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The myth of abundance: water resources in humid regions

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Abstract

Water resources in humid regions are perceived as abundant, and water-governance systems are based on the expectation of consistent availability of water to meet all needs. In arid regions, in contrast, the operating assumption is that water is a scarce resource that must be allocated systematically to avoid conflict. The 'myth of abundance' common in humid regions is counterproductive to effective water governance. This paper provides an overview of the concepts of water scarcity and water security and explains how water governance in humid regions fits into these frameworks. It then addresses the riparian system for allocating water rights and how this system promotes the myth of abundance. Three case studies are presented from humid regions of the Anglophone world, highlighting the shortcomings of abundance-based water-governance systems in these regions. Finally, the water-security framework is advocated as an alternative that addresses fundamental flaws of the abundance-based approach, namely issues related to ecosystems, water quality, disasters, and conflict. Using a goal of water security, rather than a perception of abundance, as the basis for water governance will lead to improved outcomes, especially given future climate change and population growth.

Keywords: Riparian doctrine; Water governance; Water resources; Water security

Introduction

Effective governance of water resources is essential to economic development, human health and well-being, and ecological integrity (Loucks, 2000). Water governance is the set of processes and institutions through which water-management goals (planning, developing, distributing, and facilitating the use of water resources) are defined (Lautze *et al.*, 2011). The challenges involved in accomplishing these objectives are most obvious in arid and semi-arid regions (those where average annual potential evapotranspiration exceeds average annual precipitation), where there is so little water that conflicts over its use seem inevitable wherever there is a sizable human population seeking to use the resource (Ragab & Prudhomme, 2002). Humid regions (those where average annual precipitation exceeds average annual potential evapotranspiration), in comparison, seem to enjoy an abundance of water that would greatly

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reduce the challenges of managing water quantity. For example, Mehan & Brooks (2008) point out that water is perceived to be an abundant resource in North America. In the arid western part of the continent, there is a general awareness that water is a limited resource, but this is not the case in the humid east.

This perception of abundant water resources in humid regions is demonstrated by the results of numerous public surveys and focus groups. Focus groups conducted in three Georgia cities found widespread skepticism about the severity of water-quantity problems, even though the study was conducted in the year after a drought (GDNR, 2003). Even after the severe and widely publicized 2007–2008 drought in the region, only 44% of respondents in a statewide survey of Georgia residents believed that water quantity is a problem (Evans *et al.*, 2011). In a survey of four Pacific Northwest states, over 62% of respondents believed that water quantity is not a problem in their area (Mahler *et al.*, 2004). In a 2009 survey in New Hampshire, fewer than 30% of respondents felt that water supply is a severe or moderate problem in their communities (NHDES, 2009). A 2009 national survey of New Zealanders, as well as focus groups in Auckland and Wellington, found that most residents perceive water as 'plentiful and limitless' in New Zealand (Ministry for the Environment, 2009). In a 2013 survey conducted in nine states in the southern United States, when asked if water quantity is a problem in their area, a majority of residents responded definitely or probably not in Alabama (69%), Arkansas (72%), Louisiana (74%), Mississippi (67%), Oklahoma (62%), and Tennessee (59%) (Borisova *et al.*, 2013). A 2015 survey found that residents of western North Carolina moderately agreed with the statement that there is enough water in the region to meet the needs of all its people and businesses for the next 25 years (Cockerill *et al.*, 2015). Another 2015 survey found that there is little concern among Floridians regarding the state's water quantity (Leal *et al.*, 2015). A 2017 national survey of Canadians found that 80% of the population is at least somewhat confident that Canada has enough water to meet its long-term needs (RBC, 2017). In general, residents of humid regions believe that water resources are abundant and will remain so for at least the near-term future.

This perceived abundance of water resources in humid climates, and the implication that water governance is an easier task in humid regions, is a myth. Arguably, water-resource management is just as challenging in humid as in arid regions. At an urban scale, for example, Padowsky & Jawitz (2012) conducted an analysis of water vulnerability of 225 cities in the United States that considered imported, stored, and renewable water supplies. They identified cities with the greatest danger of urban water vulnerability as those with relatively large local renewable flows (characteristic of humid climates) but small hydraulic inputs. In these cities, which include Raleigh, North Carolina, and Atlanta, Georgia, mean annual availability is enough to meet demand, but problems arise during periods of low flow because of the lack of storage infrastructure. A survey in the United States found that water managers in 36 states expected water shortages (locally, regionally, or statewide) in the near-term future, even under non-drought conditions, in 36 states, including many in the humid eastern United States (GAO, 2003). Globally, the International Water Event Database reveals that, for 110 international disputes related to water quantity from 1948 to 2008, 48% ($n = 53$) were in humid basins, including incidents in the Ganges, Great Lakes-St. Lawrence, Mekong, and Elbe basins (Yoffe & Larson, 2002). At multiple spatial scales, there is no clear correlation between climate and water-governance challenges.

This paper will address the origins and consequences of the myth of abundance and discuss how water governance has evolved (and can evolve further) as the negative consequences of the perception of abundance become increasingly clear. Throughout the paper, the geographical focus is on humid

mid-latitude regions in the Anglophone world. The reason for this focus is that all these regions share a common legal history, derived from English common law, that leads to international similarities in water governance.

The first section of the paper addresses how the myth of abundance fits into the context of the widely applied concepts of water scarcity and water security. The next section is an overview of the riparian doctrine, which is the historical basis for water allocation in Anglophone humid regions, and of how the myth of abundance is embedded into this doctrine and other aspects of water governance. Following are three examples (from the south-eastern United States, southern England, and the South Island of New Zealand) that illustrate why the perceived abundance of water resources in humid regions is a myth and how water governance in the various jurisdictions has changed (or failed to change) in response to this reality. Finally, the last section argues for adopting the water-security framework to address shortcomings of the current abundance-focused mindset.

Water scarcity and water security

The concepts of water scarcity and water security are widely used in discussions of water quantity and other aspects of water governance to describe the status of water resources in different regions of the world. Although there is some overlap between the water-scarcity and water-security frameworks, they are not directly comparable (i.e. a region with low water scarcity does not necessarily have high water security).

