

# **Bargaining for American Indian Water Rights**

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# **Bargaining for American Indian Water Rights**

When and why do resource users successfully negotiate to create certainty over property rights, and when does this process fail? We examine this question in the context of American Indian reservations' implicit water rights under a 1908 Supreme Court ruling (*Winters v. United States*). To legally quantify Winters rights, a reservation must enter into the costly process of either reaching a negotiated settlement agreement with the US government and neighboring water users, or through judicial decree in state court. To date, only 59 of 225 federally recognized reservations in the west have legally defined these rights. We use both the adjudication itself, as well as the results for the tribe in terms of water and direct federal funding secured, to quantify benefits. We show that the likelihood of entering into the adjudication process is increasing in the expected benefits of settlement. However, a costly bargaining process, as measured by the number of users, increases the duration of the adjudication process. Conditional on settlement, we show that the amount of water entitlement per acre of farmland is decreasing over time.

*JEL Codes: K11, Q25*

## **1 Introduction**

Fierce competition over limited water resources is a defining characteristic of the western United States, where population growth, climate change, and persistent drought exacerbate the gap between water supply and demand (1–3). Models predict that consumptive water use in western states will exceed water availability by 2030 (4,5). Since the late 1800's, many of the West's major rivers have been dammed, diverted, and appropriated for agriculture, energy, mining, and urban development. In this process, surface water rights were appropriated without regard to the needs of Native American reservations (4,6,7).

A 1908 Supreme Court ruling (*Winters v. United States*) affirmed that through reservation treaties, tribes received implicit rights to water “sufficient to fulfill the need of the reservation as a homeland.” These reserved water rights are referred to as Winters rights. Under the prior appropriation doctrine that governs water allocations in the west, rights are filled in the order they were filed. While it is not uncommon to have paper water right allocations that exceed actual supply—California's major river basins have paper rights exceeding natural streamflow by a factor of 10—Winters rights are unique in that they supersede non-Indian water rights in priority, and cannot be forfeited by non-use (8). To legally quantify Winters rights, a reservation must either

reach a negotiated settlement with the US government and neighboring water users or receive a judicial decree in state court.

Since the original ruling in 1908, only 59 of 226 federally recognized reservations in the western US have completed the adjudication process, setting the current volume of adjudicated Winters rights at nearly 10 million acre-feet annually. The remaining 166 reservations have yet to adjudicate their water rights of up to 45 million acre-feet per year—over three times the annual allocation of the Colorado River (9). No standardized metric for quantifying reserved water rights exists, and this is a source of great uncertainty to off-reservation water users and to tribes who cannot adequately plan for future water use. While *Winters* rights have historically applied to surface water, a 2017 ruling by the 9<sup>th</sup> Circuit Court established tribes' reserved rights to groundwater, thus setting the stage for future deliberations over tribal water (10–12).

Despite the importance of Winters rights to water resource management in the West, there is limited information about the economic determinants of when and where Winters adjudications occur or the associated outcomes. Given the inherent value of increasingly scarce water supplies and the magnitude of unadjudicated Winters claims, understanding the process by which they are adjudicated is of key importance. Identifying predictors of Winters right adjudication and analyzing subsequent outcomes to reservations provides critical information to tribes, water managers, and policy makers as they incorporate unquantified Winters rights into long-term water supply and demand planning. This paper provides an empirical analysis of the economic determinants of Winters rights negotiations. We apply the framework developed by Ayres et al (2018) to augment the research surrounding a) determinants of Winters right adjudication, b) bargaining costs associated with resolving Winters claims, and c) adjudication outcomes to tribes.

When and why do tribes and other basin users successfully negotiate to create certainty over water rights, and when does this process fail? Empirical research demonstrates that property rights to surface and groundwater (13,14), fisheries (15,16), and grazing rights (17,18) are strengthened when the benefits of doing so were high relative to the costs. In the case of Winters rights, qualitative studies suggest that adjudication benefits increase with increasing water scarcity, demand, and the consequent growth in the value of water. Off-reservation surface water rights in western states have been defined through prior appropriation, which has historically enabled appropriative rights holders to exclude others from resource use (13). However, unresolved Winters rights diminish the legal security that appropriative rights holders have historically enjoyed. Likewise, when tribes can legally call on their water rights, they acquire the ability to generate income (19). Outstanding Winters rights claims generate considerable uncertainty, and the formal resolution of claims allows all resource owners to capture benefits from long-term investments in maintaining or improving a resource; facilitates trading and high-value use of water; and provides collateral (20).

Yet many Winters claims remain unresolved. Settlements are hindered by bargaining costs, which include the costs of coordinating agreement on the allocation of property rights (21). Bargaining costs increase with the number and heterogeneity of resource users and information costs, which increase when reconciling divergent priorities for resource use (22). The size and heterogeneity of a resource increases costs of obtaining complete information, as well as monitoring and enforcing use (18). Our current understanding of how bargaining costs impede these types of negotiations is limited by a lack of clear empirical tests. Further, there has been no systematic work quantifying the outcomes of these negotiations.

To fill these gaps, this paper examines three questions: (1) What factors increase the likelihood of successful Winters adjudications? (2) What determines the difficulty of the Winters bargaining process? (3) How can the outcomes of Winters settlements be characterized? Bargaining over Winters rights on American Indian reservations in the western US offers an opportunity to observe the characteristics and outcomes of many bargaining processes over a single resource and legal framework. Because tribal resources are managed in trust by the federal government and agreements are public, we know more about these negotiations than we would about negotiations among private individuals. In addition, there is considerable heterogeneity across tribes in areas that might affect the incentives to bargain, the difficulty of bargaining, and the outcomes of the negotiations.

We construct a unique dataset on the characteristics of the Winters bargaining problem faced by or facing each of 226 federally recognized reservations in 11 western states with appropriative surface water rights: the nature of the water resource, attributes of surrounding parties, reservation features, tribal capacity, potential bargaining costs, and, where applicable, settlement characteristics. We use both the adjudication itself, as well as the results for the tribe in terms of water and direct federal funding secured, to quantify benefits. We show that the likelihood of entering into the adjudication process is increasing in the expected benefits of settlement. However, a costly bargaining process, as measured by the number of users, increases the duration of the adjudication process. Conditional on settlement, we show that the amount of water entitlement per acre of farmland is decreasing over time.

## 2 Background

### 2.1 *Winters Water Rights*

Surface waters in the western United States are generally governed by the *prior appropriation doctrine*, under which water rights are assigned based on the timing of the initial claim. For example, a farmer making a diversion through an irrigation canal would receive recognition from the state as the holder of a water right, with priority assigned to the date when that water was first diverted. The “first in time, first in right” chronological priority of appropriative water rights mandates that in times of shortage, senior water claims must be completely satisfied before junior claims are filled. Senior water rights holders are guaranteed water in all but the driest years, making these water rights potentially valuable. In many western states the majority of appropriative water rights were assigned between 1850-1920 for irrigated agriculture, and by the mid-1900’s most streams across the west had been fully allocated (4,23).

Around the time the first appropriative rights were being claimed, the US government was allocating reservation lands to Native American tribes. Although these treaty agreements often did not specify water right allocations, a 1908 ruling by the US Supreme Court (*Winters v. United States*) found that reservations hold *reserved* water rights of the amount of water needed to irrigate all of the irrigable acreage within the reservation, with a priority of the date the reservation was created, often senior to other existing water rights (8). The court ruling affirmed that implicit in reservation treaties are “Winters Rights” to sufficient water to fulfill reservation needs and the federal government’s trust responsibility to reservations obligated it to provide services “required to protect and enhance tribal lands, resources, and self-government” (1,5). However, the federal government neglected to file claims to water rights on behalf of tribes at the time reservations were created, and streams across the west were fully allocated without regard to reservation needs (25).

As western states experienced population growth in the 1950's and began to confront physical limitations of water supplies, reservations increasingly asserted claims to these reserved, but unfilled water rights.

