation more than any other source of bargaining power corroborates existing research on the relative importance of different sources of bargaining power. A party's fallback option in court, more so than wealth, patience, or political influence, determines changes to water allocations.

Findings may assuage broader uncertainty about how existing water use will adapt to accommodate newly defined Winters rights. IDs included in this study relinquished an average of 12 percent of their collective water rights. However, they maintained an average 9 AF/acre post-settlement water duty. Anecdotally, many IDs secured funding for irrigation efficiency improvements and have selected the most marginal land to remove from production (Arizona Water Settlements Act, 2004). Thus, changes to water use and broader impacts on rural economies may not be as severe as anticipated. Even moderate shifts in the distribution of water rights distribution can satisfy water users in a basin.

More broadly, results highlight the value of pairing the financial incentives embedded in negotiation with mutual litigation risks to resolve broader conflicts over increasingly scarce resources. As tribes assert high-priority water claims, the litigation is a necessary threat that prompts IDs to make concessions that they may not have made without the risk of losing in court. Settlements offer funding mechanisms that incentivize water right reallocation, whereas such compensation would be unavailable in a court adjudication.

While existing literature on Indigenous water right adjudications touts the advantages of negotiation over litigation, few studies empirically link anticipated litigation costs to negotiation outcomes (Anderson, 2010; Cosens and Royster, 2012). By showing that shortage risk under prior appropriation rules largely determines the extent to which water is reallocated across bargaining parties, findings underscore the importance of a looming legal threat to motivate compromise. Relatedly, the role of congressional influence in determining funding outcomes to IDs underscore the political undercurrents of reallocating water in the West. If funding to reallocate water is a "carrot" for reaching a settlement, then litigation is a necessary "stick" that incentivizes concessions that ultimately redistribute water rights in a way that satisfies all parties.

Understanding the effects of large-scale Indigenous water right restoration has broader implications for nations such as Australia (Hartwig et al., 2021), New Zealand (Fox et al., 2017), Canada (Hanrahan, 2017), and Chile (Edwards et al., 2018; Macpherson, 2020), who are tasked with defining and incorporating Indigenous rights into existing institutions. While this study highlights the potential to meet new needs through negotiation, it also highlights the importance of strong legal institutions and enforcement mechanisms that shape the bargaining environment.

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Appendix

Table A1: Irrigation Organizations Included in Study

Settlement	Irrigation Organization
Fort Apache	Buckeye Irrigation Company Buckeye Water Conservation District Harquahala Irrigation District Roosevelt Water Conservation District
Fort McDowell	Harquahala Irrigation District
Gila River	Buckeye Irrigation Company Buckeye Water Conservation District Central Arizona Irrigation & Drainage District Franklin Irrigation District Gila Valley Irrigation District Harquahala Irrigation District Hohokam Irrigation District Maricopa-Stanfield Irrigation & Drainage Roosevelt Irrigation District Roosevelt Water Conservation District San Carlos Irrigation and Drainage District
Paiute (UT)	Bloomington Canal Company Gunlock Irrigation District Ivins Irrigation Company Lower Gunlock Reservoir Corporation New Santa Clara Field Canal Company St. George Clara Field Canal Company
Salt River	Roosevelt Irrigation District Roosevelt Water Conservation District Wellton-Mohawk Irrigation District
San Carlos	Buckeye Irrigation Company Buckeye Water Conservation District Roosevelt Water Conservation District
San Luis Rey	Vista Irrigation District
Yavapai-Prescott	Chino Valley Irrigation District

