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Water Law and Climate Change in the United States: A Review of the Scholarship

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Abstract

Climate change's effects on water resources have been some of the first realities of ecological change in the Anthropocene, forcing climate change adaptation efforts even as the international community seeks to mitigate climate change. Water law has thus become one vehicle of climate change adaptation. Research into the intersections between climate change and water law in the United States must contend with the facts that: (1) climate change affects different parts of this large country differently; and (2) United States water law is itself a complicated subject, with each state having its own laws for surface water and groundwater and the federal government playing a significant role in interstate and international waters, in building and managing large water infrastructure, and in creating water rights for Native American tribes and other federal reservations. Within this complexity, legal research to date has tended to focus on the law governing surface water in the American West, enumerating various problems with the prior appropriation doctrine as the West grows hotter and drier and offering multiple suggestions to increase legal flexibility so that western water can be re-allocated to reflect changing social-ecological realities. These suggestions extend to new, more comprehensive, and more adaptive water governance approaches. Far less scholarly attention has focused on eastern riparian rights, the various groundwater doctrines at play in the United States, or the increasing role of tribes in managing water resources, but these areas warrant future attention.

1. INTRODUCTION

In many parts of the United States, climate change is arguably already actively challenging current water user expectations, water management regimes, and water rights—in other words, all of the components of water law. Climate-change-induced alterations to water resources include changing precipitation patterns and groundwater recharge rates; warming waters; and coastal saltwater intrusion into both rivers and aquifers as a result of sea-level rise (IPCC, 2014). The intersection of climate change and water law, moreover, has one facet of climate adaptation law in the United States. Water use certainly has connections to greenhouse gas emissions and hence to climate change mitigation, especially at the water-energy nexus (Craig, 2010a; Tarlock, 2010a; Hall, Stuntz & Abrams, 2008). However, in the main, research investigating the interactions between climate change and water law in the United States has focused far more on climate change's implications for water use and thus on how individuals, communities, and legal systems can adapt to the coming changes in water resources and water supplies.

Thus, for the 21st century and beyond, climate change will be intimately relevant to water law, the law that governs the allocation and use of water. In the United States, water law is generally

distinguished from water *quality* law (pollution control) and instead embodies a unique form of property law that grants usufructuary rights to water resources—that is, rights *to use* water instead of title ownership to the waterbody (Craig, Adler & Hall, 2017). As a form of property, water rights in the United States generally derive from *state* law (Craig, Adler & Hall, 2017). Depending on the state involved, water rights can arise from ownership of real property abutting a river or lake or overlying an aquifer; the actual taking and use of water; successful completion of a state permitting process; or successful completion a water right adjudication or other court process (Craig, Adler & Hall, 2017). The resulting rights to use water, like any other property, are protected under both the federal and state constitutions (Abrams, 2018a; Craig, Adler & Hall, 2017; Owen, 2013), although water rights are often subject to a wider array of public rights, such as navigation rights, than is generally the case for other forms of private property (Craig, Adler & Hall, 2017). Finally, although federal law generally defers to state water law, federal law remains instrumental in: (1) protecting water rights created under different nations' laws before the relevant territories became part of the United States, such as through the 1848 Treaty of Guadalupe Hidalgo with Mexico (Craig, Adler & Hall, 2017), and implementing the United States' water treaties with Mexico (Miliband & Florez, 2018) and Canada (Pentland & Shirk, 2018); (2) impressing navigable-in-fact waters and waters subject to the ebb and flow of the tide with a public trust (Craig, Adler & Hall, 2017); (3) reserving federal water rights for federal lands, including Native American reservations, National Parks, and military bases (Abrams, 2018b); (4) providing the constitutional mechanisms and institutions to govern interstate waterbodies (Oyler, Klahn & Abrams 2018); and (5) managing larger river systems for flood control, water storage, hydropower, and irrigation through federal dams and reservoirs (Nikkel & Milibrand, 2018; Firsching, 2018; Craig, Adler & Hall, 2017).

The first complication in discussing the relationship between climate change and United States water law is the fact that the United States is a large and climatologically diverse nation. As a result, climate change is having different kinds of impacts on water resources in different regions of the nation, resulting in different implications for state water law. In some regions of the United States, such as the Southwest, the predominant climate change water problem is the progressive reduction of available fresh water resources as the region grows hotter and drier, punctuated by increasingly severe droughts (USGCRP, 2019). In other regions, such as in the previously reliably humid Mississippi and Missouri River watersheds and the Southeast, climate-change driven water law problems are more likely to stem from increased variability in precipitation, where a year or two of record flooding flips to unprecedented drought (USGCRP, 2019). Finally, climate change alterations to both the form of precipitation (generally less snow and more rain) and timing of spring rains and runoff (generally earlier in the year) will challenge water law in still other regions of the United States, such as the Pacific Northwest (USGCRP, 2019).