As federal reserved rights, Winters rights supersede many of the most senior appropriative water rights and cannot be forfeited by non-use. That there is no standardized legal metric for defining the volume of water to which each tribe has rights is a source of great uncertainty for appropriative rights holders, who risk the loss of status quo water use where they benefit from Indian water without compensating tribes (26). Without quantifying these rights, state and municipal water suppliers cannot factor Winters claims into planning for long term economic growth and water demand. Prior to settlement of the Salt River Pima Reservation claims for water rights for irrigation, which were adjudicated in 1988, water users in Arizona's Salt River Valley acknowledged that continued development of the Valley, "dependent upon reliable allocation of Arizona's water resources, [had] been jeopardized by the assertion of substantial water right claims based upon Federal, State and other law (27)."

Irrigation districts risk losing security and reliability of senior water rights, whose priority may be supplanted by tribes. Such legal ambiguity undermines even seasonal investments in irrigated agriculture, and in the case of the Klamath River in Oregon, resulted in high costs to both the Klamath Tribe and to non-Indian farmers and ranchers in the Klamath Irrigation Project. In 2001, during the ongoing Klamath Basin Adjudication, the Irrigation Project abruptly reduced diversions to satisfy streamflow for endangered fish (a priority for the Tribe), and idled land increased from an average of 1,700 acres in 1998-2000 to 23,000 acres in 2001 (28). In 2002, Reclamation diverted streamflow for Project farmers, killing ~34,000 endangered salmon (29). Legal uncertainty surrounding Klamath River entitlements generated financial losses when

farmers made investments for an irrigation season, but no water was delivered. Likewise, the seemingly mercurial decision to divert streamflow for farming in 2002 damaged the Tribe's fishery and imperiled endangered fish species.

## **2.2 *Settlement Agreements***

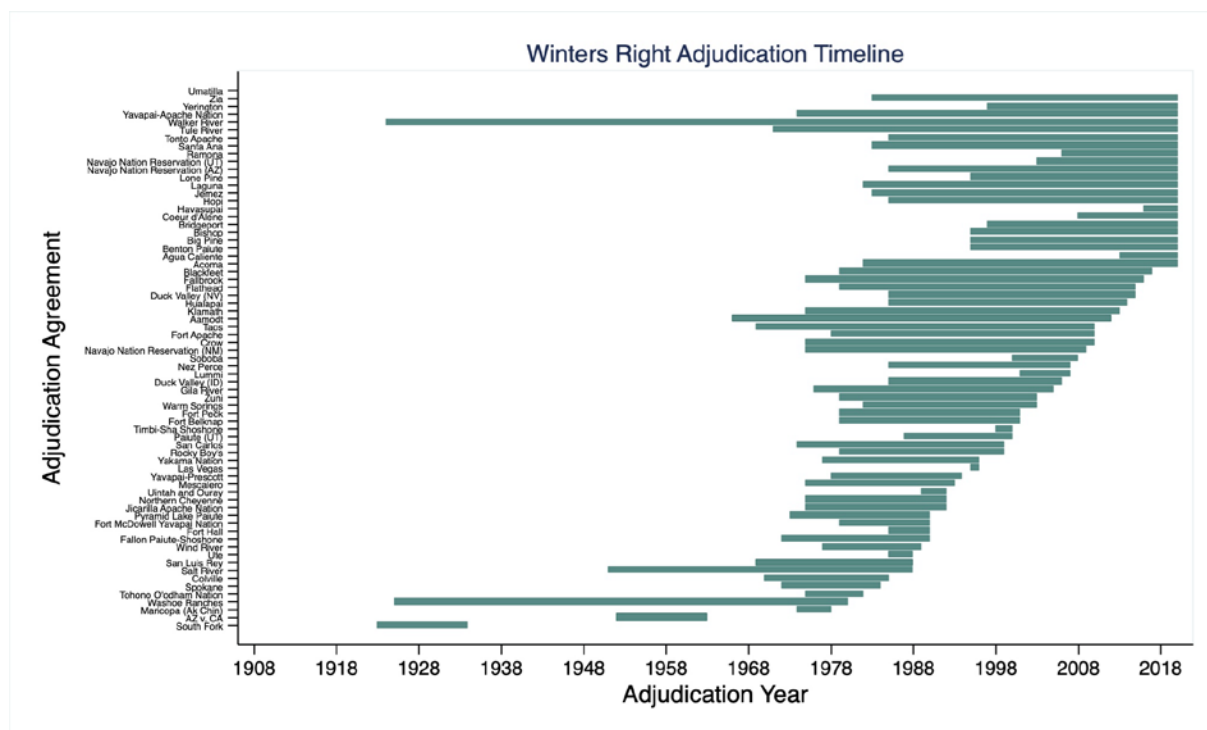
Tribes initially sought compensation from the federal government for damages when historical water supplies were diverted or depleted by off-reservation water users (30–34). Through the Indian Claims Commission (ICC) – established in 1946 to hear claims of tribes against the U.S. – tribes sued the federal government for breach of trust responsibility. While they could receive financial compensation for damages, these lawsuits did not resolve Winters claims. For example, the San Luis Rey tribes in Southern California sued the federal government in the ICC for damages resulting from lack of water that the government had neglected to claim on their behalf (35). The tribes were awarded monetary compensation in the ICC, but were required to quantify their water rights through a separate adjudication process (36).

Winters rights can be adjudicated through litigation in state courts or through negotiated settlement agreements with other water users within a basin. Litigation typically involves serving all basin water right holders with legal paperwork, assessing historic use, and then reconciling conflicting claims. Figure 1 shows the duration of adjudication proceedings for all past and current Winters adjudications. The first adjudications were initiated when reservations were included in early general stream adjudications with appropriate water rights holders. Tribes increasingly asserted Winters claims in the 1960's as a result of two court rulings. Under the 1952 McCarran Amendment, the federal government waived its sovereign immunity so that Winters rights, though federally reserved, would be settled in state courts – a setting that would be favorable to state appropriate water rights holders (37). A 1963 US Supreme Court ruling (*Arizona v. California*)



used the practicably irrigable acreage (PIA) metric, defined as the reservation acreage where benefits of irrigation exceed its costs, to quantify Winters rights of five Colorado River Basin tribes (22,23). The tribes, residing on ~135,000 acres, were ultimately awarded nearly 1 million acre-feet of water annually. The decision removed doubt about whether the 1908 Winters ruling would be upheld and established a potentially favorable quantification metric for tribes. Paired with the McCarran Amendment, it provided the legal framework for successive Winters adjudications.

**Figure 1: Timeline of Winters adjudications**



Many Winters adjudications begin in state courts but are eventually resolved through negotiated settlements. When a timely court decision seems unlikely, or litigating parties perceive high risk of unfavorable litigation outcomes, the tribe can request that Department of Interior appoint a federal negotiation team to broker an agreement between stakeholders who share the water resource (40). Each party must be willing to negotiate. While settlements occur among many

stakeholders within a basin, the federal government is involved in each adjudication to fulfill its trust responsibility to tribes and to resolve breach-of-trust claims that tribes have against it (41).

Qualitative studies document the advantages of negotiation over litigation. Litigation quantifies a tribe's water right, but does not establish administrative rules for water management or provide funding for tribes to divert and use their water in a meaningful way (42–44). Conversely, settlements specify how water can be used; stipulate plans for implementing settlement terms; specify administrative responsibilities and enforcement mechanisms; include funding for water conveyance infrastructure in exchange for tribes ceding or subverting claims to some water rights; and offer solutions tailored to individual tribes and basins in which those tribes are located (10,45–47). Settlement agreements, signed by all participating parties, legally quantify Winters rights and specify how those rights will be administered and enforced. Settlements can be enacted into law through congressional approval, whereby Congress appropriates federal funding to implement settlement agreements (41).

Federal policy favors negotiation over litigation, particularly in general basin adjudications, because litigation requires validating water claims and historical water use of every individual water user in a basin. Through negotiated settlements, tribes withdraw claims to some water rights, and a smaller number of parties comes to a decision on how to reconcile competing water needs. Most Winters adjudications start as litigation with thousands of potential claimants but are resolved relatively quickly once parties opt to negotiate. For example, the water right litigation to define Pechanga Reservation water rights was initiated in 1951 and included over 11,500 water users in California's Santa Margarita Watershed (48). Litigation continued until 2008 when the Pechanga requested that Secretary of Interior appoint a Federal Negotiation Team (49). While almost 60 years of litigation left the tribe's water rights unresolved, the reduced number of

parties involved in the negotiation, which included the tribe, the United States, and the Rancho California Water District, signed a settlement agreement in 2016 (50).

