JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
Vol. 56, No. 3 AMERICAN WATER RESOURCES ASSOCIATION June 2020

Reasonable Use?: The Challenges of Transboundary Groundwater Regulation in the Eastern United States

Robert T. Caccese and Lara B. Fowler

Research Impact Statement: Advanced planning and incorporation of best science for adaptable policy frameworks are vital tools to ensure effective regulation of transboundary aquifers in the Eastern United States.

ABSTRACT: Regulating groundwater in the Eastern United States (U.S.), particularly transboundary aquifers between states, is a challenge given the patchwork quilt of common law, statutory frameworks, and agency rules. Such regulation is made more challenging by the need for better quantification of pumping and use. These dynamics are exemplified through several case studies, including the first ever U.S. Supreme Court case related to groundwater withdrawals (set in the Eastern U.S.). As dynamics such as expanded irrigation, population increases, and ecological considerations influence groundwater use across the Eastern U.S., water use will continue to be an important driver for economic activity and interaction within and between states. To effectively regulate transboundary aquifers, governance solutions must incorporate current science into decision making and be implemented at local, state, regional, and federal scales.

(KEYWORDS: groundwater regulation; Eastern U.S. water law; water policy; riparian law; conjunctive management.)

INTRODUCTION

Groundwater pumping is significant in the Eastern United States (U.S.), where such pumping supports a variety of users and sectors: public water supply, industry, irrigation, private wells, and more. In addition, groundwater provides important baseflow for streams, lakes, and wetland areas. Despite the importance of ensuring adequate groundwater now and in the future, the governance framework for groundwater varies by state and depends on a patchwork quilt of common law, statutes and regulations, and basin commission regulations (where they exist). In addition, governance of surface water in the Eastern U.S. is through common law riparianism and differs from groundwater governance. Where states have updated their regulatory framework, they are starting to manage both sources together through "conjunctive management." However, transboundary groundwater management — management of groundwater aquifers between states — is limited and subject to litigation, as seen in the first groundwater case between Mississippi and Tennessee pending before the U.S. Supreme Court.

Going forward, proactively addressing transboundary water governance is critical as new stressors on groundwater emerge, such as drought, additional users (and uses), and saltwater intrusion along coastal areas. While regulating a resource that cannot be seen and that does not adhere to jurisdictional

Paper No. JAWRA-19-0054-N of the *Journal of the American Water Resources Association* (JAWRA). Received April 3, 2019; accepted February 25, 2020.

Office of Chief Counsel (Caccese), Pennsylvania Fish and Boat Commission, Harrisburg, Pennsylvania, USA; and Penn State Law and Penn State Institutes of Energy and the Environment (Fowler), University Park, Pennsylvania, USA (Correspondence to Caccese: bobcaccese@gmail.com).

Citation: Caccese, R.T. and L.B., Fowler. 2020. "Reasonable Use?: The Challenges of Transboundary Groundwater Regulation in the Eastern United States." *Journal of the American Water Resources Association* 56 (3): 379–386. https://doi.org/10.1111/1752-1688.12840

boundaries presents immense challenges, innovative work is needed now to expand such governance. There are example frameworks from individual states that might provide guidance at a broader level, including from Virginia, Florida, Kansas, Nebraska, and Texas. These solutions provide a template for other states addressing both in-state and transboundary aquifers by focusing on advanced planning, incorporating science into policy frameworks, and balancing human and ecological needs.

Section II of this paper reviews the location of mapped groundwater basins in the Eastern U.S., including between states, then discusses groundwater use in this region. Section III includes two parts: (1) a brief discussion of how states have started to manage groundwater withdrawals within their own boundaries and (2) how groundwater withdrawals have been addressed between states. Section IV includes some lessons learned and potential next steps.

This paper is an introduction to some tensions related to transboundary water governance in the Eastern U.S., but is not an exhaustive review. It provides insights into the types of tensions that can arise based on preliminary research of both the scientific and legal literature. While a state-by-state survey was conducted for legal requirements for ecological flows, such a survey could be done for each state's groundwater governance.

GROUNDWATER BASINS AND GROUNDWATER USE IN THE EASTERN U.S.

The Eastern U.S. has a significant number of groundwater basins, both wholly within one state but also several underlying more than one state (Figure 1). Notable aquifers include the Pennsylvanian, Ridge and Valley, Mississippian, and Northern Atlantic Coastal Plain aquifers (USGS 2003). Increases in irrigation and increased urbanization are stressing groundwater supplies, which in turn impacts baseflow that provides surface water flows critical for ecological needs. Finally, the changing climate also impacts groundwater supplies: both through increasing frequency of drought and floods and through the impact of sea level rise and saltwater intrusion. These dynamics are addressed in more detail below.