Water scarcity

As stated simply by the United Nations Food and Agricultural Organization, 'Water scarcity = an excess of water demand over available supply' (FAO, 2008). Water scarcity is often divided into two types: physical (or absolute) water scarcity, in which the supply is insufficient to meet the demand because of limitations of water in the physical environment (e.g., the region is a desert), and economic (or social) water scarcity, in which supply is insufficient because the region is not at an adequate level of economic development to build the infrastructure needed to provide water resources to its population (e.g., a poor country that cannot invest in treatment and distribution systems, wells, dams, etc.) (Kummu *et al.*, 2010). Despite this distinction, much water scarcity is essentially economic in origin, driven by poverty and inequality (UNDP, 2006). This is because the global supply of renewable freshwater is far greater than the world's current demand, and it is always at least theoretically possible to bring in additional water supplies from elsewhere. Nevertheless, there are regions with effective physical water scarcity because they are so arid that it is not economically viable to supply adequate water.

The dominant role of economic development in determining water scarcity is evident in the results of analyses that classify countries according to water scarcity (e.g., Ohlsson, 2000). These analyses show no or very low levels of water scarcity in the developed countries like those in North America and Europe. The reason is that, because the availability of water resources is so strongly controlled by the level of economic development, water-scarcity analyses are generally done at the national scale. For example, the western United States has desert regions with so little water in the natural environment that they would qualify as being water-scarce, except that the United States has spent trillions of dollars on dams, inter-basin transfers, and other large-scale infrastructure to augment water supplies. Even

California's arid Imperial Valley can now support extensive irrigated agriculture because of diversions from the lower Colorado River, which resulted in the accidental creation of the Salton Sea. As a result of these large-scale engineering projects, even these arid regions are not currently experiencing water scarcity, because their demand for water is met by the available (artificially augmented) supply. In some regions, demand is only met through the pumping of fossil groundwater, which, as a nonrenewable resource, does not count toward the available supply in some water-scarcity indices (Brown & Matlock, 2011). Nevertheless, because it can be assumed that the developed nations have the economic resources to supply renewable water to groundwater-dependent regions if needed, these nations can, in general, be considered relatively free of water scarcity.

Water security

The United Nations defines water security as the 'capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability' (UN, 2013). The scope of water security is much broader than that of water scarcity. First, the water-scarcity framework is implicitly anthropocentric, as only the human demand for water is usually considered. Water security, in contrast, explicitly considers the needs of both humans and ecosystems (Postel, 2003). Second, the water-scarcity framework can be interpreted as implicitly considering water quality, because water that is too degraded for specific uses can no longer be considered part of the available supply for those uses. Water security, however, explicitly calls for water of acceptable quality and protection against water-borne pollution. Third, the water-scarcity framework essentially considers water supply and demand in terms of long-term averages, while the water-security framework calls for protection against water-related disasters, such as floods and droughts, which can be expected to occur from time to time. Finally, the water-scarcity framework seems to assume that individual nations exist in a vacuum, with no relationship to other nations regarding water resources, and that interests within nations are aligned when it comes to use of water. The water-security framework recognizes that disputes and conflicts over water occur both between and within nations, so it calls for peace and political stability as an important component of effective water governance.

Unlike the distinction between physical (driven by the natural environment) and economic (driven by socio-economic development) water scarcity, water security is posed as an issue primarily of governance and investment. The significance of the role of the physical environment in predisposing some areas to higher or lower levels of water security is debated. For example, Grey & Sadoff (2007) argue that part of the reason that many developed countries were able to achieve water security early in their path to growth is because they have an 'easy' hydrologic legacy (i.e. relatively low rainfall variability), an idea that promulgates the myth of abundance. Vörösmarty *et al.* (2010), in contrast, contend that regions of developed countries with intensive agriculture and dense settlement, such as much of the United States and Europe, have a high incident threat or exposure to stressors. Their classification scheme challenges the myth of abundance by focusing on the population and economic stressors on water resources, rather than on water supply in the natural environment. In the developed countries, many of these regions of high incident threat have reduced their threats and improved their human water security through massive investment in water infrastructure. An investment in biodiversity

conservation, however, has been much more limited, leading to relatively low levels of ecological water security even in humid regions of developed countries.

Nevertheless, the water-security framework has challenges, such as the spatial scale at which water security should be determined. As pointed out by Bakker (2012), there is a 'scalar mismatch' between the unit of analysis at which political scientists (nation-state) and hydrologists (drainage basin) generally consider water security. Besides disciplinary biases, another reason for the scalar mismatch is that some of the drivers of water security (political stability, governance, and level of economic development) are national in scale, while others (water supply and human and ecological needs for water) are local and better represented at the scale of a drainage basin. Water security, therefore, has first-order controls of national-scale political, economic, and social constraints, with finer-scale variability explained by local watershed characteristics. It is, therefore, possible to characterize regions, or even individual drainage basins, as water-insecure even if they exist in a national context of generally high levels of water security.

The riparian doctrine and the myth of abundance

No aspect of water governance in humid regions better encapsulates the myth of abundance than the riparian doctrine. This doctrine is the basis of water rights in the Anglophone world, including the United Kingdom, Australia, New Zealand, and the eastern United States and Canada. Although many of these nations have since modified their use of the riparian doctrine, its historical significance and continued use in many humid regions necessitate a closer look at its general principles.

The riparian doctrine has its origins in eighteenth-century English common law, primarily in response to disputes between mill owners and other water users (mostly those who wished to use rivers for transport and fishing). These disputes were resolved by courts assigning rights to riparian property owners to use water adjacent to their land. Under the riparian doctrine, all landowners whose properties are adjacent to a watercourse have the right to use the water. In its most rigid form, the doctrine is based on the natural-flow principle, which states that water cannot be taken off-stream if it perceptibly diminishes streamflow, unless that water is used for subsistence purposes only. This natural-flow standard, however, is rarely used today (Ausness, 1986). More commonly, the reasonable-use principle is employed, which allows the riparian to use water for any beneficial purpose, if the amount is reasonable considering the needs of other riparian users. In the original version of the doctrine, these rights are tied to the property and cannot be sold or transferred to non-riparian landowners. Disputes about water uses are addressed through litigation, in which one party must make a case that the other party's use of water is not reasonable or is impeding their own reasonable use.