Water deliveries to reservations that have enacted settlement agreements often require investments in water conveyance infrastructure, as well as funding to secure water to fulfill reserved water rights, and to ensure that water deliveries meet water quality standards (41). A persistent challenge to federal policy makers is to enact settlement funding that is less costly than litigation (26). However, government estimates of litigation costs, which largely define its bargaining position and settlement outcomes for tribes, are not made public. Most commonly, Congress appropriates discretionary funding for individual settlements. In 2009, Congress created the Reclamation Water Settlements Fund into which \$120 million is deposited annually from 2020-2029 to implement settlements (51).

To date, 59 reservations in 11 western states have finalized the adjudication process, either through negotiated settlement or state court decree, and 22 have initiated adjudication but have not yet resolved their claims. Figure 2 illustrates the distribution of reservations in 11 western states according to whether Winters rights are a) resolved through court decree or negotiated settlement; b) subject to ongoing adjudication; or c) not adjudicated or in process.

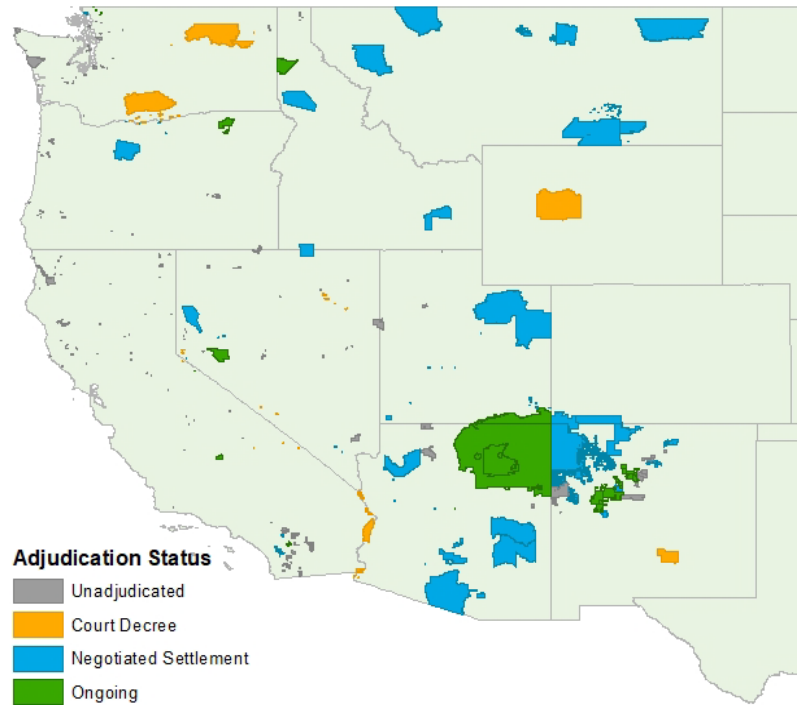
Likewise, Table 1 details the number of reservations in various states of Winters adjudication, average number of years to resolve Winters claims, and resulting water entitlements achieved through state courts and settlement negotiations.

**Table 1: Winters adjudication status by reservation**

Winters Adjudication Status	Number of Reservations*	Mean years to resolve claims**	Mean water entitlement(AFY)
Resolved through negotiation	46	24.73	229,344
Resolved through state court	13	18.08	292,169
Ongoing Adjudication	22	n/a	n/a
Not adjudicating	145	n/a	n/a

\*Navajo Nation, which overlies Arizona, Utah, and New Mexico is measured as three separate reservations, as it must quantify its water rights in separately in each state.

\*\*Number of years between initial Winters claim and final resolution of Winters rights

**Figure 2: Map of Western US Indian Reservations by Adjudication Status**

### 3 Economic Framework

In this section, we lay out a general economic framework for understanding Winters settlements by focusing on three principle bargaining parties – tribes, the federal government, and appropriative rights holders – as well as physical characteristics of basins. We expect that the distribution of adjudication costs and benefits across bargaining parties, as well the nature, size, and heterogeneity of the water resource, are correlated with adjudication outcomes. Accordingly,

we describe the bargaining positions and context in which bargaining parties participate in Winters adjudications.

### ***3.1 Bargaining Parties***

Bargaining parties in Winters adjudications include reservations, the federal government as it fulfills its trust responsibility to tribes, and appropriative water rights holders such as irrigation districts, municipal and industrial water users, energy companies, and individuals. Each party weighs anticipated benefits from participating in the quantification process against costs of redefining how water rights are distributed. The dynamic between bargaining parties, how each party fares under the status quo, and the number and type of parties involved have the potential to shape adjudication strategies, the complexity of reaching agreement, and adjudication outcomes (14).

#### ***Tribes:***

Losses from undefined Winters rights arise when tribes cannot prevent water resources that they historically relied upon from being depleted by off-reservation water users and when the incomplete definition of Winters rights undermines their ability to capture the full value of their water. Legal analyses suggest that water scarcity, streamflow depletion, growing water demand, and the subsequent loss of opportunities to generate income from water appear to converge as underlying factors that increase losses to tribes with unresolved Winters claims and help to catalyze the adjudication process (30,52).

Court documents detailing the origins of Winters right disputes offer insight into why Pacific Northwest tribes, such as the Yakama and Pyramid Lake Paiute, sued for instream flow rights: streamflow for culturally and economically important fisheries was being depleted by off-reservation irrigators (53–56). Both the Yakama and Pyramid Lake Paiute successfully acquired

instream flow rights through Winters adjudications (57,58). Acute water scarcity on the Soboba, San Luis Rey, and Tohono O’odham reservations in the Southwest prompted tribes to initiate litigation against off-reservation water users whose groundwater pumping and surface water diversions depleted reservation streams and springs (59–61). Tohono O’odham (1975) and the San Luis Rey Tribes (1969) sued relatively early on in pursuit of water right quantification, damages resulting from off-reservation water withdrawals by large municipal water providers, and for injunctions to prohibit future off-reservation water withdrawals (60,62).

When reservations legally define the priority and volume of water to which they have rights they acquire the ability to generate income from water (19). Navajo Nation in New Mexico has used partially decreed water rights to develop the Navajo Agricultural Production Industry, and the Gila River Indian Community signed a 2019 agreement to lease 18,000 acre-feet annually to the Central Arizona Groundwater Replenishment District for \$97.5 million (63) . Prime farmland area represents the value of water to the tribe, as tribes with higher prime farmland may anticipate greater net gains from adjudication. Given that many reservation economies rely on agriculture, the opportunity costs of not adjudicating are high on reservations with arable land that could be more productive with irrigation (45).

Reservations must consider whether the advantages of water right security outweigh adjudication costs and risks associated with uncertain adjudication outcomes. The adjudication process itself is inherently costly, spanning an average of 24 years between the initial filing of a Winters claim and resolution of those claims through state court or negotiation. Uncertainty surrounding anticipated net gains and losses can delay decisions to adopt new institutional controls, as parties seek more complete information and as aggregate costs of continued inaction grow (64). The lack of understanding of adjudication outcomes and water settlement metrics has

the potential to extend the bargaining process or even deter tribes from pursuing adjudication as they consider whether to expend limited time and financial resources to adjudicate when the outcome is not assured (64). For instance, the PIA standard initially offered a relatively objective metric for quantifying Winters rights, but a 2000 Arizona Supreme Court ruling rejected the notion that agricultural pursuits defined the purpose of a reservation as a “homeland”, allowing for more subjective Winters quantification metrics (65,66).

Given the potentially risky, expensive, and protracted process of resolving Winters claims, tribes’ economic and political capacity are likely to explain the decision to pursue adjudication. Throughout the adjudication process, tribes incur costs of retaining legal counsel and of conducting technical assessments of water supplies (67). For example, the Tule River Indian Tribe in California has spent \$582,600 for technical studies and needs assessments in on-going negotiations to settle their its water rights (68). Tribes with greater economic capacity may be better equipped to weather the adjudication process, as they are better able to absorb adjudication costs.