The second complication in discussing the relationship between climate change and United States water law is the fact that each state has its own water law. Two main water law systems govern surface water in the United States—prior appropriation (see **Sidebar 1) and** riparian rights (see **Sidebar 2**). However, these two divisions are general categories, and states within each category can exhibit significant legal variation. Among eastern riparian states, for example, some continue to rely primarily on the common law, while others have enacted statutes to both alter and regulate riparian water use, known as "regulated riparianism." Florida, California, and Hawaii do not fit neatly into either category, because each of these states combines prior appropriation and riparian rights in its own unique way; Hawaii also infuses its state water law with Native Hawaiian

water law principles (Craig, Adler & Hall, 2017). Groundwater law is even more complicated (see **Sidebar 3**). Most summaries and treatises recognize five legal doctrines governing groundwater use in the United States (e.g., Scanlan, 2019; Craig, Adler & Hall, 2017), although conceptually those categories can be reduced to three: absolute ownership of groundwater implemented through a rule of capture; shared reasonable use of groundwater by overlying landowners; and prior appropriation (Craig, Adler & Hall, 2017). Because research on climate change and water law in the United States tends to align with these legal distinctions, this article is also organized principally by water law doctrine, starting with the most active area of research: surface water and prior appropriation.

2. CLIMATE CHANGE, SURFACE WATER, AND WATER LAW IN THE UNITED STATES

Climate change's effects on water resources generally first become visible in surface waters. Not surprisingly, then, much scholarship on the relationship between climate change and water law in the United States focuses on how water law can cope with changes to surface waters—lakes, rivers, and streams. Because most of this scholarship has concentrated on western water issues, moreover, this part begins with prior appropriation and its relationship to climate change.

2.1 Climate Change and Western Prior Appropriation

Prior appropriation is the dominant legal system for allocating surface water in the states west of the 100th Meridian, including Alaska but excluding Hawai'i. The 100th Meridian is the line of longitude stretching from mid-Texas to mid-North Dakota, which traditionally has represented the water resource and water law divide of the continental United States: east of that line, farming was possible without irrigation, while west of that line irrigation has always been necessary, except in a few rainy pockets of the Pacific Northwest (Craig, Adler and Hall, 2017). Notably, western writer Wallace Stegner both memorialized and helped to mythologize the importance of this line in his 1953 book, *Beyond the Hundredth Meridian: John Wesley Powell and the Second Opening of the American West*, tracing Powell's journey down the Colorado River. Aridity and a relative paucity of surface water resources have always been the defining water characteristics of the United States' West, and those characteristics combined with a territorial mining history to promote the adoption of prior appropriation (see **Sidebar 1**).

Sidebar 1: The Basics of Prior Appropriation

Prior appropriation has different origins in the United States, but its development and adoption is generally linked to early mining customs in the western territories, when miners operated on federally-owned lands and hence did not have riparian rights. Prior appropriation is a "first in time, first in right" system, where the first person to divert water from a particular source and use it for a beneficial use (mining, farming, cattle, domestic use, and so forth) acquires a right to that quantity of water superior to anyone who later withdraws water from the same source—i.e., the senior water right. Water can be used anywhere, but once the place of use is established, the water right becomes appurtenant to that property and transfers with the real property unless explicitly severed in the transfer. Western states eventually transitioned the common-law system of prior appropriation to permit systems or, in Colorado, water courts. In addition, most western states have eliminated riparian rights entirely (albeit at different times), the major exception being California, which continues to recognize both types of water rights in a complicated and highly idiosyncratic version of surface water law. Under prior appropriation, in times of shortage or drought, the most

junior water users are cut off ("curtailed") from using any water, while senior water rights holders continue to take their full right. (Waters & Spitzig, 2018; Craig, Adler & Hall, 2017; Dellapenna, 2010; Tarlock, 1992; Tarlock. 1991).

In one sense, prior appropriation is perfectly suited to climate change adaptation in the West. States in this region adopted prior appropriation in the first place in acknowledgement that water was scarce compared to in the East, and the West is projected to become even drier and hotter as a result of climate change. "First in time, first in right" has always meant that when the water runs out, junior water rights holders get no water. Prior appropriation *law* thus handles drought and scarcity fairly automatically—although on-the-ground enforcement is usually necessary to ensure that junior water rights holders actually stop using water. Nevertheless, prior appropriation rests on a false assumption about water resources—namely, that while western water supplies are inherently variable, they vary within a fairly stationary envelope (Hall, 2015), allowing dams, reservoirs, and other storage "solutions" to tide communities over between droughts (Tarlock, 1992). Climate change obliterates this assumption of stationarity (Craig, 2010b; Milly et al., 2008), but prior appropriation law generally remains unchanged.

Moreover, as historically developed, western prior appropriation poses three main problems for climate change adaptation. First, prior appropriation provides no incentive to leave water *in situ*, and most surface waters in the West are now fully or over-appropriated (Craig, 2018). As a result, prior appropriation has left much of the West without a water buffer to support either human surface water use or aquatic ecosystems under changing conditions. Thus, *any* climate change impact that reduces water supply almost certainly undermines somebody's water right or damages what remains of the relevant aquatic ecosystems, or both. Second, appropriative water rights are perpetual, and, given historical western settlement patterns, senior water rights remain concentrated in agriculture and ranching despite rapidly growing western cities (Craig, 2018). As a result, as climate change reduces water supplies in the West, it is humans in cities that tend to feel the pinch first, with potential public health implications (Craig, 2018). Finally, these perpetual appropriative rights are not very flexible. To change how or where the water is being used, the water right holder must successfully navigate a time-consuming state statutory approval process. Moreover, westerns states mandate that no proposed change can injure *any* other water user, including downstream junior users dependent on return flows, nor can the new use actually consume more water than the old use did (Craig, Adler & Hall, 2017). As a result, it is currently very difficult to re-allocate water in the West, especially at large scales, to reflect new social and economic realities or to support instream uses and aquatic ecosystems (Craig, 2018; Bretsen & Hill, 2009).