Settlement	Irrigation Organization
Nez Perce	A&B Irrigation District Aberdeen Springfield Canal Company Bell Rapids Mutual Irrigation Company Big Bend Irrigation District Boise-Kuna Irrigation District Burgess Canal & Irrigation Company Burley Irrigation District Egin Bench Canal, Inc. Enterprise Irrigation District Falls Irrigation District Harrison Canal & Irrigation Company Lewiston Orchards Irrigation District Milner Irrigation District Minidoka Irrigation District New York Irrigation District North Freemont North Side Canal Company People's Canal & Irrigation District Pioneer Irrigation District Progressive Irrigation District Settlers Irrigation District Snake River Valley Irrigation District Twin Falls Canal Company Wilder Irrigation District
Ute	Dolores Water Conservancy District Florida Canal Florida Ditch Florida Water Conservancy District Mancos Water Conservancy District
Zuni	Lyman Water Company St. Johns Irrigation and Ditch Company

Estimating Relative Shortage Risk: The following tables depict example of the step-by-step process to calculate IDs' water shortage risks relative to other IDs within a single tribal water right negotiation.

Table A2: Calculating an ID's relative risk of water shortage

Water Rights				Percentage of Total Water Supply Reduction								
IO	Priority	AFY		10%	20%	30%	40%	50%	60%	70%	80%	90%
A	1887	7,000	AFY Curtailed	0	0	0	0	0	0	0	0	-3,000
B	1889	4,250		0	0	0	0	0	0	0	-3,250	-4,250
C	1904	3,500		0	0	0	0	0	0	-2,750	-3,500	-3,500
A	1906	4,000		0	0	0	0	0	-2,750	-4,000	-4,000	-4,000
B	1922	6,250		0	0	0	-1,000	-5,000	-6,250	-6,250	-6,250	-6,250
C	1936	4,500		0	0	-1,500	-4,500	-4,500	-4,500	-4,500	-4,500	-4,500
A	1942	3,000		0	-500	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000
B	1945	3,000		0	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000	-3,000
C	1952	4,500		-4,000	-4,500	-4,500	-4,500	-4,500	-4,500	-4,500	-4,500	-4,500
Total Shortfall		0		4,000	8,000	12,000	16,000	20,000	24,000	28,000	32,000	36,000
Available Supply		40,000		36,000	32,000	28,000	24,000	20,000	16,000	12,000	8,000	4,000

Notes: This table depicts the volume of an ID's water right that would be curtailed under water increasingly severe water shortage scenarios. As total water availability - measured as the volume of water held collectively by IDs participating in the negotiation - decreases in 10 percent increments, appropriative water law mandates that the most junior rights are cut first.

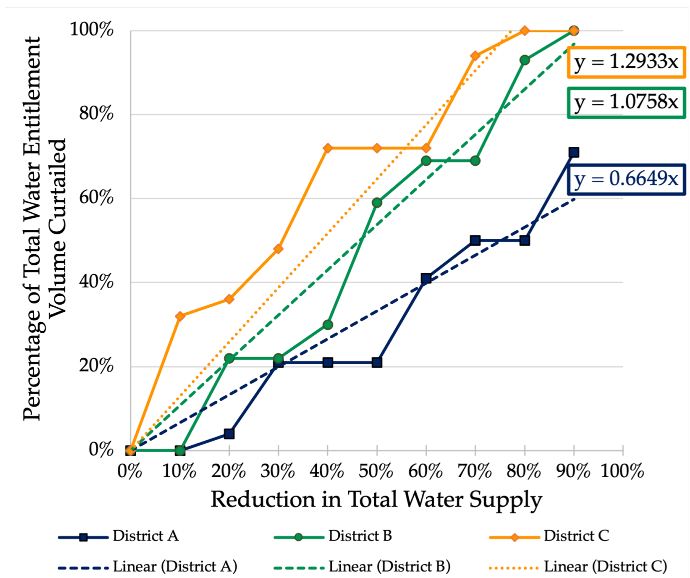
Table A3: Volume and percentage of ID water rights curtailed under increasing levels of shortage