Empirical analyses of the relationship between land tenure and economic outcomes demonstrate that privately owned land on reservations is positively correlated with higher per capita income and agricultural productivity (69–72). Conversely allotted land - land held in trust by the federal government – is subject to BIA approval should an interest holder wish to make changes to land use, and where it is highly fractionated may be underutilized (73–76). The percentage of allotted land area on a reservation plausibly reflects that reservation’s economic capacity to initiate and sustain participation in an adjudication, and it reflects the reservation’s lost income generation potential when Winters rights remain undefined.

### ***Appropriative Water Right Holders:***

Appropriative water right holders participating in Winters right adjudications include municipal and industrial water users, irrigation districts, individual water right holders, and, less commonly, energy companies, mining, and environmental groups. For almost 150 years, appropriative water right holders have enjoyed the economic benefits of diverting and developing water resources without consideration for competing claims from tribes (13). Impending adjudications of Winters rights threaten the legal security that appropriative rights holders have enjoyed and generate significant uncertainty. Appropriative rights holders participate in the bargaining process as parties in settlement negotiations, or as litigants in state courts. How each bargaining party fared under the status quo of undefined Winters rights and the distribution of anticipated gains and losses across parties likely influences bargaining positions, willingness to bargain, and ultimately, costs of resolving Winters claims.

Advantages to Winters right adjudications to appropriators include resolving looming uncertainty about the quantity of tribal water rights and how (i.e. from which appropriative rights holders) Winters rights will be accommodated. For example, in Arizona threats of litigation over unresolved Winters claims impede off-reservation infrastructure projects, undermine long-term municipal water planning, and have drawn off-reservation water-users to the bargaining table. The state has experienced rapid population growth in recent decades (77). However, permits to construct new housing developments are approved contingent upon access to a 100-year water supply which cannot be acquired or validated when tribes may have rights to that water (78). The state has resolved Winters rights with 16 of the 21 reservations within its boundaries and is currently negotiating with 4 reservations, ostensibly because resolving Winters reduces opportunity costs of forgoing investments in future growth due to legal uncertainty.



Heterogeneity in the marginal product of water, such as between reservations and urban water users, influences the power dynamics and bargaining positions of adjudication parties (79). Municipal water providers such as Metropolitan Water District (MWD) in Los Angeles, and City of Phoenix in Arizona generally hold junior water rights but have substantial financial resources to devote to obtaining favorable adjudication outcomes. Where cities require secure, long-term water supplies but are junior to other water users, leasing provisions in settlements provide tribes with reserved water rights and a potential revenue stream, while enabling cities to maintain access to water rights (80,81). While heterogeneity across water users complicates the bargaining process, it also provides opportunities to resolve disputes through side payments, for instance through federal funding in negotiation settlements and off-reservation water leasing provisions (82,83).

Disputes over Winters right quantification stem from perceptions of fairness and disagreements over what each party feels that it deserves (84). Specifically, irrigators maintain that the legal seniority of their water rights should be maintained even as tribes assert Winters claims, whereas tribes argue that irrigators have no inherent right to water, but rather have benefited from free use of the tribes' water (85). Irrigators who have enjoyed benefits of low-priced access to water for decades may resist efforts to reallocate water to tribes. Prior to the Klamath River adjudication, Klamath Irrigation Project irrigators – senior appropriative rights holders – enjoyed reliable annual deliveries of Klamath water from the Project. The Klamath Tribe is likely to call on its senior entitlement to supplement streamflow in dry years, eroding the certainty of annual irrigation deliveries to irrigators (86). The Walker River Irrigation District in Northern Nevada has effectively delayed quantification of the Walker River Paiute Tribe's water rights for almost 95 years through litigation in Nevada state courts (87). In contrast, Federal funding in negotiated settlement agreements can compensate irrigators for losses. In Arizona, negotiated settlements

have included compensation for irrigation districts that forfeit water to satisfy newly defined Winters rights (88).

### ***The Federal Government:***

The U.S. government's federal trust responsibility to reservations is a legal obligation to protect tribes' treaty rights, resources, and assets and to manage them in tribes' best interest (89). The federal government fulfills its trust responsibility by asserting claims to water for tribes; assisting tribes in resolving these claims through litigation and negotiation; and supporting implementation of settlement agreements (41). Many tribes have breach of trust claims against the U.S. government for damages they incurred when the government neglected to claim water on their behalf after the initial 1908 Winters ruling. To this end, congressionally approved negotiated settlement acts contain a "Waiver of Claims Against the United States" which releases the government of "any and all existing claims against the United States arising in whole or in part from or concerning water rights" (90).

Direct costs to the federal government include federal funding allocated to implement settlement agreements and to compensate tribes for damages incurred from previously unsettled Winters rights. The federal government's Criteria and Procedures guidance, issued in 1990, emphasizes that the cost to the government of settling should not exceed the sum of a) calculable legal exposure, defined as litigation costs and legal obligations if the case were lost, and b) additional costs related to the trust responsibility (91). Federal funding within settlements must be approved and appropriated by Congress. The prospects of federal funding may help settle disputes between bargaining parties and is instrumental in enabling tribes to develop and use their water rights. However, the process of enacting federal funding is politically challenging. Only 17% of

settlements have been approved by a Republican congressional majority, and concerns about costs have caused some settlements to be renegotiated (92,93).

Less frequently, federal agencies such as Fish and Wildlife and Bureau of Reclamation are parties to Winters adjudications to ensure that settlement terms meet Endangered Species Act (ESA) and Clean Water Act (CWA) standards. In some instances, ESA-mandated environmental impact assessments for tribal water resource plans delayed the settlement process (94). Conversely, in the Pacific Northwest ESA mandates have aligned with the tribes' goal of restoring streamflow for endangered fish species and in some cases provide a funding mechanism for purchasing environmental water from farmers (56).

### **3.2 *Environmental Characteristics***

Physical water scarcity and the corresponding growth in the value of water may increase the benefits of securing water rights; while increasing resource size and heterogeneity may raise costs of adjudication agreements. The value of surface water increases where precipitation and streamflow are scarce. Legal complaints filed by tribes in Arizona and California offer explicit examples of how acute water scarcity factors into decisions to pursue Winters right security. The Soboba Tribe sued for damages in California when a tunnel constructed by MWD drained the reservation's springs and streams. Limited rainfall compounded damages the tribe incurred from unregulated off-reservation water use.<sup>2</sup> Farm enterprises on the Tohono O'odham Reservation in Arizona grew until "surface flow of the Santa Cruz River...disappeared" in 1975 due to mining, irrigation, and growth in nearby Tucson (95). In 1975, the tribe initiated litigation to quantify its water rights (60).

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<sup>2</sup> An expert witness testified that the tunnel "materially destroyed the ground water supply underlying the Soboba Indian Reservation", and due to limited precipitation and low recharge rates, it was likely that "the springs would never flow again" (30).

Natural water availability also plays an important role. To the extent that adjudication costs are fixed, greater volumes of water, such as found in larger streams, may be prioritized because they have lower adjudication costs per unit of water (96). Spatial variation in rainfall patterns and in the rate at which water resources are recharged, presents bargaining parties with different levels of losses and gains. Water users located in water scarce areas of a basin may be more willing to cooperate than water users where water is plentiful. Heterogeneity in the physical availability of water presents logistical challenges associated with delivering water from a relatively wet to relatively dry location to satisfy needs of bargaining parties (62).

Asymmetric information across bargaining parties about the quality and quantity of water in question increase the cost of obtaining complete information about the resource. Similarly, in large basins with many streams, obtaining an accurate measure of the amount of water available can be more costly than if the basin were small and had just a few easily accessible streams to monitor. Scientific uncertainty about the state of the resource can deter or delay the adjudication process as parties require more time to obtain such information or until adjudication benefits are sufficiently high to offset even high anticipated bargaining costs (64).

