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

Leslie Sanchez †

October 28, 2024

**Abstract**

Water use in the western United States remains highly concentrated in irrigated agriculture, primarily due to the "first in time, first in right" tenets of appropriative water law, which shield 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 across 11 negotiations. The bargaining power of an irrigation district is evaluated as its relative vulnerability to water shortage under prior appropriation law, representing its fallback position if tribes' water claims were resolved in court. Findings indicate that as shortage risk increases relative to other districts, irrigation districts relinquish larger shares of their water rights, presumably to avoid litigation. Financial compensation obtained in exchange for relinquishing water rights is increasing with the political influence of a settlement act's congressional sponsor and with water scarcity. Results underscore the importance of tribes' legally enforceable senior water rights as an important mechanism that motivates settlements through water right reallocations. They also demonstrate how legal and political institutions shape bargaining outcomes.

**Keywords:** Irrigation districts, water, Indigenous water rights, bargaining power, prior appropriation

*This research was generously supported by the Babbitt Center for Land and Water Policy and the Property and Environment Research Center.

†USFS Rocky Mountain Research Station, 240 Prospect Street, Fort Collins, CO 80526; leslie.sanchez@usda.gov

## 1 Introduction

Laws governing natural resource rights define allocations, stipulate how shortages are shared, and provide a framework for resolving competing claims when disputes arise (Libecap, 1989). If parties cannot resolve disputes on their own, they can go to court, where an adjudicator resolves their disputes for them according to existing law. Court rulings, however, expose litigants to risks of potentially unfavorable but binding decisions and can result in economically inefficient resource allocations (Cooter et al., 1982). Alternatively, parties can bargain in the shadow of an expected judicial decision. By strategically gauging likely litigation outcomes, they can make and exact concessions from one another to reach mutually beneficial agreements that preempt a return to court (Mnookin and Kornhauser, 1979).

Empirical tests of air and water quality markets, and conflicts over land, minerals, and hunting rights illustrate the importance of the legal setting in shaping negotiation outcomes that, relative to litigation, yield a surplus of benefits (Reeling et al., 2018; Byun, 2015; Hanley and Summer, 1995). The distribution of surplus benefits across bargaining parties is a function of bargaining power disparities, which are determined primarily by a party's fallback option, or, its expected outcome if negotiation fails and the dispute is resolved in court (Mnookin and Kornhauser, 1979). Those expecting favorable court outcomes wield more bargaining power in a negotiation, make fewer concessions, and capture larger shares of the benefits while those anticipating greater losses concede more to avoid litigation (Harsanyi, 1959; Cooter et al., 1982).

Wealth, heterogeneity, and patience also confer influence over the bargaining process by enabling parties to absorb bargaining costs and raise costs to others (Esteban et al., 2019). Parties benefiting from status quo resource allocations therefore wield a unique influence over negotiations: even with weak legal positions, they can resist change by delaying settlement while maintaining resource use (Hubbard, 2018). Delays, exacerbated by uncertainty about settlement outcomes (Libecap, 2008), deprive others of benefits of resource use, perpetuate inefficiencies, and deplete resource stores (Sanchez et al., 2020; Edwards, 2016). Thus, reducing uncertainty about bargaining outcomes to status quo beneficiaries is key to resolving disputes. Yet, there are few empirical *ex post facto* tests of the factors that motivate settlement from their perspective.

This study examines a complex bargaining problem - the process of restoring Native American water rights through settlements negotiated in the shadow of water law in the western United States - from the perspective of irrigation districts (IDs), who benefit from status quo water allocations.[1] Under the prior appropriation doctrine governing surface water in the West, water rights are established based on the chronological priority of the initial claim. The earliest established rights are filled in their entirety before relatively junior rights receive water. The first rights were established for irrigators in the mid-1800s, ensuring their water access even in dry years. Despite growing non-agricultural water demand, water law protects irrigated agriculture from legal challenges to its water use (Benson, 1998).

The relatively recent adjudication of Native American water right claims, however, presents a rare legal threat to the primacy of IDs' senior water rights. Native American reservations have unresolved, but potentially large claims to water rights that supersede most appropriative rights in priority (Winters v. U.S., 1908). Tribal water rights (referred to as *Winters* rights), when adjudicated in court, are quantified and inserted into the existing priority order, potentially divesting even senior appropriators of their water use. High costs and uncertainty of litigation have prompted water users to negotiate to resolve Winters claims in a way that maintains water security for existing users. Negotiations typically include tribes, federal and state agencies, and cohorts of IDs and cities. The high concentration of relatively low-value, low-efficiency water use in irrigated agriculture has made IDs likely sources of water that can be reallocated to meet tribal and non-agricultural needs (Garrick et al., 2019). In exchange, they can bargain for financial compensation from those hoping to expedite settlement and avoid a court ruling. Because status quo water use continues until a settlement is reached, IDs more so than tribes or junior appropriators have an incentive to stall.

To date, 61 IDs across the West have participated in 11 settlement negotiations that have resulted in a patchwork of changes to ID water rights.[2] However, 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 bargaining power, relative to other IDs in a negotiation, on changes to its pre-settlement water rights and on funding outcomes to those ceding water. The

[1] "Irrigation districts" include 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.

[2] Forty-one of 226 federally recognized reservations in 11 western states have secured water rights through 39 federally enacted settlements. Of these, 11 settlements included irrigation districts as bargaining parties.

*ad hoc* nature of establishing appropriative water rights has meant that IDs in a negotiation are exposed to heterogeneous risks of water shortage under priority-based shortage rules that curtail junior rights first. As IDs bargain with one another over how to meet competing water needs, those with higher relative shortage risks under priority-based curtailment rules are expected to give up larger shares of their existing rights in a negotiation to avoid a return to court. A worse fallback option is expected to yield worse funding outcomes, though this relationship is likely tempered by additional measures of bargaining power and the bargaining environment.

Legal analyses detailing the theoretical underpinnings of how water law shapes Winters settlement outcomes discuss the advantages of negotiation over litigation (Smith, 1992; Anderson, 2010). As the first empirical test of the effects of bargaining power disparities on large-scale water right reallocations negotiated in the shadow of the law, this study empirically links expected litigation costs to negotiation outcomes. In doing so, it resolves uncertainty about how legal mechanisms motivate compromise, alter resource allocations, and ultimately reallocate water to Indigenous communities.

## 2 Institutional Setting

### 2.1 Appropriative Water Rights

Under the prior appropriation doctrine, irrigators hold high priority rights to large volumes of water. 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. The first rights were established for irrigated agriculture between 1850 and 1920, ensuring that irrigators receive their full entitlements before junior rights are filled. Surface water in most basins was fully appropriated by the mid-1900s. Thus, junior rights, typically held by cities and environmental interests, are at higher risk of being curtailed during a shortage (Kendy et al., 2018).

By protecting early claimants against water diversions by new entrants, appropriative rights facilitated capital investments in water conveyance and storage infrastructure (Leonard and Libecap, 2019). Such legal certainty enabled individual farmers to pool infrastructure costs and form irrigation districts to manage water. The gradual expansion of surface water use has meant that individual IDs often hold multiple water rights, each to different volumes and with a different priority date.

Federal investments in irrigation infrastructure under the 1902 Reclamation Act further concentrated water use in agriculture. Nearly 20 percent of irrigators across the West receive water from Reclamation projects through long-term service contracts that provide them with large volumes of subsidized water (USBR, 1977). 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, Reclamation has overlooked overuse violations, while federal subsidies contribute to water use inefficiencies within project areas (Benson, 1998).

Growing cities, with relatively high-value water use and junior rights, have sought water transfers from neighboring irrigators amidst increasing water scarcity (Garrick et al., 2019). Barriers to water marketing, however, impede such transfers, leaving junior appropriators vulnerable to water shortages (Leonard et al., 2020). Consequently, irrigated agriculture accounts for nearly 90 percent of consumptive water use in western states much like it did 100 years ago (Libecap, 2007; Deiter et al., 2018).

### 2.2 Winters Rights

Around the time that the first appropriative rights were established for irrigated agriculture, tribes across the West were confined to reservations that were established by treaties signed with the federal government. The Supreme Court affirmed in Winters v. U.S. (1908) that reservation treaties implicitly entitle tribes to enough water to support reservations as permanent homelands. Winters rights cannot be forfeited through non-use, and with a priority date of when the reservation was established, they supersede almost all appropriative rights in priority. While the *Winters* ruling affirmed the existence of tribal water rights, it did not set aside or quantify water rights for tribes. As such, tribes must quantify their water rights through an adjudication process if those rights are to be legally enforceable.

The federal government, through its treaty obligations to tribes, has a "legally enforceable fiduciary obligation . . . to protect tribal treaty rights, lands, assets, and resources" (BIA, 1977). Recognizing the differences between Winters and appropriative rights, its role in developing and delivering water for off-reservation use, and its obligations to tribes, the government waived its sovereign immunity to adjudicate and administer Winters rights through the McCarran Amendment (1952). The McCarran Amendment established that Winters rights could be adjudicated in state courts.

In 1963, Arizona v. California clarified that tribes have rights to enough water to cultivate every irrigable acre on a reservation (the Practicably Irrigable Acreage, or PIA, standard). The ruling did not precisely define what constitutes a "practicably irrigable" acre, but the potential magnitude of PIA-based Winters claims likely exceeds natural water availability in most basins (Johnson, 1983). By affirming that Winters rights would be upheld in court, even if they displaced existing users, Arizona v. California established that they were a credible legal threat to incumbent right holders.[3]

### 2.3 Bargaining in the Shadow

Despite lingering ambiguities surrounding Winters quantification metrics and the extent to which incumbent rights would be displaced, legal institutions provide a path for adjudicating Winters rights and inform parties' expectations about potential court outcomes. Their fallback options, in turn, inform their bargaining positions in a negotiation. Winters rights can be adjudicated in court or through negotiated settlements. Both pathways result in legally enforceable water rights for tribes, but high costs and uncertainty of court adjudications have meant that most Winters claims are resolved via negotiation (Sanchez et al., 2020).