Within this area, groundwater is pumped primarily for two major purposes: irrigation and public water supplies (Dieter et al. 2018). Irrigation on the eastern shore of Maryland and Virginia has increased in recent years as drought conditions persist throughout summer months and additional acres have gone into crop production (Pipkin 2018). To account, increased use of groundwater reliant center-pivot systems has spread throughout the coastal region (Tyson 2016). Likewise, Virginia's Eastern Shore has experienced an increase in poultry operations; increased pumping has caused aquifers in this area to be depleted as pumping exceeds recharge from rainfall (Pipkin 2018). In South Carolina, a recent proposal by Google involved the potential pumping of over a million gallons of water a day to cool a data center, highlighting a "new water use" opposed by local residents over concerns of impacts to the underlying aquifer (McCammon 2017). In Wisconsin, the increase in high capacity irrigation wells in sand and gravel aquifers over the last few decades have raised concerns over the impact on flows in nearby streams and lakes. Local towns in Wisconsin struggle to regulate uses when state law has not spoken explicitly on the subject (Walton 2017).

Groundwater is also an important source of water through private drinking water wells. Nationwide, about 13% of the population, or more than 42 million people, depend on drinking water supplies from domestic (self-supplied or private) wells, many of these in the Eastern U.S. (Johnson et al. 2019). The "largest number of domestic well users" is in Michigan (2.4 million users), with Pennsylvania and North Carolina close behind (Johnson et al. 2019). Counties with the most people who use a well include Prince George's County, Maryland, and Erie County, New York (Walton 2018).

In addition to increased demand for human needs, aquifers provide crucial ecological benefits. Many headwater and coldwater fisheries depend on groundwater discharge to surface streams to stabilize water temperatures critical for species such as brook trout; groundwater also provides baseflow during times of the year when precipitation decreases (Taylor et al. 2013). Likewise, macroinvertebrates and amphibians in wetlands often rely upon the contribution of groundwater to provide suitable habitat in surface streams (Kennen et al. 2014). This is especially noteworthy for species of concern that may be threatened or endangered. In areas near the U.S.–Mexico border, for example, federally listed species such as the Quitobaquito Desert Pupfish and the Sonoran Mud Turtle rely on water supplies from springs linked with aquifer systems underlying both countries (Sanchez et al. 2016).

Along with competing uses, changing climate patterns have impacted how aquifers are used. Uncertain and changing weather patterns (Hayhoe et al. 2007; USGCRP 2018) are resulting in periodic droughts (Ficklin et al. 2015) and increased floods (Collins 2009). Although they may occur with less frequency and persistence than in the Western U.S., droughts in the Eastern U.S. can and do occur (Bidgood 2016), affecting most or all of a river basin, state or region. As surface sources dry up, increased