ID	Total Right (AFY)			Water Supply Reduction Scenarios								
				-10%	**-20%**	**-30%**	**-40%**	**-50%**	**-60%**	**-70%**	**-80%**	**-90%**
A	14,000	Water Curtailment	AFY	0	-500	-3,000	-3,000	-3,000	-5,750	-7,000	-7,000	-10,000
			Pct.	0%	4%	21%	21%	21%	41%	50%	50%	71%
B	13,500		AFY	0	-3,000	-3,000	-4,000	-8,000	-9,250	-9,250	-12,500	-13,500
			Pct.	0%	22%	22%	30%	59%	69%	69%	93%	100%
C	12,500		AFY	-4,000	-4,500	-6,000	-9,000	-9,000	-9,000	-11,750	-12,500	-12,500
			Pct.	32%	36%	48%	72%	72%	72%	94%	100%	100%

For each irrigation district, i, within the settlement negotiation, s, we calculate the total AFY water right curtailment under each shortage scenario. An irrigation district's "Total Right (AFY)" (col. 2) is the sum of the volume of its individual rights. The main body of this table shows the AFY volume, and the percentage of each IO's total water right curtailed under increasing levels of water shortage. These AFY values are the sum of each IO's water right curtailment under each shortage scenario. Under the 20% shortage scenario, District A does not receive 500 AFY, or 4 percent, of its 14,000 AFY entitlement, while District B does not receive 3,000 AFY, or 22 percent of its 13,500 AFY total entitlement.

Notes: Table depicts the volume (AFY) and percentage of water rights curtailed for each negotiating ID under as water availability decreases in 10 percent increments.

Figure A1: Relative Shortage Risk Under Prior Appropriation Rules



Notes: Graph is a visual depiction of the independent variable construction of an ID's risk of shortage relative to other IDs in the negotiation. The graph is constructed from Table A3. The percentage of an ID's water entitlements that are curtailed under prior appropriation rules is on the y-axis. The percentage reduction to total water supply is on the x-axis. β_{is}^{risk} is the linear relationship between an ID's water curtailment as a function of diminishing water availability. A steeper line (β_{is}^{risk}) relative to other IDs indicates greater shortage risk.

Table A4: Dirksen Center Congressional Power Index

1. Is of the majority party in the chamber
   If "yes", rates a 3. If a member is of the minority party, rates a -3. If Independent, score a 0.

2. Holds formally elected party membership post.
   Speaker of the House or Majority Leader of the Senate = 5
   Minority Leader or Assistant Majority Leader = 4
   Majority or Minority Whip, Assistant Minority Leader = 3
   Assistant Whips, Rep./Dem. Conference Chair = 2
   Rep./Dem. Conference Sec. or Policy Chair = 1

3. Chairs (or is ranking member of) a "money" committee.
   Committee chair rates a 5, ranking member a 3.
   House "money" committees: Appropriations, Budget, and Ways and Means
   Senate "money" committees: Appropriations and Finance

4. Chairs (or is ranking member of) another committee.
   Chairs rates a 4, ranking member a 2.

5. Chairs (or is ranking member of) a subcommittee.
   Chair rates a 3, ranking member a 1.

6. Is a member of one of the following committees (rates a 3 for each).
   House: Appropriations, Armed Services, Energy and Commerce, Rules, or Ways and Means
   Senate: Appropriations, Armed Services, Budget, Finance, Judiciary

7. Seniority
   0-2 terms rate a 0, then 1 point for every additional two terms
   4 terms. = 1
   6 terms =2, etc.

8. Margin of victory in the last election – not percentage of vote.

>60% = 3	56-58% = 1	50-52% = -1
59-60% = 2	53-55% = 0	< 50% = -2

9. Amount of campaign funds on hand. Amounts depend on individual situation, such as competitiveness of the district.

< $100,000 = -5	$400,000-$499,999 = -1	$800,000-$899,999 = 3
$100,00-$199,999 = -4	$500,000-$599,999 = 0	$900,000-$999,999 = 4
$200,000-$299,999 = -3	$600,000-$699,999 = 1	≥$1,000,000 = 5
$300,000-$399,999 = -2	$700,000-$799,999 = 2	