Given these limitations in prior appropriation, climate change scholarship addressing western water law has tended to focus on finding or creating flexibility in prior appropriation law to allow for the necessary re-allocations of water. By far, the flexibility-adding mechanisms that most interest researchers are water markets, including improved water transfer mechanisms and water banking (e.g., Halvorsen, 2018; Schilling, 2018; Hansen, Howiit & Williams, 2014; Rieblich & Klein, 2014; Hamburger, 2011; Makar, 2010; Tarlock, 2010a; Winchester & Hadjigeorgalis, 2009; Hall, Stuntz & Abrams, 2008; Glennon, 2005; Howe, 2000; Anderson & Snyder, 1997; Tarlock 1992). As one of the earliest investigators of this option, Tarlock (1992, p. 177) cautiously endorsed the water market approach, noting that water transfers traditionally "were the exception rather than the

norm" in the West but also that "the exception may become the norm. There is a growing consensus in the national environmental community and among urban suppliers that water should be reallocated from agricultural uses to municipal, industrial and instream uses in order to protect a broad range of environmental and recreational values." More than 25 years later, Schilling (2018, p. 117) enthusiastically argues that "[b]y providing a new mechanism and market by which rights may be acquired, water banks can help alleviate the overburdened state application system" and "promote conservation, create a secure water supply in dry years, help maintain instream flows, and ensure regulation compliance."

Nevertheless, not all scholars are convinced that markets and water banking will work (e.g., Craig, 2018) or that they will be enough to handle the West's water future (e.g., Hall, Stuntz & Abrams, 2008). Indeed, researchers have suggested that no amount of increased flexibility in western water law will be enough to allow western communities to adequately adapt to climate change. While some scholars propose developing new sources of water, such as rainwater harvesting (Harris, 2016; Bretsen, 2011; Findlay, 2009), many more emphasize reducing water demand. At the extreme, some scholars argue that water law must become a means of limiting western growth (Tarlock, 1991), but more commonly climate change becomes a reason for arguing that existing water use in the West needs to be drastically reduced through conservation and increased efficiency (Schilling, 2018; Clowes, Hustead & Kolowitz, 2016; Tarlock, 2010a; Amos, 2008; Hall, Stuntz & Abrams, 2008).

In addition, research has also proposed other legal mechanisms besides water markets to improve prior appropriation's flexibility in the face of climate change. Some scholars reach back to earlier moments in water law history and understanding, arguing for re-invigoration of common-law doctrines such as the public trust doctrine (Craig, 2010c; Craig, 2009) and the doctrine of public necessity (Craig, 2018; Craig, 2010d) or court decisions that recognized that even prior appropriation must be reasonable (Tarlock, 2012). These doctrines and case decisions share a recognition that water is a public resource critical to human and ecological well-being and hence that private water rights, even though they constitute property rights, must always be balanced against, and limited by, the greater public good. Other researchers advocate for an "all hands on deck" approach that would pursue multiple water law reforms simultaneously (Olson, 2016; Hall, Stuntz & Abrams, 2008).

Because California both has been experiencing unprecedented drought and has a more idiosyncratic system of state water law than most western states, a significant portion of recent climate change-water law scholarship focuses specifically on California water law (Hajarizadeh, 2019; Harris, 2016; Kavounas, 2016; Pearah, 2016: Hall, 2015; Gray, 2008). Several doctrines in California water law arguably provide California with more water law flexibility than is true in other western states. For example, California's public trust doctrine both is dynamic and applies to water rights (Pearah, 2016; see also Craig, 2010c). California's state constitution also requires that *all* water use be reasonable (Pearah, 2016). Noting that "the California courts have held that the definition of reasonable use is dynamic," Gray (2008, pp. 1459-1460) argues that water managers could better deploy California's reasonable use doctrine to emphasize that "a use of water that once was reasonable may become unreasonable as economic, social, and environmental conditions change over time," allowing managers to retire outdated water rights as climate change alters social-ecological circumstances. Nevertheless, scholars of California water law and climate change also take on some of the root elements of prior appropriation, such as beneficial use. Hall (2015, p. 33), for

example, advocates a "new vision of beneficial use [that] will encompass environmental factors and the sustained continuation of state economies, not just what the water is used for and how much water is used. Thus, the water rights that vest outmoded and unnecessary water projects will be lost to make room for new diversions." Still other scholars stress the need for California to move quickly to conjunctive management of surface water and groundwater (Gray, 2008; see also Hobbs, 2010 (stressing the importance of this integration for Colorado)). This research acknowledges that California's historically lax laws concerning groundwater generally ignored the connections between surface water and groundwater resources and also allowed water users deprived of surface water rights during a drought to turn to massive groundwater pumping instead, to the detriment of both surface waters (and surface water rights) and the long-term sustainability of groundwater.