## **4 Data**

### ***4.1 Dependent Variable Specification***

The study focuses on 226 federally recognized reservations in 11 western states<sup>3</sup>. Eighty-one reservations have initiated the process of adjudicating their water rights. Of these, 59 reservations have resolved their Winters claims – 46 through negotiated settlements, and 13 through state court decree. We collect data on a cross-section of reservations according to whether they have initiated the process of legally defining Winters rights. Navajo Nation, which overlays

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<sup>3</sup> Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming

Utah, New Mexico, and Arizona, is included as three district reservations, as the Nation must pursue separate adjudications in each state. Duck Valley Indian Reservation is similarly assessed as two separate reservations as it settled its Winters rights separately in Idaho and Nevada. Using a full sample of 226 reservations, we test for the probability of a reservation having initiated the Winters adjudication process as a function of underlying determinants of adjudication costs and benefits. We construct a binary dependent variable where reservations are assigned a value of 1 if they have started adjudicating, and a value of 0 if they have not started adjudicating.

A second set of data is collected for 46 adjudication agreements that have resolved Winters claims for 59 reservations. Four adjudications (one court decree and three negotiated settlements) resolved Winters claims for multiple tribes. We select the adjudication agreement rather than the reservation as the unit of analysis for our examination of bargaining costs. Primary data on negotiated settlement agreements, settlement terms, bargaining parties, water entitlements, and federal funding were collected from individual settlement texts housed at the University of New Mexico's Native American Water Rights Settlement Project. Primary data on litigated adjudications was collected from individual State and District court filings and from the Indian Claims Commission Decisions housed at the Oklahoma State University Library. We measure bargaining costs as the number of years between initiating and finalizing adjudication.

Finally, we assess the distribution of outcomes of 37 negotiated settlement agreements to reservations included in those settlement agreements. Independent variables include total federal funding, federal funding per prime farm acre, and acre-feet/year (AFY) per prime farm acre. The ultimate distribution of a tribal water entitlement as defined in each adjudication agreement is measured as the annual volume (acre-feet per year) of non-consumptive water rights assigned to the reservation per prime reservation acre (AFY/prime reservation acre). Measuring non-

consumptive rights, as opposed to consumptive rights, more fully captures the volume of water available to tribes, particularly when those rights are used to maintain streamflow. Total federal funding for each adjudication settlement is recorded from individual negotiated settlement acts and is adjusted for inflation to 2010\$. Federal funding per prime reservation divides the adjusted settlement funding amount by the number of prime acres on the reservation.

## ***4.2 Independent Variable Specification***

### ***Water Demand:***

Prime Farmland: We construct an exogenous measure of prime farmland acreage on reservations, using spatial data on soil quality, as a proxy for PIA. We use the Schaetzl soil index, an ordinal 21-point soil productivity index (PI), which ranks soil productivity based on soil taxonomy and structural characteristics rather than on nutrient or water content, and is exogenous to differences in irrigation and farm management across reservations over time (97). We adapt the measure from Leonard et al (2018) to define prime farmland acreage as log of total reservation acreage where  $PI \geq 9$  (98). Schaetzl (2012) demonstrates that the PI on randomly selected agricultural sites for field crops in Michigan averaged 10.94 ( $SD \pm 2.36$ ) (97). A PI of 9 represents a lower standard for what comprises “prime” farmland. Tribes note that they often farm less than “prime” farmland due to lack of mechanization, traditional farming practices, and the need to produce food in spite of inefficiencies (30).

Population growth rate: Decadal population growth rate is calculated for counties that intersect a reservation using US Census data from the decade prior to adjudication start. For reservations with unadjudicated water, 2000-2010 Census data are used to calculate the population decadal growth rate. County level census data prior to 1980 exclude reservation populations. Beginning in 1980, reservation population is subtracted from county-level population counts.

Water Right Price: We assess the marginal value of water to off-reservation water users as the market price per acre-foot of water (\$/AFY) in the year when the adjudication agreement was finalized. Using the Water Strategist Water Transactions Database, we construct the off-reservation marginal value of water by basin by year from 1987-2010 (99).

***Environmental Characteristics:***

Stream order: Stream order is an ordinal variable defined according to USGS as the highest stream order on a reservation. USGS assigns a numeric order to each link in a stream network, where a first order stream is the tributary closest to the headwaters in a watershed, a second order stream is the combination of two first order streams, a third-order stream is a combination of two order-two streams, and so forth.

Spatial variance of precipitation: Calculated as using 800m x 800m resolution PRISM 30-year normal precipitation from 1980-2010 that fell within the boundaries of basins that intersect reservations included in each adjudication agreement.

Basin area: Defined as the total area (square miles) of basins (HUC 6) that intersect the reservation included in each adjudication agreement.

Mean precipitation: Calculated as mean 30-year normal precipitation (mm) from 1980-2010, that fell within boundaries of the reservation during the months of April - September. The variable is calculated by interpolating monthly PRISM 30-year normal precipitation data with reservation boundaries in ArcGIS, and averaging precipitation over summer months.

Reservation to Basin Area Ratio: A proxy for a reservation's bargaining power within an adjudication, as a large land base within a fixed basin area signifies that a tribe has larger claims to water rights within that basin. The variable is calculated as the ratio of total reservation area to the sum of area of basins (HUC 6) included in the adjudication agreement.

***Depletion Potential:***

POD Density: The total number of off-reservation surface water points of diversion (POD) per square mile of basins (HUC6) intersecting each reservation. Basin area excludes reservation area. Surface water rights were almost fully allocated prior to the start of most Winters adjudications and are plausibly exogenous measures of Winters rights adjudication determinants. Groundwater PODs are excluded as they are monitored inconsistently across states and many were established after Winters adjudications had started. Spatial data containing the POD location and water source were acquired from individual state water resource departments and state engineer's offices.

***Economic Capacity:***

Existing Irrigation infrastructure: Irrigation infrastructure is defined as a dummy variable where a reservation is assigned a value of 1 if a BIA irrigation project is present and a value of 0 if a BIA irrigation project is not present. BIA projects were constructed on 15 reservations in the early 1900s (100).

Fractionation: Level 1 fractionated acreage, as defined by Department of Interior (DOI), includes reservation acres with >1 unique ownership interest. Using data from the 2014 DOI Land Buy-Back Program status report, we calculate fractionated acreage as the percentage of total reservation area (101).

Access to credit: The number of lending institutions to which a reservation had access in 2018. Data identifying tribal lending institutions in the U.S. is available from the Minneapolis Federal Reserve. We collected supplementary data on the tribes served by each institution through information available on the institution's individual websites.

Per capita reservation income: From year 2000, available from the US Census.



Casino: A reservation is assigned a value of 1 if it operated a casino prior to adjudication start and is assigned a value of 0 if it did not operate a casino prior to adjudicating. Reservation with unadjudicated water rights are assigned a value according to their current casino operation. Data on casino operations was collected from 500nations.com, individual reservation websites, and worldcasinodirector.com. Casinos were first authorized in 1988 under the Indian Gaming Regulatory Act.

***Bargaining Parties:***

Number of bargaining parties: For negotiated settlements, the number of bargaining parties is calculated as the total number of signatories to the settlement agreement. Bargaining parties in state court adjudications are calculated as the total number of parties recorded in individual case dockets.

Urban land cover: A proxy for heterogeneous water demand, urban land cover area is defined as a percentage of off-reservation county area. The variable employs spatial data from the 1970-1980 Enhanced Historical Land Use and Land Cover Data Sets of the U.S. Geological Survey. Urban land cover is defined as “developed land” (classification codes 21-24) and is calculated for counties intersecting (but excluding) each reservation. While the dataset shows relatively rough urban landcover features in 200m x 200m polygons, we sacrifice resolution for an estimate of urban landcover that predates most adjudication start dates. We construct an additional measure of the percent change in off-reservation county urban land cover using 30mx30m resolution National Land Cover Data from 2001 and 2011.

Democratic Congressional Majority: Calculated as the number of years when Democrats have a majority in the House and Senate, as a percentage of total years to resolve Winters claims.

## 5 Predictions and Empirical Strategy

Winters right adjudications, particularly when resolved through negotiated settlements, result in a combination of water entitlements and federal funding for tribes. As water scarcity grows over time, so do the constraints associated with how easily water can be reallocated amongst water users. Federal funding in negotiated settlements can defray high bargaining costs. We analyze three stages of Winters right adjudications:

1. *Initiation of adjudication.* We predict that all else equal, the probability that a reservation initiates the Winters right adjudication process increases when the benefits of water right security exceed the costs of acquiring, administering, and enforcing those rights.
2. *Bargaining.* We expect that on average, costs of resolving claims to Winters rights increase as the size and heterogeneity of the resource and of bargaining parties increase.
3. *Settlements.* All else equal, we predict that settlements are more likely to include federal funding in lieu of water as water scarcity and the off-reservation marginal value of water increase.