Court adjudications of Winters rights often occur in the context of basin-wide adjudications (Anderson, 2010). Tribes assert their Winters claims in state courts based on their homeland needs, while appropriators typically provide evidence of their existing water rights and historical beneficial use. Both parties risk unfavorable rulings that diminish their claims. For instance, an ID's declining water demand, which can coincide with urbanization in its service area, may diminish its legal justification for retaining large water entitlements under beneficial use rules (Aylward, 2006). Tribes may not receive their full claims if a judge rules that claims exceed the volume necessary to support the reservation. Parties whose claims are rejected or diminished are not entitled to compensation for financial losses (Baley v. U.S., 2019).

[3] Successive court rulings have expanded quantification metrics to include non-agricultural uses (Cordalis and Cordalis, 2014), but many reservations continue to assert PIA-based claims to maximize their potential adjudication outcomes (Sanchez et al., 2020)

When adjudicated in court, Winters rights are quantified according to a "homeland" standard, assigned a priority date of when the reservation was established, and inserted into the existing priority order ahead of nearly all appropriative rights. New Winters rights are created regardless of physical water availability, and because adjudications occur in the context of water scarcity (Sanchez et al., 2020), they potentially displace existing use (see Figure A1). Appropriative and Winters rights alike are curtailed under prior appropriation rules during shortages. As such, court decreed Winters rights pose heterogeneous shortage risks to appropriators. Risk varies based on water right volume and priority, with junior rights facing the highest shortage risks as Winters rights are added into the priority order.

Negotiations typically include tribes, the federal government on behalf of tribes, state and federal government agencies, multiple IDs, and cities. Settlements are ultimately enacted by Congress. Parties bargain to reach mutually beneficial agreements that resolve tribal water claims as well as basin-wide water conflicts. This can involve reallocating existing rights or generating conserved water to meet more water needs 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. In exchange they can bargain for settlement terms that quiet future claims against their water rights, result in long-term water security, and provide financial compensation.

Most settlements rely on federal funding to generate conserved water and compensate parties for relinquishing water right claims. The government's competing legal obligations to protect tribal water rights, uphold Reclamation project contracts, and enforce environmental laws expose it to legal and financial risks if broader water disputes are not resolved efficiently through negotiation (Stern, 2019). To the extent that its contributions do not exceed the expected costs of its calculable legal exposure, it has funded water infrastructure, water buy-backs from irrigation districts, and development of water resources on reservations (DOI, 1990). The government does not reveal the estimated costs of its legal exposure; however, its legal liability is likely increasing with the strength and volume of tribal water claims.

Reclamation project water presents a relatively low cost option for the government to secure water for tribes and other parties to which it has legal obligations. For instance, by leveraging IDs' federal water project debt obligations, it has renegotiated IDs' water contracts, and reallocated project water to tribes (AWSA, 2004) and to streamflow for endangered fish (Wolfley, 2016). Similarly, variation in the marginal value of water across bargaining parties creates opportunities for market-based reallocations that would be difficult outside the context of a settlement (Colby and Young, 2018). Federal and municipal governments have financed irrigation infrastructure improvements to generate conserved water that is reallocated from IDs to tribes, and then leased back to cities from tribes. IDs can maximize potential gains from a settlement by reallocating water and removing the most marginal farmland from production (Griffin, 2012).

## 3 Methods

### 3.1 Bargaining Framework

Winters settlement negotiations represent a multilateral bargaining problem, where coalitions of multiple parties including tribes, cities, IDs, and 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 (Muthoo, 2001; Cooter et al., 1982; Cooter and Rubinfeld, 1989). Accordingly, this study assesses an ID's bargaining power as a function of its risk, relative to that of other IDs in a negotiation, of exposure to water shortage under prior appropriation rules that would be applied in a court adjudication. It 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.

Sanchez et al. (2020) show that scarcity catalyzes the adjudication process. Hence, a key assumption is that tribal water needs must be met through changes to existing water rights. As such, IDs in a negotiation are bargaining over changes to the fixed annual acre-foot (AFY) volume of their collective pre-settlement water rights, $\Sigma AFY_{is}$. A second assumption is that IDs bargain to minimize reductions to their water respective 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, $\pi$, where $\pi > 0$. A Winters negotiation surplus, $\pi$, can be characterized as avoided losses had the dispute been resolved in court, with IDs relinquishing smaller shares of their water in a settlement than they would have expected to lose in court. 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 $\pi$ 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 $\pi$ 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 $\pi$ that maximizes their joint utility of $x_i$:

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

Where $\partial_i$ is the bargaining weight for party, $i$, defined as:

$$\sum_{i-1}^{n} \partial_i = 1 \tag{2}$$

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, as it 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 for tribes. Final funding decisions occur at the federal level, as most settlements rely on federal funding to secure water rights for tribes and support infrastructure to make that water available for on-reservation use. Because Congress is responsible for appropriating settlement funding, relatively powerful congressional sponsors may be better able to secure spending packages that result in higher levels of funding for bargaining parties (Anderson, 2006). Prior research shows that relatively large, wealthy, homogeneous IDs wield greater political influence are better equipped to endure a protracted settlement process (Esteban et al., 2019; Libecap, 2009). As IDs bargain in the political arena, wealthier, patient, and more influential IDs may be able to exact higher levels of funding in a negotiation. The non-satiation assumption applies to settlement funding outcomes as well, as federal guidelines stipulate that settlement funding should not exceed anticipated litigation costs (Stern, 2019).

The bargaining solution is weighted by the bargaining weight, $\partial_i$, 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 its likelihood of securing a larger share of the surplus, $\pi$. Relatedly, an ID's aversion to risk shapes its utility function. 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 relatively low-value, low-efficiency water use, may accept less funding to resolve Winters rights more quickly.

### 3.2 Data

This study tests for the effects of Winters 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 right volumes and measures of bargaining power, and 2) a water right-level dataset containing pre and post-settlement water entitlement volumes and priority dates of the IDs' 851 water rights.

**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 $AFY^{pre}_{WR,is}$, and specifies the priority date of when the water right was established, the entitlement volume, and water source. 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, $AFY^{\Delta}_{WR,is}$. The percent change to an ID's water entitlements is calculated as:

$$\%\Delta AFY_{is} = \frac{\Sigma AFY^{\Delta}_{WR,is}}{\Sigma AFY^{pre}_{WR,is}} \times 100 \tag{3}$$

The volume of water rights exceeds natural water availability in many basins. Ascertaining the effects of a settlement on water access therefore requires an examination of which water rights an ID gave up. To gain additional insight into the effects of bargaining power on the value of water rights ceded in a negotiation, a second dependent variable measures the relative priority of the individual water right relinquished in a settlement. The relative priority of a water right, $WR$, held by ID, $i$, in negotiation, $s$, is assessed as 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) ranking the pre-settlement water rights ($AFY^{pre}_{WR,is}$) held by each ID and for each settlement in descending chronological priority order (junior to senior), 2) assigning each water right a value, $p_{WR,is}$, from 1 (assigned to an ID's lowest priority water right) to the highest return value (assigned to the highest priority right), and 3) calculating the percentile rank as:

$$PctRank_{WR,is} = \frac{(p_{WR,is} - 1)}{(n_{WR,\ is} - 1)} \times 100 \tag{4}$$

Here, $PctRank_{WR,is}$ 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 senior most right has a value of 100 percent. The most junior has a value of zero. An ID's sole water right is assigned a value of 100 percent, as it is, by default, the ID's most valuable right.

Finally, settlement funding, $\$/AF_{is}$, is the total adjusted (2020$) dollar per acre-foot allocated to each ID that forfeited water rights in a settlement. 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, $\$/AF_{is}$, is the total funding received by an ID divided by the total volume of relinquished water, $AFY_{is}^{\Delta}$.

**Independent Variable Construction**

An ID's bargaining power is assessed primarily as a function of its risk, relative to other negotiating IDs, of having its water rights curtailed under prior appropriation rules. An ID's relative shortage risk ($risk_{is}$) is constructed using data on the volumes and priority dates of IDs pre-settlement water right claims. First, individual water rights, $WR_{is}^{pre}$, claimed by IDs in a negotiation are ranked in order of ascending priority. Pre-settlement water right claims are summed for each ID, $AFY_{is} = \sum WR_{is}^{pre}$, and then for each settlement, $AFY_s = \sum AFY_{is}$. The assumption is that IDs in a negotiation can bargain over a fixed volume of water equal to the sum of their collective water right claims. Next, the volume and then percentage of each ID's pre-settlement claims that would be curtailed under prior appropriation rules are estimated under simulated water shortages, where total water availability, $AFY_s$, 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 $\beta_{is}^{risk}$, 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:

$$PctCurtailment_{is} = \alpha_0 + \beta_{is}^{risk}(\sum AFY_{is} \times \gamma) \tag{5}$$

Where $\alpha_0$, the y-intercept, equals zero under the assumption that all IDs receive their full entitlements when there are no water shortages, and $\gamma$ is the simulated level of water shortage system shortage, where $\gamma = 0, .1, .2, .3, \ldots, .9$. $\beta_{is}^{risk}$ is calculated as the linear best fit line:

$$\beta_{is}^{risk} = \frac{n_{is}\sum(x_s y_{is}) - \sum(x_s)\sum(y_{is})}{n_{is}\sum({x_s}^2) - (\sum x_s)^2} \times 100 \tag{6}$$

Where $n_{is}$ is the number of observations for each ID in a settlement. Relative shortage risk is assessed as a percentage where $risk_{is} = \beta_{is}^{risk} \times 100$.

