Water rights, river compacts, and legal-policy stationarity in the American West*

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Abstract
This article examines static-data assumptions trapped in water rights and, separately, in larger interstate river compacts in the American West. These reflect assumptions of scalar stationarity embedded in water codes in western states. State water adjudications sort how much water is being used, but the resulting data are often publicly unavailable and unchanged. Interstate river compacts often divide fixed, erroneous river flow data. River compact data, based on early 20th century optimistic estimates of river flow, have not changed in policy language. At both the micro- and the macro-scale, these separate data remain fixed, complicating water management in the American West.

1. Introduction: water-data stationarity in legal policy
For over a century, states in the American West have struggled to ‘count’ their surface and groundwaters, water-rights holders, and changes to water use over time. These data are vital to assigning individual water rights yet remain static, fixed in time, and often obsolete given their age.

Separately, interstate agreements and river compacts, such as those governing water flows in the Colorado River and Rio Grande, are essential for water management at larger scales. Yet these too are often based on spurious river flow estimates from a century ago. Integrating across scales using a socioecological framework, for water in the American West, remains a challenge because of the disconnected or unavailable data.

This article examines the static nature of both state-level water rights at the microscale and fixed river flow numbers in river compacts at the macroscale. Both sets of data contribute to the central legacy problem presented here, legal-policy stationarity over water resources in the American West (Christian-Smith et al 2012).

In essence, water agencies and courts have relied on fixed data, reflecting an assumption of both biophysical stationarity and legal-policy fixity, for both water rights and water flows that have not existed in half a century (Kuhn and Fleck 2019). As originally framed by Milly et al (2008), physical stationarity is ‘the idea that natural systems fluctuate within an unchanging envelope of variability.’ That idea became a powerful assumption in the operations of legal policy in river compacts across the US. However, we now know that we cannot expect river flows to be unchanging, even in their averages.

As complex socioecological systems, river flows have been much more variable that previously assumed, are now heavily modified by human uses (Linton and Budds 2014), and increasingly prone to hydrological variability from climate change. Over the last decade, climate scientists have provided increasingly refined evidence of paleo-, historical, and current flows and anticipated future climate change in the American West (Cook et al 2015, McCabe et al 2017, Udall and Overpeck 2017).

Despite historical and contemporary scientific data suggesting lower flows in rivers, policy-makers in states and signatories to river compacts remain beholden to static data and policies (Kuhn and Fleck 2019). Recent scholarship has demonstrated that institutions remain difficult to change even when scientific
understanding would suggest legal and policy changes (Owen et al 2019).

The argument presented here is that legal and policy stationarities—solidified in western water legal doctrines, institutions, and more importantly, unchanging data—challenge collaborative water compromises and conflict resolution in western states (McKinney and Thorson 2015).

Western states often have to rely on partial data derived from ongoing state adjudications of water rights. Since no state, apart from Colorado, has a full accounting of its own water rights, errors scaling up or down in water allocation can theoretically cascade into the basin level of decision making. Bridging the micro- and the macro-scale is made impossible because of the lack of complete and publicly available data from all states, even those that share major rivers in compact arrangements. This is a serious challenge for using socioecological systems (SES) frameworks since these SES approaches have largely focused on smaller-scale commons resources (Partelow 2018).

Historical errors, using fictitious or optimistic river flow averages over time, are cemented in interstate river compacts, and have remained static in the legal compact language for the last century. This macro-stationarity in western legal and river compacts arrangements complicates the work of water managers and policy makers. To be sure, water managers are aware of the problems created by assuming fixed amounts and averages. However, they also know how difficult it would be to modify water codes and compacts.

Frameworks of SES could complement more frequently used decision-making systems regarding water resources in the American West (see figure 1). The insights of SES theorists and researchers are valuable in nested and well-defined cases in this region (Jones et al 2019), yet the direct links and feedback data necessary for thorough examinations of water are unavailable. Thus, it is difficult to integrate across scales of water use, allocation, using SES or other integrated frameworks (Engle et al 2011, Partelow 2018).

As one perceptive critic has noted, when incommensurate ‘measurement gaps’ or ‘data transformation gaps’ cannot be translated across scales or bridged, SES becomes difficult to apply much less replicate (Partelow 2018). The central problem here is actually worse since it involves a complete data gap, as micro-level water rights data are incomplete or not available.

These data problems in using SES theory or methods are two-fold: lack of comparative adjudication data at the micro-scale (state level water rights) and the erroneous ‘fixed’ numbers in historical river compacts (at the macro-scale). Because adjudication data are often unavailable, incomplete, or poorly updated (depending on the state) a full SES application to water beyond defined basins remains challenging (see Chaffin et al 2014, Cabello et al 2015).