10. Exposure in national press. Use ONE of the following:
    Washington Post Online Search for one week (1 point for every 4 hits with 5 points the maximum) OR
    New York Times Online Search for one-month (1 point for every 4 hits with 5 points the maximum) OR
    CNN.com search (cnn.com only) (1 point for every 30 hits with 5 points the maximum)

Table A5: Covariates

IO-Level Covariates	Definition	Data Source
Water Rights (#)	Number of individual water rights in IO's pre-settlement water right portfolio	State water right databases
Pre-settlement water duty	Total acre-foot volume of an IO's pre-settlement water rights divided by IO service area acreage	State water agencies
Precipitation	Mean 1980-2010 precipitation normal from April through September within IO boundaries	PRISM
IO Urbanization Rate (%)	Percent change in developed land cover (categories 21-27) within IO boundaries in decade prior to adjudication start.	Falcone, 2015
Hay/Pasture Land Cover	Hay/pasture land cover (category 44) within IO boundaries as a percentage of total IO area	Falcone, 2015
USBR Contract Rights (%)	Percentage of IO's pre-settlement water entitlement volume under USBR contract	State water right databases
Settlement-Level Covariates	**Definition**	**Data Source**
Prime Reservation Acreage	Logged reservation acreage with soil productivity index > 9	Schaetzl, 2012 Sanchez, 2020
Year Reservation Established	Year reservation was established by federal treaty or executive order	Bureau of Indian Affairs
Municipal Pop. Growth Rate (%)	Population growth rate within boundaries of cities/municipal water providers participating in negtiation	Settlement Agreement
Congressional Power Index (CPI)	Index calculated according to Dirksen Congressional Center definition	Congressional Quarterly
Water Right-Level Covariates	**Definition**	**Data Source**
Winters Right Priority	Year when reservation was established subtracted from the priority year of an IO's water right.	Bureau of Indian Affairs and State Water Agencies
WR under USBR Contract	Water right assigned a value of 1 if it is provided via USBR contract, and a value of 0 if it is not.	State water right databases

Table A6: Summary Statistics

Unit of Analysis	Variable	Mean	Std. Dev.	Obs
Irrigation Organization	%Δ AFY	-11.74	20.72	61
	Settlement Funding (2020$/AF)	466.23	738.26	28
	Pre-Settlement Entitlement (AF)	446,289	889,357	61
	Prior Appropriation Shortage Risk (%)	90.03	47.45	61
	Number of Water Rights in Portfolio (#)	9.07	8.39	61
	Pre-Settlement Water Duty (AF/acre)	9.95	8.93	61
	Post-Settlement Water Duty (AF/acre)	8.65	7.24	61
	Precipitation (mm)	19.76	8.16	61
	IO Acreage	48,192	63,402	61
	Urbanization Rate	13.87	22.63	59
	Hay/Pasture Land Cover (%)	6.94	9.37	59
	Percentage of Water Right Entitlement Volume under USBR Contract	0.17	0.35	61
Water Right	Percentile Rank of Water Right Changed in Negotiation	55.47	29.67	204
	Water Right Under USBR Contract=1	0.27	0.45	550
	Winters Relative Priority (Years IO Right is Superceded by Winters Right)	60.73	33.21	549
Settlement	Prime Reservation Acreage (PI>9)	399,985	562,236	11
	Municipal Population Growth Rate (%)	34.13	18.61	11
	Congressional Power Index	12.64	10.26	11

Table A7: MLR Estimates of Bargaining Power Effects on ID Water Rights. (State FE)

