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DUSTBOWL WATERS: DOCTRINAL AND LEGISLATIVE SOLUTIONS TO SAVE THE OGALLALA AQUIFER BEFORE BOTH TIME AND WATER RUN OUT

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Eighty-three years after the Dust Bowl, residents of America's High Plains face a dire threat: their primary aquifer faces depletion, and entire sections of the country are set to run out of groundwater by the end of the century or sooner.

The Ogallala Aquifer provides a significant amount of America's agricultural irrigation water and is a primary source of drinking water for Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. This Article argues that policymakers should slow the Aquifer's depletion rate by implementing changes to irrigation technology, crop choice, consumer behavior, legal doctrine, and legislation.

This Article recommends specific legislative and legal solutions. First, the 2020 Farm Bill should expand water conservation incentives through voluntary metering and with-

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drawal limits, improved irrigation equipment investments, and high-water crop subsidy eliminations. Second, policymakers should encourage long-term planning through doctrinal changes, such as changing the "safe-yield" time horizon from decades to centuries. Third, Congress should empanel a National Aquifer Commission to spearhead collective management of this precious resource. Fourth, state and federal entities should work together to coordinate both information-gathering processes and reporting on groundwater depletion.

> "Columbia's waters taste like sparklin' wine; Dust Bowl waters taste like picklin' brine."[1]
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> –Woody Guthrie, *Columbia's Waters*

INTRODUCTION

In 1932 only twelve inches of rain fell near Boise City, Oklahoma—less than half the amount needed to produce a crop.[2] A

1. WOODY GUTHRIE, *Columbia's Waters*, *on* COLUMBIA RIVER COLLECTION (TRO Essex Music Grp. 1988).
2. *See* SALEH TAGHVAEIAN ET AL., OKLA. STATE UNIV., THE OGALLALA AQUIFER at BAE-1531-2 (2014), http://pods.dasnr.okstate.edu/docushare/dsweb

mixture of dust and sand thick enough to bury the remaining sod kept animals from grazing, leaving them to eat tumbleweeds.[3] The states overlying the Ogallala Aquifer[4] were the epicenter of the 1930s Dust Bowl.[5] Poor soil management practices and poor crop choices left the region unable to sustain life under the cloud of blowing sand. The already-severe droughts were aggravated by harsh dust storms that destroyed crops, machinery, and buildings.[6] Together, nature and man transformed the once-fertile Midwest into a Dust Bowl, or what mapmakers of the

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/Get/Document-10183/BAE-1531web.pdf [https://perma.cc/MP8V-56YP] (noting that the Panhandle region has a semi-arid climate with an average annual rainfall of about twenty inches during the past 120 years and that drought is common in the area); Warren B. White, Alexander Gershunov, & Jeffrey Annis, *Climatic Influences on Midwest Drought During the Twentieth Century*, 21 J. CLIMATE 517, 528 (2008) (observing that during the Dustbowl Era drought, rainfall variability was ten to forty millimeters per month below normal and most severe across Oklahoma, Kansas, eastern Nebraska, and Iowa).

3. *See* TIMOTHY EGAN, THE WORST HARD TIME: THE UNTOLD STORY OF THOSE WHO SURVIVED THE GREAT AMERICAN DUST BOWL 119 (2006).

4. The states that overlie the Ogallala Aquifer include Kansas, Nebraska, South Dakota, Wyoming, New Mexico, Colorado, Texas, and Oklahoma. MARTHA G. ROBERTS ET AL., ENVTL. DEFENSE, POTENTIAL IMPACTS OF BIOFUELS EXPANSION ON NATURAL RESOURCES: A CASE STUDY OF THE OGALLALA AQUIFER REGION 2 (2007), http://www.globalbioenergy.org/uploads/media/07_Environmental_Defense_-_Potential_Impacts_of_Biofuels_Expansion_on_Natural_Resources.pdf [https://perma.cc/B9LN-7BQ3].

5. The Dust Bowl refers to an extensive and unusual environmental phenomenon which took place in the Midwest in the 1930s. During that period, high winds and high temperatures exacerbated the impacts of mechanized agriculture. As a result, recurrent dust storms swept through the plains, causing extensive human hardship and economic ruin. *See* Jess C. Porter, *What Was the Dust Bowl? Assessing Contemporary Popular Knowledge*, 35 POPULATION & ENV'T 391, 391 (2014). In the 1930s, widespread, massive, destructive, and vision-blocking dust storms covered parts of Texas, Oklahoma, Kansas, Colorado, and New Mexico. John Steinbeck's novel *The Grapes of Wrath* describes the human dislocation of this period with heartbreaking vividness. JOHN STEINBECK, THE GRAPES OF WRATH (1939). The Dust Bowl was the result, at least in part, of an ecological crisis caused by humans. Some argue that it resulted from uncontrolled, mechanized agriculture in the delicate topsoil of the tallgrass prairie, which was subject to high winds, variable and erratic rainfall, and occasional small dust storms. *See* Hamid R. Ekbia & Venkata Ratnadeep Suri, *Of Dustbowl Ballads and Railroad Rate Tables: Erudite Enactments in Historical Inquiry*, 48 INFO. & CULTURE 260, 265–69 (2013). Drought destroyed crops and made water for livestock scarce. The combination of difficult climatic conditions, crop failure, and socioeconomic decline led to dramatic mass migration. At least three hundred thousand people left the southern plains for California in search of wage work. *See, e.g.*, Robert McLeman, *Migration out of 1930s Eastern Oklahoma: Insights for Climate Change Research*, 26 GREAT PLAINS Q. 27, 28 (2006).

6. Bryant Putney, *Reconstruction in the Dust Bowl*, 2 EDITORIAL RES. REP. (1937), http://library.cqpress.com/cqresearcher/cqresrre1937080300 [https://perma.cc/3FZ9-VL6L].