2.2 Climate Change and Eastern Riparian Rights

Less research attention has been paid to eastern water law, based on the common-law riparian rights system inherited from England (see **Sidebar 2**) and climate change. In part, this paucity of research engagement reflects the fact that eastern states, for the most part, still have sufficient water to avoid the kinds of shortage conflicts that tend to inspire calls for legal reform. Instead, as Spring 2019 amply demonstrated, flooding remains the larger water problem in eastern states for now—and flood control is an infrastructure (i.e., political and financial), not water use and allocation (i.e., legal), problem.

Sidebar 2: The Basics of Riparian Water Rights

The United States inherited the system of riparian water rights from England, and it still remains the dominant system governing rights to use surface water in the eastern states of the United States, where waterbodies and rainfall are plentiful. Under this system, real property that borders a surface water—a lake, river, stream, or the ocean—comes with a suite of rights to use that waterbody. These rights include the right to wharf out (build a dock), to fish and recreate in and on the water, to navigate the water's surface, to accretions, and—most importantly for water law—to take and use fresh water on the property. In the United States, riparian properties—that is, real properties that border a stream or river—and littoral properties—that is, properties that border a lake or the ocean—are generally treated the same. Traditionally, use of water was strictly limited to use on the riparian or littoral property in a manner that did not limit the natural flow of the waterbody. Most riparian rights states, however, have moved to a rule of reasonable use and have adopted special laws to doctrines to accommodate industrial users, starting with water wheels and mills in the 17th century; off-tract use of water by riparians; dams; and cities, which are generally *not* considered riparian owners even when they abut a waterbody. Importantly for climate change, all riparian or littoral owners on the same waterbody having co-equal rights to reasonably use the water at any time. Thus, common-law riparian rights are inherently adjustable and must accommodate new users and changing water conditions. (Waters & Spitzig, 2018; Craig, Adler & Hall, 2017; Tarlock 2010b).

Nevertheless, the United States East is already experiencing climate anomalies that impact water use, including water scarcity. For example, by Fall 2019, several states in the Southeast were experiencing what newspapers referred to as "flash drought," threatening water supplies and agricultural crops and promoting wildfire. Indeed, drought and heat temperatures have become increasingly common threats to water resources in the East. As one example, of the 43 incidents

between 2000 and 2015 where power plants had to either reduce or stop electricity production because water sources were either too hot or too reduced in volume to use for cooling water, all but four occurred east of the 100th Meridian—including all 25 of the incidents involving nuclear power plants (McCall, Macknick & Hillman, 2016, pp. 8-9 & fig. 5). These impacts help to explain the sharp increase over the last decade in eastern state litigation before the U.S. Supreme Court over shared water resources: South Carolina challenged North Carolina in 2007 over the Catawba River, but the two states settled their differences; Florida remains in litigation with Georgia over the Apalachicola-Chattahoochee-Flint River Basin after filing suit in 2013; and Mississippi remains in litigation with Tennessee over a shared aquifer after filing suit in 2014. The last major eastern interstate water dispute before this new wave was New Jersey's challenge against New York over the Delaware River, decided first in 1931 and revisited in 1954.

Common-law riparian rights are inherently adjustable (see **Sidebar 2**), arguably giving eastern states in the United States an inherent legal advantage in adapting to climate change's impacts to surface waters. As Tarlock (2010b) points out, however, many eastern states have sought to make riparian rights more legally certain by protecting existing uses to some degree or by adopting permit systems to regulate riparian water use, a legal evolution known as "regulated riparianism." While "[r]egulated riparian permits are potentially more adaptive compared to prior appropriation permits because legislation often gives state water administers some flexibility to condition new uses, use public interest considerations in deciding among competing applicants, and refuse, in whole or part, to renew time-limited permits," Tarlock (2010b, pp. 11-12) nevertheless posits that, because of these legal changes and the political difficulties that arise when governments try to end water permits, eastern states, like western states, will have to rely on water markets and water transfers to fully cope with climate change (see also Dellapenna (2004)). Following the same impulse, Rieblich and Klein (2014) provide a nation-wide survey of water transfer laws, analyzing such transfers as having potential relevance in *all* states—western and eastern—for water-related climate change adaptation.

In addition, most eastern states are unprepared, in terms of water law, for the droughts that they are increasingly suffering (e.g., Elliott, 2012). The reasonable use basis of riparian rights does not provide sufficient legal structure to deal with drought rationally or efficiently, even in many regulated riparian states; the traditional mantra of "share the shortage" (Craig, Adler & Hall, 2017) is an egalitarian but often inappropriate approach to managing drought or establishing priorities for water use in times of shortage. As Dellapenna further expounds (2010, p. 423):

> Riparian rights thus have serious problems as a mechanism for addressing water shortages, and thus for addressing the most serious disruptions relating to fresh water that arise because of global climate disruption. The problems include the vagueness, instability, and unpredictability of the criteria of decision in any dispute over water, the lack of a process for managing water during extreme shortages or for protecting public values, and a systematic bias in favor of large users

In light of riparianism's general inability to deal with drought, researchers have argued that additional storage capacity (where possible), increased conservation (Hall, Stuntz & Abrams, 2008), and innovations such as runoff capture (Tarlock, 2010b) may be necessary in eastern riparian states to adapt to water resources that are becoming significantly more variable. However, Elliott (2012)

argues that the enactment of a particular form of regulated riparianism would almost singlehandedly fix Alabama's looming water crises, including increased drought.