	% Δ Pre-Settlement Entitlement (AFY)					
	(1)	(2)	(3)	(4)	(5)	(6)
Shortage Risk (%)	-0.216***	-0.222***	-0.221***	-0.192***	-0.176**	-0.154**
	(0.0713)	(0.0706)	(0.0686)	(0.0646)	(0.0707)	(0.0662)
ln(Prime Res. Acres)	1.031	1.281*	1.256*	1.491***	1.655***	1.545**
	(0.794)	(0.672)	(0.703)	(0.511)	(0.533)	(0.580)
Year Reservation Estab.		0.0774	0.0703	0.0952	0.110**	0.0914
		(0.0543)	(0.0607)	(0.0592)	(0.0541)	(0.0628)
Water Rights (#)			0.345	0.455	0.396	0.358
			(0.476)	(0.440)	(0.500)	(0.485)
Pre-Settlement AFY/Acre			-0.0472	-0.131	-0.0620	-0.127
			(0.401)	(0.412)	(0.365)	(0.377)
Precip. (mm)				0.526*	0.493	0.588
				(0.282)	(0.306)	(0.381)
IO Acreage				-2.25e-05	-2.18e-05	-1.91e-06
				(3.15e-05)	(3.36e-05)	(3.42e-05)
USBR Contract Rights (%)					-7.345	-8.013
					(9.918)	(10.31)
IO Urbanization Rate (%)						0.0719
						(0.0660)
Hay/Pasture (%)						-0.571**
						(0.282)
Constant	-4.631	-151.6	-140.7	-202.2*	-231.4**	-195.6
	(10.50)	(103.5)	(116.5)	(115.2)	(105.3)	(121.4)
Settlement FE	x	x	x	x	x	x
Observations	61	61	61	61	61	59
R-squared	0.359	0.374	0.385	0.414	0.426	0.457

Notes: Specifications include state-level fixed effects and settlement-level controls as a robustness check to models specified in 1.1. Settlement-level variables presented in columns 2-6 include a) reservation prime acreage as a proxy for a tribe's water right claim, and b) the year when the reservation was established as a measure of its water right priority. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A8: MLR Estimates of Bargaining Power Effects on ID Water Rights. (Quadratic Risk Function)

	% Δ Pre-Settlement Entitlement (AFY)					
	(1)	(2)	(3)	(4)	(5)	(6)
Shortage Risk (%)	-0.109**	-0.114**	-0.114**	-0.111**	-0.108**	-0.107**
	(0.0427)	(0.0453)	(0.0453)	(0.0416)	(0.0433)	(0.0397)
Shortage Risk^2 (%)	-0.0530	-0.0584	-0.0574	-0.0645*	-0.0679*	-0.0692*
	(0.0390)	(0.0401)	(0.0388)	(0.0380)	(0.0395)	(0.0365)
Water Rights (#)		0.370	0.385	0.535	0.486	0.391
		(0.514)	(0.510)	(0.480)	(0.544)	(0.510)
Pre-Settlement AFY/Acre			-0.0940	-0.170	-0.0825	-0.147
			(0.438)	(0.439)	(0.360)	(0.377)
Precip. (mm)				0.587	0.598	0.657
				(0.420)	(0.435)	(0.484)
IO Acreage				-3.22e-05	-2.91e-05	-6.84e-06
				(3.42e-05)	(3.61e-05)	(3.35e-05)
USBR Contract Rights (%)					-7.619	-8.170
					(13.49)	(14.02)
IO Urbanization Rate (%)						0.115
						(0.0781)
Hay/Pasture (%)						-0.635*
						(0.319)
Constant	-1.660	-4.598	-3.834	-14.85	-14.73	-12.74
	(3.475)	(5.482)	(7.135)	(11.35)	(12.25)	(14.15)
Settlement FE	x	x	x	x	x	x
Observations	61	61	61	61	61	59
R-squared	0.356	0.367	0.368	0.404	0.414	0.460