Models include several ID-level controls. An ID's service area acreage reflects size as a determinant of bargaining power. Pre-settlement volume of water right claims per service area acre (AFY/acre) reflects an ID's capacity to continue irrigating during water shortages or after relinquishing some rights. Decadal urbanization rate within ID boundaries prior to settlement is a measure of heterogeneous water demand. The percentage of hay/pasture land cover within ID boundaries prior to settlement capture heterogeneity in water demand and well an ID's marginal value of water use. Measures of water shortages lasting at least 12 months and with a 50-year return period are derived from Sanchez et al. (2023). County-level shortage volumes are measured as million cubic meters per month (MCM/mo) deficit when fresh water demand exceeds supply. ID-level water shortage variables are constructed by averaging shortage volumes across counties overlying each ID. The percentage of pre-settlement water rights provided via Reclamation contract captures the federal role in the bargaining process. The government's competing obligations to tribes and Reclamation contract holders may make contract rights more vulnerable in court.

Water right level controls include two dummy variables: one for whether the pre-settlement water right was delivered via Reclamation contract, and another for whether the ID was compensated for giving up the right. Settlement-level controls include prime reservation acreage and pre-settlement reservation population as proxies for the potential magnitude of tribes' water right claims. Following Sanchez et al. (2020), tribes' water entitlements are increasing in volume with prime reservation acreage. Pre-settlement population growth rate in municipalities represented in negotiations captures competing demand from relatively junior appropriators. The number of negotiating IDs is included as a measure of bargaining complexity, which raises bargaining costs (Libecap, 1993). Finally, the political influence of the congressperson sponsoring the settlement act is assessed according to the Dirksen Congressional Power Index (CPI) (Table A1). See Table A2 for variable construction, and Table A3 for 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:

$$\%\Delta AFY_{is} = \beta_0 + \beta_1 risk_{is} + \beta_2 X_{is} + \xi_s + u_{is} \tag{7}$$

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 $\beta_1$ indicates that a higher shortage risk is correlated with a reduction in water right volume. Models include settlement fixed effects, $\xi_s$, to account for unobserved factors that may systematically vary across settlements.

A multilinear regression estimates the relationship between measures of bargaining power and the seniority, relative to other water rights in an ID's water right portfolio, of an individual water right that changed as the result of the settlement:

$$PctRank_{WR,is} = \beta_0 + \beta_1 X_{is} + \beta_2 X_{WR,is} + \xi_s + u_{is} \tag{8}$$

Here, $PctRank_{WR,is}$ 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 and $X_{WR,is}$ is a vector of water right-level characteristics. Because $PctRank_{WR,is}$ is increasing with the seniority of a water right, a negative coefficient on $\hat{\beta}_n$ indicates a negative correlation between independent variable is correlated with the reduction of a relatively junior water right. It is expected that those in weaker bargaining positions will cede higher priority water rights. Models include settlement-level fixed effects, $\xi_s$ and standard errors clustered at the ID-level.

Determinants of settlement funding are estimated using logistic and multilinear regressions. A logit model estimates the probability of an ID receiving any funding:

$$Pr(Funding)_{is} = \beta_0 + \beta_1 X_{is} + \beta_2 Z_s + +u_{is} \tag{9}$$

Here, $Pr(Funding)_{is}$, is a dummy variable where an ID is assigned a value of 1 if it ceded water in a settlement and received funding in exchange, and a value of zero if it ceded water, but did not secure settlement funding. The sample is restricted to a subset of 35 IDs whose water right claims were diminished as a result of the adjudication process. $X_{is}$, 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. Given the small sample size, a LASSO regression is used to identify the variables most strongly associated with the dependent variable. Finally, a series of simple linear regressions estimate per-AF funding outcomes ($\$/AF_{is}$) to the 11 IDs that received funding.

# 4 Results

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

Table 1 presents estimates of the effects of shortage risk on changes to ID water entitlements. On average, a 1 percent increase in risk is correlated with a .18 to .22 percent decrease in water entitlement volume. Robustness checks that assess shortage risk as a quadratic function (Table A4) and that control for Winters claims and competing demand (Tables A5 and A6) corroborate results showing that shortage risk more than other factors that may elevate is the key determinant of changes to water entitlements. This supports the intuition that IDs with the lowest priority rights give up more water to avoid litigation.

The relationship between relative shortage risk and water entitlement changes is tempered by the inclusion of an ID's share of water delivered via Reclamation contract. While the an ID's share of Reclamation contract water is not significantly correlated with changes to pre-settlement entitlements, its mediating effect on the $Risk$ coefficient suggests that IDs with larger shares of

Table 1: MLR Estimated effects of relative water shortage risk on changes to water entitlements

| | Y = %$\Delta AFY$ | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Risk (%) | -0.192*** | -0.196*** | -0.222*** | -0.194** | -0.181** | -0.120 |
| | (0.067) | (0.069) | (0.075) | (0.079) | (0.078) | (0.130) |
| Urbanization Rate (%) | | 0.078 | 0.072 | 0.062 | 0.084 | 0.058 |
| | | (0.063) | (0.079) | (0.085) | (0.097) | (0.102) |
| ID Acreage | | | 0.000 | 0.000 | 0.000 | 0.000 |
| | | | (0.000) | (0.000) | (0.000) | (0.000) |
| Hay/Pasture (%) | | | -0.400 | -0.280 | -0.331 | -0.328 |
| | | | (0.304) | (0.292) | (0.316) | (0.287) |
| AF/acre | | | | 0.527 | 0.522 | 0.477 |
| | | | | (0.745) | (0.755) | (0.730) |
| Water Shortage (MCM/mo) | | | | | -10.703 | -7.464 |
| | | | | | (14.575) | (15.562) |
| USBR Contracts (%) | | | | | | -0.116 |
| | | | | | | (0.169) |
| Constant | 7.505 | 6.390 | 9.827 | 1.771 | 7.026 | 4.419 |
| | (5.597) | (5.826) | (7.417) | (11.664) | (14.157) | (13.538) |
| Observations | 61 | 60 | 60 | 60 | 60 | 60 |
| $R^2$ | 0.299 | 0.316 | 0.363 | 0.375 | 0.381 | 0.400 |
| Settlement FE | Yes | Yes | Yes | Yes | Yes | Yes |

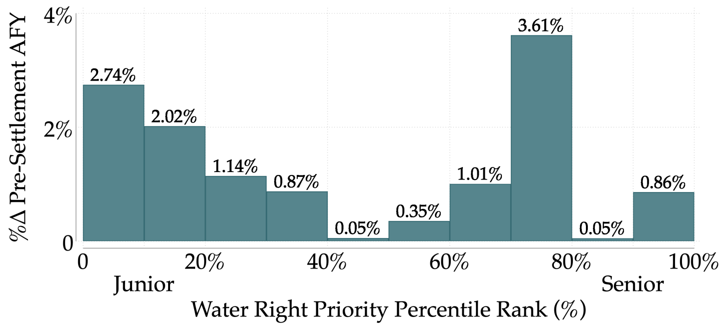
**Notes:** Robust standard errors are in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Reclamation contract rights may be more vulnerable in court if the federal government's obligations to tribes and to uphold federal laws like Endangered Species Act take precedence.

### 4.2 IDs Maintain Relatively Senior Rights as Shortage Risks Increase

Given that the volume of water rights exceeds available supply in most basins, examining the relative seniority of individual water rights that change hands in a settlement provides insight into the resulting changes to water access. Figure 1 shows the distribution of changes to the volume of IDs' collective pre-settlement water right claims, by the relative seniority of each right in an ID's water right portfolio. IDs relinquish relatively junior and, to a lesser extent, senior rights from their respective portfolios, while maintaining mid-level priority rights. While senior rights are less likely to be curtailed, IDs may relinquish senior rights if doing so enhances the reliability of relatively junior rights in their portfolios.

Figure 1: Share of IDs' Total Water Entitlements Ceded in Negotiation, by Relative Priority




**Notes:** Figure shows the percent change to the total volume pre-settlement water rights claimed by IDs in all settlements, by percentile rank of each right in an ID's water right portfolio. Senior-most rights have a rank of 100%.

Table 2 presents estimates of the relationship between various measures of bargaining power and the relative priority of water rights relinquished in a settlement. The distribution of curtailed water right claims by relative priority, shown in Figure 1, suggests that the relationship between shortage risk and the priority of the water right given up is non-linear. Hence, relative shortage risk is assessed as a quadratic function.

While IDs do cede some high-value, high-priority rights, the relative priority of the water right ceded is decreasing by an average of 0.49 to 0.72 percent for each 1 percent increase in shortage risk. The negative sign on $Risk^2$, which is significantly correlated with the relative priority of the ceded right in models 2 through 6, shows that at higher levels of shortage risk, IDs cede increasingly junior rights. That the effect size of $Risk$ and $Risk^2$ is increasing as additional controls for scarcity are introduced suggests that IDs cede junior rights to preserve higher-value senior rights that are more likely to be filled during shortages. However, receiving compensation for the water right–an option that would be unavailable in a court decreed adjudication–is correlated with a 25 percent increase in the relative priority of the ceded right. Thus, side-payments motivate the reallocation of relatively senior rights in a settlement.