### ***Determinants of Adjudication:***

We test the probability of entering into the adjudication process against a set of exogenous, reservation-level independent variables that measure underlying determinants of adjudication costs and benefits. The primary outcome of interest for assessing this first step in the analysis is a reservation's adjudication status. Independent variables (Table 2) are either time-invariant or constructed to measure conditions prior to the start of adjudication.

For each reservation we would like to observe whether that reservation opted to initiate the Winters right adjudication process according to the different levels of benefits associated with adjudication. We run a regression of current adjudication status on determinants of costs and benefits. Predicted slopes on parameter estimates indicate whether a variable increases or decreases the benefits of adjudication. Table 3 shows the variables and their predicted effect.

**Table 2: Summary Statistics, Mean and (standard deviation), by Adjudication Status**

	Adjudicating	Not Adjudicating	Total
Number of Reservations	81	145	226
ln(Prime Acres)	9.421 (4.330)	5.727 (3.046)	7.075 (3.970)
Highest Stream Order (#)	5.321 (2.241)	2.74 (2.137)	3.667 (2.498)
Population Growth Rate (%)	31.318 (30.686)	12.58 (11.082)	19.296 (22.237)
POD Density (POD/mi <sup>2</sup> )	0.001 (.0013)	0.001 (0.002)	.001 (.001)
Precipitation (mean)	24.949 (14.713)	30.013 (21.858)	28.198 (19.715)
BIA project (dummy)	.198 (.401)	1 (0)	0.071 (0.257)
Lending Institutions in 2018 (n)	1.086 (1.196)	0.455 (0.764)	0.681 (.987)
Casino Prior to Adj. Start	.074 (.264)	0.51 (0.502)	.354 (0.479)
Reservation PCI 2000	11168.240 (4148.087)	12216.75 (5746.38)	11651.010 (4957.478)
Fractionated Area (%)	18.491 (23.089)	24.642 (40.083)	22.016 (33.842)

**Table 3: Empirical predictions for Reservation benefits of Winters Adjudication**

Variable	Predicted Coefficient Sign
Prime Farmland Acres	+
Highest Stream Order	+
Population Growth	+
Mean Precipitation	-
POD Density	+
BIA Project	+
Fractionated Area	-
Lending Institutions in 2018	control
Reservation PCI (2000)	control
Casino Prior to Adj. Start	control

Reservations with larger potential water right claims—higher order streams and more prime farmland—see greater benefits to adjudication and we predict these reservations are more likely to begin adjudication. On average, higher population growth, which reflects growing off-reservation demand, is expected to increase the likelihood of adjudication. While more precipitation decreases the value and predicted likelihood of adjudicating, more depletion of the resource as measured through points of diversion and streamflow depletion are expected to increase the likelihood of adjudication. The presence of BIA irrigation project facilitates

negotiation by providing common information and bargaining structure, and therefore should be associated with a higher probability of adjudicating. We control for reservation population using 2000 and 2010 US Census Data, and land tenure on reservations with a measure of allotted land area as a percentage of total reservation area.

***Bargaining Costs:***

Conditional on having started the process of Winters right adjudication, we test for factors that increase costs of legally resolving Winters claims. We assess bargaining costs as the duration of time between adjudication start and the resolution of Winters claims. We use a Cox Proportional Hazard Model (CPH) to analyze the number of years required to resolve Winters rights. Conditional on having started the adjudication process, the hazard function represents the probability that the adjudication is completed. The CPH function is:

$$\lambda(t|X) = \lambda_0(t) * \partial(X\beta')$$

$\lambda(t|X)$  represents the proportional hazard as a function of the number of years to complete adjudication conditional on covariates representing determinants of bargaining costs.  $X$  is a vector of covariates and  $\lambda_0$  is the hazard function. The slope  $\beta$  describes the effects of covariates on the hazard rate once a reservation has initiated adjudication—note that as defined, a negative slope on  $\beta$  represents a longer adjudication process. Table 4 shows the predicted effects.

**Table 4: Empirical predictions for duration of Winters resolution**

Variable	Bargaining Duration
Number of Bargaining Parties	+
Democratic Majority Congress	-
Basin Precipitation Spatial Variance	+
% County Urban Land Cover in 1980	-
Lending Institutions in 2018	-
2000-2010 Reservation Pop. Growth Rate	-

We expect that the number and heterogeneity of water users, and the size of the resource to increase bargaining duration. All else equal, we anticipate higher adjudication costs as rainfall across basins increases in heterogeneity. Increasing the number of bargaining parties is predicted to increase bargaining costs because competing claims and priorities for water use become more difficult to accommodate.

### ***Adjudication Outcomes:***

We assess two settlement outcomes – water entitlements and federal funding – as functions of characteristics of the bargaining problem faced by the tribe and other basin users. The unit of analysis is the adjudication agreement. The measure of volumetric water rights per prime reservation acre reflects a common metric for reserved water right claims – tribes commonly claim Winters rights based on practicably irrigable acreage; a metric established in *Arizona v. United States* (1963), and reserved rights often have been decreed according to this metric. Table 5 shows the predicted signs of determinants of adjudication outcomes.

**Table 5: Predicted signs of determinants of adjudication outcomes**

Variable	Water Entitlement/Acres	Federal Dollars/Acres
Settlement Year	-	+
Water Value	-	+
Basin Precipitation	-	-
Democratic Majority Congress	+	+
Bargaining Power	+	+

Tribes will receive more water or federal funding, all else equal, if their bargaining position is stronger. Where water value is higher, in areas with high water right prices or low precipitation, we predict that tribal water entitlements from adjudication will be lower. To compensate tribes for receiving less water in areas where water prices are high, more federal funding will be required, but where precipitation is high, both water rights and federal funding will be lower. We also predict that over time, less water per acre and more funding has been

included in the agreements. Finally, Republican control of congress, which must approve all tribal water settlements, is expected to decrease the amount of water and federal funding received in settlement agreements.

## **6 Results**

### **6.1 *Adjudication Determinants***

We apply a logistic regression model to test for relationship between predicted determinants of Winters adjudication benefits and the probability that a reservation has initiated the adjudication process. Table 6 shows results of six different specifications. Columns 1-3 report estimates for adjudication probability across all 226 reservations, while columns 4-6 limit the sample to reservations with a population of at least 100. Columns 2 and 5 include estimates of controls for fractionated land area, which limits the sample size. Columns 3 and 6 include controls for lending institutions, operation of a casino prior to adjudication start, and 2000 reservation per capita income, which limits the sample size to 136, but enable us to compare reservations with similar levels of economic capacity.<sup>4</sup>

Across all specifications, coefficients can be compared with the predictions of Table 3. Broadly, the directionality of coefficients included in our models corroborate our hypothesis that tribes pursue legal certainty in their water rights when the benefits of doing so are high relative to costs.

Population growth rate in counties prior to adjudication start is positive and statistically significant in all 6 specifications. As populations grow, water demand increases as do the expected benefits of adjudication. Mean precipitation is negatively and significantly correlated at the 10% level with the probability of a reservation having initiated adjudication in model specifications 1

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<sup>4</sup> Appendix A presents linear probability model regression results of the same six specifications.

and 4. Its level of significance and magnitude depend on whether the controls for economic capacity were included and whether the full sample was used. Less mean summer precipitation is indicative of water scarcity, which increases the relative value of water. As predicted, reservations are significantly more likely to adjudicate when water is scarce and therefore more valuable.