The myth of abundance is embedded within the riparian doctrine. It is a system of water rights in which the underlying assumption is that water is always available, so that each riparian has the right to as much 'reasonable' use of water as desired (Gould, 2002). There is no mechanism within the riparian doctrine for dealing with water shortages, other than litigation in which one party must prove that they are being harmed by another's water use. The riparian doctrine, therefore, lacks clear mechanisms to prioritize among users and does not promote efficiency or conservation. The implicit assumption is that the times in which not enough water is available to meet all users' needs are rare enough to be the exception rather than the rule.

The riparian doctrine's ties to the myth of abundance are illustrated by its geographic pattern of adoption in North America. The humid eastern states and provinces of the United States and Canada adopted

the riparian doctrine, which they had inherited from English law. In the western states and provinces, the doctrine was found to be unsatisfactory because, in these arid and semi-arid regions, the assumption of abundant water supply could not be sustained. Water shortages were the rule rather than the exception. Instead, western states (and later western Canadian provinces) adopted the doctrine of prior appropriation. This doctrine has its origins in Gold Rush California, when miners began diverting streams to support their operations. A dispute between two miners, *Irwin v. Phillips*, went to the California Supreme Court, which ruled in 1855 that the right to water is allotted to the first to use it (Benson, 2012). Often stated as 'first in time, first in right,' the prior-appropriation doctrine is like the staking of mining claims in mineral rights. Unlike the abundance-assuming riparian doctrine, the prior-appropriation doctrine operates under the assumption that water will not always be available to supply all users. The most senior user, defined as the first person to take water from a source for 'beneficial use' (domestic, irrigation, or industrial use), is prioritized in the continued use of that water. In times of shortage, the most junior rights-holders are cut off, while more senior users can continue to use their full allotment if water is available. As such, the prior-appropriation doctrine has clear mechanisms for allocating water in times of shortage, which gives it an advantage over the riparian doctrine in arid and semi-arid regions.

Both the riparian and prior-appropriation doctrines have shortcomings. The criticism that the riparian doctrine does not encourage efficiency and conservation can be leveled even more strongly against the prior-appropriation doctrine, because its 'use it or lose it' provision arguably discourages conservation. That is, water-right holders who do not use their full allocation for beneficial use risk having the right stripped away. Also, both doctrines can be criticized for prioritizing human uses of water at the expense of ecological benefits. Although the natural-flow formulation of the riparian doctrine could theoretically be used to protect environmental interests, there are no reported cases in which courts have used it for such a purpose (Ausness, 1986). Moreover, because ecosystems do not have legal standing, the right of non-human organisms to water is not guaranteed by the riparian doctrine (Katz, 2006). In the prior-appropriation system, meanwhile, water rights can be allocated to ecological uses, although they would generally be junior to other rights unless an overriding statute is in place (Sophocleous, 2007). Neither water-rights doctrine inherently considers ecological needs for water, an anthropocentric bias illustrated by the 'reasonable' and 'beneficial' terminology used to describe human uses of water, as if it were a waste to simply leave water in rivers to be unused by humans.

The number of states, provinces, or countries where the strict riparian doctrine is practiced has decreased in the past half-century. Many riparian jurisdictions, including about half of the riparian-doctrine states in the United States, have used the legislative or regulatory process to modify the riparian doctrine to form new hybrid systems known as 'regulated riparianism' (Dellapenna, 2011). These regulated-riparian systems are primarily intended to address two of the flaws in the strict riparian doctrine: the inability for non-riparian landowners to put water to beneficial use and the expense and difficulty of addressing disputes only through litigation (Jungreis, 2005). The most common modification put into place to address these problems is to add a water-permitting system. In these systems, users can apply for a permit to withdraw a specified quantity of water, often over a specified timeframe, from a specific location, and for a specific use (Beck, 2000). When non-riparian users are eligible to apply for these permits, the system addresses the first problem of strict riparianism, the inability of non-riparian landowners to use water. It is worth noting that this element of regulated riparianism does not negate the myth of abundance, but rather reinforces it by potentially increasing the number of users, amount of use, and impacts on a watercourse. It suggests that water is so abundant that it can be exported to off-stream and potentially even interbasin users.

The other main problem with strict riparianism, the difficulty of resolving disputes, is also purportedly addressed by permitting systems at least to a degree. Permitting allows agencies to make decisions about water allocations before disputes arise, to consider the needs of all water users and the public interest, and to incorporate the expertise of water scientists (Plager & Maloney, 1968). Another benefit of the permitting system is that it allows minimum environmental instream flow standards to be enforced, as is done in several eastern US states and Canadian provinces (MacDonnell, 2009). Finally, permitting allows agencies to know where water is being withdrawn, which is useful for planning. In practice, these benefits may or may not be realized, depending on the resources and effectiveness of the regulatory agencies, especially their ability to monitor and enforce permits. However, a more fundamental point about regulated riparianism is that it still assumes abundance. While the prior-appropriation doctrine assumes that water will not always be available to meet the needs of all users, riparianism (even regulated riparianism) assumes that water is abundant. While the regulatory agencies may have total annual water availability in mind when they issue permits, they are not necessarily considering drought or other disasters, trans-sectoral or transboundary water disputes, water quality, or ecosystems, unless they are required to by other laws or regulations. While a regulated-riparian framework may result in better water-allocation decisions than strict riparianism, it is not, by itself, enough to promote water security, because it still labors under the myth of abundance.

Given the riparian doctrine's inextricability with perceived abundant water resources, it is worthwhile to examine specific regions in which some form of the riparian doctrine is currently, or has historically been, employed. All three examples are in humid regions of developed Anglophone countries. In each case, the perceived abundance of water is at odds with the reality of significant water-governance problems.