Traditional solutions for water scarcity in western states and interstate compacts included water augmentation plans, importing water from other basins, and water infrastructure such as reservoirs and dams to even out seasonal and annual flows to make river and water allocations more predictable and manageable.

Paradoxically—despite the expense, complexity, and pushback by citizen and environmental groups—new dam or augmentation projects seem more feasible than altering the institutional and legal policies that structure and make water management more difficult (Perry and Praskievicz 2017).

As detailed next, the seemingly ‘fixed’ water rights assigned to individual water users, and the separate macroscale problem of the ‘fixed’ river compact water allocations (by state) seem impervious to serious amendments. The immobility of legal policy at two different scales presents serious challenges to flexibly managing the water that is actually available. First, water adjudications and their micro-stationarity are addressed.

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**Figure 1.** A socioecological system framework (SES). Source: McGinnis and Ostrom (2014).
2. Water rights: micro-stationarity in the American West

As one water agency manager recently reminded an audience at a recent 2019 policy conference about the Colorado River, ‘You can’t manage what you can’t count.’ Water managers and policy makers have long held to some version of this credo. However, counting fluid water as a water right is not an easy task, as western states well know.

Across the American West, various 20th century codes tasked water managers with counting state waters and assigning water rights. Most western states have yet to complete this challenge. Furthermore, completed measures might be inaccurate, given alterations of streamflow under regional climate change.

The processes to count water users and state waters are known collectively as water-rights adjudications and vary by state. In general, adjudication procedures sort the beneficial uses of water by priority date, diversion locations, water rights, the amount of water per acre awarded to users (water duty), and the relative seniority of water users for priority management. In Colorado, this is done by individual water-right claimants in a state court. In contrast, New Mexico the Office of the State Engineer (OSE) sues, maps, and offers claims to individual water users by basin in giant adjudication lawsuits. These lawsuits are lengthy, expensive, and adversarial (Perramond 2019).

Other states, such as California, have not attempted to track or count all water users. As a consequence, one study estimated that California has given four to five times as many water rights awarded, on paper, as there is actual water in the state (Grantham and Viets 2014).

Furthermore, data recorded during water-rights adjudications are rarely if ever updated. The information becomes static, dormant in time at the point of final decree of waters, and is rarely available to water users (in any state). This is problematic for states with data from adjudications that may now be decades old as the numbers reflect past historical, often agrarian, uses.

Water is constantly moving, yet in water codes throughout the west, it is treated as a fixed property right. For example, ‘x acre feet of water’ are awarded per acre of land to individuals. The vast majority of that water awarded is applied, then percolates, and drains away downstream. Most western states do not measure the consumptive use of water (by a crop, for example) in adjudications (Bryan 2015).

In some years, the quantity of water awarded might not be available. Drought may have dried the river or senior water-rights holders, with rights that date back further than more recent those of more recent ‘junior’ users, may have used all the water first. Individuals do not own the water itself, rather the use right to it. This matters because many water-rights users think of their ‘right’ as an absolute ownership, up to the quantity afforded in law, rather than as a contingent right affected by older (senior) water rights.

To explain this dilemma of micro-stationarity of water rights, the next section discusses how adjudications produce inaccurate data that complicate future outcomes by locking in data from decades past.

2.1. State adjudications and static data

Water adjudications are highly complex and expensive. They do produce an emerging picture about how many water rights were awarded and how much water—if any—is left in a state. However, the static results of these water-rights adjudications complicate the flexible needs and goals of water managers and state agencies.

Given the historical priorities of states and the mandates of early water codes, attention to the micro-scale of water rights was logical. Only decades later did the macro-scale interstate river compacts become a reality. Understanding these two scalar inputs of unknown and misestimated water data, respectively, is key to providing more accurate water scenarios in this century.

Viewed from the SES framework, water basins are complex socioecological systems, yet they remain difficult to integrate because of data challenges. Water rights are a key component that can structure whole outcomes in a basin system, shaping feedback effects. Internal errors from the unfinished efforts to assign fixed water rights can feed into larger miscalculations of available water when scaled up to basins or interstate river calculations and allocations, which can misinstruct a state’s understanding of its own water.

As an example, New Mexico has been adjudicating its waters since 1907. Over a century on, the process is only halfway complete (see figure 2). New Mexico’s ‘general stream adjudications’ take the shape of lawsuits, entraining every water-rights user in every basin. This means every individual with an assumed or recognized water right is sued by the state, along with their neighbors, to show proof of their water use.

This approach is thorough. It is also extravagantly time-consuming, expensive, and adversarial. Water users are forced into court and can also contest the water rights of other users in their basin (Perramond 2019). On the other hand, as a recent overview of adjudication has suggested, New Mexico’s is the only western state to consider the actual consumptive use of water (Bryan 2015).