3. CLIMATE CHANGE AND GROUNDWATER LAW

Climate change can impact groundwater directly, most obviously by altering (usually reducing) aquifer recharge rates from surface precipitation and flows or, on the coast, through saltwater intrusion as sea levels rise (IPCC, 2014). However, the more immediate climate change concern for groundwater law in the United States is that people turn to groundwater as an emergency water supply in times of drought (e.g., Hammond, 2013, p. 599). Indeed, abuse of groundwater in California during the 2012-2016 drought became the major impetus for the state legislature to enact California's first groundwater statute, leading multiple researchers recently to examine how the state's new Sustainable Groundwater Management Act might become a vehicle for adapting to climate change (Scanlan, 2019; Bick, 2018; Forsythe, Jones & Kemp, 2018; Mettler, 2016; Pearah, 2016; Brown, 2015; Pace, 2015; Perona, 2015).

Sidebar 3: Groundwater Law Doctrines in the United States

Groundwater regulation varies considerably across the United States, and a state's groundwater law does not always match up well with the law it uses to govern surface water. In addition, not all states engage in *conjunctive management*—that is, recognizing legally that surface water and groundwater are often interconnected resources. From England, the United States inherited the **rule of capture** for groundwater. This approach, based on the fact that groundwater at common law was "secret" and occult, allows anyone who can find groundwater and pump it to own the water pumped and use it wherever the pumper desires. The rule of capture creates many perverse management incentives, and states—with the prominent exception of Texas—have largely replaced it with other doctrines. Many states, especially in the East, replaced the rule of capture with one of the three doctrines based on shared reasonable use of the aquifer by overlying property owners. The **American reasonable use rule** is groundwater's corollary to riparian rights: property owners overlying an aquifer can pump and make reasonable use of that water on the overlying property, co-extensive with every other property owner's right to do the same. The **Restatement (2nd) of Torts** variation on this rule gives more protection to pre-existing uses, recognizes the connections between groundwater and surface water, and allows for off-tract use. Finally, the **correlative rights doctrine** allowed an overlying landowner to pump water proportional to the amount of the aquifer that the land covered. The correlative rights doctrine was most strongly associated with California, but in 2014, in the middle of the 2012-2016 drought, California's legislature enacted the Sustainable Groundwater Management Act, which emphasizes local management of groundwater, particularly in areas where aquifers are overpumped. The last groundwater doctrine in the United States is **prior appropriation**, which, as for surface water, is based on "first in time, first in right." Most western states besides California use prior appropriation for groundwater as well as surface water, but Arizona non-conjunctively manages groundwater through its 1980 Groundwater Management Act, for designated Active Management Areas, and under common-law reasonable use everywhere else. (Scalan, 2019; Craig, Adler & Hall, 2017; Dellapenna, 2013).

Nevertheless, despite long recognition that the United States' groundwater resources, especially in the West, are in trouble (Glennon, 2002; Votteler, 2002; Glennon, 1991), research

focusing on groundwater *law* and climate change in the Unites States is far more limited than expositions on surface water law. Some of the improvements posed for surface water management, such as water conservation and flexible legal doctrines like the public trust doctrine (Tuholske, 2008), are also potentially important to groundwater management in a climate change era. However, as in California, researchers are more interested in *new* groundwater law—either legislative action (Scanlan, 2019; Paul, 2017; Welles, 2013; Votteler, 2002; Glennon, 1991) or new interstate compacts (Mann, 2009)—to protect groundwater than in the more traditional groundwater legal doctrines. In one of the most recent examples of this focus, Takacs (2018, p. 221), recognizing that groundwater resources are becoming problematic in the East as well as in the West, criticizes the Wisconsin Legislature's decision to reduce regulation of groundwater extraction, proactively arguing that even water-rich "[s]tates and local governments should maintain the authority to regulate the quantity of groundwater supplies with flexibility and adopt policies that focus on long-term sustainable water use" in preparation for climate change.

Otherwise, researchers have been generally unwilling to address traditional groundwater legal regimes as a climate change issue. In part, this reluctance arises because traditional groundwater doctrines operate slightly differently than surface water law, particularly in the East. As Scanlan (2019, p. 73) notes, "While the five groundwater doctrinal approaches . . . provide after-the-fact remedies in groundwater disputes that rise to the level of litigation in court, they do not generate forward-looking comprehensive approaches to managing common pool groundwater resources, much less conjunctive management of interconnected surface and ground waters."

Like Scanlan (2019), researchers consistently argue that conjunctive management of surface water and groundwater is not only inherently more rational than treating the two types of waters as separate resources, but is also an important legal path to climate change adaptation (Hedges, 2011; Hobbs, 2010; Gray, 2008). Thus, Davis (2004) argues that states should protect surface water runoff because of its role in recharging groundwater and drinking water supplies in part because of global warming. Specific new legal tools can also ease the necessary adjustments to water rights that come when states acknowledge in law that what used to be independent water rights to two separate water resources are really competing rights to the same water. For example, Nelson (2015, p. 193) has argued that groundwater offsets—a tool that allows a groundwater user to offset harm to connected surface water users—is a "strong, pre-existing structure" in many states that could help to the transition to more conjunctive management of changing water resources, while Scanlan (2019) has suggested that Aquifer Storage and Recovery could become a tool in promoting conjunctive management. Most expansively, Lindsey (2014-2015, pp. 624-625) would extend the concept of hydrological connectivity to nationwide management of water resources, arguing that climate change demands this step:

> In order to effectively govern water rights allocations, the entire water system needs to be analyzed in the context of climate change to ensure the preservation of sufficient water for our whole country. There is not enough of this precious resource to let it fall through the gaps of our management systems. We need to adopt a holistic approach to accounting for climate change impacts on every element of the water system in an environment where every drop counts.