The myth of abundance in action

Apalachicola–Chattahoochee–Flint basin, United States

The Apalachicola–Chattahoochee–Flint (ACF) basin, located in the south-eastern United States, is notorious as the site of the so-called Tri-State Water Wars. The basin at first seems an unlikely candidate for such an acrimonious water dispute, given that the region has a humid subtropical climate, with average annual precipitation of over 1,400 mm yr^{-1}, and the Apalachicola River has average annual streamflow of over 600 $m^3 s^{-1}$ (USGS, 2019). Nevertheless, the water-governance challenges and conflicts are as serious in the ACF basin as anywhere in the arid western United States, given that the basin has experienced one of the longest-running (and still unresolved) interstate water disputes in US history (Ruhl, 2005).

The Chattahoochee River has its headwaters in the Blue Ridge Mountains of northern Georgia, where it flows through the Atlanta suburbs, then turns south to form the Georgia–Alabama state line. The headwaters of the Flint River are in metropolitan Atlanta near the Hartsfield-Jackson International Airport, from which it flows south through western Georgia. The Chattahoochee and the Flint converge at the Florida–Georgia state line to form the Apalachicola River, which flows south across the Florida panhandle into Apalachicola Bay on the Gulf of Mexico. The total drainage area of the ACF basin is 50,505 km^2.

Georgia's main interest in the ACF basin is the water supply for the Atlanta region. Atlanta has grown rapidly over the past several decades, lacks significant groundwater reserves because of the crystalline

bedrock of the region, and does not have major surface-water supplies nearby other than those in the ACF basin, as well as the Coosa and Tallapoosa rivers, which are the subject of a separate interstate dispute with Alabama in the Alabama–Coosa–Tallapoosa (ACT) basin. Water from the Flint River is also used for the irrigation of western Georgia's agricultural regions. Alabama uses Chattahoochee River water for irrigation, industry, fisheries and recreation, hydropower, navigation, water supply and waste assimilation, and habitat for endangered sturgeon and mussels. Florida's main concern in the dispute is maintaining freshwater inflows to Apalachicola Bay, which are needed for optimal salinity levels to support the bay's highly productive oyster and shrimp fisheries, a vital economic resource for the region.

The ACF case highlights the shortcomings of abundance-based water governance in the southeast United States. First, despite the region's humid subtropical climate, the southeast is subject to periodic drought. For example, from 2007 to 2009, a severe drought had widespread impacts throughout the region, including leaving cities such as Atlanta and Athens in northern Georgia with the possibility of water-supply reservoirs being completely depleted. More recently, a short-lived but severe drought occurred in the southeast United States in fall of 2016 (Praskievicz *et al*., 2018). Tree-ring records indicate that droughts of equal or greater severity than the recent events have occurred frequently in the past 400 years and that the period of instrumental data used to make water-management decisions may be among the wettest since 1665 (Pederson *et al*., 2012). Future climate change may further exacerbate droughts in the region (Seager *et al*., 2009). At the same time, increased demand in the basin has further stressed water resources. Campana *et al*. (2012) found that, although the 2007–2009 drought was not more severe than other historical droughts in the region according to precipitation-based drought indices, with an expected recurrence interval of approximately 25 years, its hydrologic impacts were more severe because of population growth and development that had occurred since the previous drought of similar severity in 1985–1987. Although several cities and counties in Georgia put mandatory water-conservation measures into place that were effective in saving water, in 2008, the State of Georgia passed a new law to prevent local governments from independently implementing water-use restrictions (Campana *et al*., 2012). In short, droughts in the region are more common than typically perceived, the impacts of drought are becoming more severe, and the perception of abundance makes the water-governance systems in the basin ineffective in responding to drought.

Another deficiency of the abundance-assuming riparian doctrine is illustrated in the ACF basin: the inability to effectively resolve water conflicts. The spatial organization of the ACF basin presents challenges, in that there is an upstream water user with high demand (the Atlanta metropolitan region), while downstream users are more spatially diffuse (smaller cities, irrigators, and fishers). Under the riparian doctrine, upstream users have an inherent advantage, as their needs are met first as water flows from upstream to downstream, leaving downstream users with whatever is left. In the ACF basin, this upstream advantage is magnified because the upstream user, Atlanta, is politically and economically powerful relative to the multitude of downstream users (Colten, 2012). It is worth considering what the situation in the ACF basin would be if, instead of being an interstate basin, the entire basin was contained within one state. In that situation, instead of states challenging one another in federal courts, the upstream interests of Atlanta and the downstream interests of Apalachicola Bay would be pitted against one another in the context of the riparian doctrine. In that case, Atlanta would have an even stronger advantage, because the Apalachicola Bay interests would still have to prove (in the state rather than a federal court) that they are harmed by Atlanta's use, but without the power of the State of Florida behind them. In a prior-appropriation system, in contrast, whichever party had the senior water right

would have the advantage. While such a system may be no more likely than the riparian doctrine to result in a just or socially desirable outcome, the relative success of different interest groups would be based on history (senior versus junior water rights) rather than geography (upstream versus downstream).

As it is, the transboundary nature of the ACF basin offers at least the potential for eventually resolving the conflict in a way that would be unlikely within a single riparian-doctrine state. Interstate water disputes can be resolved by Congressional allocations, interstate compacts, US Supreme Court rulings, or indirectly through litigation under federal laws such as the Endangered Species Act (ESA) and Clean Water Act (CWA). In prior interstate water disputes, the Supreme Court and other federal courts have shown favor to states with comprehensive water-management plans, including efficiency and conservation measures, which is one potential mechanism for overcoming the abundance-oriented mindset. It is worth noting that interstate compacts in the ACF and ACT basins, which were initially negotiated in 1997, failed after only a few years, while the Colorado River Compact in the arid southwestern United States (although disastrous in its over-allocation) has been in effect for nearly a century.