### 4.3 Political Influence and Scarcity Determine Funding Outcomes

Figure 2 presents estimates of binary and continuous measures of funding outcomes to IDs as a function of four LASSO-identified independent variables. CPI, water shortage, an ID's urbanization rate, and pre-settlement AF/acre emerged as key determinants of an ID having secured funding in exchange for reductions to their water entitlements. Simple logistic regression estimates (panel A) show that the probability of an ID having secured funding is increasing with the CPI score of the settlement act's sponsor and with water shortage volumes. Politically influential

Table 2: Relative Priority of Individual Rights Ceded in a Negotiation

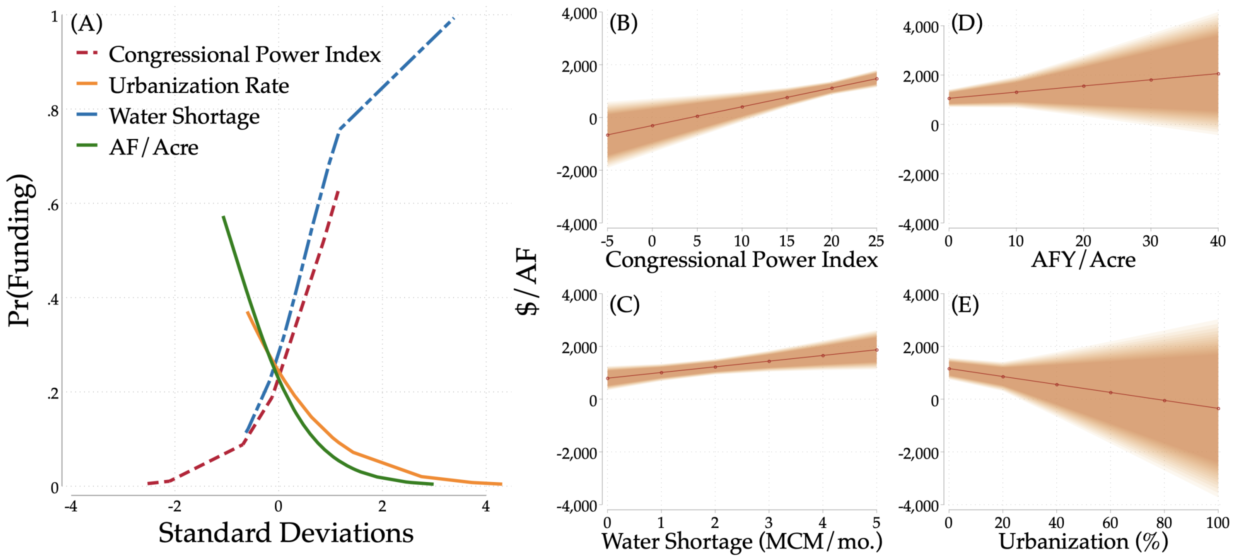
| | Y = Percentile Rank (%) | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Risk (%) | -0.188 | -0.491* | -0.709* | -0.711* | -0.724** | -0.718** |
| | (0.404) | (0.278) | (0.365) | (0.369) | (0.305) | (0.294) |
| Risk $^2$ (%) | -0.199 | -0.456* | -0.638* | -0.640* | -0.656** | -0.650** |
| | (0.346) | (0.238) | (0.307) | (0.311) | (0.258) | (0.255) |
| Hay/Pasture (%) | | -1.973*** | -1.752** | -1.736** | -1.220* | -1.223* |
| | | (0.631) | (0.673) | (0.697) | (0.646) | (0.659) |
| Water Shortage (MCM/mo) | | -6.006 | -8.652** | -6.525 | -10.639 | -10.607 |
| | | (5.816) | (3.996) | (10.060) | (9.286) | (9.248) |
| USBR Contracts (%) | | | 0.161 | 0.171 | 0.127 | 0.127 |
| | | | (0.149) | (0.154) | (0.145) | (0.146) |
| ln(Prime Res Acres) | | | -2.176 | -0.952 | -2.258 | -2.256 |
| | | | (5.202) | (7.409) | (6.602) | (6.679) |
| Municipal Pop. Growth (%) | | | | 0.200 | 0.129 | 0.130 |
| | | | | (0.939) | (0.739) | (0.742) |
| AFY/acre | | | | | 0.611 | 0.604 |
| | | | | | (0.495) | (0.510) |
| Received Compensation=1 | | | | | 25.487** | 25.366** |
| | | | | | (9.820) | (9.837) |
| USBR Contract$_{WR}$=1 | | | | | | -0.318 |
| | | | | | | (7.525) |
| Constant | 62.947 | 118.128*** | 162.608*** | 137.968 | 143.810 | 143.398 |
| | (45.541) | (34.715) | (55.019) | (124.901) | (105.945) | (106.820) |
| Observations | 64 | 63 | 63 | 63 | 63 | 63 |
| $R^2$ | 0.039 | 0.212 | 0.234 | 0.234 | 0.303 | 0.303 |

**Notes:** Table presents estimates of the relationship between measures of ID bargaining power and the relative seniority of water rights that were relinquished/diminished in a negotiation. The dependent variable is the percentile rank of water right, $WRis$, claimed by ID, $i$, prior to settlement. The percentile rank is increasing with a water right's seniority. A positive coefficient on $\hat{\beta}_n$ indicates correlation with the cession of a relatively senior right. Robustness checks are included in Table A7. Standard errors clustered at the ID-level are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

congressional sponsors may be more effective at moving expensive legislation through congress. Scarcity may incentivize federal payments to expedite settlement, as costs of supply augmentation or protracted litigation increase relative to costs of financing water transfers.

The probability of securing funding is decreasing with increasing ID urbanization and pre-settlement AF/acre water right claims – two factors that potentially diminish to an ID's legal justification for maintaining relatively large entitlement volumes. Robustness checks corroborate the positive effects of CPI and water shortage on the probability of obtaining funding, with water shortage predicting funding acquisition more consistently across specifications than CPI (Table A9).

Figure 2: Determinants of Funding Outcomes




**Notes:** Panel A shows results from four simple logit regressions (Table A8) estimating the relationship between the probability of an ID having secured funding in exchange for water, and four LASSO-identified measures of an ID's bargaining power. Panels B through E graph point estimates and 95% confidence intervals of four simple linear regressions (Table A11) that use the $/AF level of funding as the dependent variable.

Simple linear regression estimates of the relationship between LASSO-identified independent variables and per AF funding outcomes (Figure 2, panels B through E) show that water shortage and CPI are the strongest predictors of funding outcomes, as they exhibit the least variance. Each additional CPI point is correlated with an average increase of $71.11 per AF while each additional MCM/mo where water demand exceeds supply is correlated with an average $215.43/AF increase (Table A11). Urbanization and AF/acre are not significantly correlated with funding outcomes. Robustness checks using alternative measures of legal risk show that relative shortage risk, prime reservation acreage (a measure of PIA-based Winters claims), and an ID's share Reclamation contracts are uncorrelated with both binary and continuous funding outcomes (Tables A9 and A12). Thus, shortage risk appears to influence IDs' decisions about the volume and priority of water rights to part with. Contingent on giving up water, political and economic factors that characterize the broader bargaining environment shape funding outcomes.

### 4.4 Settlements Generate "Surplus" Benefits to Bargaining Parties

To better understand the extent to which settlements generate surplus benefits beyond what would be possible in court, this section examines differences between a) average $/AF funding obtained by IDs through settlement, b) the $/AF generated from status quo water use in agriculture, and c) the $/AF price of water if it was purchased on the open market.

The federal government, through its trust relationship with tribes, is legally and financially liable for losses stemming from federal mismanagement of resources to which tribes are legally entitled. Federal policy states that the government's financial obligations in a settlement should not exceed expected costs of litigation (DOI, 1990). It can avoid costly litigation by facilitating settlements that resolve Winters claims and absolve it of legal liability. The estimated value of the government's legal obligations to tribes therefore represents a rent-seeking ceiling under which parties bargain for financial compensation. The government, however, does not reveal its expected litigation costs. Doing so would reveal its fallback option, enabling other parties to drive up settlement costs to the government to just below this threshold.

Because the federal government's expected costs of resolving Winters claims in court are unknown, data from Burns et al. (2022) 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. This value represents the government's fallback option, as it is the estimated maximum marginal value of water for which the it would pay to acquire existing water rights to settle Winters claims. Burns et al. (2022) provide state-specific averages of the per AF price of water sold on the open market between 2002 and 2019. Average water sale prices represent a rent-seeking ceiling based on the assumption that they are the maximum price that the federal government would pay to IDs, and the maximum price that and ID could secure in exchange for giving up water in a negotiation.

IDs can maximize settlement gains by removing from production marginal farmland that generates relatively low marginal returns and requires low-cost inputs from production. Hay and alfalfa, with comparatively low $/AF marginal returns, may be more likely than crops with higher marginal returns to be removed from production when irrigators have the option to market their water rights. The estimated $/AF generated from hay and from alfalfa therefore represents the marginal value of water generated from status quo agricultural water use.

The U.S. Department of Agriculture's Farm and Ranch Irrigation Survey provides state, year, and crop-specific data on the irrigation duty and yield. The National Agricultural Statistics Service provides state, year, and crop-specific data on the market price of hay and alfalfa. From these data, the average 2020\$/AF generated by status quo water use in agriculture is estimated as:

$$\frac{2020\$^{crop}_{st}}{AF} = \frac{2020\$^{crop}_{st}}{Ton} \times \frac{tons^{crop}_{st}}{Acre} \div \frac{AF^{crop}_{st}}{Acre} \tag{10}$$

Here, $\frac{AF^{crop}_{st}}{Acre}$ is the AF per acre annual applied to hay, and, separately, alfalfa in state, $s$, in year, $t$; yield is depicted as $\frac{tons^{crop}_{st}}{Acre}$, and $\frac{2020\$^{crop}_{st}}{Ton}$ is the crop-specific market price per ton, adjusted for inflation. The marginal value of water had it remained in agriculture represents a lower bound for what an ID might expect in exchange for ceding water in a negotiation.

On average, one AF generated \$165 of hay or \$213 of alfalfa, while the average market price per AF sold between 2002 and 2019 was \$2,832/AF.[4] The 11 IDs that were financially compensated for ceding water in a settlement received an average of \$706.82/AF, which is 3 to 4 times the \$/AF generated from farming alfalfa or hay.[5] Meanwhile, the federal government acquired water for $\approx 25\%$ of the market price. The disparity between \$/AF generated through farming, the \$/AF secured in a settlement, and the \$/AF market price demonstrates how negotiations, relative to judicial rulings, yield mutual benefits for both water right "buyers" (i.e., the government) and "sellers" (i.e. irrigation districts).