Thus, Lindsey would radically change not only water law but water federalism, simultaneously converting both groundwater and surface water into *national* resources. Leshy (2008), similarly, has noted that the federal government could play a larger role in groundwater management.

4. CLIMATE CHANGE AS THE CAUSE OF MORE SIGNIFICANT RESTRUCTURINGS OF UNITED STATES WATER LAW AND GOVERNANCE

In addition to examining the implications of climate change for riparian rights and prior appropriation, researchers have also explored the implications of climate change for the larger legal structures applicable to water resources. Such explorations have generated four main subsets of scholarship: examinations of interstate and international water allocations in light of climate change; investigations of climate change's implications for traditional water law federalism; arguments that water law can no longer operate in a legal silo, detached from related areas of law; and advocacy for new kinds of water governance that can better respond to rapidly changing social-ecological conditions.

4.1 Re-Working International Treaties and Interstate Compacts and Apportionments

One of the aspects of water law that has always had a federal component is the sharing or co-management of interstate and international water resources. Under the U.S. Constitution, the federal government is the only government that can negotiate international treaties, including water treaties (art. II, § 2, cl. 2). Interstate issues are also inherently federal under the U.S. Constitution's Interstate Commerce Clause (art. I, § 8). Through negative implication, the Interstate Compacts Clause (art. I, § 10) allows states to negotiate interstate agreements—compacts—about shared water resources (and other matters) so long as Congress approves those agreements. In addition, the U.S. Supreme Court has original jurisdiction to equitably apportion waterways between or among states, and Congress can (although rarely does) dictate how states will share interstate water resources (Craig, Adler & Hall, 2017).

Most major interstate water bodies in the United States are now governed by interstate compacts, and climate change poses challenges to those compacts' operations (Brown, 2016; Hall, 2010). In the East, scholarly attention has focused on the Great Lakes (e.g., Kane, 2017; Dellapenna, 2014; Camacho, 2008; Hall & Stuntz, 2008). These relatively shallow lakes, although huge in surface area, are remarkably sensitive to water withdrawal. The interstate compacts and international agreements that govern these lakes are on paper remarkably protective of them—protections that grew even stronger when less water-rich areas of the United States, and even foreign countries like Japan, began to seriously consider the Great Lakes as a new source of water to import (Anderson, 1999). Nevertheless, Kane (2017) argues that the United States and Canada still need to formalize their "no withdrawal" agreements into a legally binding treaty to ensure that the Great Lakes are not drained in this climate change era.

In the West, although researchers also pay attention to the Columbia River Treaty renegotiations with Canada (Cosens, 2016; Cosens & Fremier, 2014; Cosens, 2012; Osborn, 2012; Cosens, 2010), the Colorado River is widely recognized as presenting the most daunting interstate and international water law challenges in light of projected climate change impacts (e.g., Ferguson, 2019; Halvorsen, 2018; Dikeman, 2017; Kenney et al, 2011; Adler, 2008; Craig, 2008; Mulroy, 2008; Powell, 2008; Wegner, 2008). The "Law of the River"—the collective reference to the statutes,

compacts, U.S. Supreme Court decisions, water projects, operations manuals, treaty, minutes to the treaty, and tribal water settlements that govern who gets how much water from the Colorado River—has always over-allocated the river. Satisfying all of the states' and Mexico's claims to the river requires an average flow of 16.5 million acre-feet of water per year (tribal allocations come from the relevant state's share of the river) (Craig, Adler & Hall, 2017); an acre-foot is the amount of water it takes to cover an acre of land with a foot of water, amounting to almost 326,000 gallons. Historical records indicate that the Colorado River's average flow has been more like 15 million acre-feet, and climate change will drop that average even lower (Powell, 2008), perhaps drastically so. In 2008 (p. 22), Adler suggested that the 1922 Colorado River Compact that began the Law of the River, like prior appropriation, does "not contain sufficient flexibility to address the magnitude of changes in scientific knowledge and understanding, social and political views and forces, and physical circumstances that have occurred since 1922." Most recently, Ferguson (2019, p. 118) argues that fixing the Law of the River would be "the most effective way of solving the water crisis," allowing the entire Southwest to more effectively adapt to climate change.

4.2 Climate Change Challenges to State-Law Dominance in Water Law

Federalism denominates the division of legal authority in the United States between the various states and the federal government, and scholars generally acknowledge climate change is a federalism issue in this country (e.g., Glicksman, 2010). Water law can emphatically highlight climate change federalism issues. As noted, water law in the United States is generally a state law issue, and Congress often defers to state water law (Craig, Adler & Hall, 2017; Adler, 2010). However, there has always been a substantial federal law component to water law in the United States, creating federalism tensions even before climate change became a pressing water law issue (Benson, 2015; Adler, 2010).