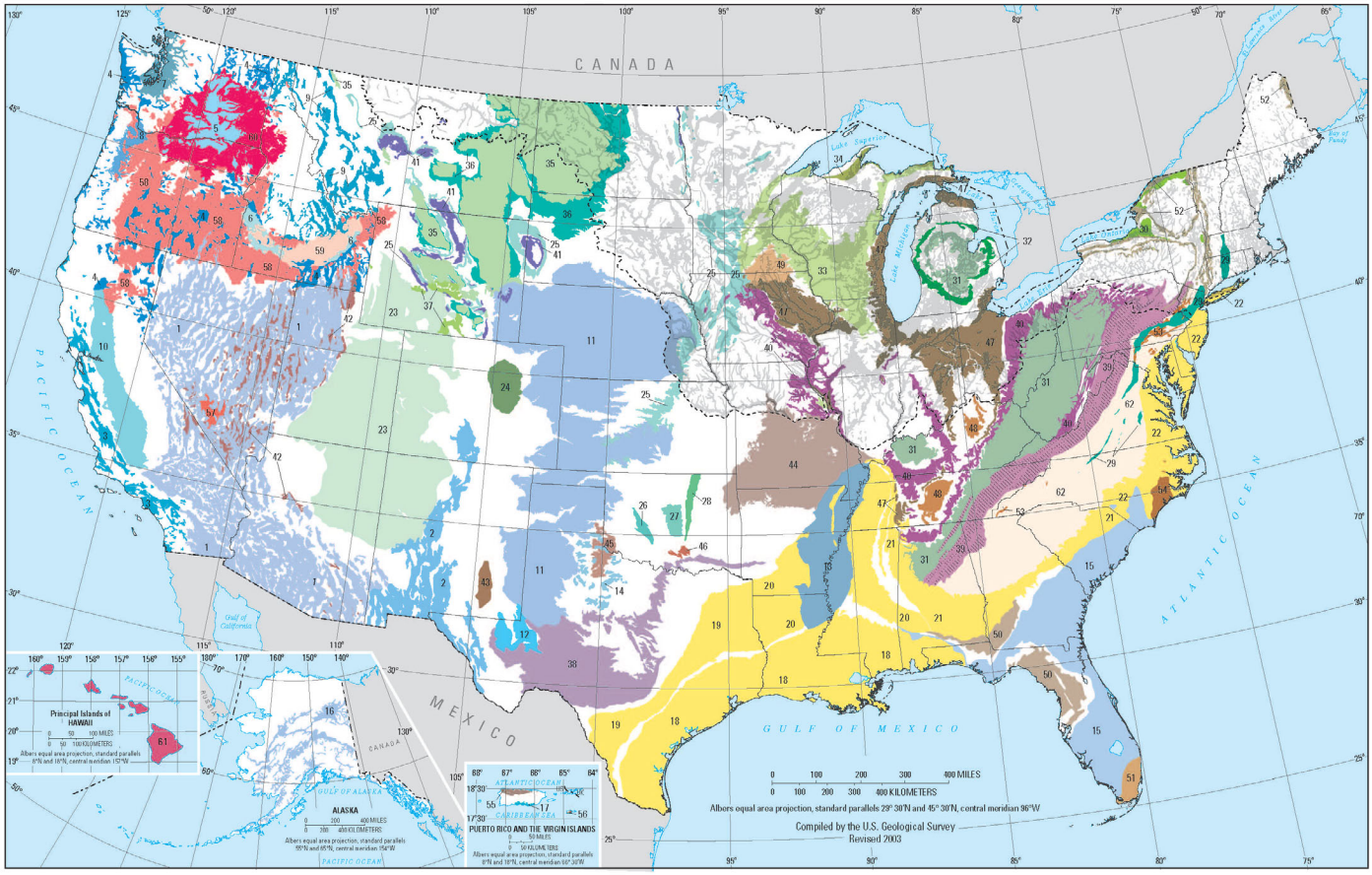

FIGURE 1. Groundwater Basins in the Eastern United States (USGS Groundwater Atlas 2003). The map is available online at https://water.usgs.gov/ogw/aquifer/map.html

groundwater pumping is the primary option for most users. During the widespread 2016 drought in the Eastern U.S. (see Figure 2), pumping increased dramatically and wells dried up (Edelstein 2016).

There are other climate related impacts that affect water directly. Over the last few decades, extreme precipitation and flooding have increased in the Eastern U.S. (Georgakakos et al. 2014), with potential impacts to groundwater wells. In addition, as sea levels rise, saltwater intrusion has threatened potable water sources in coastal areas, especially where groundwater pumping increased and drought impacted pumping and recharge (Mitchell 2019).

There are both actual and rising conflicts over water allocation at an interstate level. For example, Mississippi sued Tennessee in the U.S. Supreme Court over pumping of the Memphis Sand Aquifer by the City of Memphis (more on this case is discussed below). Similarly, the use of the Michindoh Aquifer underlying nine counties in Michigan, Indiana, and Ohio has caused controversy: a private water company has proposed a pipeline to send pumped water from the aquifer to cities along Lake Erie that currently receive their water from the City of Toledo, Ohio (Henry 2019). Local residents oppose the project (Henry 2019). Both examples highlight the challenge of adapting the law to address an increased demand on groundwater as a resource.

GROUNDWATER LAW WITHIN AND BETWEEN STATES

Because aquifer boundaries rarely align with jurisdictional boundaries at federal, state, and local scales, regulatory reality often differs from hydrologic reality. Each state has a mix of court decisions (common law), statutes, and regulations that vary by state; however, most relate to the general "rule of capture:" if you can pump groundwater, it's yours. In contrast, the U.S. Supreme Court applies the equitable apportionment doctrine to transboundary conflicts over water allocation between states; this doctrine is being