1880s called the "Great American Desert."[7] Many Americans starved during the Dust Bowl years.[8] Families abandoned their failing farms and moved elsewhere. "Dust came to characterize the 1930s . . . ."[9]

A second Dust Bowl now threatens the Southwest and Midwest regions in the second half of the twenty-first century. Confusing and conflicting groundwater laws, poorly planned agricultural practices, and a lack of willingness by farmers, consumers, and lawmakers to limit excessive groundwater withdrawals threaten to turn the region back into the 1880s desert. Without significant, rapid changes to irrigation technology, farmer behavior, and groundwater law, several American aquifers will be depleted within our lifetime, and the High Plains may experience another dust bowl.[10]

America's aquifers[11] are being rapidly depleted[12] and seriously threatened.[13] The grandest of these is the High Plains Aquifer, also known as the Ogallala Aquifer.[14] Ogallala, a Sioux word meaning "to scatter their own" or "to spread throughout,"

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7. *See* Ben Livneh & Martin P. Hoerling, *The Physics of Drought in the U.S. Central Great Plains*, 29 J. CLIMATE 6783, 6783 (2016).

8. *See* Robert A. McLeman et al., *What We Learned from the Dust Bowl: Lessons in Science, Policy, and Adaptation*, 35 POPULATION & ENV'T 417, 418 (2013) (providing a comprehensive review of literature spanning the ecological, meteorological, and atmospheric causes and impacts, as well as the socioeconomic impacts of the Dust Bowl).

9. Gary A. Fine & Tim Hallet, *Dust: A Study in Sociological Miniaturism*, 44 SOC. Q. 1, 7 (2003).

10. *See* S.A. LEAKE, A.D. KONIECZKI & J.A.H. REES, U.S. DEP'T OF THE INTERIOR, U.S. GEOLOGICAL SURVEY, FACT SHEET 086-00, GROUNDWATER RESOURCES FOR THE FUTURE: DESERT BASINS OF THE SOUTHWEST (2000), https://pubs.usgs.gov/fs/0086-00/report.pdf [https://perma.cc/9H9D-SJ5S].

11. An aquifer is "a rock formation that contains and can transmit water." Aquifers are the physical storage system for groundwater. BEN MANDLER, AM. GEOSCIENCES INST., GROUNDWATER USE IN THE UNITED STATES (2017), https://www.americangeosciences.org/sites/default/files/CI_Factsheet_2017_2_groundwater_170309.pdf [https://perma.cc/4WHW-7PKZ].

12. Groundwater depletion refers to the "reduction in the volume of groundwater in storage in the subsurface . . . ." LEONARD F. KONIKOW, U.S. DEP'T OF THE INTERIOR, SCI. INVESTIGATIONS REP. 2013-5079, GROUNDWATER DEPLETION IN THE UNITED STATES (1900–2008), at 1 (2013), https://pubs.usgs.gov/sir/2013/5079/SIR2013-5079.pdf [https://perma.cc/2VXZ-AK7Q].

13. *See id.* (noting that groundwater depletion "is becoming recognized as an increasingly serious global problem that threatens sustainability of water supplies").

14. The scientific name for the system under discussion in this Article is the "High Plains Aquifer." However, laypeople use the names Ogallala and Ogallala Aquifer interchangeably. I find the name Ogallala Aquifer to be more evocative, so I use it throughout the Article.

refers to the Sioux diaspora, and fittingly suggests that the waters of the Aquifer are scattered under several states.[15] Although the Ogallala Aquifer is invisible to the naked eye, it is one of America's "greatest natural wonders."[16] This huge underground body of water, "one of the largest aquifers in the world,"[17] runs beneath eight states: New Mexico, Colorado, Wyoming, South Dakota, Nebraska, Kansas, Oklahoma, and Texas, covering 174,000 square miles.[18] Additionally, it is the largest underground aquifer system in the United States.[19]

Water drawn from the Aquifer irrigates millions of acres of cropland, representing about 27 percent of the nation's total irrigated area.[20] In 1990, the Ogallala Aquifer comprised approximately 3.5 billion acre-feet.[21] To put this in perspective, one acre-foot of ground water is enough to cover an acre of land with one foot of water. If pumped out, the water in the Aquifer could cover the entire continental United States with nearly a foot and a half of water.[22] For over seventy years, farmers in eight states have been mining the Ogallala Aquifer, which has resulted in a highly unsustainable rate of use.[23] Indeed, the Ogallala Aquifer

15. Robert R.M. Verchick, *Dust Bowl Blues: Saving and Sharing the Ogallala Aquifer*, 14 J. ENVTL. L. & LITIG. 13, 17 (1999).

16. Jack Lewis, *The Ogallala Aquifer: An Underground Sea*, 16 EPA J. 42, 42 (1990).

17. Noah Gallagher Shannon, *The Water Wars of Arizona*, N.Y. TIMES MAG. (July 30, 2018), https://www.nytimes.com/2018/07/19/magazine/the-water-wars-of-arizona.html [https://perma.cc/92A4-4VPM].

18. Verchick, *supra* note 15, at 17.

19. TAGHVAEIAN ET AL., *supra* note 2; Lewis, *supra* note 16, at 42.

20. Sandra Postel, *Texas Water District Acts to Slow Depletion of the Ogallala Aquifer*, NAT'L GEOGRAPHIC (Feb. 7, 2012), https://blog.nationalgeographic.org/2012/02/07/texas-water-district-acts-to-slow-depletion-of-the-ogallala-aquifer/ [https://perma.cc/567V-2NSE].