## 5 Discussion

High-priority water rights not only protect IDs from legal challenges to their water use, but they also insulate IDs from reductions to their water entitlements in settlement negotiations. This is because water right seniority, a key determinant of an ID's fallback option in court, confers bargaining power within a negotiation. IDs with the lowest risk of having their water rights curtailed under prior appropriation rules give up smaller shares of their entitlements and maintain their most senior rights. The concessions made correlate with the opportunity costs associated with litigation more than any other source of bargaining power. This underscores that a party's fallback option in court, rather than factors like wealth, patience, or political influence, determines changes to its water allocations during negotiations.

These findings may alleviate broader uncertainties about how existing water use will adapt to

[4] Pricing data was unavailable for the state of Idaho. For IDs in Idaho, the market price for Arizona was used as a substitute, as Arizona provided the most conservative estimate of water sales prices.

[5] Average settlement funding, \$706.82/AF, is the mean weighted by the AF each of the 11 IDs ceded in the negotiation.

accommodate newly defined Winters rights. While IDs relinquished approximately 13 percent of their collective pre-settlement water rights, they managed to maintain an average of 7.1 acre-feet per acre, sufficient to meet almost all crop requirements (Johnson and Cody, 2015). Moreover, many IDs secured funding for irrigation efficiency improvements and opted to remove the most marginal land from production (AWSA, 2004). Consequently, changes to water use and broader impacts on rural economies may not be as severe as initially anticipated, as even moderate shifts in the distribution of water rights can satisfy water users in a basin.

More broadly, these results underscore the value of pairing financial incentives inherent in negotiations with mutual litigation risks to resolve broader conflicts over increasingly scarce resources. As tribes assert high-priority water claims, litigation serves as a necessary threat prompting IDs to make concessions they might not have otherwise considered without the risk of losing in court. Settlements also offer the opportunity for side-payments to incentivize the reallocation of water rights, an option not available in court.

While existing literature on Indigenous water right adjudications extols the advantages of negotiation over litigation, few studies empirically link anticipated litigation costs to negotiation outcomes (Anderson, 2010; Cosens and Royster, 2012). By demonstrating that shortage risk under prior appropriation rules largely determines the extent to which water is reallocated across bargaining parties, these findings emphasize the significance of an impending legal threat in motivating compromise. Moreover, the role of congressional influence in determining funding outcomes for IDs underscores the political dynamics underlying water reallocation in the West. If funding for reallocating water serves as a "carrot" for reaching a settlement, litigation functions as a necessary "stick" incentivizing concessions that redistribute water rights in a manner satisfying all parties.

Critically, this study underscores the importance of the legal and political framework for restoring water access to tribes. Winters rights, being legally enforceable property rights stemming from reservation treaties, afford tribes legal recourse when they are not upheld. Supreme Court rulings have affirmed this, while legislation such as the McCarran Amendment provides a pathway to quantify Winters rights, rendering them enforceable. The experience of tribes in the U.S. stands in contrast to that of Indigenous communities elsewhere. For instance, in countries like Australia (Hartwig et al., 2021), New Zealand (Fox et al., 2017), Canada (Hanrahan, 2017), and Chile

(Edwards et al., 2018; Macpherson, 2020), defining and incorporating Indigenous water rights into existing institutions remains a challenge. In most cases, the legal mechanisms required to establish and enforce water rights for Indigenous communities or to reallocate water from existing uses are inadequate or do not exist. While this study highlights the potential to meet new needs through negotiation, results also underscore the importance of legal institutions in motivating change and shaping bargaining outcomes.

## References

Anderson, R. T. (2006). Indian water rights: Litigation and settlements. *Tulsa Law Review 42*(1), 23–36.

Anderson, R. T. (2010). Indian water rights, practical reasoning, and negotiated settlements. *California Law Review 98*(4), 1133–1164.

Arizona v. California (1963). 373 u.s. 546.

Arizona Water Settlements Act (2004). Public law 108-451.

Aylward, B. (2006). Growth, urbanization and land use change: Impacts on agriculture and irrigation districts in central oregon.

Baley v. U.S. (2019). 942 f.3d 1312, 1322.

Benson, R. D. (1997). Whose water is it? private rights and public authority over reclamation project water. *Virginia Environmental Law Journal 16*(3), 363.

Benson, R. D. (1998). Maintaining the status quo: protecting established water uses in the pacific northwest, despite the rules of prior appropriation. *Environmental Law 28*(4), 881–882.

Bureau of Indian Affairs (2017). What is the federal Indian trust responsibility?

Burns, J. B., M. Payne, M. G. Smith, and C. Landry (2022). Measuring trends in western water prices. *JAWRA Journal of the American Water Resources Association 58*(2), 203–219.

Byun, C. H. (2015). The Coase Theorem and the Alaska Native Claims Settlement Act. *Journal of Economics & Economic Education Research 16*(2).

Colby, B. and R. Young (2018). Tribal water settlements: Economic innovations for addressing water conflicts. *Western Economics Forum 16*(1), 9.

Cooter, R., S. Marks, and R. Mnookin (1982). Bargaining in the shadow of the law: A testable model of strategic behavior. *The Journal of Legal Studies 11*(2), 225–251.

Cooter, R. D. and D. L. Rubinfeld (1989). Economic analysis of legal disputes and their resolution. *Journal of Economic Literature 27*(3), 1067–1097.

Cordalis, A. and D. Cordalis (2014). Indian water rights: How arizona v. california left an unwanted cloud over the colorado river basin. *Arizona Journal Environmental Law & Policy 5*, 333–388.

Cosens, B. and J. V. Royster (2012). *The Future of Indian and Federal Reserved Water Rights: The Winters Centennial*. UNM Press.

Deiter, C. A., M. A. Maupin, R. R. Caldwell, M. A. Harris, T. I. Ivahnenko, J. K. Lovelace, N. L. Barber, and K. S. Linsey (2018). *Water availability and use science program: Estimated Use of Water in the United States in 2015*. Geological Survey.

Department of the Interior (1990). Criteria and procedures for the participation of the federal government in negotiations for the settlement of indian water rights claims. *Federal Register*, 9223–9225.

Edwards, E. C. (2016). What lies beneath? aquifer heterogeneity and the economics of groundwater management. *Journal of the Association of Environmental and Resource Economists 3*(2), 453–491.

Edwards, E. C., O. Cristi, G. Edwards, and G. D. Libecap (2018). An illiquid market in the desert: estimating the cost of water trade restrictions in northern chile. *Environment and Development Economics 23*(6), 615–634.

Esteban, E., A. Dinar, and J. Albiac (2019). Determinants of water lobbying: irrigators' behavior in a water-stressed basin. *Water Policy 21*(5), 1107–1122.

Falcone, J. A. (2015). U.s. conterminous wall-to-wall anthropogenic land use trends (nwalt), 1974-2012. Technical report, US Geological Survey.

Fox, C. A., N. J. Reo, D. A. Turner, J. Cook, F. Dituri, B. Fessell, J. Jenkins, A. Johnson, T. M. Rakena, C. Riley, A. Turner, J. Williams, and M. Wilson (2017). "the river is us; the river is in our veins": re-defining river restoration in three indigenous communities. *Sustainability Science 12*(4), 521–533.

Garrick, D., L. De Stefano, W. Yu, I. Jorgensen, E. O'Donnell, L. Turley, I. Aguilar-Barajas, X. Dai, R. de Souza Leão, B. Punjabi, B. Schreiner, J. Svensson, and C. Wight (2019). Rural water for thirsty cities: a systematic review of water reallocation from rural to urban regions. *Environmental Research Letters 14*(4), 043003.

Griffin, R. C. (2012). Engaging irrigation organizations in water reallocation. *Natural Resources Journal 52*(2), 39.

Hanley, N. and C. Summer (1995). Bargaining over common property resources: Applying the Coase theorem to Red Deer in the Scottish Highlands. *Journal of Environmental Management 43*(1), 87–95.

Hanrahan, M. (2017). Water (in)security in canada: national identity and the exclusion of indigenous peoples. *British Journal of Canadian Studies 30*(1), 69–89.

Harsanyi, J. C. (1959). A bargaining model for the cooperative n-person game. In A. W. Tucker, H. W. Kuhn, M. Dresher, P. Wolfe, and R. D. Luce (Eds.), *Contributions to the Theory of Games*, Volume 3, 4, pp. 325–355. Princeton University Press.

Hartwig, L. D., S. Jackson, F. Markham, and N. Osborne (2021). Water colonialism and indigenous water justice in south-eastern australia. *International Journal of Water Resources Development*, 1–34.

Heidari, H., M. Arabi, and T. Warziniack (2021). Vulnerability to Water Shortage Under Current and Future Water Supply-Demand Conditions Across U.S. River Basins. *Earth's Future 9*(10).

Hubbard, W. H. (2018). Stalling, conflict, and settlement. *Coase-Sandor Working Paper Series in Law and Economics* (839).

Johnson, N. K. (1983). Indian water rights in the west. *Western States Water Council*.

Johnson, R. and B. A. Cody (2015). California agricultural production and irrigated water use. *Congressional Research Service Sacramento, California, USA*.

Kendy, E., B. Aylward, L. S. Ziemer, B. D. Richter, B. G. Colby, T. E. Grantham, L. Sanchez, W. B. Dicharry, E. M. Powell, S. Martin, P. W. Culp, L. F. Szeptycki, and C. V. Kappel (2018). Water transactions for streamflow restoration, water supply reliability, and rural economic vitality in the western united states. *Journal of the American Water Resources Association 54*(2), 487–504.

Leonard, B., C. Costello, and G. D. Libecap (2020). Expanding water markets in the western united states: Barriers and lessons from other natural resource markets. *Review of Environmental Economics and Policy*.

Leonard, B. and G. D. Libecap (2019). Collective action by contract: Prior appropriation and the development of irrigation in the western united states. *Journal of Law and Economics 62*(1).

Libecap, G. (2008). Open-access losses and delay in the assignment of property rights. *Arizona Law Review 50*, 379.

Libecap, G. D. (1989). Distributional issues in contracting for property rights. *Journal of Institutional and Theoretical Economics 145*(1), 6–24.