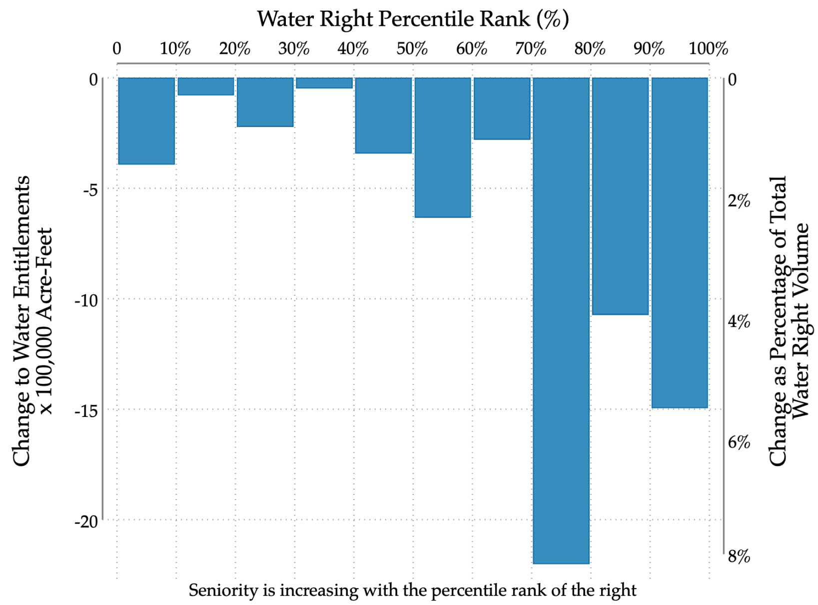
Notes: As a robustness check to models specified in 1.1, models include shortage risk as a quadratic function of diminishing water availability. As shortage risk increases, so too does the share of pre-settlement entitlements that an ID gives up in a settlement. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A9: MLR Estimates of Bargaining Power Effects on ID Water Rights. (Quadratic Risk Function; State FE)

	% Δ Pre-Settlement Entitlement (AFY)					
	(1)	(2)	(3)	(4)	(5)	(6)
Shortage Risk (%)	-0.0609*	-0.0597	-0.0610	-0.0744**	-0.0688*	-0.0630**
	(0.0354)	(0.0364)	(0.0377)	(0.0342)	(0.0367)	(0.0309)
Shortage Risk^2 (%)	-0.0129	-0.0114	-0.0128	-0.0352	-0.0352	-0.0330
	(0.0341)	(0.0350)	(0.0343)	(0.0339)	(0.0345)	(0.0311)
ln(Prime Res. Acres)	1.046	1.236	1.221	1.644**	1.779**	1.630**
	(0.894)	(0.744)	(0.801)	(0.674)	(0.732)	(0.797)
Year Reservation Estab.		0.0621	0.0537	0.0882*	0.102**	0.0799
		(0.0417)	(0.0518)	(0.0520)	(0.0500)	(0.0611)
Water Rights (#)			0.322	0.505	0.456	0.387
			(0.486)	(0.452)	(0.518)	(0.484)
Pre-Settlement AFY/Acre			-0.0719	-0.168	-0.103	-0.173
			(0.427)	(0.423)	(0.355)	(0.370)
Precip. (mm)				0.685	0.679	0.747
				(0.410)	(0.425)	(0.465)
IO Acreage				-3.61e-05	-3.37e-05	-1.14e-05
				(3.31e-05)	(3.44e-05)	(3.22e-05)
USBR Contract Rights (%)					-6.054	-6.634
					(11.70)	(12.30)
IO Urbanization Rate (%)						0.0919
						(0.0877)
Hay/Pasture (%)						-0.640**
						(0.302)
Constant	-18.32*	-136.6*	-122.8	-203.7*	-231.4**	-186.1
	(10.87)	(79.30)	(99.34)	(104.6)	(101.1)	(120.4)
Settlement FE	x	x	x	x	x	x
Observations	61	61	61	61	61	59
R-squared	0.313	0.323	0.332	0.384	0.392	0.434