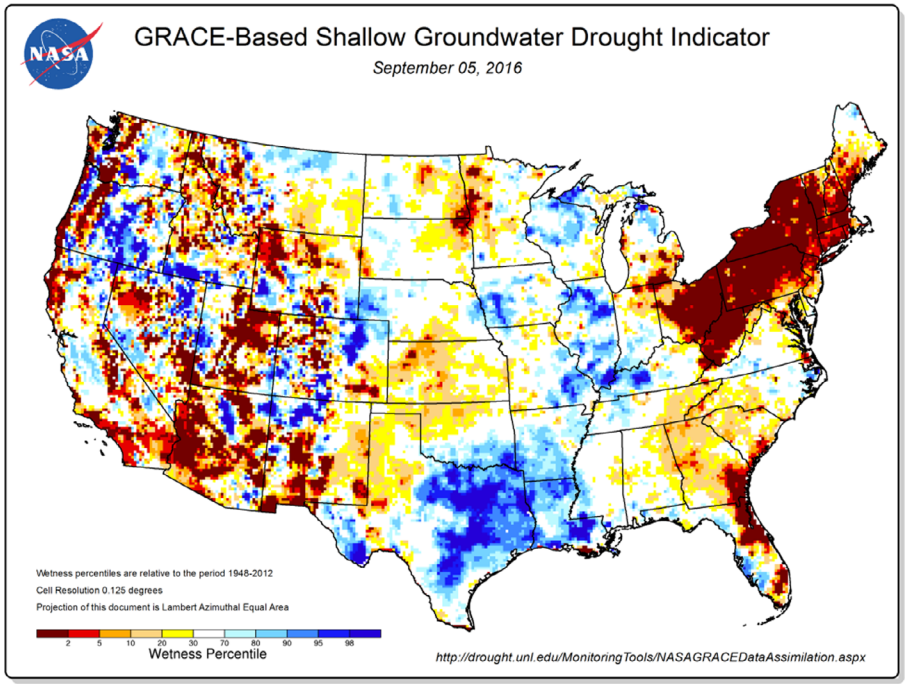

FIGURE 2. 2016 Shallow groundwater drought indicator.

considered for the first ever groundwater case in in the pending *Mississippi vs. Tennessee* case over the Memphis Sands aquifer. In limited areas, interstate water commissions regulate both surface and groundwater withdrawals. The lack of established law for transboundary groundwater governance in the Eastern U.S. creates an opportunity for proactive planning and governance.

Groundwater Governance within States

Each eastern state has its own rules for groundwater pumping, primarily governed under one of five legal principles developed by the courts and modified over time by state legislatures. Eastern states regulate groundwater through a variety of common law doctrines, such as the rule of capture, reasonable use principles, or correlative rights (Weston 2008a, b). Under all variations is the "rule of capture:" an overlying landowner may withdraw as much groundwater as necessary for any legal means without a permit (i.e., irrigation, domestic, etc.). Most jurisdictions provide groundwater used on land overlying where the water is pumped from as "reasonable," provided the user does so without malice or waste (Weston 2008a). Reasoning for this kind of practice is grounded in an 1861 Ohio Supreme Court case, *Frazier vs. Brown*, which ruled that groundwater resources are "too 'secret, occult, and concealed' to be regulated." Unless states have adopted statutes or regulations requiring permits for groundwater pumping for designated uses or above certain thresholds, the lack of data on aquifer availability and use rates can hinder a consistent legal approach for solving conflicts. Therefore, conflicts between users must be sorted out on a case by case basis.

More recently, several eastern states have passed statutes to regulate groundwater use within a state; such innovations may offer solutions for transboundary management between states. In 1992, Virginia adopted a statewide law regulating groundwater pumping. The Groundwater Management Act recognizes and controls groundwater resources for the public health and safety (Code of Virginia 2019). However, this law did not address existing groundwater pumping where coastal regions have declining water tables, increased pumping (including significant amounts for irrigation), and saltwater intrusion. Of note, aquifers are the sole source of potable freshwater on Virginia's Eastern Shore. To address these concerns, Virginia worked with fourteen major pumpers over 10 years to reduce pumping; the eventual agreement designated "groundwater management areas" where recharge rates currently fall behind usage rates and updated water permit requirements for poultry houses to promote efficiency (Zullo 2017). The Commonwealth also developed a "governance solution" for Eastern Shore aquifers by stopping withdrawals from a particular aquifer and promoting use of another with faster recharge rates.

Another example comes from Florida. In 2016, Florida passed the Florida Springs and Aquifer Protection Act to establish minimum levels in springs and prevent further harm to ecological resources (Ackerman LLP 2016). Although the statute calls for restoration plans for thirty springs with a focus on water quality, the minimum levels designated for springs focuses on water quantity for ecological necessities. In its declaration, the legislature noted the relationship between water quantity and quality, observing the dependence of springs on the aquifers. The legislature also noted the important role played by local governments in ensuring aquifer sustainability (Florida Statutes 2019).