Climate change will likely exacerbate these federalism tensions in water law by creating adaptation needs at geographic and political scales larger than the state (Benson, 2015; Lindsey, 2014-2015; Abrams & Hall, 2010). Because of the economic importance of water, increasing water crises, and the interstate nature of most major rivers and lakes, the federal government may have to play a bigger role in water allocation and management as climate change increasingly upsets settled expectations (Adler, 2010). The prominent federal role in national energy policy and the reality that most sources of energy depend on water supply (the "water-energy nexus") provides another reason that the federal role in water management and allocation may increase as climate change progresses (Craig, 2010e). In addition, federal agencies such as the Bureau of Reclamation already manage significant surface water reservoirs and water delivery systems that will need to be part of water law's climate change adaptation (Benson, 2017; Benson, 2012; Makar, 2010), while Leshy (2008) has described federal legal authority to increasingly manage groundwater. Finally, the growing involvement of tribes in water management in this climate change era is an important but under-theorized aspect of changing water authorities and law in our federalist system (e.g., Greetham, 2012).

4.3 Adapting to Climate Change by Unifying Water Law with Other Areas of Law

State water law often operates independently of other legal considerations that seem inherently relevant to water management. In many western states, for example, water allocation

law and prior appropriation have almost no legal intersection with water quality law (Craig & Firsching, 2018), and across the country, states have only recently begun to connect land development permissions to the acquisition of sufficient water rights to support that development (see Arnold, 2005). At a slightly larger scale, energy law and water law have operated independently and occasionally at cross-purposes (Craig, 2010e), despite recognition on both sides that there is a water-energy nexus (Craig, Adler & Hall, 2017). Finally, state water law has traditionally ignored the estuaries and marine ecosystems into which (depleted) rivers and streams empty, even in coastal states (Craig, 2008).

Researchers increasingly argue, however, that climate change will demand the unification of several of these previously siloed areas of law (e.g., Loë & Patterson, 2017; Benson, 1998). These arguments are particularly prevalent regarding the need to merge water law and land use/development law (Hajarizadeh, 2019; Kavounas, 2016; Bryan Mudd, 2013; Hammond, 2013, p. 581; Arnold, 2005). For example, Kavounas (2016, p. 1078-1079) laments the fact that "[i]n California, there are no laws that specifically prohibit land development when there is no adequate water supply to support a new development."

At the same time, climate change impacts on water are beginning to influence how state water law intersects with federal environmental law. Perhaps most visibly, federal protection of aquatic species under the Endangered Species Act increasingly threatens to override state water rights (Craig, Adler & Hall, 2017). Nevertheless, given prior appropriation's well-documented tendencies to drain rivers and streams dry, Tuholske (2010) advocates for increased use of the Endangered Species Act in the face of climate change, as one of the most effective legal methods available to ensure that at least some water remains in western rivers and streams for fish and wildlife. In turn, Wegner (2008) praises both the Endangered Species Act and the National Environmental Policy Act (NEPA) as legal vehicles for improving management of the Colorado River. In the East, Hammond Wagner (2019, p. 574) notes that Vermont's system of regulated riparianism is failing to protect Lake Champlain water quality, arguing that "in practice, [Vermont's] environmentally sound legislation defers to economic, anti-ecological decisions" and that "Vermont, and other riparian states, should reframe the role of government—and the riparian regime—around an environmental ethic that prioritizes respect for ecological boundaries over economic growth and development." Similarly, Camacho (2008) argues the Great Lake's overall governance for natural resources is too fragmented to provide real adaptive capacity in the face of climate change, requiring more unification of water law and other forms of natural resources management. More generally, Ruhl (2010, p. 402) foresees a unification of environmental law, water law, *and* land use law in response to climate change, emphasizing that "[m]any contemporary large-scale problems involve all three fields of law working in a complex amalgam, making it difficult to characterize the problem as about land use, water allocation, or the environment. Climate change will rapidly move the three fields of law even closer together, likely to the point that it will be meaningless in many contexts to think of them as separate fields of law and policy."

4.4 The Emergence of More Adaptive Water Governance

As noted for both prior appropriation and riparianism, water law has evolved in the United States to favor surety of property rights. This evolution has substantially reduced water law's flexibility to deal with either changing social realities such as the shift of population from rural areas

to cities or climate change and its impacts on aquatic resources and ecosystems. While much research focuses on adding flexibility from within the existing water law systems, researchers increasingly suggest that, ultimately, water governance itself may need to become (indeed, in some places is already becoming) not only broader than the traditional United States conception of "water law" but also inherently more adaptive and responsive to the realities of climate change, in order to promote social-ecological resilience to those changes (Arnold, 2014). What all of this research shares is an advocacy for water governance approaches that can change water allocation arrangements and their own goals for water management as the water resource itself changes, especially in response to climate change.

Several versions of this more adaptive water governance have been proposed. For example, adaptive management is often described as "learning by doing" and, done properly, would allow water managers to experiment with new management techniques and water allocations over cycles of learning to find better ways to achieve management goals as a particular water resource changes (Hoffman & Zellmer, 2013; Neuman, 2001). However, existing administrative law imposes serious impediments that generally prevent governmental water agencies from engaging in scientifically valid adaptive management, leading Craig and Ruhl (2014) to propose entirely new legislation to allow true adaptive management to proceed.