21. L. Allen Torell et al., *The Market Value of Water in the Ogallala Aquifer*, 66 LAND ECON. 163, 163 (1990).

22. Lewis, *supra* note 16, at 42.

23. Richard M. Cruse et al., *Irrigation Aquifer Depletion: The Nexus Linchpin*, 6 J. ENVTL. STUDIES & SCIS. 149 (2016) (observing that water level declines began in portions of the aquifer after extensive irrigation, and observing that the Ogallala Aquifer is being depleted at a historic rate). The term groundwater "mining" refers to withdrawals from an aquifer that exceed the aquifer's average rate of annual recharge. A. DAN TARLOCK ET AL., WATER RESOURCE MANAGEMENT: A CASEBOOK IN LAW AND PUBLIC POLICY 330 (7th ed. 2013). The term "mining" is a more neutral term than "over-pumping" and applies to aquifers with recharge rates so low that they cannot reasonably be used unless they are mined. Some states respond by limiting pumping rates. Other states, such as New York, forbid drilling wells over natural springs. *Id.* at 330–32.

will empty if nothing is done in the medium-to-long run (which scientists consider to be one hundred years).[24]

The Ogallala is being depleted at an alarmingly fast rate; for instance, it lost ten cubic kilometers (km^3) every year between 2000 and 2008.[25] Because these numbers can be difficult to visualize, it is helpful to imagine these numbers in terms of volume—the water a person sees and experiences. To put this in such terms, in 2009, the Aquifer was depleted at the annual rate of eighteen Colorado Rivers.[26] According to geoscientists, the Ogallala depletion rate has not stabilized, and its total depletion between 2001 and 2008 represents 32 percent of the cumulative depletion in the twentieth century.[27] As of 2012, the groundwater in the High Plains Aquifer was depleted by approximately 330 km^3 between the 1950s and the mid-2000s.[28] More immediately, the Ogallala's depletion rate can be understood in terms of the wells in our backyards: in 2013, a well in Texas measured the Aquifer's maximum water decline at 256 feet.[29] If the immediate impact of a well doesn't translate, imagine this: a Kansas

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24. *See* NAT. RES. CONSERVATION SERV., U.S. DEP'T OF AGRIC., OGALLALA AQUIFER INITIATIVE: 2017 PROGRESS REPORT (2017), https://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcseprd1407817.pdf [https://perma.cc/CD44-93FX]; Cruse et al., *supra* note 23; M. Alexander Pearl, *The Tragedy of the Vital Commons*, 45 ENVTL. L. 1021, 1023 (2015); Jack Tuholske, *Trusting the Public Trust: Application of the Public Trust Doctrine to Groundwater Resources*, 9 VT. J. ENVTL. L. 190, 191 (2008).

25. Burke W. Griggs, *Beyond Drought: Water Rights in the Age of Permanent Depletion*, 62 U. KAN. L. REV. 1263, 1265 (2014); KONIKOW, *supra* note 12, at 22.

26. Jane Braxton Little, *The Ogallala Aquifer: Saving a Vital U.S. Water Source*, SCI. AM. (Mar. 1, 2009), https://www.scientificamerican.com/article/the-ogallala-aquifer/ [https://perma.cc/L6TS-EPSK]. The Colorado River is the nation's seventh-longest river. Sarah Zielinski, *The Colorado River Runs Dry*, SMITHSONIAN MAG. (Oct. 2010), https://www.smithsonianmag.com/science-nature/the-colorado-river-runs-dry-61427169/ [https://perma.cc/FGQ2-7M8L]. The 100-year flow of the Colorado River (1906 to 2011) is about 16.4 million acre-feet. BUREAU OF RECLAMATION, U.S. DEP'T OF THE INTERIOR, COLORADO RIVER BASIN WATER SUPPLY AND DEMAND STUDY 3 (2012), https://www.usbr.gov/lc/region/programs/crbstudy/finalreport/Study%20Report/CRBS_Study_Report_FINAL.pdf [https://perma.cc/XJA3-GQSH].

27. KONIKOW, *supra* note 12, at 22. Imagine a kilometer of water in length. A kilometer cubed represents the volume of a kilometer of water viewed in three dimensions.

28. Bridget R. Scanlon et al., *Groundwater Depletion and Sustainability of Irrigation in the US High Plains and Central Valley*, 109 PNAS 9320, 9321 (2012).

29. TAGHVAEIAN ET AL., *supra* note 2, at BAE-1531-1; *see also* Sandra Postel, *Drought Hastens Groundwater Depletion in the Texas Panhandle*, NAT'L GEOGRAPHIC (July 24, 2017), https://blog.nationalgeographic.org/2014/07/24/drought-hastens-groundwater-depletion-in-the-texas-panhandle/ [https://perma.cc/58WT-7BQ4]; Postel, *supra* note 20.

State University study predicts that if current withdrawal rates continue, 69 percent of the Aquifer's volume will be depleted by 2063.[30] These extraordinary numbers illuminate the extent of the threat people in the High Plains face. If these numbers do not inspire policymakers to act, it is possible that we have just one more generation of access to the Aquifer's waters.

Several American aquifers, such as the Central Valley Aquifer and the Arizona Alluvial Aquifer, are rapidly approaching depletion, and several other aquifers, including the Mississippi Embayment, will approach depletion within the next generation.[31] Depleting the nation's aquifers will result in severe economic and social dislocation nationwide. The U.S. economy heavily relies on groundwater to meet half of its water needs for both agricultural uses and domestic water supplies, including drinking water.[32] Many U.S. regions depend on aquifers for fresh water. Aquifer depletion endangers the ability of western states to access adequate drinking water. Indeed, the Golden State of California relies on groundwater for at least 60 percent of the state's water needs in drought years.[33]

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30. Roxana Hegeman, *Ogallala Aquifer Will Be 69 Percent Depleted in 50 Years, K-State Study Says*, WICHITA EAGLE (Aug. 26, 2013), https://www.kansas.com/news/article1121517.html [https://perma.cc/6FRN-P4JJ].