Applications for new water use permits continue to be filed with and given by the Office of the State Engineer (OSE), although the agency lacks a complete picture of whether there is enough surface or groundwater to honor these new permits.

Notably, as seen in figure 2, New Mexico has not yet adjudicated the main segment of the Rio Grande, the state’s largest river. That segment contains not only the largest water conservancy district and but also the
largest city, Albuquerque and its expanding suburbs. The state has spent a century and a fortune counting water in smaller headwater basins, and yet its main population and agricultural core remains unaccounted for.

In contrast, Colorado is considered both fully adjudicated and well-sorted (legally) for enforcing water rights using prior appropriation water law. Colorado follows a structured approach that enables individual claimants to water rights to present their evidence to a state water court (state courts that also serve as a ‘water court’). These claims are then entered into the state’s inventory of active water rights, sorted by historical priority (first use date). While fully adjudicated, the process of adjudication in Colorado is considered ‘live’ and organic and can be updated (Bryan 2015).

Consumptive use is not considered as part of Colorado’s water-rights adjudication process. However, the net aggregate of recorded water-rights data are considered accurate compared to New Mexico or Idaho. Colorado also maintains a robust and publicly available set of data for the full spectrum of the state’s public trust responsibilities including its instream flow program.

In Idaho, the recently completed Snake River adjudication is a major accomplishment. The Snake, Idaho’s largest river, was given priority in the adjudication process. Tributaries were also addressed, and while minor work continues, the Snake River adjudication has provided the state agency with useful and current data. Like in New Mexico, the resulting data are fixed. The final calculations also lack information on consumptive use of water, but they do presumably reflect more current water use and water-user diversions in the 21st century (Bryan 2015).

Water-rights adjudication procedures and outcomes vary markedly across the western states. Even completed adjudications may not offer a predictable dataset for how much actual water is contemporary within each western state since most states (except for Colorado) do not update water-use changes over time.

State agencies rarely have a complete water-rights data set to engage in rigorous and actual data modeling. Worse yet is that institutional mechanisms to quantify water rights may be obsolete, and water users may have a false impression that they have absolute rights to fixed water quantities.

The lack of current and publicly available data thus hinders modeling and understanding of complex socioecological systems across multiple scales. Furthermore, the lack of data may give false impressions on water availability. Without a full water accounting, states may also continue to dole out rights, even knowing that ‘paper’ rights exceed the actual amount of water available.

At every level and scale of water use, the perception of water’s fixity offers few solutions to water managers. Western water managers struggle to fulfill multiple demands, from expanding urban centers, laws requiring ‘living water’ for rivers, and multi-state river
3. River compacts and macro-stationarity

The problems of obsolete and fixed data at the microscale can also be seen separately at the macroscale. Throughout the American West, states not only have to manage their own water and water-rights users. They must also satisfy compacts where multiple states share the same river. The data used in river compacts are different from those obtained (or not obtained) in water-rights adjudications. However, similar complications arise from erroneous data and policy stationarities.

At the macro-scale, along larger river basins and interstate river compacts, the rigid structures of water deliveries and water compacts between states reflect the challenges of fixed water quantity assumptions and averages. The reluctance to move away from dated state and interstate water agreements is strong; after all, these are often legally mandated in state water codes and in old river compacts.

The Colorado River Compact of 1922 is an ideal example of these cemented legal-policy data. The compact numbers were built on an almost comically high, yet politically desirable, estimate for dividing up the Colorado River (see figure 3). Framers of the 1922 compact chose an optimistic period of the river’s hydrology to fix the 18.1 million acre feet (maf) estimate used to divide the basin between upper and lower basin states.

Just six years prior, the best available study suggested the river carried only 14.8 maf. Since the 1980s, the Colorado River has often averaged around 13.1 maf, nearly 30% less than the compact’s allocations. Political expediency and western state development plans created a structural deficit between the waters imagined to exist in 1922, its century-flow average, and the more recent 13.1 maf now flowing since the 1980s (as reviewed in Kuhn and Fleck 2019).

These policy data stationarity concerns matter to real water users, as well as water managers. New Mexico, which is still unsure of its internal total count of water rights, is an upper basin state that has recently begun to move water out of the Colorado River basin based on the optimistic data of 1922. This new inter-basin diverted water has largely gone to New Mexico’s cities for drinking water. Figure 3 illustrates out-of-basin regions that are also dependent on Colorado River water or its tributaries.

The diverted Colorado River water in New Mexico then mingles with flow through the Río Grand, much of which has not been adjudicated. New Mexico faces a real challenge to discern between local water (Río
Grande) and new imported water (Colorado River water). Cities such as Albuquerque and Santa Fe are also increasingly dependent on these augmented waters in the Rio Grande, having spent hundreds of millions of dollars (each) for water pumping and water treatment facilities.