Florida is also pursuing important voluntary initiatives. For example, the Central Florida Water Initiative is a collaboration by several entities — including three water management districts, state agencies, nonprofits, advocacy groups, and citizens — to understand Florida's aquifers and the ecological requirements for natural systems, and to develop rules and regulations to meet goals of sustainable groundwater use (Central Florida Water Initiative 2019a, b). A goal is to develop regulatory strategies to meet demands on the aquifer system within the yield limits of the resource. This initiative developed as a result of overlapping regulatory programs, increased demand on aquifers, and continued threats to diminishing recharge rates. As the project progresses, work groups are collecting data on groundwater availability, use, ecological needs, and sustainability rates (Central Florida Water Initiative 2019a, b). A regulatory work group is focused on potential changes to legislation, development of resource recovery strategies from a regulatory perspective, and expedited permit review procedures for water users (Central Florida Water Initiative 2019a, b). A similar collaboration has been created through the North Florida Regional Water Supply Partnership (2019).

Other states across the U.S. also offer important lessons on managing groundwater, including Texas, Nebraska, and Kansas. For example, Groundwater Conservation Districts in Texas, where groundwater is considered a private property right, seek to prevent waste and depletion of aquifers by developing a management plan and instituting regulator measures that often include "production limits, well spacing rules, export regulation, historic use limitations, and 'desired future conditions'" (Caroom and Maxwell 2013). If regulations are reasonably necessary to protect the aquifer and do not discriminate among landowners, then the regulation is likely not a "taking" (Howe 2012). Elsewhere, Natural Resources Districts in Nebraska mandate preparation of groundwater management plans across the state to regulate groundwater within the confines of correlative rights (Kelly 2010).

Another promising example of improved state governance to help address the needs of a transboundary aquifer comes from Kansas. To address declining aquifer levels, particularly in the transboundary Ogallala Aquifer, Kansas passed legislation allowing for the development of Groundwater Management Districts (GMD) and Intensive Groundwater Use Control Areas to conserve water. In addition, Kansas created opportunities for local citizens to develop their own solutions (Kansas Department of Agriculture 2018): Local Enhanced Management Areas allow water rights holders and permittees to employ voluntary practices to help restore aquifers to sustainable levels and recharge rates (Owen 2016). Through this, landowners owning land overlying aquifers may submit a proposal to a GMD board. The board works with the State Water Resources Department to develop an official management plan for the aquifer at issue and once agreed upon, the plan goes to the Legislature and Governor to become law. This model of regulation has shown positive results: pumping reduction is ahead of schedule for a number of areas, most notably in a sector known as Sheridan 6 (Golden 2016) as self-enforcement among water users has proven successful.

Transboundary Groundwater Governance

Because groundwater aquifers can and do underly multiple states, managing transboundary groundwater withdrawals is a challenge. Some states have tried to work out agreements, such Nevada and Utah. Elsewhere, and notably in the Eastern U.S., disagreements over withdrawals can lead to court challenges. The doctrine of equitable apportionment is being applied in the first ever inter-state groundwater case before the U.S. Supreme Court in *Mississippi vs. Tennessee*. Finally, inter-state water river basin commissions offer an alternative to adjudicating groundwater pumping between states.

Although not in the Eastern U.S., Nevada and Utah's attempt to develop an agreement regulating the Snake Valley Aquifer underlying both states is instructive (Brean 2013). Although the agreement between these states never materialized, the framework offers a template for other states to potentially follow (Hall and Cavataro 2013). Specifically, the proposed agreement mandated environmental monitoring, capped withdrawals to ensure a safe yield from the aquifer, and categorized water availability on whether it was allocated or not (Hall and Cavataro 2013).

While the U.S. Supreme Court applies the doctrine of equitable apportionment to disputes between states

over surface water allocation, extension of this doctrine is being argued for the first ever Supreme Court case associated with groundwater. Filed in 2014, Mississippi sued Tennessee over groundwater pumping, alleging over-pumping of an aquifer that underlies both states. See *Mississippi vs. Tennessee* (Docket Number 220143). The case centers on whether a shared aquifer lying beneath Mississippi and Tennessee, the Memphis Sand Aquifer, is a shared interstate resource, or whether Mississippi was damaged as a result of groundwater pumping of nearly 252 billion gallons of water by the City of Memphis from the Mississippi portion of the aquifer (SCOTUSblog 2019). Mississippi seeks payment for the damage (SCOTUSblog 2019).

Up to this point, the Court has managed such disputes through the doctrine of equitable apportionment: a common law doctrine whereby the Court weighs a number of factors (i.e., use, climate conditions, economic benefits, consumptive uses, etc.) to determine how a waterway should be used by states claiming ownership. Each state has an equal right to the water, but not necessarily an equal amount (Patashnik 2014). Such factors are likely to be applied in this case, where a special master assigned to the case is scheduled to give a recommendation to the Supreme Court on how the Court should rule on the issues (Associated Press 2019). Currently, the case is scheduled for closing arguments on February 25, 2020 in Nashville, Tennessee (United States Court of Appeals for the Sixth Circuit 2019). If the Court rules the aquifer is a shared interstate resource, then pumping by Tennessee is deemed appropriate. However, if Mississippi wins the case, Tennessee will be responsible monetarily for how much water has been pumped (Associated Press 2019). The Court's decision will set a precedent for how future transboundary aquifer disputes will be addressed in the U.S.