Another example of a rancorous water conflict in an arid region (in this case between sectors of users rather than between states) took place in Oregon's Klamath River basin during a drought in 2001, when a court ordered a shutoff of irrigation water to 1,400 farms to maintain instream flows for threatened and endangered fish species (Chaffin *et al.*, 2016). After highly publicized protests and lawsuits by the farmers, key stakeholders engaged in a collaborative process (prompted by the federally required relicensing of a hydroelectric project in the basin) to resolve conflicts over water allocation. The eventual result was the 2010 Klamath Basin Restoration Agreement, a plan to manage water for agriculture, recreational and commercial fishing, and ecosystem restoration. The prior-appropriation system that governs the Klamath basin was a key to the eventual agreement both by prompting the initial crisis in 2001 by the shutting off of the farmers' water rights and by a later court decision asserting the senior water rights of the Klamath Tribes, thus bringing several groups who had previously refused to negotiate into the process. Arguably, the prior-appropriate system made the eventual resolution of the conflict possible by providing clear standards for allocation priorities to the courts and stakeholders, unlike in the ACF basin, where the core issues remain unresolved. These comparisons between the humid ACF basin and arid Western basins indicate that the absolute amount of water availability is not by itself the determining factor in how easy or difficult it is to settle transboundary water conflicts. In some cases, as in the ACF basin, having more water can just mean more to fight over.

River Thames, England

The River Thames is the longest river entirely in England, at 346 km, with a drainage area of 12,935 km^2. Because it drains relatively dry portions of south-eastern England and is subject to extensive withdrawals for municipal drinking water, its annual average streamflow is relatively small for its drainage area at 66 $m^3 s^{-1}$ at its mouth on the Thames Estuary on the North Sea near London (Wilby & Harris, 2006). In addition to being heavily abstracted for drinking water, the Thames also receives vast quantities of treated wastewater from Swindon, Oxford, Reading, Windsor, and London. Currently, like many older cities, London has a combined sanitary and stormwater sewer system, which leads to frequent combined sewer overflows (CSOs), with on average 50–60 incidents per year totaling 39–55 million tonnes of raw sewage entering the Thames (Mourato *et al.*, 2005). In response, the under-construction Thames Tideway Scheme (planned completion date of 2023) will capture, store,

and convey the combined sewage and stormwater discharge through a 25-km tunnel under the river to a wastewater treatment plant, thus reducing CSOs to a few per year (Thomas & Crawford, 2011).

The low streamflow and large tidal influence, combined with the large inputs of treated and untreated wastewater, have historically caused serious water-quality problems in the Thames estuary. Upstream agricultural inputs also contribute to the water-quality problems. These problems are especially severe during low flows when insufficient water is available for wastewater dilution. Periodic droughts also threaten water supplies in Southeast England. For example, during a 1976 drought, London reservoirs were depleted, and the city came within days of running out of water (Whitehead *et al*., 2013). London's utility, Thames Water, has proposed building a new reservoir to augment the city's future water supply, but earlier versions of the proposal have been rejected.

Water governance in England was transformed in 2000 when the European Union (EU) adopted the Water Framework Directive (WFD). The WFD commits EU member states to achieve the good qualitative and quantitative status of all water bodies. An advantage of the WFD is that it takes a comprehensive view of water resources, including water quality and ecosystems. Although the WFD does not explicitly address water quantity, the achievement of good ecological status necessarily involves maintaining environmentally beneficial flow regimes. The UK was the first European country to implement the projects designed to address the environmental-flow component of good ecological status, with one project focused on restricting abstractions and another on setting flow releases from reservoirs (Acreman & Ferguson, 2010). The WFD also indirectly inspired the UK's Water Act of 2003, which required 'the provision of the sufficient supply of good quality surface water and groundwater as needed for sustainable, balanced and equitable water use.' Specifically, the Water Act implemented a permitting system for water withdrawals, transforming UK water rights to a regulated-riparian system. As such, the WFD contributed to a shift in perceptions and in actual policy in the UK, away from the *ad hoc* riparianism associated with the myth of abundance and toward a more comprehensive water policy with a water-security and sustainability basis. It is not clear how the impending exit of the UK from the EU will affect the continued implementation of the WFD. Nevertheless, in promoting a water-security outlook, the WFD has changed perceptions of water resources in the UK and elsewhere in Europe.

Canterbury Region, New Zealand

As an island nation with a temperate maritime climate, New Zealand is like England in the perceived abundance of its water resources. In addition, environmental sustainability is a part of New Zealand's national identity, especially in the area of conservation of biodiversity. Nevertheless, New Zealand has major water-governance challenges. For one, climatic conditions in New Zealand include sharp local rainfall gradients, resulting from the mountainous topography. Interannual rainfall variability is also relatively high. Despite the spatial and temporal variability of water-resource availability, early European migrants to New Zealand brought with them the English system of riparian water rights, thus enshrining the myth of abundance. In 1991, however, New Zealand passed a sweeping new Resource Management Act (RMA), which guides decision-making on land, air, and water resources through a decentralized and integrated approach. Many environmental decisions, including on water allocation, are delegated to regional councils, which are governed by elected members and have extensive statutory authority and budgets (Curtis *et al*., 2014). The RMA is like the EU's WFD (or federal environmental legislation in the United States, such as the CWA) in that it sets out broad and comprehensive goals for environmental management and

delegates much of the implementation to the regional level. Where it differs from these other approaches is that it is even more comprehensive, regulating natural resources of all kinds under a single law, unlike the water-specific approaches taken by many other governments.

The challenges of water governance in New Zealand are exemplified by the Canterbury region in the central-eastern South Island. Because the region is in the rain shadow of the Southern Alps, the annual average rainfall is approximately 600 mm. Although this amount is much lower than in the western windward side of the island, the region is still considered to have a humid temperate climate according to the ratio between mean annual precipitation and potential evapotranspiration (Garnier, 1946). Agriculture is the leading sector of the region's economy, producing the majority of New Zealand's wheat and barley, as well as extensive viticulture, sheep farming, and dairy farming. As a result, water use has significantly increased since the 1990s, mostly for the irrigation of pasture (Lennox *et al.*, 2011). The region now manages 70% of New Zealand's irrigated land and uses 60% of all water allocated for consumptive use in New Zealand (Weber *et al.*, 2011). This increasingly intensive water use, as well as recent periods of lower-than-average rainfall, leads lowland streams to run low or dry during parts of the year. In response, construction began in 2014 on the Central Plains Water Enhancement Scheme, which will divert water from the Rakaia and Waimakariri rivers to a storage reservoir, which will be used to irrigate 60,000 hectares through a series of canals and water races (Morgan, 2010). The project is highly controversial, with environmental groups opposing it because of habitat impacts for the endangered Canterbury mudfish and other ecological impacts, and additional opposition from recreation groups and from smallholder farmers who will lose land to the storage reservoir.