31. Determining the actual water levels in aquifers is very difficult because most states do not require monitoring. This problem is discussed later in the Article. *See infra* Section I.A. That being said, we do know whether active wells are still operational. The Central Valley Aquifer in California is in crisis, as are the western alluvial basins in Arizona. *See* KONIKOW, *supra* note 12, at 22–26. In the Antelope Valley on the edge of the Mojave Desert in Southern California, water level declines exceed three hundred feet. Groundwater level declines near Las Vegas, Nevada, also exceed nine hundred feet. Significant declines have also been observed in Suffolk County, New York; in Tampa, Florida; in Baton Rouge, Louisiana; and in Memphis, Tennessee. *See* J.R BARTOLINO & W.L. CUNNINGHAM, U.S. DEP'T OF THE INTERIOR, U.S. GEOLOGICAL SUR., FACT-SHEET 103-03, GROUNDWATER DEPLETION THROUGHOUT THE NATION (2003), https://pubs.usgs.gov/fs/fs-103-03/JBartolinoFS(2.13.04).pdf [https://perma.cc/954V-4CSD]; *see also* Felicity Barringer, *As California's Groundwater Free for All Ends, Gauging What's Left*, STAN. UNIV. (Nov. 9, 2018), https://earth.stanford.edu/news/californias-groundwater-free-all-ends-gauging-whats-left#gs.tromk4 [https://perma.cc/5PSQ-MKD7]; Abdul Khan & Dan McManus, *California's Groundwater Update 2013: A Compilation of Enhanced Content for California Water Plan Update 2013* (2015), https://water.ca.gov/LegacyFiles/waterplan/docs/groundwater/update2013/other/webex_presentations/2_California_Groundwater_Update_2013_Final.pdf [https://perma.cc/8NHZ-NZM9].

32. *See* TARLOCK ET AL., *supra* note 23, at 293.

33. *Groundwater*, WATER EDUC. FOUND. https://www.watereducation.org/general-information/groundwater (last visited Apr. 6, 2020) [https://perma.cc/MY6M-3CFN]; *Groundwater in California*, PUB. POL'Y INST. OF CAL., https://www.ppic.org/publication/groundwater-in-california/ (last visited Apr. 6,

Yet, given increasing depletion rates and low recharge rates, it is entirely possible that parts of the Ogallala Aquifer could dry up completely within our lifetime,[34] resulting in dramatic consequences. Because of the Ogallala's size and importance to American agriculture, the effects of it going dry would be catastrophic. This magnificent, unseen national treasure helped transform the former dust bowl into an agricultural grain belt. The Ogallala is the most majestic of the American aquifers, crosses numerous state lines, and supports the most agriculture of any American aquifer. The Ogallala Aquifer supports the majority of irrigated agriculture in the southern Great Plains and "provides one-fourth of the total water supply used for agricultural production across the U.S."[35] Furthermore, the Ogallala represents the "canary in the coal mine" of groundwater policy in the United States.[36] Indeed, John Opie argues that the "Ogallala problem," as he calls it, represents a case study in how a modern technological society will succeed—or not—in achieving sustainability.[37]

2020) [https://perma.cc/6HN5-DGUG] (observing that, on average, aquifers provide nearly 40 percent of the water used by California's farms and cities and may provide more during drought periods. About 85 percent of Californians depend on groundwater for some portion of their water supply.).

34. *See* Laura Parker, *What Happens to the US Midwest When the Water's Gone?*, NAT'L GEOGRAPHIC (Aug. 2016), https://www.nationalgeographic.com/magazine/2016/08/vanishing-midwest-ogallala-aquifer-drought/_[perma.cc/4F6N-HWL6] (observing that parts of the Ogallala could endure for a century, but noting that the heart of the Ogallala, which runs from the Texas Panhandle to the Kansas/Nebraska state line, will likely dry up more quickly).

35. TAGHVAEIAN ET AL., *supra* note 2, at BAE-1531-1; *see also* ROBERTS ET AL., *supra* note 4.

36. Coal mining has always been an extremely dangerous profession. Miners in the United States, Britain, and Canada used canaries in coal mines from the early 1900s until the 1980s. Miners frequently died of "mine gas," or carbon monoxide, which is colorless, odorless, and tasteless. When too much "mine gas" was in the air, the miners' bodies replaced the oxygen in their red blood cells with this gas, leading to headaches, weakness, dizziness, confusion, blurred vision, and ultimately loss of consciousness, culminating in death. Canaries represent a sentinel species. Canaries are more sensitive than humans are to carbon monoxide. If the canary became ill or died, miners knew that they should evacuate, as the presence of such gases could lead to an explosion. *See* Kat Eschner, *The Story of the Real Canary in the Coal Mine*, SMITHSONIAN MAG. (Dec. 30, 2016), https://www.smithsonianmag.com/smart-news/story-real-canary-coal-mine-180961570 [https://perma.cc/SD9Y-3YP8]; *The Canary in a Coal Mines*, APPALACHIAN MAG. (Sept. 11, 2019), http://appalachianmagazine.com/2019/09/11/the-canary-in-a-coal-mines [https://perma.cc/HRK4-YGQK]. As a result, the phrase "canary in the coal mine" warns of impending danger of a potentially catastrophic nature.

37. JOHN OPIE ET AL., OGALLALA: WATER FOR A DRY LAND (3d ed. 2018).

Given the risks associated with Ogallala depletion, this Article identifies new solutions that will confront these risks and also contains three original contributions to the legal literature on groundwater. First, it draws attention to the crisis facing American farming within the next generation. Second, it integrates legal scholarship on the Ogallala Aquifer with the latest scientific and social science literature on America's aquifers. Finally, the Article builds on other scholars' research and presents novel doctrinal and legislative approaches for increasing aquifer sustainability. This Article argues that implementing a suite of changes—ranging from small, incremental, and politically feasible solutions to grand, dramatic, and politically contentious solutions—will enable state and federal lawmakers to incentivize protecting groundwater at the national level.

Since time is running out, this Article proposes that in the short-term, state and federal lawmakers must acknowledge that the Ogallala's groundwater is a nonrenewable resource.[38] These stakeholders should consider imposing state and federal groundwater limitations and fines for exceeding such limits. Once lawmakers have acknowledged the crisis facing American groundwater, Congress should use its legislative powers under the Agricultural Appropriations Act (informally known as, and referred to in this Article as, the Farm Bill) to better encourage conservation-related activities.