Libecap, G. D. (1993). *Contracting for Property Rights*. Cambridge University Press.

Libecap, G. D. (2007). The assignment of property rights on the western frontier: Lessons for contemporary environmental and resource policy. *The Journal of Economic History 67*(2), 257–291.

Libecap, G. D. (2009). Chinatown revisited: Owens valley and los angeles—bargaining costs and fairness perceptions of the first major water rights exchange. *Journal of Law, Economics, & Organization 25*(2), 311–338.

Macpherson, E. (2020). Indigenous water rights in comparative law. *Transnational Environmental Law 9*(3), 393–402.

McCarran Amendment (1952). 43 U.S.C. §666.

Mnookin, R. H. and L. Kornhauser (1979). Bargaining in the shadow of the law. *Yale Law Journal 88*(5), 950–997.

Muthoo, A. (2001). The economics of bargaining. *EOLSS*, 37.

Reeling, C., C. Garnache, and R. Horan (2018). Efficiency gains from integrated multipollutant trading. *Resource and Energy Economics 52*, 124–136.

Sanchez, L., E. Edwards, and B. Leonard (2020). The economics of indigenous water claim settlements in the american west. *Environmental Research Letters 15*(9), 094027.

Sanchez, L., T. Warziniack, and M. Knowles (2023). The inequitable exposure of socially vulnerable groups to water shortages across the united states. *Environmental Research Letters 18*(4), 044022.

Schaetzl, R. J., F. J. Krist, and B. A. Miller (2012). A taxonomically based ordinal estimate of soil productivity for landscape-scale analyses:. *Soil Science 177*(4), 288–299.

Smith, R. T. (1992). Water Right Claims in Indian Country: From Legal Theory to Economic Reality. In T. L. Anderson (Ed.), *Property Rights and Indian Economies*, pp. 167–194.

Stern, C. V. (2019). Indian water rights settlements. *U.S. Congressional Research Service, Washington D.C.*.

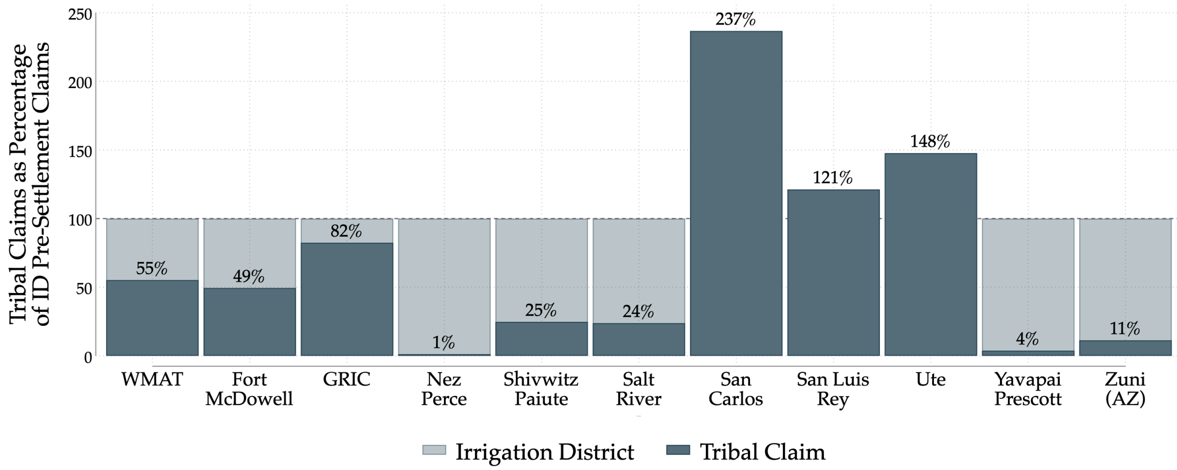
U.S. Bureau of Reclamation (1977). *Summary Report: Federal Reclamation Projects, Water & Land Resource Accomplishments*. Department of the Interior, Bureau of Reclamation.

Winters v. U.S. (1908). 207 us 564, 28 s. ct. 207, 52 l. ed. 340.

Wolfley, J. (2016). Biagaweit: Securing water from the mighty river in the snake river basin adjudication. *Idaho Law Review 52*(313), 23.

## Appendix

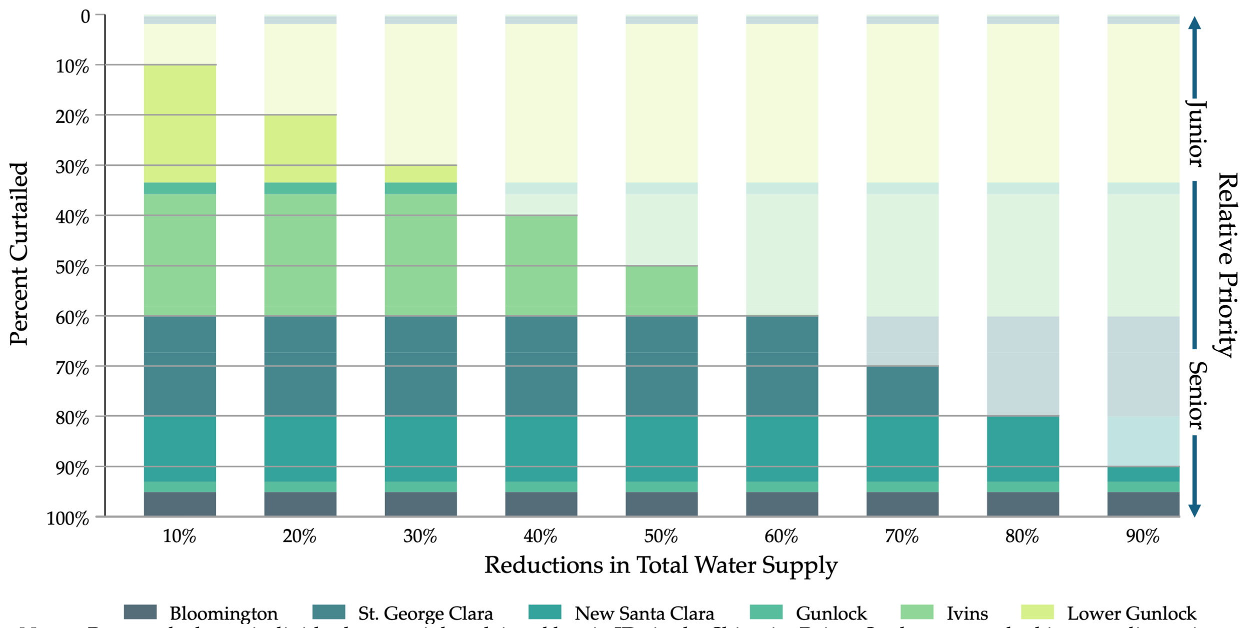
Figure A1: Projected Curtailments under Court Adjudication




**Notes:** Figure shows the percentage Winters right claims relative to IDs' collected pre-settlement water entitlements in each settlement. Data on Winters claims was collected from adjudication records and Statement of Claimants.

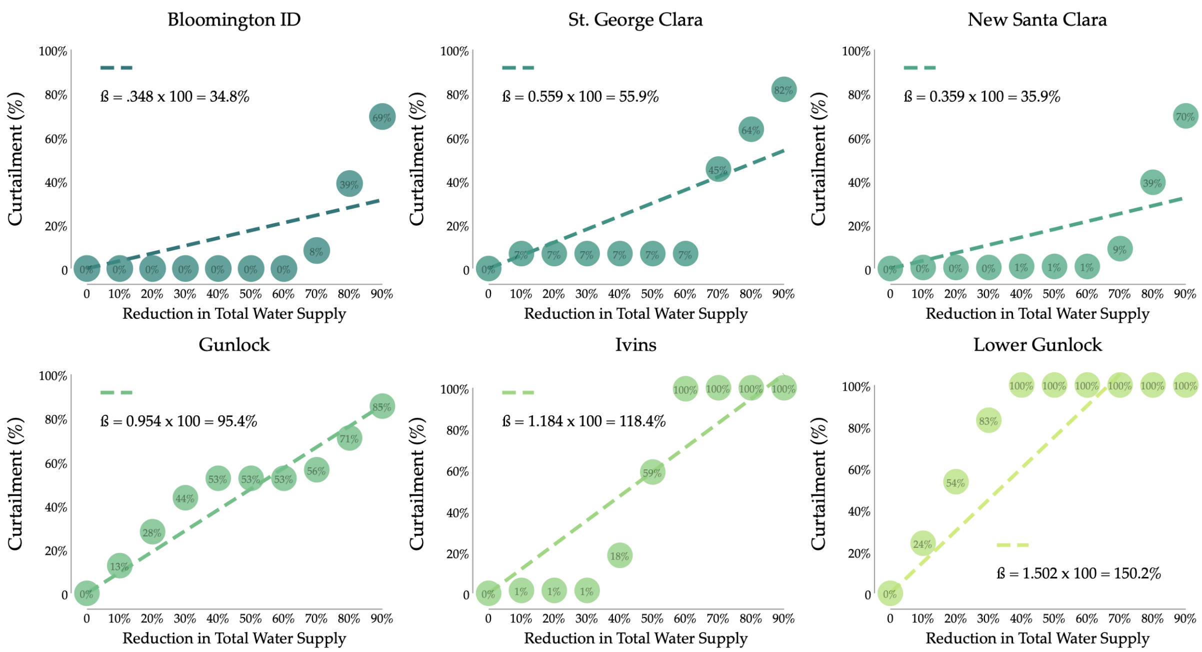
**Estimating Relative Shortage Risk**: The following figures provide an example of the step-by-step process to calculate IDs' water shortage risks relative to other IDs within a single tribal water right negotiation.

Figure A2: ID Pre-Settlement Water Right Claims, by Relative Priority




**Notes:** Bar graph shows individual water rights claimed by six IDs in the Shivwitz Paiute Settlement, ranked in ascending priority order. From left to right along the x-axis, total water availability is reduced by ten percent increments. Relatively transparent bars above the grey, horizontal lines show corresponding curtailments to IDs water rights. 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.