The Canterbury case study illustrates that, even in a generally humid region like New Zealand, major regional differences in water availability can present challenges to water governance. In New Zealand, these regional differences occur over short distances because of topography. In addition, the controversy over the Canterbury Plains scheme demonstrates that, despite New Zealand's reputation as a leader in environmental sustainability with integrated environmental management, inter-sectoral water disputes cannot be avoided completely. Economic and environmental uses of water are often in conflict with one another, and these issues can only be resolved through the messiness of the political process.

Managing for water security

The regional examples have highlighted some of the challenges of water governance in humid regions, namely those related to ecosystems, water quality, disasters, and conflict. The following section will synthesize those challenges and how various water-governance approaches address (or fail to address) them.

Ecosystems

One of the basic challenges of water governance is to reconcile human needs for water with preserving aquatic ecosystems. All three examples involve this conflict to some degree whether aquatic species are endangered by upstream withdrawals in the ACF basin, pollution on the River Thames, or large-scale irrigation schemes in the Canterbury region. If anything, ecological challenges tend to be even greater in humid regions than arid ones, because wetter climates are more likely to be hotspots for biodiversity, as are the Southeast United States and New Zealand.

The traditional humid-region approach to water governance, based on common-law riparian rights, is completely anthropocentric in its outlook, considering human uses of water as the only possible beneficial use. As ecological concerns have become more prominent in the past few decades, many Anglophone countries have adopted legislation that mandates the consideration of the environmental impacts of water use. These laws often include a general overarching environmental goal ('to halt and reverse the trend toward species extinction' for the US ESA of 1973, to achieve 'good ecological status' for all water bodies in the EU WFD, 'safeguarding the life-supporting capacity of air, water, soil and ecosystems' in New Zealand's RMA), with the details of implementation delegated to member states (in the EU) or regional councils (in New Zealand). Although the US ESA has been a powerful tool for environmental protection, its species-focused outlook is less comprehensive than the entire-ecosystem approach of the WFD and RMA. A more fundamental limitation of all these laws for the purposes of water governance is that water quantity is only an incidental concern, involved inasmuch as it is needed to protect endangered species, maintain good ecological status, or safeguard water's life-supporting capacity.

Water quality

Ensuring good water quality is another fundamental goal of water governance, because water that is excessively degraded is of no use to either humans or ecosystems without extensive treatment. Although maintaining good water quality is an objective in all three examples, it is most challenging in the case of the River Thames, where small river flow, large tidal influence, and extensive inputs of pollutants from municipal wastewater and agriculture conspire to create especially difficult conditions for water-quality management. As with ecosystems, water quality is equally as challenging in humid as in arid regions, if not more so because humid regions tend to have larger populations and more intensive agriculture.

During the inception of the environmental movement in the 1970s, water quality was a major focus because of the pervasiveness and visibility of polluted waterways. In response, the United States passed the CWA in 1972, with a stated goal of making 'all US waters fishable and swimmable'. Like the WFD in the EU and RMA in New Zealand, the implementation of this overarching goal is carried out by regional authorities (by states in the United States under authorization by the US Environmental Protection Agency). Although water quality in the United States has greatly improved as a result of the CWA, there is no explicit connection made between water quantity and quality. Water quantity affects quality because it determines dilution capacity, and quality affects quantity because it determines the uses to which water resources can be put. As with ecosystems, the US legislative framework is narrow in its scope (with no federal law governing water quantity). Legislative frameworks like the WFD and RMA at least allow for the integrated management of water quantity and quality by defining the good ecological status or safeguarding life-supporting capacity as the goal, even if they also suffer from being subject to interpretation by regional authorities.

Disasters

Water governance is most challenging during disasters, such as drought. Lack of water availability during drought often spurs water conflict, as in the disputes between municipal and fishing interests in the ACF basin or between irrigation and aquatic habitat in the Canterbury region. Although arid regions have less absolute water availability than humid regions, it can be argued that humid regions are less well prepared to deal with drought, because the myth of abundance is so pervasive in the

public imagination, and water-governance systems are also generally based on the assumptions of abundant water. As noted earlier, the riparian water-rights system has no mechanism to manage water shortages other than litigation. In regulated riparianism, agencies have at least a theoretical ability to monitor and enforce water withdrawals, although the extent to which they do varies. But what is critically missing from the most existing water-governance approaches in humid regions is preparedness for droughts and other disasters, and the myth of abundance is a major driver of this lack of preparedness. Average citizens in humid regions generally do not think about their water use at all, unless there is a drought. During droughts, local authorities often implement voluntary or mandatory conservation programs, but these are usually lifted as soon as the drought ends, and most people immediately go back to their previous water use. Moreover, the water-governance systems of humid regions generally do not include incentives for conservation in the long term.

Conflict

One of the central questions of managing water resources is 'for whom' and 'for what' the resource is being managed. Conflicts often occur that are transboundary (as in the interstate borders of the ACF basin) or inter-sectoral (as in between upstream farmers and downstream city-dwellers in the River Thames basin or between agriculture and the environment in the Canterbury region) in nature. Although water conflict is common in arid regions as well, the myth of abundance that prevails in humid regions arguably makes the resolution of these conflicts more difficult.