There are also several eastern river basin commissions that proactively regulate groundwater withdrawals across multiple states and in a regional watershed-based scale. Agencies such as the Delaware River Basin Commission (DRBC) and the Susquehanna River Basin Commission (SRBC) result from federal interstate compacts signed by participating states and the federal government. Once created, such commissions have the power to issue water withdrawal permits, collect data, designate at-risk aquifers from further exploitation, and pursue enforcement actions (DRBC 2019; SRBC 2019). Both the DRBC and the SRBC require permits and project approval for groundwater withdrawals averaging 100,000 gallons per day over a 30-day period (Weston 2011). Different commissions have slightly different powers. For example, the DRBC may designate "protected areas" where water withdrawals exceed recharge rates, limiting who can withdraw groundwater and when (Weston 2008a, b). The oversight of such commissions over groundwater use within their jurisdictions has been the most promising development to balance interstate groundwater pumping.

Rather than wait for a dispute to ripen into a conflict, as is the case in the Michindoh Aquifer briefly mentioned above, developing ways to better manage transboundary groundwater resources is critical. Potential governance solutions can be drawn from both intra-state and inter-state groundwater governance.

LESSONS LEARNED AND POTENTIAL NEXT STEPS

Developing the legal framework for regulating transboundary groundwater in the Eastern U.S. is a challenge given the hard-to-see nature of groundwater and the lack of fully quantified use. As pumping within states increases, stress on transboundary aquifers that underly multiple states will also increase. Based on the brief survey above, there are several lessons learned that can help going forward:

1. Quantification of actual pumping (permitted and nonpermitted) is needed, especially from transboundary aquifers and in places where irrigation is increasing.
2. For transboundary aquifers in coastal areas, the combination of drought and sea level rise is of particular concern.
3. Ecological flows also depend on the support of baseflows from groundwater and need to be incorporated into water budgets and allocations.
4. Incorporating good data and science into governance is critical.
5. Promoting cooperative relationships between neighboring users can help lead to innovative solutions, much like in Kansas.
6. Broader public involvement may also be helpful by developing statewide water plans, updating permit requirements, designating management areas, and conducting outreach activities.

The common law doctrine of the rule of capture is ill-equipped for appropriately regulating transboundary groundwater in present day. To sustainably regulate transboundary aquifers going forward, an inclusive approach of cooperative governance is warranted, if not, a necessity.

SUPPORTING INFORMATION

Additional supporting information may be found online under the Supporting Information tab for this article: This includes a map showing the number of states intersected by aquifer boundary lines.

ACKNOWLEDGMENTS

This work was supported by the Agriculture and Food Research Initiative (AFRI) Water for Agriculture grant no. 2017-68007-26584/project accession no. 1013079 from the USDA National Institute of Food and Agriculture.

LITERATURE CITED

Ackerman LLP. 2016. "The Florida Springs and Aquifer Protection Act." JDSUPRA. https://www.jdsupra.com/legalnews/the-florida-springs-and-aquifer-20350/

Associated Press. 2019. "Judge to Report to Supreme Court on Memphis v. Mississippi Water Rights Case." Associated Press. https://wreg.com/2019/06/04/judge-to-report-to-supreme-court-on-memphis-vs-mississippi-water-rights-case/

Bidgood, J. 2016. "Scenes from New England's Drought: Dry Wells, Dead Fish and Ailing Farms." *New York Times*. https://www.nytimes.com/2016/09/27/us/scenes-from-new-englands-drought-dry-wells-dead-fish-and-ailing-farms.html

Brean, H. 2013. "Utah Rejects Water Deal with Nevada." *Las Vegas Review-Journal*. https://www.reviewjournal.com/news/utah-rejects-water-deal-with-nevada/

Caroom, D.G., and S.M. Maxwell. 2013. "Texas Water Law Overview." Presented at 2013 Texas Water Law Institute, Austin, TX, 4–6 Dec 2013. https://www.bickerstaff.com/wp-content/uploads/2014/08/007211771.pdf

Central Florida Water Initiative. 2019a. "What is the CFWI?" https://cfwiwater.com/what_is_CFWI.html

Central Florida Water Initiative. 2019b. "Regulatory." https://cfwiwater.com/regulatory.html

Code of Virginia. 2019. "Groundwater Management Act of 1992. Section 62.1-254 to 62.1-270." https://law.lis.virginia.gov/vacodepopularnames/ground-water-management-act-of-1992/

Collins, M. 2009. "Evidence for Changing Flood Risk in New England Since the Late 20th Century." *Journal of the American Water Resources Association.* 45 (2): 279–90.