Most legal scholars have overlooked the opportunities for aquifer sustainability inherent in modifications to the Farm Bill.[39] The Farm Bill is renewed every four years. Congress has not used the Farm Bill as completely as it should, in part because the bill is a gigantic and complex statute that covers everything from commodity subsidies to federal crop insurance policy. However, the first Farm Bill was passed in 1933 in response to the ravages caused by both the Great Depression and the Dust Bowl, and Congress included an explicitly environmental bent as it

38. Groundwater is not inherently a nonrenewable resource. Some aquifers have recharge rates that enable them to produce significant quantities of water in a sustainable manner. The problem arises when groundwater is pumped at a rate faster than the aquifer's recharge rate. Sadly, in many regions, aquifers are being mined as if they were nonrenewable, depletable resources like oil. TARLOCK ET AL., *supra* note 23, at 294 (observing that pumping from groundwater deposits with slow refill rates means mining a finite resource).

39. *See* Consolidated Appropriations Act, 2019, Pub. L. No. 116-6, 133 Stat. 3, 54–58 (discussing farm production and conservation programs).

sought to reverse the catastrophic damage to soil and grassland caused by agricultural overproduction.[40]

The 2020 Farm Bill should be incrementally adjusted to change farmers' incentives regarding aquifer depletion. Farmers should receive increased tax deductions to support (1) investing in water-saving irrigation equipment, (2) voluntarily investing in water-metering equipment, (3) collaborating with state and federal agencies engaged in groundwater conservation, and (4) switching to crops that use less water in areas of rapid groundwater depletion. In addition to these policy changes, doctrinal changes are also required. For instance, state horizons for groundwater use must be lengthened, meaning that doctrines contemplating the useful life of an aquifer as twenty-five or fifty years should instead contemplate a useful life as one hundred and fifty to three hundred years.[41] Whereas some states, like Colorado, have extended groundwater depletion horizons to contemplate at least one hundred years of aquifer use, other states such as Oklahoma, have horizons as short as twenty years. Although not all of these measures will be politically popular, the consequences of doing nothing may result in a return to the Dust Bowl conditions of the 1930s.

A. *Overview of the Agricultural and Social Crisis Caused by Groundwater Depletion*

This Section explains aquifers and groundwater generally and discusses the differences between groundwater withdrawals and groundwater depletion. It then reviews how difficult it is to measure aquifer depletion and water levels and discusses the dangerous effects aquifer depletion has on health, the economy, and agriculture.

When people think of water resources, they often think of surface water, such as ponds, lakes, rivers, and reservoirs; when they think of precipitation, they think of rain, snow, hail, and mist. Invisible, and therefore often unconsidered, underground aquifers are a crucial component to hydrologically connected

40. McLeman et al., *supra* note 8.

41. Statutes that consider the useful life of an aquifer to last twenty years assume that after twenty years the aquifer will be drained, and no usable groundwater will be left. A longer horizon would assume that it takes much longer to exhaust the usable water in the aquifer, and, in theory, states could set limits to allow the aquifer to be used forever.

surface water.[42] Underground aquifers contain groundwater, which is defined as water found underground in the cracks, crevices, and pores of soil, sand, or rock.[43] Aquifers are both a storage system for groundwater and a crucial freshwater resource. Aquifers are primarily recharged when rainfall soaks into the ground. However, the recharge rate can be extremely slow, and it can take thousands of years to replace what humans extract in a few days.[44]

Today, machine pumps allow farmers to withdraw hundreds of gallons in minutes while an aquifer may take hundreds or thousands of years to recharge. Hydrologists use the term "groundwater mining" to describe conditions where groundwater is removed at rates that exceed the aquifer's natural recharge rate.[45] When groundwater is removed at such high rates, the aquifer becomes "nonrenewable." Under such conditions, the recharge rate is low and humans extract water more quickly than it can be replenished.[46] For example, if the Ogallala Aquifer is depleted entirely, it will take approximately 1,300 years to refill.[47]

Groundwater withdrawal is not the same as groundwater depletion. Sustainably withdrawing groundwater is possible. At its most restrictive, a sustainable withdrawal rate would limit withdrawals to amounts below the aquifer's recharge rate. Studies of water resources inform us that the vast reserves of water in aquifers accumulate very slowly, not just over centuries, but over millennia. The challenge is to extend the aquifer's life to benefit the ecosystem, wildlife, future generations of farmers,

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42. Dennis Dimick, *If You Think the Water Crisis Can't Get Worse, Wait Until the Aquifers Are Drained*, NAT'L GEOGRAPHIC (Aug. 21, 2014), https://news.nationalgeographic.com/news/2014/08/140819-groundwater-california-drought-aquifers-hidden-crisis/ [https://perma.cc/D3FB-8VLM].

43. MANDLER, *supra* note 11.

44. *Id.*

45. Tuholske, *supra* note 24.

46. Dimick, *supra* note 42; OPIE ET AL., *supra* note 37, at 3–4. In particular, the Ogallala is nonrenewable because its key sources were cut off thousands of years ago. The Ogallala Aquifer has a low natural recharge rate. WILLIAM M. ALLEY ET AL., U.S. DEP'T OF THE INTERIOR, *Sustainability of Ground Water Resources*, 1186 U.S. GEOLOGICAL SURV. CIRCULAR 1 (1999). According to KONIKOW, *supra* note 12, at 22, evaporation rates in the High Plains are high relative to precipitation, so there is little water available to recharge the Ogalla Aquifer. *See also* Parker, *supra* note 34 (noting that for the past 60 years the Ogallala has been pumped out faster than rain and snowmelt can replenish it).