The riparian water-rights system has no mechanism other than litigation to resolve water conflicts. It is important to note that water disputes lead to cooperation more often than they lead to conflict (Wolf, 1999). Transboundary basins can resolve issues through compacts or treaties. Because of the complexity of transboundary water conflicts, hydrologists often consider the drainage basin as the 'natural unit' at which water-resource management decisions should be made. The assumption is that conflict will be reduced if water-management decisions are made considering the entire water budget of the drainage basin, without artificial political boundaries imposed. This assumption is not necessarily true. First, resolving inter-sectoral conflicts within a single political jurisdiction is not necessarily easier to resolve than a transboundary conflict in which each jurisdiction has a seat at the table and is seen as an equal partner. In contrast, intersectoral conflicts within a state or nation must be addressed through the political process or the courts, where power imbalances among actors are of critical importance. Also, because of interbasin transfers and virtual water exports, in many cases, the 'natural' drainage-basin boundary is just as arbitrary from a water-resource management perspective as any political boundaries. Instead of assuming all water conflicts will be resolved by making decisions at the drainage-basin scale, water-governance systems should experiment with approaches such as conflict resolution and participatory natural resource management. Dealing with conflicts effectively will be important to the future of effective water governance, given that climate change and population growth will increasingly stress water resources.

Conclusions

The myth of abundance implies that, because water resources are abundant in humid regions, these regions have less serious water-resource challenges than drier regions. This perception is a myth

because, even if there is no physical or economic water scarcity, that does not necessarily mean that there is a high level of water security. Many elements of water-governance systems in humid regions of the Anglophone world, notably the riparian system for allocating water rights, actively promote the perception of abundant water resources. Examples from the Southeast United States, England, and New Zealand demonstrate that significant water resource challenges – related to ecosystems, water quality, disasters, and conflict – occur, but that their seriousness is under-emphasized because of the perceived abundance of water resources in these humid regions. Approaches to water resources that are explicitly designed to enhance water security will lead to more effective water governance in all regions, regardless of the perceived abundance or scarcity of the resource.

References

Acreman, M. C. & Ferguson, A. J. D. (2010). Environmental flows and the European Water Framework Directive. *Freshwater Biology 55*, 32–48.

Ausness, R. (1986). Water rights, the public trust doctrine, and the protection of instream uses. *University of Illinois Law Review 407*, 407–437.

Bakker, K. (2012). Water security: research challenges and opportunities. *Science 337*, 914–915.

Beck, R. E. (2000). The regulated riparian model water code: blueprint for twenty first century water management. *William and Mary Environmental Law and Policy Review 25*, 113–168.

Benson, R. D. (2012). Alive but irrelevant: the prior appropriation doctrine in today's western water law. *University of Colorado Law Review 675*, 675–714.

Borisova, T., Evans, J., Smolen, M., Olexa, M., Adams, D. C. & Calabria, J. (2013). Current and future water availability: public opinion in the southern United States. *Journal of Extension 51*, 1.

Brown, A. & Matlock, M. D. (2011). *A Review of Water Scarcity Indices and Methodologies*. The Sustainability Consortium, Fayetteville, AR.

Campana, P., Knox, J., Grundstein, A. & Dowd, J. (2012). The 2007–2009 drought in Athens, Georgia, United States: a climatological analysis and an assessment of future water availability. *Journal of the American Water Resources Association 48*, 379–390.

Chaffin, B. C., Garmestani, A. S., Gosnell, H. & Craig, R. K. (2016). Institutional networks and adaptive water governance in the Klamath River basin, USA. *Environmental Science and Policy 57*, 112–121.

Cockerill, K., Groothuis, P. A., McDaniel Mohr, T. & Cooper, C. (2015). Individualized water sources as an indicator of attitudes about water management and conservation in humid regions. *Journal of Environmental Management and Planning 59*, 1341–1359.

Colten, C. E. (2012). Fluid geographies: urbanizing river basins. In: *Urban Rivers: Remaking Rivers, Cities, and Space in Europe and North America*. Castonguay, S. & Evenden, M. (eds). University of Pittsburgh Press, Pittsburgh, PA, pp. 201–218.

Curtis, A., Ross, H., Marshall, G. R., Baldwin, C., Cavaye, J., Freeman, C., Carr, A. & Syme, G. J. (2014). The great experiment with devolved NRM governance: lessons from community engagement in Australia and New Zealand since the 1980s. *Australasian Journal of Environmental Management 21*, 175–199.

Dellapenna, J. W. (2011). The evolution of riparianism in the United States. *Marquette Law Review 95*, 53–90.

Evans, J., Calabria, J., Brown, W., Miller Keyes, A. & Risse, M. (2011). *Water Issues in Georgia: A Survey of Public Perceptions and Attitudes about Water*. The University of Georgia, Athens, GA.

Food and Agriculture Organization (FAO) (2008). *Coping with Water Scarcity: An Action Framework for Agriculture and Food Security*. FAO, Rome, Italy.

Garnier, B. J. (1946). The climates of New Zealand: according to Thornthwaite's classification. *Annals of the Association of American Geographers 36*, 151–177.

General Accounting Office (GAO) (2003). *Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages*. General Accounting Office, Washington, DC.

Georgia Department of Natural Resources (GDNR) (2003). *Understanding the Georgia Public's Perception of Water Issues and the Motivational Messages to Which They Will Respond: Focus Group Findings*. Georgia Department of Natural Resources, Atlanta, GA.

Gould, G. A. (2002). A westerner looks at eastern water law: reconsideration of prior appropriation in the East. *University of Arkansas at Little Rock Law Review 25*, 89–121.

Grey, D. & Sadoff, C. W. (2007). Sink or swim? Water security for growth and development. *Water Policy 9*, 545–571.

Jungreis, J. N. (2005). 'Permit' me another drink: a proposal for safeguarding the water rights of federal lands in the regulated riparian East. *Harvard Environmental Law Review 29*, 369–419.

Katz, D. (2006). Going with the flow: preserving and restoring instream water allocations. In: *The World's Water 2006–2007: The Biennial Report on Freshwater Resources*. Gleick, P. H. (ed.). Island Press, Washington, DC, pp. 29–47.

Kummu, M., Ward, P. J., de Moel, H. & Varis, O. (2010). Is physical water scarcity a new phenomenon? Global assessment of water shortage over the last two millennia. *Environmental Research Letters 5*, 034006.