**Table 6: Logistic Regression Results: Net Effects of Adjudication Determinants (Odds Ratios)**

	All Reservations			2010 Reservation Population $\geq 100$		
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Prime Acres)	1.152** (0.0730)	2.092*** (0.577)	1.115 (0.0809)	1.150** (0.0754)	2.000** (0.549)	1.119 (0.0815)
Highest Stream Order (#)	1.315*** (0.130)	1.438 (0.526)	1.126 (0.151)	1.223* (0.134)	1.403 (0.572)	1.097 (0.150)
Population Growth Rate (%)	1.035*** (0.00978)	1.104** (0.0450)	1.032** (0.0125)	1.032*** (0.0102)	1.097** (0.0444)	1.030** (0.0124)
POD Density (POD/mi <sup>2</sup> )	1.685e+50 (2.247e+52)	2.632e+48 (8.348e+50)	3.578e+80 (6.653e+82)	1.488e+32 (2.058e+34)	1.093e+37 (3.451e+39)	3.104e+74 (5.741e+76)
Precipitation (mm)	0.976* (0.0129)	0.977 (0.0233)	0.970 (0.0185)	0.976* (0.0133)	0.978 (0.0229)	0.971 (0.0180)
BIA project	19.37* (29.29)	7.537 (13.35)	5.675 (8.681)	17.88* (27.03)	7.846 (13.90)	5.670 (8.656)
Lending Institutions (2018)			1.426 (0.405)			1.416 (0.405)
Casino Prior to Adj. Start			0.0913*** (0.0525)			0.0915*** (0.0519)
Reservation PCI 2000			1.000 (4.35e-05)			1.000 (4.37e-05)
Fractionated Area (%)		1.010 (0.0101)			1.010 (0.0104)	
Observations	226	82	139	159	69	136

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Prime farmland acreage reflects net adjudication benefits to tribes because legal precedent allows them to claim larger volumes of Winters rights. All else equal, reservations with incrementally higher prime farm acreage are anywhere from 10% more likely to twice as likely as their counterparts to pursue adjudication. Likewise, higher order streams are also positively correlated with adjudication (though statistically significant at different levels in model

specifications 1 and 4). The greater volume of water in high order streams suggests that tribes are poised to receive a greater volume of water per unit of adjudication costs.

## **6.2 *Duration Analysis***

We use a CPH model to test the hypothesis that Winters right adjudication costs, measured as adjudication duration, increase with increasing bargaining parties and party heterogeneity, and increasing resource size and heterogeneity. Table 7 presents results from the CPH regressions on the years to resolve claims to Winters rights. Specifications 1-4 present estimates for all finalized adjudication agreements. Results shown in column 4 include controls for 2000 reservation per capita income, operation of a casino prior to adjudication start, and the number of lending institutions in 2018. Despite a small number of observations, we observe statistically significant results across model specifications.<sup>5</sup>

Coefficients in the CPH model influence the hazard rate, or the relative risk of resolving a Winters adjudication. A negative coefficient indicates negative marginal effects on the hazard rate, which, all else equal, increases the anticipated time to resolve Winters right claims. Columns 1-4 indicate that, all else equal, an increasing number of bargaining parties is highly correlated with a more protracted adjudication process. Litigation typically coincides with a higher number of bargaining parties than negotiation, as individual appropriative rights holders assert claims for water. Accordingly, these findings lend empirical strength to federal policy, legal analyses, and qualitative studies that advocate for negotiation over litigation as a strategy for reducing bargaining costs. Tribes typically spend a number of years pursuing Winters adjudications in state courts prior

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<sup>5</sup> Appendix B presents results of a CPH regression that includes basin size rather than precipitation variance as a measure of the water resource characteristics of bargaining costs. Regression results and signs are similar, as basin size is correlated with precipitation variance



to requesting negotiation teams. Pursuing negotiation earlier in the adjudication process may reduce overall costs of resolving Winters claims.

**Table 7: Cox Proportional Hazard Regression Results**

	(1) Adj Duration v2	(2) Adj Duration v3	(3) Adj Duration v4	(4) Adj Duration v5
Bargaining Parties	-0.00481** (0.00222)	-0.00661** (0.00314)	-0.00681*** (0.00242)	-0.00874** (0.00345)
Democratic Congressional Majority	0.0154** (0.00774)	0.0259*** (0.00804)	0.0125 (0.00824)	0.0259*** (0.00873)
Basin Precipitation Variance	0.00176* (0.000995)	0.00229** (0.00116)	0.00240** (0.000981)	0.00298*** (0.00114)
% County Urban Land Cover (1980)	-0.00899 (0.00867)	-0.00840 (0.00940)	-0.0225** (0.0111)	-0.0215* (0.0122)
Operated Casino Prior to Adj. Start			0.109 (0.882)	0.473 (0.948)
Lending Institutions (2018)			-0.419*** (0.161)	-0.366** (0.165)
Reservation PCI 2000		2.49e-06 (5.30e-05)		9.29e-06 (5.19e-05)
Observations	46	43	46	43

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Urban land cover, a proxy for heterogeneous water demand, is associated with a slower adjudication process when controlling for a reservation's economic capacity. Marginal increases in the spatial variance of rainfall within adjudicated basin, on average, corresponds to faster adjudication timeline. While we predicted that heterogeneous water distribution across basins complicates and therefore prolongs the adjudication process, this variable is correlated with basin size, which, after controlling for number of bargaining parties, reduces the duration of negotiations.

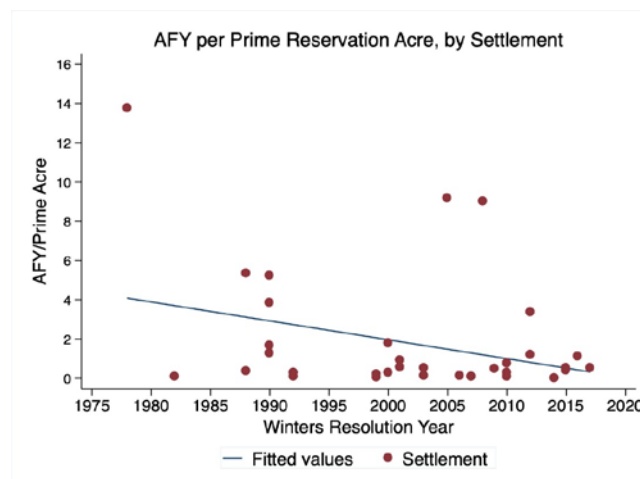
On average, a higher percentage of years of Democratic congressional majority during the adjudication process is highly correlated with a more expedited adjudication process—significant at a 1% level all but one specification. While bargaining parties to each adjudication have little

influence over the congressional majority, the partisan component of bargaining cost determinants has implications for how the federal government strategies to reduce adjudication costs. While Republican Congressional majorities enact less negotiated settlements, largely due to cost, corresponding delays carry additional costs.

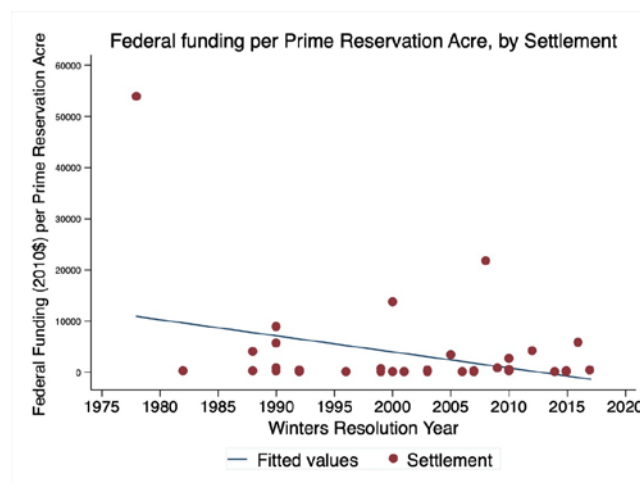
### 6.3 Adjudication Outcomes

We use a regression model to analyze outcomes of 37 negotiated settlement agreements. Figures 3, 4, and 5 illustrate the diminishing outcomes to tribes over time, as water entitlements, total federal funding, and per-prime acre federal funding have declined.