Dieter, C.A., M.A. Maupin, R.R. Caldwell, M.A. Harris, T.I. Ivahnenko, J.K. Lovelace, N.L. Barber, and K.S. Linsey. 2018. "Estimated Use of Water in the United States in 2015." U.S. Geological Survey Circular 1441, 65 pp. https://doi.org/10.3133/cir1441

DRBC (Delaware River Basin Commission). 2019. "About DRBC." https://www.state.nj.us/drbc/about/

Edelstein, B. 2016. "Drought causes wells to dry up across NH." *The Eagle Tribune*. https://www.eagletribune.com/news/new_hampshire/drought-causes-wells-to-dry-up-across-nh/article_bcc4151f-c0c6-5b65-a8a0-1ae63eb85565.html

Ficklin, D.L., J.T. Maxwell, S.L. Letsinger, and H. Gholizadeh. 2015. "A Climatic Deconstruction of Recent Drought Trends in the United States." *Environmental Research Letters* 10: 04409.

Florida Statutes 2019. "Florida Springs and Aquifer Protection Act. Title 28: Section 373.801 to 373.813." http://www.leg.state.fl.us/Statutes/index.cfm?App_mode=DisplayStatute&Search_String=&URL=0300-0399/0373/0373PARTVIIIContentsIndex.html

Georgakakos, A., P. Fleming, M. Dettinger, C. Peters-Lidard, T.C. Richmond, K. Reckhow, K. White, and D. Yates. 2014. "Ch. 3: Water Resources. Climate Change Impacts in the United States." The Third National Climate Assessment, 69–112. https://www.researchgate.net/publication/262876843_Ch_3_Water_Resources_Climate_Change_Impacts_in_the_United_States_The_Third_National_Climate_Assessment

Golden, B. 2016. "Monitoring the Impacts of Sheridan County 6 Local Enhanced Management Area." Kansas Department of Agriculture. https://agriculture.ks.gov/docs/default-source/lemas/2016-12-15_lema-report-formal-review.pdf?sfvrsn=4

Hall, N.D., and B.L. Cavataro. 2013. "Interstate Groundwater Law in the Snake Valley: Equitable Apportionment and a New Model for Transboundary Aquifer Management." *Utah Law Review* 2013 (6): 1572.

Hayhoe, K., C.P. Wake, T.G. Huntington, L. Luo, M.D. Schwartz, J. Sheffield, E. Wood et al. 2007. "Past and Future Changes in Climate and Hydrological Indicators in the US Northeast." *Climate Dynamics.* 28 (4): 381–407.

Henry, T. 2019. "Fight to Protect Michindoh Aquifer will Continue Even if Toledo Settles with Suburbs, Group Says." *The Blade*. https://www.toledoblade.com/local/environment/2019/09/22/fight-to-protect-michindoh-aquifer-will-continue/stories/20190922030

Howe, B. 2012. "Groundwater Ruling Balances Conservation and Property Rights." Upper Trinity Groundwater Conservation District. https://uppertrinitygcd.com/groundwater-ruling-balances-conservation-and-property-rights/

Johnson, T.D., K. Belitz, and M.A. Lombard. 2019. "Estimating Domestic Well Locations and Populations Served in the Contiguous U.S. for Years 2000 and 2010." *Science of the Total Environment* 687: 1261–73. https://doi.org/10.1016/j.scitotenv.2019.06.036

Kansas Department of Agriculture. 2018. "Local Enhanced Management Areas Fact Sheet." https://agriculture.ks.gov/docs/default-source/dwr-water-appropriation-documents/lema_fact_sheet.pdf?sfvrsn=bfce80c1_4

Kelly, M. 2010. "Nebraska's Evolving Water Law: Overview of Challenges and Opportunities." https://www.platteinstitute.org/Library/docLib/20100927_Kelly_Paper_-_FINAL.pdf

Kennen, J.G., M.L. Riskin, and E.G. Charles. 2014. "Effects of Streamflow Reductions on Aquatic Macroinvertebrates: Linking Groundwater Withdrawals and Assemblage Response in Southern New Jersey Streams, USA." *Hydrological Sciences Journal* 59 (3–4): 545–61. https://doi.org/10.1080/02626667.2013.877139