47. Hegeman, *supra* note 30; *see also* TAGHVAEIAN ET AL., *supra* note 2, at BAE-1531-3 (observing that the Ogallala Aquifer has a very low recharge rate).

and those who depend on their products.[48] Alternatively, a less sustainable option would allow withdrawals that exceed the recharge rate but still extend the aquifer's life, sometimes for as long as centuries. For those scientists and scholars who recognize the crucial interconnections between groundwater and surface water, the best option for the Ogallala is to limit withdrawals so that the Aquifer lasts centuries.

Although both recharge and depletion rates are known, they operate against a backdrop of uncertainty. Scientists, farmers, and water managers have inadequate information regarding the amount of water left in most American aquifers. Therefore, decision-making about aquifer management operates amid this tension between the known and unknown. Hydrologist Alexandra Richey from the University of California, Irvine, observes that incomplete data exists regarding how much water remains in aquifers, despite the availability of satellites and other modern technologies.[49] While aquifer withdrawal rates are known in areas where measurements are available, exactly how much water remains is unknown. Accordingly, it is difficult for scientists to calculate the moment of complete depletion. As a result, scientists can only estimate when the aquifer will run dry.[50] In arid areas, high demand for groundwater and slow replenishment provide serious challenges for sustainable groundwater management, but these challenges are even more ominous against the unknown factor of the capacity of the aquifer itself.[51] Due to agricultural demands, changes in precipitation due to climate change, and population pressures, American aquifers are being depleted at a rate much faster than their recharge,[52] and the

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48. Little, *supra* note 26.

49. Alexandra S. Richey et al., *Quantifying Renewable Groundwater Stress with GRACE*, 51 WATER RES. RESEARCH, 5217, 5222-23 (2015) [hereafter Richey et al., *GRACE*]; Alexandra S. Richey et al., *Uncertainty in Global Groundwater Storage Estimates in a Total Groundwater Stress Framework*, 51 WATER RES. RESEARCH, 5198, 5198–216 (2015).

50. Accounts of groundwater depletion are estimates. *See* KONIKOW, *supra* note 12, at 1, 4–6 (discussing methodology).

51. MANDLER, *supra* note 11. Withdrawal is not the same as depletion. It is possible to withdraw from aquifers at a sustainable rate. Groundwater sustainability is defined as developing and using groundwater in a way that can be maintained over the long term without causing unacceptable environmental, economic, or social consequences.

52. American aquifers also face significant threats from contamination by pesticides, fertilizers, or other contaminants, which can render the pure waters of the aquifer toxic. For the sake of coherence, this Article deals only with the issue of depletion. ENVTL PROT. AGENCY, GETTING UP TO SPEED: GROUND WATER

estimated rate of depletion is increasing.[53] Further, according to the United States Geological Survey ("USGS"), the rate of U.S. groundwater depletion has increased significantly, with particularly rapid depletion occurring between 2000 and 2008.[54]

Mechanized pumps allow farmers to withdraw hundreds of gallons of water in minutes.[55] In fact, advancements in mechanized pumping technology have resulted in the groundwater-mining rate doubling between 1960 and 2000.[56] Over this same time period, aquifers have also supported the increased burden stemming from a growing population, unabated agricultural irrigation, and increasingly variable weather.[57] Further, expansion of the U.S. energy sector is also expected to increase regional demands for water.[58] In most river basins of the western United States, surface water supplies are fully appropriated, and opportunities for large-scale water supply development are

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CONTAMINATION (1991), https://www.epa.gov/sites/production/files/2015-08/documents/mgwc-gwc1.pdf [https://perma.cc/59D3-FN6W].

53. A third of the world's largest aquifers are in trouble. Hydrologists Alexandra Richey and Jay Famiglietti of NASA's Jet Propulsion Laboratory assert that a global effort to determine the water availability in aquifers is needed and that the U.S. Geological Survey needs additional funding to conduct such exploration work. Richey et al., *GRACE*, *supra* note 49, at 5222–23; *see also* Ian James, *Study: A Third of World's Major Aquifers Threatened*, USA TODAY, (June 17, 2015), https://www.usatoday.com/story/news/world/2015/06/17/water-aquifer-drought/28893121/ [https://perma.cc/TA8W-NXHW].

54. KONIKOW, *supra* note 12, at 1.

55. Jesse Newman, *The Water Wars that Defined the American West Are Heading East*, WALL ST. J. (Dec. 2, 2019, 2:35 PM), https://www.wsj.com/articles/the-water-wars-that-defined-the-american-west-are-heading-east-11575315318 [https://perma.cc/3DAA-G287] (observing that at peak times, farmers in the lower Flint River basin pull hundreds of millions of gallons of water a day from the Floridian aquifer). One mechanized well pumped the equivalent of twenty-five thousand gallons per day. *Groundwater and the Rule of Capture*, TEX. STATE LIBRARY & ARCHIVES COMM'N (May 20, 2016), https://www.tsl.texas.gov/lobbyexhibits/water-capture [https://perma.cc/PX3J-S9AC]; *see also* Nicole C. Brambila, *Drying Times: Could the Rapidly Depleting Ogallala Aquifer Run Dry?*, LUBBOCK AVALANCHE J. (Aug. 9, 2014), https://www.lubbockonline.com/article/20140809/NEWS/308099828 [https://perma.cc/5BLQ-ANP2] (noting that pumping capacity is declining in some Texas counties and observing that wells that once produced five hundred gallons a minute are now producing fifty gallons a minute).

56. KONIKOW, *supra* note 12, at 1 (observing that groundwater withdrawals in the United States have increased dramatically during the 20th century—more than doubling from 1950 through 1975).