New Mexico is not alone. Colorado, as seen in figure 3, and California, are also highly dependent on out-of-basin transfers from the Colorado River. Colorado is well positioned to understand how upper-basin shortfalls might impact water rights in the state since it is fully adjudicated. California is not, having foregone attempts to measure its water.

Junior and senior rights also apply to states. Arizona has junior water rights to California, as the former diverted water from the Colorado River later than California. Arizona is thus in an even more precarious position should water deficits and curtailments occur. Because of the lack of flexibility in the 1922 compact language, lower basin states have been forced to draft drought contingency plans.

As in the state water-rights adjudications, with few updates to water rights, most early compacts poorly reflect historical changes to water use, much less contemporary, hydrological conditions. The fixity with which individual states treat water rights is duplicated, at this larger scale, by historical errors in estimate river flows in inter-state river compacts. These errors occur at different scales, beginning with water rights, to the erroneous and optimistic data used in river compacts.

The macro-scale fixity of river flows can and does affect how states use or store water on the Colorado. Because of California’s senior water rights on the river, for example, any severe drought might provoke curtailments to water use in the upper basin if a long-term arrangement cannot be negotiated (Kuhn and Fleck 2019).

Furthermore, climate change will claim its own water right regardless of river compact amendments or interim guidelines for apportionment. Planning for increased evaporation and conveyance loss from increased warming is in the best interests of managers, users, and politicians, rather than clinging to old accords based on inaccurate data (Kuhn and Fleck 2019).

Ensuring that new social (water) data are then coupled to accurate biophysical water data would seem logical. For water resource managers and policymakers, finally addressing the static natures of state-level and river flow data in river compacts would provide an opportunity for agencies to make adjudications and compacts more accurate for the next century.

4. Discussion and conclusion

As argued here, the dimensions of legal and policy stationarity occur at two problematic scales: in water rights at the micro-scale and in interstate compacts and basins at the macro-scale. These separate types of data provide a misleading picture for water resource managers. Like most environmental challenges, the root causes are not scientific but social, legal, and political in their dimensions. They also reflect a difficult data gap for modeling using SES frameworks (Partelow 2018).

The data needed to accurately quantify any meso-scale connections between basins and water rights remain murky and uncounted. Scaling up, river compacts that divide gross amounts of water in million acre feet units rely on historically optimistic river flow amounts that no longer exist.

Water managers, scientists, and users have long recognized that biophysical stationarity of most rivers was a fiction. Yet the ‘Law of the River,’ in the case of the Colorado, has not been amended to reflect our current scientific understanding of the river’s hydrology. Legal-policy stationarity will have to change to reflect new water and climate realities (Christian-Smith et al 2012, Udall and Overpeck 2017). This would mean addressing both scales of ‘stationarity’ and cemented water rights and compacts (Milly et al 2008, Kuhn and Fleck 2019).

Our current understanding about the seasonal, annual, and decadal variability of rivers is certainly better than it was a century ago. That scientific understanding has not yet affected the static nature of our legal policies, either at the micro-scale of water rights or the macro-scale of misleading river compact numbers. This is the central challenge, as other studies have noted for both groundwater and surface water (Jones et al 2019, Kuhn and Fleck 2019).

More specifically the data recorded by treating water as a property right, and the data trapped in false river flow assumptions, drive a continued stasis in formal policy and legal statutes. This is true within individual states for water rights, as it is for larger interstate water compacts.

The concept of uncertainty is a vital principle of the scientific method and evolving practices for hydrological measurement and monitoring. However, uncertainty is an uncomfortable fit for legal water codes and interstate compacts, although western water policy makers still rely on firm, yet fictional hydrological data.

Water managers, politicians, and policy makers strive to manage water for all expected outcomes and water users, yet the current focus remains on often fixed and inaccurate water allocation, not on how water policy and infrastructures can be made more resilient and less vulnerable (Berrouet et al 2018).

New water infrastructure itself, or by itself, will not resolve the dual nature of static water rights or the erroneous hydrological data discussed herein (Bryan 2015, Kuhn and Fleck 2019). The institutional stasis, or unchanging form of the social and legal systems, is as important a challenge as the diminishing or varying seasonal flows of water from less snowpack in this century.
As western water agencies consider new demands on water from burgeoning cities (Garrick et al 2019) and the demands to protect endangered species and support ‘living’ rivers (Perramond 2019), these new and competing mandates are now more pressing for managers and policy-makers alike (Postel 2014).

The unchanging empirical data, trapped in assumptions of biophysical stationarity and legal-policymaking stationarity are equal challenges in the 21st century. It is time to manage for water that actually exists in rivers, rather than the static and inaccurate water quantities used a century ago by western policy-makers to craft interstate river compacts.

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