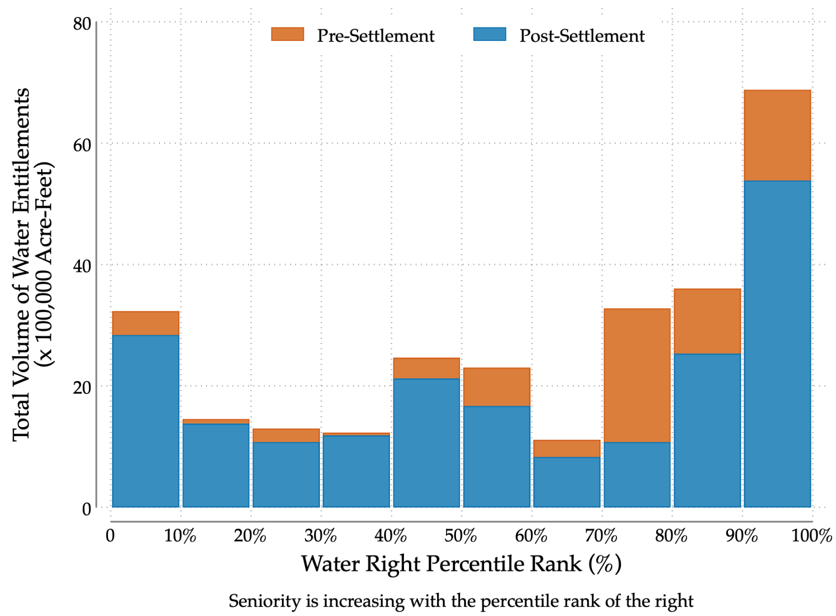
Notes: As a robustness check to models specified in 1.1, models include shortage risk as a quadratic function of diminishing water availability. As shortage risk increases, so too does the share of pre-settlement entitlements that an ID gives up in a settlement. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure A2: Volume of Water Entitlements Ceded in Negotiation, by Priority Rank (%)



Notes: Figure A2 depicts the number of individual water rights that were relinquished or diminished in a settlement by their priority date relative to other water rights owned/claimed by the ID.

Figure A3: Pre and Post-Settlement Water Entitlement Volumes, by Priority Rank (%)



Notes: Figure A3 depicts the volume of pre- and post-settlement water entitlements as a function of their priority date relative to other water rights owned/claimed by the ID.

Table A10: MLR Estimates of Relative Priority of Water Rights Ceded in a Negotiation

	Y = Water Right Priority Rank (%)				
	(1)	(2)	(3)	(4)	(5)
Shortage Risk (%)	0.0722	0.0477	0.0470	0.0179	0.0147
	(0.0855)	(0.0818)	(0.0827)	(0.0806)	(0.0730)
Shortage Risk^2 (%)	0.00184	-0.0154	-0.0228	-0.0370	-0.0466
	(0.0755)	(0.0713)	(0.0741)	(0.0702)	(0.0651)
ln(Prime Reservation Acres)	-9.607	-10.43	-10.68	-5.435	-5.351
	(13.54)	(13.66)	(13.95)	(12.39)	(12.85)
Winters Right Priority	-0.0308	-0.595	-0.595	0.193	0.273
	(3.022)	(3.047)	(3.006)	(2.621)	(2.596)
Winters Priority × ln(Prime Res. Acres)	-0.0592	-0.0209	-0.0221	-0.0788	-0.0862
	(0.223)	(0.225)	(0.222)	(0.193)	(0.191)
WR under USBR Contract=1		10.66**	11.05**		
		(5.103)	(5.382)		
USBR Contract Rights (%)				19.40***	21.89***
				(5.969)	(6.449)
IO Urbanization Rate (%)			0.0972		0.125
			(0.0984)		(0.0849)
IO Acreage			6.11e-05***		7.08e-05***
			(1.73e-05)		(1.69e-05)
Constant	224.6	237.8	236.1	172.1	165.0
	(181.1)	(182.9)	(186.6)	(165.3)	(171.8)
State FE	x	x	x	x	x
Observations	204	204	204	204	204
R-squared	0.499	0.521	0.548	0.543	0.580