57. Pearl, *supra* note 24, at 1023.

58. RON PATE ET AL., SANDIA NAT'L LABS., OVERVIEW OF ENERGY-WATER INTERDEPENDENCIES AND THE EMERGING ENERGY DEMANDS ON WATER RESOURCES (2007), https://amfarid.scripts.mit.edu/resources/Media/Pate2007.pdf [https://perma.cc/J7J4-T8VH].

limited.[59] Aquifers from the Mississippi Embayment to the Atlantic Aquifer face the threat of rapid depletion, as does the Ogallala Aquifer.[60]

Depleted aquifers not only destroy local wildlife and crops, they also result in severe economic and social dislocation nationwide. The U.S economy was built upon irrigation drawn from these underground seas.[61] The market value of the agricultural products in the Ogallala Aquifer region was $35 billion in 2012.[62] Accordingly, finding ways to enhance aquifer sustainability is important for future crop production in the United States. The largest groundwater users, ascending according to their percentage of groundwater withdrawals, include California, Arkansas, Texas, Nebraska, and Idaho. States most dependent on groundwater include Kansas, Arkansas, Mississippi, Florida, and Hawaii.[63]

Rapid groundwater withdrawals carry additional risks beyond water loss, including health risks, decreased property values, seawater penetration, subsidence, and destruction of connected surface water. While dependent regions would see reduced supplies of drinking water and agricultural irrigation in the near and medium term, this takes effect more concretely in terms of losses in property values and threatened health.[64] As a result of rising sea levels, withdrawing groundwater in areas adjacent to the Atlantic Aquifer may cause seawater to penetrate

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59. Mark T. Anderson & Lloyd H. Woosley, Jr., *Water Availability for the Western United States: Key Scientific Challenges*, 1261 U.S. GEOLOGICAL SURV. CIRCULAR 1 (2005), https://pubs.usgs.gov/circ/2005/circ1261/pdf/C1261.pdf [https://perma.cc/VRF5-8NWT].

60. KONIKOW, *supra* note 12, at 5; Tuholske, *supra* note 24, at 190. Other aquifers experiencing duress include the Arizona alluvial basins and the Central Valley Aquifer in California.

61. Pearl, *supra* note 24, at 1062.

62. Scanlon et al., *supra* note 28, at 9320.

63. MANDLER, *supra* note 11.

64. BARTOLINO & CUNNINGHAM, *supra* note 31 (observing that where groundwater is pumped from an aquifer, surface water of poor or differing quality may be drawn into the aquifer, which can degrade the water quality of the aquifer directly or mobilize naturally occurring contaminants in the aquifer); WORLD HEALTH ORG., PROTECTING GROUNDWATER FOR HEALTH 8 (Oliver Schmoll et al. eds., 2006) (noting that overpumping of groundwater may change conditions in the subsurface environment substantially—e.g., redox conditions—and thus induce mobilization of natural or anthropogenic contaminants that can lead to waterborne disease, and also observing that lack of a safe water supply affects disease incidence—for instance, by restricting options for personal and household hygiene); Dimick, *supra* note 42.

the freshwater aquifer,[65] reducing, or even destroying, crucial freshwater supplies. Groundwater depletion may lead to reduced surface-water flows,[66] loss of wetlands, an increased incidence of earthquakes,[67] and destruction of natural springs and wildlife habitat.[68] Furthermore, groundwater is important for flow in streams and rivers.[69] With record-breaking droughts affecting states overlying the aquifers, surface water supplies are drying up,[70] leading to desertification. Additionally, declining aquifer levels results in increased electricity costs to run pumps, decreased water quality,[71] and damage to land values.[72] Land subsidence constitutes one of the most serious problems attributable to groundwater pumping, and is increasing in California, Texas, Florida, Delaware, New Mexico, New Jersey, Colorado, Idaho, Georgia, and Virginia.[73]

In addition to severe economic and ecological consequences, the current state of affairs raises urgent legal and regulatory problems regarding groundwater depletion. Because current legal regimes are localized, they form a confusing patchwork of laws and regulations that differ from state to state and locality to locality. This patchwork causes aquifer water rights to be over-appropriated, resulting in massive depletion rates. Left unabated, permanent water shortages could result.[74] In fact, over-pumping U.S. aquifers combined with the variability in state laws has led to interstate litigation. For example, Kansas and Colorado engaged in a lengthy legal battle over violations to the Arkansas River Compact.[75] Such conflicts are likely to increase in frequency and severity as the climate becomes dryer and demands on aquifers increase.

65. KONIKOW, *supra* note 12, at 4; Tuholske, *supra* note 24, at 192.

66. Anderson & Woosley, *supra* note 59, at 40–45.

67. Colin B. Amos et al., *Uplift and Seismicity Driven by Groundwater Depletion in Central California*, 509 NATURE 483, 483–86 (2014).

68. KONIKOW, *supra* note 12, at 1; Anderson & Woosley, *supra* note 59, at 41; J. B. Ruhl, *Farms, Their Environmental Harms, and Environmental Law*, 27 ECOLOGY L.Q. 263, 279 (2000).

69. Anderson & Woosley, *supra* note 59, at 42.

70. *Id.*

71. BARTOLINO & CUNNINGHAM, *supra* note 31, at 1.

72. Torell et al., *supra* note 21, at 172.

73. Tuholske, *supra* note 24, at 197.

74. Griggs, *supra* note 25, at 1311.

75. Kansas v. Colorado, No. 105, 2000 WL 34508307 (U.S. 2000).

B. *American Aquifers Face Depletion as Water Demands Increase*

The Ogallala Aquifer is between thirty-three million and twelve million years old.[76] Almost all of its recharge is based on percolation of surface water or precipitation. Because the Great Plains region is semi-arid, the Ogallala has a low recharge rate. Little precipitation—less than one inch per year—reaches the groundwater because most of it evaporates before sinking into the earth.[77] In effect, the Ogallala Aquifer is—like oil and gas—a nonrenewable resource[78] because current pumping levels exceed the very slow recharge rate.[79] If precipitation is consistent, aquifers can recharge slowly as rainfall and stream seepage seep into any ground not covered by asphalt.[80] During droughts, however, the water table drops.[81] During times of water scarcity, communities relying heavily on aquifers pump groundwater faster than the aquifers can recharge.[82] Withdrawal rates greatly exceed recharge rates in Texas and New Mexico, where groundwater lies hundreds of feet below the surface and does not recharge quickly.[83]

Groundwater is heavily used for agricultural irrigation in the United States and is also an important source of drinking water. As many as eight states, including Nebraska, Kansas, South Dakota, Oklahoma, California, and Hawaii, rely on

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76. The Ogallala Aquifer comprises a porous body of complex sediments and sedimentary rock formations that conduct groundwater. The rocks which make up the aquifer range in age from 33 million years old to sediments which are in the process of being deposited today. However, the majority of rock and sediment in the Aquifer are close to 12 million years old. R. F. Diffendal, Jr., *Ogallala Aquifer*, ENCYCLOPEDIA GREAT PLAINS (2011), http://plainshumanities.unl.edu/encyclopedia/doc/egp.wat.018 [https://perma.cc/9FTK-H7NS].