Lautze, J., de Silva, S., Giordano, M. & Sanford, L. (2011). Putting the cart before the horse: water governance and IWRM. *Natural Resources Forum 35*, 1–8.

Leal, A., Rumble, J. N. & Lamm, A. J. (2015). Setting the agenda: exploring Florida residents' perceptions of water quality and quantity issues. *Journal of Applied Communications 99*, 5.

Lennox, J., Proctor, W. & Russell, S. (2011). Structuring stakeholder participation in New Zealand's water resource governance. *Ecological Economics 70*, 1381–1394.

Loucks, D. P. (2000). Sustainable water resources management. *Water International 25*, 3–10.

MacDonnell, L. J. (2009). Return to the river: environmental flow policy in the United States and Canada. *Journal of the American Water Resources Association 45*, 1087–1099.

Mahler, R. L., Simmons, R., Sorensen, F. & Miner, J. R. (2004). Priority water issues in the Pacific Northwest. *Journal of Extension 42*, 5RIB3.

Mehan III, G. T. & Brooks, D. B. (2008). *Water Abundance in Canada and the United States: Myth or Reality?* Woodrow Wilson International Center for Scholars, Washington, DC.

Ministry for the Environment (2009). *On Tap? Attitudes, Behaviours, and Perceptions of Household Water Use: Informing Demand Management*. Ministry for the Environment, Wellington, New Zealand.

Morgan, R. K. (2010). *An Evaluation of the Health Impact Assessment for the Central Plains Water Enhancement Scheme*. Ministry of Health, Wellington, New Zealand.

Mourato, S., Atkinson, G., Ozdemiroglu, E., Newcombe, J. & de Garis, Y. (2005). Does a cleaner Thames pass an economic appraisal? *Water International 30*, 174–183.

New Hampshire Department of Environmental Services (NHDES) (2009). *Summary Report of Statewide Policy Maker Survey on Water Issues*. New Hampshire Department of Environmental Services, Concord, NH.

Ohlsson, L. (2000). Water conflicts and social resource scarcity. *Physics and Chemistry of the Earth 25*, 213–220.

Padowsky, J. C. & Jawitz, J. W. (2012). Water availability and vulnerability of 225 large cities in the United States. *Water Resources Research 48*, W12529.

Pederson, N., Bell, A. R., Knight, T. A., Leland, C., Malcomb, N., Anchukaitis, K. J., Tackett, K., Scheff, J., Brice, A., Catron, B., Blozan, W. & Riddle, J. (2012). A long-term perspective on a modern drought in the American Southeast. *Environmental Research Letters 7*, 014034.

Plager, S. J. & Maloney, F. E. (1968). Emerging patterns for regulation of consumptive use of water in the eastern United States. *Indiana Law Journal 43*, 383–405.

Postel, S. (2003). Securing water for people, crops, and ecosystems: new mindset and new priorities. *Natural Resources Forum 27*, 89–98.

Praskievicz, S., Luo, C., Bearden, B. & Ernest, A. (2018). Evaluation of low-flow metrics as environmental instream flow standards during long-term average and 2016 drought conditions: Tombigbee River Basin, Alabama and Mississippi, USA. *Water Policy 20*, 1240–1255.

Ragab, R. & Prudhomme, C. (2002). Climate change and water resources management in arid and semi-arid regions: prospective and challenges for the 21st century. *Biosystems Engineering 81*, 3–34.

Royal Bank of Canada (RBC) (2017). *2017 RBC Canadian Water Attitudes Study*. RBC, Toronto, ON, Canada.

Ruhl, J. B. (2005). Water wars, eastern style: divvying up the Apalachicola-Chattahoochee-Flint river basin. *Journal of Contemporary Water Research and Education 131*, 47–54.

Seager, R., Tzanova, A. & Nakamura, J. (2009). Drought in the southeastern United States: causes, variability over the last millennium, and the potential for future hydroclimatic change. *Journal of Climate 22*, 5021–5045.

Sophocleous, M. (2007). The science and practice of environmental flows and the role of hydrogeologists. *Ground Water 45*, 393–401.

Thomas, G. B. & Crawford, D. (2011). London tideway tunnels: tackling London's Victorian legacy of combined sewer overflows. *Water Science and Technology 63*, 80–87.

United Nations (UN) (2013). *What Is Water Security?* UN, New York, NY.

United Nations Development Programme (UNDP) (2006). *Beyond Scarcity: Power, Poverty and the Global Water Crisis*. UNDP, New York, NY.

United States Geological Survey. (USGS) (2019). *USGS Water Data for the Nation*. Available at: https://nwis.waterdata.usgs.gov/nwis (Accessed 27 June 2019).

Vörösmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., Prusevich, A., Green, P., Glidden, S., Bunn, S. E., Sullivan, C. A., Reidy Liermann, C. & Davies, P. M. (2010). Global threats to human water security and river biodiversity. *Nature 467*, 555–561.

Weber, E. P., Memon, A. & Painter, B. (2011). Science, society, and water resources in New Zealand: recognizing and overcoming a societal impasse. *Journal of Environmental Policy and Planning 13*, 49–69.

Whitehead, P. G., Crossman, J., Balana, B. B., Futter, M. N., Comber, S., Lin, J., Skuras, D., Wade, A. J., Bowes, M. J. & Read, D. S. (2013). A cost-effectiveness analysis of water security and water quality: impacts of climate and land-use change on the River Thames system. *Philosophical Transactions of the Royal Society A 371*, 20120413.

Wilby, R. L. & Harris, I. (2006). A framework for assessing uncertainties in climate change impacts: low-flow scenarios for the River Thames, UK. *Water Resources Research 42*, W02419.

Wolf, A. T. (1999). The transboundary freshwater dispute database project. *Water International 24*, 160–163.

Yoffe, S. & Larson, K. (2002). Basins at risk: water event database methodology. In *Basins at Risk: Conflict and Cooperation Over International Freshwater Resources*. Yoffe, S. (ed.), PhD Dissertation. Department of Geosciences, Oregon State University, Corvallis, OR, pp. 6–41.

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