McCammon, S. 2017. "Google Moves in and Wants To Pump 1.5 Million Gallons of Water Per Day." National Public Radio. https://www.npr.org/2017/05/08/527214026/google-moves-in-and-wants-to-pump-1-5-million-gallons-of-water-per-day

Mitchell, D.J. 2019. "Baton Rouge Groundwater Commissioners Grapple with Size of Aquifer Problems, Path for Future." *The Advocate*. https://www.theadvocate.com/baton_rouge/news/article_40ec02e4-c68f-11e9-9142-c31fc51d212e.html

North Florida Regional Water Supply Partnership. 2019. "An Overview of the North Florida Regional Water Supply Partnership." https://northfloridawater.com/

Owen, C.C. 2016. "Local Enhanced Management Areas or 'What's not the matter with Kansas'?" Oral presentation at 2016 Annual American Water Resources Association Conference, Florida Hotel & Conference Center, Orlando, 13–17 Nov 2016.

Patashnik, J. 2014. "Arizona v. California and the Equitable Apportionment of Interstate Waterways." *Arizona Law Review.* 56 (1): 1–51. http://arizonalawreview.org/pdf/56-1/56arizlrev1.pdf

Pipkin, W. 2018. "Groundwater: The Next Frontier of Concern on Virginia's Eastern Shore." *Bay Journal*. https://www.bayjourna

l.com/article/groundwater_the_next_frontier_of_concern_on_virginias_eastern_shore

Sanchez, R., V. Lopez, and G. Eckstein 2016. "Identifying and Characterizing Transboundary Aquifers along the Mexico-US Border: An Initial Assessment." *Journal of Hydrology*. 535: 101–19. https://doi.org/10.1016/j.jhydrol.2016.01.0700022-1694/

SCOTUSblog. 2019. "Mississippi v. Tennessee." https://www.scotusblog.com/case-files/cases/mississippi-v-tennessee/

SRBC (Susquehanna River Basin Commission). 2019. https://www.srbc.net/about/about-us/

Taylor, R.G., B. Scanlon, P. Döll, M. Rodell, R. van Beek, Y. Wada, L. Longuevergne et al. 2013. "Ground Water and Climate Change." *Nature Climate Change* 3: 322–29. https://doi.org/10.1038/nclimate1744

Tyson, R. 2016. "For Delaware Farms, a Water 'Win-Win'." Delmarva Now. https://www.delmarvanow.com/story/news/local/delaware/2016/03/24/sussex-irrigation-systems/82203102/

United States Court of Appeals for the Sixth Circuit. 2019. "Special Master. Mississippi v. Tennessee; City of Memphis, Tennessee; and Memphis Light, Gas & Water Division, No. 143, Original." Order for Joint Proposal on Procedure and Schedule for Closing Arguments. https://www.ca6.uscourts.gov/sites/ca6/files/documents/special_master/No.%20120%20Order%20for%20Joint%20Proposal%20on%20Procedure%20and%20Schedule%20for%20Closing%20Arguments.pdf

USGCRP. 2018. *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment* (Volume II)." U.S. Global Change Research Program. https://doi.org/10.7930/NCA4.2018

USGS (United States Geological Survey). 2003. "Principal Aquifers of the United States." https://water.usgs.gov/ogw/aquifer/USAaquiferMAP11_17.pdf

Walton, B. 2017. "Wisconsin Towns Face Groundwater Crisis Alone." Circle of Blue. https://www.circleofblue.org/2017/water-management/wisconsin-towns-face-groundwater-crisis-alone/

Walton, B. 2018. "Infographic: Household Wells in the United States." Circle of Blue.https://www.circleofblue.org/2018/world/infographic-household-wells-in-the-united-states/

Weston, R.T. 2008a. "Harmonizing Management of Ground and Surface Water Use under Eastern Water Law Regimes." *University of Denver Water Law Review*. 11 (2): 239–82.

Weston, R.T. 2008b. "Development of the Marcellus Shale Water Resource Challenges." http://www.klgates.com/files/tempFiles/25afaae7-fcd1-4d5f-944b-1dd5950549c/Water_Resources_Issues_Related_to_Marcellus_Shale_Development.pdf

Weston, R.T. 2011. "Water and Wastewater Issues." Penn State Marcellus Shale Law and Policy Symposium. https://pennstatelaw.psu.edu/_file/aglaw/Marcellus_Shale/Water_and_Wastewater_Issues_Weston.pdf

Zullo, R. 2017. "State Reaches Deals with Large Water Users to Preserve Aquifers." *Richmond Times-Dispatch*. https://www.richmond.com/news/virginia/state-reaches-deals-with-large-water-users-to-preserve-aquifers/article_c607fb2e-c757-5017-8e6f-de923a456ac4.html