Adaptive watershed planning is a second conception of this drive toward more responsive governance. Watershed-based planning and management have long been proposed as improvements to state water law by focusing management attention on natural water systems—the entire watershed or river basin—rather than fragmenting water management at arbitrary political boundaries (e.g., Teclaff, 1996). Adaptive watershed planning both makes watershed-based management more responsive to climate change and, through the planning process, "gives some direction and focus to adaptive ecosystem management activities by combining decisional structures, goal-setting processes, and resource availability with flexibility, adaptability, multi-criteria decision making, and iterative feedback loops with continual or periodic plan adjustments" (Arnold, 2010, p. 421).

Even newer and more radical is adaptive water governance, which is governance "that allows adaptive processes to emerge" (Cosens, Gunderson & Chaffin, 2014, p. 3). Adaptive water governance builds on the recognition that new, extra-legal governance arrangements have emerged in several river basins in the United States as a result of changing social-ecological realities. For example, in the Klamath River Basin straddling the Oregon-California border, drought and the demands of the Endangered Species Act at the beginning of this century led first to litigation and bitter legal battles, but eventually induced the various stakeholders to craft new governance arrangements that may lead eventually to the removal of several outdated dams in the system (Chaffin, Craig & Gosnell, 2014). (An interim quantification of very senior tribal water rights to the river has also significantly changed the governance dynamics for the River Basin.) Such emergent and more flexible water governance "enables society to navigate the dynamic, multi-scalar nature of social ecological systems" while simultaneously enhancing their resilience to climate change (Cosens, Gunderson & Chaffin, 2014, p. 3).

Conclusion

Water law and water law research both respond to scarcity. As such, proposed and actual innovation in water law related to climate change has been most robust for areas of the United States already experiencing the most noticeable new or worsening drought, progressive loss of water resources, or both—in broad strokes, the West (especially the Southwest) and Southeast. Consensus has yet to emerge, however, as to whether existing state water law systems can adapt to climate change impacts through relatively limited and state-based legal tinkering—water markets, increased conservation, increased and better regulation and conjunctive management, revival and strengthening of legal doctrines that add flexibility—or whether instead major structural overhauls of the current state-based allocation systems will become necessary, even critical—the federalization and nationalization of water resource management; the fusion of water law, ecosystem-based management, land use planning, environmental law, and coastal protection; the replacement of stationarity- and common-law-based water law systems with far more flexible and adaptive governance institutions that pursue overall social-ecological resilience to climate change rather than the reification of private property rights in water; or, perhaps most simply, the massive resettlement of the United States population away from increasingly water-scarce regions.

This is an important debate regarding the interactions between water law and climate change in the United States, but it is unlikely to be resolved until both: (1) the full impacts of climate change on United States water resources are better understood and appreciated; and (2) patterns of voluntary human adjustments become clearer. As for the first, as one example, it makes a large difference to the future of western water law whether average flows in the Colorado River drop by 10 percent, or by half, or if the river runs dry—and how fast that change occurs. As for the second, California faces a very different water law problem if its Silicon Valley industries, Hollywood film studios, agriculture, and their attendant societal support systems move *en masse* to Michigan and Wisconsin than if they stay where they are.

In the meantime, well-developed arguments about how to improve water law in the face of uncertainties about climate change allow both consensus regarding water law best practices and new legal innovations for discussion to emerge. In turn, a well-developed research literature regarding these best practices and suggested innovations becomes available to legislatures and courts that are motivated to adapt to changing water realities. From this perspective, it is worth pointing out some of the more under-theorized aspects of water law's intersections with climate change—areas where research is not yet supporting future legal adaptation. Eastern riparianism, including regulated riparianism, has received scarce legal research attention compared to western prior appropriation. Nevertheless, given the changing circumstances in the East and the growing variety of state regulatory systems, researchers should be able to begin to identify forms of riparianism and regulatory mechanisms that promote beneficial adaptation to climate change—or at least avoid the worst consequences of climate disruption. Similarly, beyond a strong and growing consensus that states should manage groundwater conjunctively with surface water, work on how to improve groundwater law in the face of climate change is fairly limited. Finally, Native American tribes are becoming increasingly important water rights holders and water managers across the United States. Particularly in the West, water rights settlements and court decrees are progressively quantifying tribal water rights, which are often very senior water rights. Across the nation, tribes are increasingly accepting Congress's invitation through the Clean Water Act to manage water quality on their reservations. The sometimes fairly dramatic and legally controversial activation of this third water sovereign can visibly change water management power dynamics and politics, as has occurred

in the Klamath River Basin—and yet tribes' roles at the nexus of climate change and water law have received embarrassingly little attention, even in places like Florida where tribes have had independent management authority for decades.

Climate change is *the* water law issue for the 21st century, and much work remains to be done. Researchers, stakeholders, courts, and legislatures will all do important work in ensuring that the United States as a whole can adapt to its changing water resources—but that work is better accomplished through thoughtful and creative anticipation of future water law needs than through hurried decision making in response to worsening crises.

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