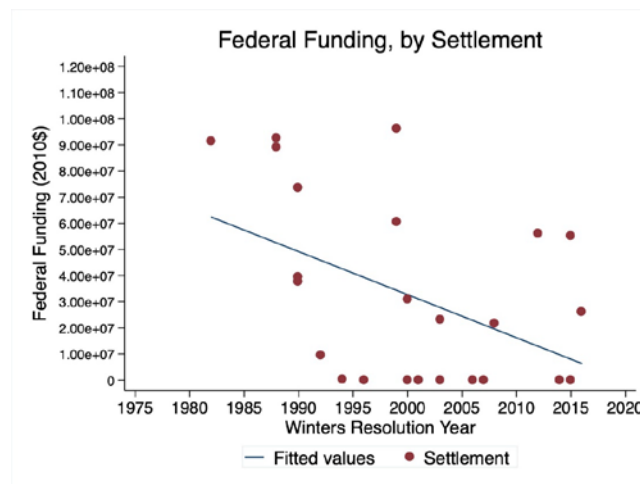
**Figure 3: AFY Entitlement per Prime Reservation Acre, by Settlement**



**Figure 4 Federal Funding per Prime Reservation Acre, by Settlement Agreement**



Water entitlements per prime acre decrease over time as bargaining parties move away from the PIA standard and as tribes subvert some Winters claims during the negotiation process in exchange for federal funding. Graphically, we do not see a corresponding per prime acre increase in federal funding over time. Likewise, the total adjusted federal funding per negotiated settlement also declined.



Water entitlements are decreasing with the increasing percentage of years throughout the adjudication when Democrats hold a majority in both houses of Congress. While we expected tribes to fare better during a Democratic Congress, results in column 3 show trade-offs between water entitlements and funding as a function of political party in the legislative branch. All else equal, Democratic majority in congress predicts increased federal funding per prime reservation acre.

**Table 8: Multilinear Regression Estimated Effects on Negotiated Settlement Outcomes**

	AFY Entitlement per Prime Reservation Acre	Total Federal Funding (2010\$)	Federal Funding per Prime Reservation Acre
Year Settlement Finalized	-0.938* (0.532)	6.542e+06 (4.073e+06)	610.2 (381.2)
Off Reservation \$/AFY	-0.00479 (0.00781)		
Democratic Congress	-0.371** (0.170)	1.707e+06 (1.251e+06)	217.2* (114.6)
Mean Basin Precipitation	-0.254 (0.279)	179,722 (2.145e+06)	74.55 (192.7)
Reservation: Basin Size Ratio	0.0737 (0.465)		-601.3* (311.9)
Prime Reservation Acreage		130.1** (58.06)	
2000-2010 % Δ Urban Land Cover		7.707e+06 (5.170e+06)	837.9* (479.2)
Constant	1,910* (1,068)	-1.317e+10 (8.193e+09)	-1.229e+06 (766,677)
Observations	34	37	36

Column 3 shows that reservation-to-basin size ratio, indicative of a reservation's potential claims to water, yields less funding per prime acre, while increasing urban land cover in off-reservation counties is, on average, correlated with higher per unit levels of funding. The only significant predictor of total federal funding is a reservation's prime farmland acreage (column 2). All else equal, each prime acre is correlated with a \$130 increase in total funding.

## 7 Conclusion

Growing demand, diminishing supply, and corresponding increases in the relative value of water appear to catalyze Winters rights adjudications. In addition to contributing to the economics literature on property rights theory by examining the outcomes of a relatively high number of similar bargaining scenarios, our findings contribute to a understanding where and when Winters adjudications occur. Adjudications are more likely to occur in areas characterized by high-quality farmland and high order streams. Likewise, our findings provide insight into how tribes and appropriative water rights holders may respond to time-variant factors, such as population growth rate and fluctuations in the physical water supply.

Our findings corroborate to broader economic theory that the number and heterogeneity of resource users increase bargaining costs. More practically, that our findings demonstrate lower bargaining costs of negotiation relative to litigation informs adjudication strategies. Lower costs of negotiation relative to litigation are reflected in the positive correlation between number of bargaining parties involved in an adjudication and the time to finalize the adjudication. While federal policy and legal analyses tout the merits of negotiation over litigation due to the lower number of bargaining parties, to our knowledge, this is the first empirical test of whether the number of parties is correlated with higher Winters adjudication costs. By opting to negotiate sooner in the adjudication process, bargaining parties may save significant time and financial resources.

Likewise, that adjudication costs and funding outcomes are driven partially by partisan priorities in Congress highlight the distribution of costs amongst bargaining parties as well as the trade-offs that legislators can consider as they debate federal funding for settlement agreements. While the adjudication process appears to move more quickly under a Democratic congressional majority, thus reducing bargaining costs, federal funding per prime reservation under a Democrat majority is likely to be higher than under a Republican majority.

Looming uncertainty from unadjudicated Winters rights may not be as severe as anticipated. Over time, reservations receive, on average, less water per prime acre, while the largest reservations, poised to receive the most water, have already adjudicated. As such, current estimates of unresolved claims to Winters rights, based on early negotiated settlements, overstated the entitlements that tribes are currently receiving. The only reliable predictor of federal funding is prime farm acreage, which is fixed for each tribe, and the total water entitlement per settlement agreement is decreasing over time. This suggests that tribes incur additional losses in the form of

foregone benefits when they wait to adjudicate, regardless of the combination of settlement funding and water. Thus, tribes have “implicit” rights to water, yet diminishing adjudication benefits demonstrate the erosion of the value of those claims over time.

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## 9 Appendix

Appendix A: Linear Probability Model Regression Results: Net Effects of Adjudication Determinants

	All Reservations			2010 Reservation Population $\geq 100$		
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Prime Acres)	0.0247*** (0.00905)	0.0673*** (0.0147)	0.0208* (0.0114)	0.0290*** (0.0109)	0.0766*** (0.0173)	0.0219* (0.0115)
Highest Stream Order (#)	0.0422*** (0.0138)	0.0251 (0.0210)	0.0163 (0.0186)	0.0354* (0.0179)	0.0147 (0.0259)	0.0122 (0.0190)
Population Growth Rate (%)	0.00597*** (0.00122)	0.00619*** (0.00161)	0.00445*** (0.00133)	0.00548*** (0.00139)	0.00657*** (0.00178)	0.00423*** (0.00134)
POD Density (POD/mi <sup>2</sup> )	13.98 (19.42)	-9.383 (26.82)	28.58 (23.15)	12.17 (23.27)	-17.54 (29.23)	26.61 (23.36)
Precipitation (mean)	-0.00337** (0.00155)	-0.00359* (0.00194)	-0.00563** (0.00218)	-0.00446** (0.00190)	-0.00422* (0.00216)	-0.00563** (0.00220)
BIA project (dummy)	0.359*** (0.110)	0.285*** (0.107)	0.171 (0.114)	0.315*** (0.120)	0.264** (0.115)	0.165 (0.114)
Lending Institutions (n)			0.0663* (0.0383)			0.0649* (0.0386)
Casino Prior to Adj. Start			-0.427*** (0.0750)			-0.441*** (0.0756)
Reservation PCI 2000			-3.98e-07 (6.60e-06)			-8.76e-07 (6.64e-06)
Fractionated Area (%)		0.000216 (0.00117)			0.000401 (0.00127)	
Constant	-0.0306 (0.0639)	-0.344*** (0.115)	0.362*** (0.134)	0.0526 (0.0913)	-0.346** (0.152)	0.399*** (0.135)
Observations	226	82	139	159	69	136

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

# Appendix B: Cox Proportional Hazard Regression Results

	(1) Adj Duration	(2) Adj Duration	(3) Adj Duration	(4) Adj Duration
Bargaining Parties	-0.00400* (0.00216)	-0.00562* (0.00302)	-0.00582** (0.00231)	-0.00728** (0.00314)
Democratic Congressional Majority	0.0162** (0.00805)	0.0267*** (0.00847)	0.0142* (0.00838)	0.0271*** (0.00939)
Basin Size	1.85e-05 (1.25e-05)	1.61e-05 (1.45e-05)	2.72e-05** (1.27e-05)	3.23e-05** (1.59e-05)
% County Urban Land Cover (1980)	-0.00722 (0.00890)	-0.00802 (0.00977)	-0.0194* (0.0106)	-0.0179 (0.0114)
Operated Casino Prior to Adj. Start			0.0222 (0.862)	0.0504 (0.895)
Lending Institutions (2018)			-0.430*** (0.159)	-0.435** (0.180)
Reservation PCI 2000		5.72e-05 (5.53e-05)		9.60e-05 (5.84e-05)
Observations	46	42	46	42

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1