Notes: Table depicts the relationship between various measures of ID bargaining power and the relative seniority of the water right relinquished/diminished in a settlement, as estimated by Equation 1.8. The quadratic function of an ID's relative shortage risk is included as a robustness check. The dependent variable is the percentile rank of an ID's, i, individual water right priority, WR, (relative to other water rights in its portfolio) that changed as the result of the settlement, s. The relative priority of the water right, WR_{is} is increasing with its seniority. A negative coefficient on $\hat{\beta}_n$ indicates correlation with the cession of a relatively junior right. Standard errors clustered at the ID-level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A11: MLR Estimates of Funding Outcomes Using Backwards Elimination Process

	Y = $/AF (adj. 2020)					
	(1)	(2)	(3)	(4)	(5)	(6)
Congressional Power Index	65.41**	66.58**	65.16**	56.04***	47.34***	52.09***
	(25.46)	(26.68)	(24.92)	(17.72)	(14.01)	(15.28)
IO Urbanization Rate (%)	-6.201	-6.212*	-5.812*	-6.333*	-7.893***	-6.932***
	(3.704)	(3.541)	(3.278)	(3.270)	(2.586)	(2.295)
ln(Prime Reservation Acres)	-97.05*	-98.59*	-99.70*	-81.66*	-54.42*	-70.09**
	(51.53)	(53.38)	(53.03)	(44.80)	(31.50)	(29.97)
IO Acreage	-0.00123	-0.00121	-0.00122	-0.00101	-0.00166	
	(0.000892)	(0.000830)	(0.000828)	(0.000633)	(0.00106)	
Municipal Pop. Growth Rate (%)	-13.92	-13.68	-13.99	-15.13		
	(13.06)	(12.29)	(12.28)	(12.70)		
Hay/Pasture (%)	11.02	11.19	12.21			
	(14.75)	(14.85)	(14.63)			
USBR Contract Rights (%)	-124.5	-110.3				
	(339.6)	(294.2)				
Shortage Risk (%)	0.381					
	(2.858)					
Constant	1,168	1,190	1,195	1,250	616.3	590.7
	(740.0)	(748.3)	(736.6)	(754.8)	(366.4)	(345.7)
Observations	28	28	28	28	28	28
R-squared	0.550	0.550	0.547	0.539	0.454	0.425

Notes: Table presents MLR estimates of funding outcomes as explanatory variables are dropped from the model using a backwards elimination procedure. Column 1 includes the full model. Progressing from columns 2-5, each successive model omits the variable from the prior model that reduces R^2 the least. Column 6 specifies explanatory variables to be included in the primary regression results presented in Table 1.3. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A12: Estimated effects of bargaining power on per acre-foot funding (Robustness check)

	Y = $/AF (adj. 2020)				
	(1)	(2)	(3)	(5)	(6)
Congressional Power Index	37.69**	57.90*	29.20*	38.00**	38.68***
	(13.62)	(32.39)	(15.31)	(16.22)	(13.56)
Urban Pop. Growth Rate	-13.29	-13.60	-12.71	-13.23	-12.67
(%)	(16.06)	(16.11)	(15.45)	(15.67)	(15.32)
ln(Prime Reservation Acres)		-64.71			
		(77.29)			
IO Urbanization Rate (%)			-7.642*		
			(4.022)		
USBR Contract Rights (%)				-10.95	
				(283.8)	
Hay/Pasture (%)					20.30
					(16.61)
Constant	326.5	785.5	570.8	322.2	136.2
	(647.2)	(837.2)	(654.9)	(616.3)	(573.8)
State FE	x	x	x	x	x
Observations	28	28	28	28	28
R-squared	0.494	0.510	0.581	0.494	0.513

Notes: The sample is restricted to IDs that ceded water in a negotiation. Model specifications replace measures of IDs' legal risks (as depicted in Table 1.3) with variables that measure economic determinants of settlement funding. Hay/pasture land cover – a measure of relatively low-value – represents relatively low-value water use. Municipal population growth rate is a measure of competing water demand from cities. All specifications include state-level fixed effects, as the willingness and capacity to fund settlements likely varies by state. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.