Figure A3: ID Pre-Settlement Water Right Claims, by Relative Priority




**Notes:** The percentage of each ID's water right claims that would be curtailed under prior appropriation rules is on the y-axis. The percentage reduction to total water supply is on the x-axis. $\beta_{is}^{risk}$ is the linear relationship between an ID's water curtailment as a function of diminishing water availability. A steeper line ($\beta_{is}^{risk}$) relative to other IDs indicates greater shortage risk.

Table A1: Dirkson Center Congressional Power Index

**Congressional sponsor is:**

1. Is one 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 points
Minority Leader or Assistant Majority Leader: 4 points
Majority or Minority Whip, Assistant Minority Leader: 3 points
Assistant Whips, Democratic or Republican Conference Chair: 2 points
Democratic or Republican Conference Secretary or Policy Chair: 1 point

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

4. Chairs (or is ranking member of) another committee:
Chairs rates 4 points; ranking member rates 2 points

5. Chairs (or is ranking member of) subcommittee:
Chairs rates 3 points; ranking member rates 1 point

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

7. Seniority:
Zero to 2 terms rates 0, then 1 point for each additional two terms

8. Margin of victory in last election (not percentage of vote):
60%: 3 points; 59-60%: 2 points; 56-58%: 1 point; 53-55%: 0 points; 50-52%: -1 point; ≤50%: -2 points

9. Campaign funding on hand:
$100,000: -5 points; $100,000-$199,999: -4 points; $200,000-$299,999: -3 points; $300,000-$399,999: -2 points; $400,000-$499,999: -1 point; $500,000-$599,999: 0 points; $600,000-$699,999: 1 points; $700,000-$799,999: 2 points; $800,000-$899,999: 3 points; $900,000-$999,999: 4 points; ≥$1,000,000: 5 points

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

Table A2: Variable Definitions

| **Irrigation District-Level** | **Definition** | **Data Source** |
|---|---|---|
| AFY/Acre | Total AFY volume of water claimed by an ID prior to settlement divided by ID service area acreage | State water right databases |
| Acres | ID service area acreage | State water agencies |
| Hay/Pasture (%) | Hay/pasture land cover (category 44) within ID boundaries in decade prior to settlement, as a percentage of ID acreage | Falcone (2015) |
| Agriculture (%) | Hay/pasture and cropped land cover (categories 43 and 44) within ID boundaries in decade prior to settlement, as a percentage of ID acreage | Falcone (2015) |
| USBR Contract (%) | Percentage of ID pre-settlement water right claims delivered via US Bureau of Reclamation contract | State water right databases |
| Urbanization Rate (%) | Percent change in developed land cover (Classes 21-27) within ID boundaries in decade prior to settlement | Falcone (2015) |
| Water Shortage | Water shortages, occurring when freshwater demand exceeds supply, are assessed as the million cubic meter per month (MCM/mo.) difference between demand and renewable freshwater supply between 1985-2015. Shortages are defined as a deficit that lasts at least 12 months and has a 50-year return period. | Heidari et al. (2021) and adapted from Sanchez et al. (2023). |
| **Settlement-Level** | **Definition** | **Data Source** |
| Prime Reservation Acreage | Logged reservation acreage with a soil productivity index $> 9$ | Schaetzl et al. (2012) |
| Reservation Population | Reservation population in decade prior to settlement | Sanchez et al. (2020) |
| Congressional Power Index | Index score calculated according to Dirksen Congressional Center definition | Various sources |
| Municipal Population Growth Rate (%) | Population growth rate within boundaries of municipal water providers represented in negotiation prior to settlement | U.S. Census |
| Negotiating IDs | Number of IDs participating in a negotiation | Sanchez et al. (2020) |
| **Water Right-Level** | **Definition** | **Data Source** |
| USBR Contract | Water right claimed by ID is assigned a value of 1 if it was delivered via Reclamation contract and a zero if it was not | State water right databases |
| Received Compensation | Water right relinquished by ID is assigned a value of 1 if ID received compensation for that water right, and a value of zero if it did not | Water settlement texts |

Table A3: Summary Statistics

| **ID-Level** | **Mean** | **SD** | **Min** | **Max** | **n** |
|---|---|---|---|---|---|
| % $\Delta AFY$ | -11.505 | 22.009 | -99.97 | 0 | 61 |
| Risk (%) | 99.230 | 42.049 | 0 | 158.9 | 61 |
| $/Acre-Foot | 1,163.78 | 523.56 | 329.30 | 2,182.65 | 11 |
| Pre-Settlement AFY/acre | 7.837 | 6.556 | 1 | 28 | 61 |
| Post-Settlement AFY/acre | 7.062 | 6.054 | 0.626 | 25 | 60 |
| Hay/Pasture (%) | 9.849 | 11.847 | 0 | 44 | 60 |
| Urbanization Rate (%) | 18.662 | 28.136 | 0 | 113 | 60 |
| Water Shortage (MCM/mo) | 0.675 | 1.012 | 0 | 5 | 61 |
| ID Acreage | 48,727 | 63,198.808 | 410 | 337,684 | 61 |
| USBR Contracts (%) | 38.067 | 41.749 | 0 | 100 | 61 |
| **Settlement-Level** | **Mean** | **SD** | **Min** | **Max** | **n** |
| Congressional Power Index | 12.636 | 10.259 | -2 | 24 | 11 |
| ln(Prime Res Acres) | 10.357 | 4.086 | 0 | 14 | 11 |
| Reservation Pop. | 4,959 | 4,339 | 176 | 12,429 | 11 |
| Municipal Pop. Growth (%) | 42.089 | 25.505 | 2 | 75 | 11 |
| Settlement IDs (n) | 6 | 6.788 | 1 | 24 | 11 |
| **Water Right-Level** | **Mean** | **SD** | **Min** | **Max** | **n** |
| USBR Contract = 1 | 0.231 | 0.422 | 0 | 1 | 851 |
| Received Compensation = 1 | 0.203 | 0.406 | 0 | 1 | 64 |
| Priority Rank if Ceded (%) | 44.278 | 34.881 | 0 | 100 | 64 |

Table A4: MLR Estimates of Shortage Risk and ID Water Entitlement Changes – Tribal Claims

| | Y = %$\Delta AFY$ | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Shortage Risk (%) | -0.179** | -0.179** | -0.252*** | -0.227** | -0.214** | -0.156 |
| | (0.071) | (0.070) | (0.083) | (0.097) | (0.101) | (0.102) |
| Shortage Risk$^2$(%) | -0.123* | -0.120* | -0.190** | -0.173* | -0.164* | -0.124 |
| | (0.070) | (0.069) | (0.078) | (0.089) | (0.093) | (0.077) |
| Urbanization Rate (%) | | 0.081 | 0.067 | 0.056 | 0.078 | 0.050 |
| | | (0.065) | (0.080) | (0.083) | (0.097) | (0.108) |
| ID Acreage | | | 0.000 | 0.000* | 0.000* | 0.000* |
| | | | (0.000) | (0.000) | (0.000) | (0.000) |
| Hay/Pasture (%) | | | -0.442 | -0.323 | -0.373 | -0.376 |
| | | | (0.276) | (0.284) | (0.302) | (0.273) |
| Pre-Settlement AF/acre | | | | 0.544 | 0.539 | 0.495 |
| | | | | (0.734) | (0.745) | (0.714) |
| Water Shortage (MCM/mo) | | | | | -10.634 | -7.302 |
| | | | | | (14.928) | (16.049) |
| USBR Contracts (%) | | | | | | -0.119 |
| | | | | | | (0.178) |
| Constant | 6.472 | 4.871 | 12.640* | 4.725 | 9.899 | 7.623 |
| | (5.913) | (6.046) | (6.949) | (13.378) | (14.936) | (13.428) |
| Observations | 61 | 60 | 60 | 60 | 60 | 60 |
| $R^2$ | 0.300 | 0.317 | 0.366 | 0.378 | 0.384 | 0.404 |
| Settlement FE | Yes | Yes | Yes | Yes | Yes | Yes |

**Notes:** Risk is assessed as a quadratic function of curtailed water availability. All specifications include settlement-level fixed effects. ID urbanization rate prior to settlement is a measure of an ID's water demand; AFY/acre reflects an ID's pre-settlement capacity to support irrigated agriculture; and hay/pasture land cover represents the marginal value of an ID's water use. Robust standard errors are in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table A5: MLR Estimates of Shortage Risk and ID Water Entitlement Changes – Tribal Claims

| | Y = %$\Delta AFY$ | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Risk (%) | -0.182*** | -0.182*** | -0.182*** | -0.190*** | -0.188*** | -0.108 |
| | (0.065) | (0.065) | (0.066) | (0.066) | (0.067) | (0.131) |
| ln(Prime Res Acres) | 0.957 | 0.943 | 0.816 | -1.778** | -1.018 | 0.164 |
| | (0.888) | (1.177) | (1.271) | (0.712) | (0.854) | (1.840) |
| Reservation Pop. | | 0.000 | 0.000 | 0.004*** | 0.003** | 0.002 |
| | | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) |
| Municipal Pop. Growth (%) | | | 0.076 | 0.376** | 0.225 | 0.104 |
| | | | (0.148) | (0.162) | (0.166) | (0.267) |
| Settlement IDs (n) | | | | -2.830** | -2.350** | -1.410 |
| | | | | (1.089) | (0.968) | (1.588) |
| Water Shortage (MCM/mo) | | | | | -3.179 | -4.979 |
| | | | | | (3.268) | (3.997) |
| USBR Contracts (%) | | | | | | -0.136 |
| | | | | | | (0.146) |
| Constant | -4.938 | -4.869 | -7.377 | 27.698** | 25.519** | 9.764 |
| | (11.489) | (12.155) | (13.216) | (12.779) | (12.095) | (22.997) |
| Observations | 61 | 61 | 61 | 61 | 61 | 61 |
| $R^2$ | 0.272 | 0.272 | 0.273 | 0.294 | 0.299 | 0.329 |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes |

**Notes:** All specifications include state-level fixed effects. Settlement-level variables include prime reservation acreage as a measure of the potential magnitude of a tribe's PIA-based water right claim; reservation population prior to settlement as a measure of reservation water needs; the population growth rate within service area boundaries of municipal water interests participating in the negotiation; and the number of IDs participating in the settlement. Robust standard errors are in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table A6: MLR Estimates of Shortage Risk and ID Water Entitlement Changes – Tribal Claims

| | Y = %$\Delta AFY$ | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Risk (%) | -0.174** | -0.173** | -0.172** | -0.178** | -0.175** | -0.098 |
| | (0.067) | (0.068) | (0.070) | (0.070) | (0.071) | (0.087) |
| Risk$^2$ (%) | -0.120* | -0.120* | -0.119* | -0.122* | -0.119* | -0.065 |
| | (0.066) | (0.067) | (0.069) | (0.069) | (0.070) | (0.061) |
| ln(Prime Res Acres) | 0.972 | 0.940 | 0.807 | -1.794** | -1.024 | 0.156 |
| | (0.915) | (1.188) | (1.280) | (0.743) | (0.882) | (1.896) |
| Reservation Pop. | | 0.000 | 0.000 | 0.004*** | 0.003** | 0.002 |
| | | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) |
| Municipal Pop. Growth (%) | | | 0.079 | 0.380** | 0.227 | 0.106 |
| | | | (0.150) | (0.169) | (0.170) | (0.277) |
| Settlement IDs (n) | | | | -2.837** | -2.350** | -1.413 |
| | | | | (1.120) | (0.988) | (1.631) |
| Water Shortage (MCM/mo) | | | | | -3.232 | -5.016 |
| | | | | | (3.374) | (3.988) |
| USBR Contracts (%) | | | | | | -0.136 |
| | | | | | | (0.149) |
| Constant | -5.816 | -5.681 | -8.432 | 26.576** | 24.185** | 8.777 |
| | (12.546) | (13.166) | (14.302) | (12.449) | (11.837) | (18.831) |
| Observations | 61 | 61 | 61 | 61 | 61 | 61 |
| $R^2$ | 0.272 | 0.272 | 0.274 | 0.294 | 0.300 | 0.330 |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes |

**Notes:** All specifications include state-level fixed effects. Settlement-level variables include prime reservation acreage as a measure of the potential magnitude of a tribe's PIA-based water right claim; reservation population prior to settlement as a measure of reservation water needs; the population growth rate within service area boundaries of municipal water interests participating in the negotiation; and the number of IDs participating in the settlement. Robust standard errors are in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table A7: Estimates of Relative Priority of Ceded Water Rights – Robustness Check

| | Y = Percentile Rank (%) | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Risk (%) | 0.029 | 0.316 | 0.272 | -0.339 | -0.448 |
| | (0.474) | (0.491) | (0.535) | (0.280) | (0.337) |
| Risk $^2$ (%) | -0.016 | 0.225 | 0.189 | -0.325 | -0.415 |
| | (0.412) | (0.421) | (0.458) | (0.252) | (0.296) |
| USBR Contract$_{WR}$=1 | -12.752 | -13.680 | -13.420 | -9.973 | -10.373 |
| | (11.468) | (10.247) | (10.085) | (8.735) | (8.622) |
| ln(Prime Res Acres) | | -8.577 | -8.935 | -7.210 | -12.490 |
| | | (5.358) | (6.273) | (9.368) | (13.208) |
| Reservation Pop. | | | 0.002 | 0.002 | 0.004 |
| | | | (0.002) | (0.003) | (0.004) |
| Hay/Pasture (%) | | | | -1.782*** | -1.747** |
| | | | | (0.611) | (0.630) |
| Water Shortage (MCM/mo) | | | | -12.872* | -22.843 |
| | | | | (6.506) | (17.035) |
| Municipal Pop. Growth (%) | | | | | -0.678 |
| | | | | | (1.172) |
| Constant | 48.139 | 130.212* | 129.324* | 190.137* | 292.983 |
| | (48.297) | (63.448) | (68.387) | (97.722) | (206.526) |
| Observations | 64 | 64 | 64 | 63 | 63 |
| $R^2$ | 0.057 | 0.098 | 0.105 | 0.235 | 0.241 |

**Notes:** Table presents estimates of the relationship between measures of ID bargaining power and the relative seniority of water rights that were relinquished/diminished in a negotiation. The dependent variable is the percentile rank of water right, $WRis$, claimed by ID, $i$, prior to settlement. The percentile rank is increasing with a water right's 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 in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A8: Probability of an ID Securing Settlement Funding

| | Y = Pr(Funding) | | | | |
|---|---|---|---|---|---|
| | LASSO | Logit | | | |
| | (1) | (2) | (3) | (4) | (5) |
| Congressional Power Index | 0.023 | 0.219** | | | |
| | (0.097) | (0.102) | | | |
| Urbanization Rate (%) | -0.082 | | -0.043 | | |
| | (0.063) | | (0.036) | | |
| Water Shortage (MCM/mo) | 1.860 | | | 1.500*** | |
| | (1.141) | | | (0.570) | |
| AFY/acre | -0.231 | | | | -0.212** |
| | (0.202) | | | | (0.104) |
| Constant | -0.572 | -4.745** | -0.529 | -2.056*** | 0.428 |
| | (1.627) | (2.039) | (0.467) | (0.492) | (0.657) |
| Observations | 36 | 37 | 36 | 37 | 37 |

**Notes:** Table presents estimated probability of an ID having secured funding in a settlement. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A9: Probability of an ID Securing Settlement Funding - Simple Logistic Model

| | Y = Pr(Funding) | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Risk (%) | -0.001 | | | | | |
| | (0.011) | | | | | |
| ln(Prime Res Acres) | | -0.214 | | | | |
| | | (0.320) | | | | |
| USBR Contracts (%) | | | -0.002 | | | |
| | | | (0.010) | | | |
| Urbanization Rate (%) | | | | -0.043 | | |
| | | | | (0.036) | | |
| Hay/Pasture (%) | | | | | -0.030 | |
| | | | | | (0.047) | |
| Municipal Pop. Growth (%) | | | | | | -0.004 |
| | | | | | | (0.032) |
| Constant | -0.707 | 1.733 | -0.761 | -0.529 | -0.666 | -0.707 |
| | (1.173) | (4.051) | (0.572) | (0.467) | (0.553) | (1.177) |
| Observations | 37 | 37 | 37 | 36 | 36 | 37 |

**Notes:** Table presents estimated probability of an ID having secured funding in a settlement. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A10: Probability of an ID Securing Settlement Funding - Logistic Model

| | Y = Pr(Funding) | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Congressional Power Index | 0.185** | 0.232* | 0.189 | 0.057 | | | |
| | (0.090) | (0.136) | (0.120) | (0.072) | | | |
| AFY/acre | -0.204* | | -0.164* | -0.390 | | -0.422* | -0.231* |
| | (0.110) | | (0.088) | (0.244) | | (0.245) | (0.134) |
| Urbanization Rate (%) | | -0.062 | -0.050 | | -0.116 | | -0.085 |
| | | (0.059) | (0.053) | | (0.074) | | (0.061) |
| Water Shortage (MCM/mo) | | | | 1.269* | 2.517** | 1.547** | 2.040* |
| | | | | (0.694) | (1.106) | (0.692) | (1.064) |
| Constant | -2.870 | -4.453* | -2.695 | -1.004 | -1.538*** | -0.136 | -0.280 |
| | (1.996) | (2.432) | (2.325) | (1.386) | (0.575) | (0.819) | (0.773) |
| Observations | 37 | 36 | 36 | 37 | 36 | 37 | 36 |

**Notes:** Table presents estimated probability of an ID having secured funding in a settlement. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A11: SLR Estimated effects of bargaining power on $/AFY funding

| | Y = $/AF (adj. 2020) | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Congressional Power Index | 71.108*** | | | |
| | (21.193) | | | |
| Water Shortage (MCM/mo) | | 215.428** | | |
| | | (91.886) | | |
| AFY/acre | | | 25.059 | |
| | | | (28.565) | |
| Urbanization Rate (%) | | | | -15.081 |
| | | | | (15.752) |
| Constant | -303.619 | 796.660*** | 1,057.883*** | 1,161.079*** |
| | (450.307) | (201.561) | (155.953) | (177.551) |
| Observations | 11 | 11 | 11 | 10 |
| $R^2$ | 0.551 | 0.408 | 0.021 | 0.104 |

**Notes:** Table presents SLR estimates of the relationship between LASSO-identified independent variables and per AF funding outcomes to 11 IDs that received funding in exchange for water in a negotiation. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A12: SLR Estimated effects of bargaining power on $/AFY funding – Robustness Check

| | Y = $/AF (adj. 2020) | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Risk (%) | -1.170 | | | | |
| | (2.332) | | | | |
| ln(Prime Res Acres) | | -27.970 | | | |
| | | (104.364) | | | |
| USBR Contracts (%) | | | -0.019 | | |
| | | | (3.111) | | |
| Hay/Pasture (%) | | | | 3.091 | |
| | | | | (9.227) | |
| Municipal Pop. Growth (%) | | | | | -16.068** |
| | | | | | (6.939) |
| Constant | 1,285.605*** | 1,479.619 | 1,164.670*** | 1,036.313*** | 1,729.220*** |
| | (219.659) | (1165.200) | (290.942) | (164.794) | (279.642) |
| Observations | 11 | 11 | 11 | 10 | 11 |
| $R^2$ | 0.016 | 0.006 | 0.000 | 0.008 | 0.348 |

**Notes:** Table presents SLR estimates of the relationship between alternative measures of bargaining power and per AF funding outcomes to 11 IDs that received funding in exchange for water in a negotiation. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$