77. TAGHVAEIAN ET AL., *supra* note 2, at BAE-1531-1.

78. Michon Scott, *National Climate Assessment: Great Plains Aquifer Drying Out*, CLIMATE.GOV (Feb. 19, 2019), https://www.climate.gov/news-features/featured-images/national-climate-assessment-great-plains%E2%80%99-ogallala-aquifer-drying-out [https://perma.cc/TB4T-ZR5B].

79. Mark Somma, *Institutions, Ideology, and the Tragedy of the Commons: West Texas Groundwater Policy*, 27 PUBLIUS 1, 1 (1997).

80. Dimick, *supra* note 42.

81. The water table refers to the depth at which water is found below the surface. *Id.*

82. Hegeman, *supra* note 30.

83. Dimick, *supra* note 42.

groundwater for close to half of their freshwater supply.[84] Further, more than thirteen million households rely on private wells for drinking water in the United States.[85] According to the USGS, about two-thirds of groundwater withdrawals in 2000—the most recent year for which a comprehensive compilation exists—were made for irrigation.[86] However, nearly 97 percent of water pumped from the Ogallala is used for irrigation.[87] In addition, the Aquifer is also the main source of drinking water for those who live within its boundaries.

As the Great Plains states continue to deplete the Ogallala Aquifer, it is important to recognize that these states have consistently relied on agricultural models that disregard social and ecological sustainability. For instance, there has been a growing demand for ethanol, a corn-based biofuel.[88] As biofuels and ethanol gain traction, farmers have strong financial incentives to increase corn production, which requires significant groundwater.[89] Because farmers overlying many aquifers have viewed groundwater as an inexhaustible resource, they have planted crops and raised animals that are highly water dependent, such as corn and cattle, which would be unsuitable in the High Plains Region without groundwater.[90] Perversely, increased subsidies for crop insurance encourage producers to expand crop production in the Great Plains.[91] Subsidies for ethanol incentivize corn production in a region that lacks adequate water supplies. The grasslands overlying the Ogallala Aquifer experience marginal precipitation, making farmers highly reliant on aquifer water.[92]

84. Bruce Pengra, UNITED NATIONS ENV'T PROGRAMME, *A Glass Half Empty: Regions at Risk From Groundwater Depletion*, (Jan. 2012), https://na.unep.net/api/geas/articles/getArticleHtmlWithArticleIDScript.php?article_id=76 [https://perma.cc/P4X7-7SDN]; *Which Areas in the United States Are Most Dependent on Groundwater?*, AM. GEOSCIENCES INST., https://www.americangeosciences.org/critical-issues/faq/which-areas-united-states-are-most-dependent-groundwater (last visited Mar. 1, 2019) [https://perma.cc/T9JB-HEEX].

85. *Private Drinking Water Wells*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/privatewells (last visited Mar. 1, 2019) [https://perma.cc/4LC6-ZPTT].

86. Thomas E. Reilly et al., U.S. DEP'T OF INTERIOR, *Ground-Water Availability in the United States*, 1323 U.S. GEOLOGICAL SURV. CIRCULAR 11 (2008).

87. *Id.* at 57.

88. ROBERTS ET AL., *supra* note 4, at 1.

89. Little, *supra* note 26.

90. Verchick, *supra* note 15, at 19.

91. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-07-1054, AGRICULTURAL CONSERVATION: FARM PROGRAM PAYMENTS ARE AN IMPORTANT FACTOR IN LANDOWNERS' DECISIONS TO CONVERT GRASSLAND TO CROPLAND 12 (2007).

92. *Id.* at 44.

Increased corn production could require an additional 120 billion gallons of Ogallala water annually.[93]

Indeed, ethanol production represents an environmental dilemma. On the one hand, ethanol-based fuels are intended to reduce dependence on fossil fuels. On the other hand, ethanol production requires a highly centralized agricultural model that depends on irrigation, is destructive of the family farm, and is neither socially nor ecologically sustainable.[94] As noted above, corn is a thirsty crop, and corn production on the high plains cannot be maintained without using large amounts of groundwater. Without regulatory structures to pace and measure the water depletion caused by corn grown in a monoculture over the Ogallala, the damages of ethanol production will continue unchecked.

C. How Technology Contributes to Current Ogallala Aquifer Depletion

The ancient underground water supplies of the Ogallala Aquifer were discovered just before the Dust Bowl of the 1930s.[95] However, the technology in the 1930s was not sophisticated enough to fully extract the Aquifer's groundwater. It took at least a decade, and significant technological improvements, to fully exploit the Ogallala's groundwater reserves. Between World War II and 1960, a technological revolution facilitated deep-well drilling, low-cost engines, and low-cost fuels.[96] Center-pivot irrigation, with its gasoline-powered sprinklers anchored to a central pivot in a field, revolutionized High Plains economies by permitting farmers to produce water-intensive crops like corn and alfalfa, despite the region's low precipitation levels.[97]

In the 1950s, farmers thought that the Aquifer was inexhaustible. They drilled numerous wells and pumped as much as they wanted.[98] Diesel-powered pumps increased the extraction rate from a few gallons per minute to a few hundred gallons per minute.[99] More than 90 percent of the extracted water is used to

93. ROBERTS ET AL., *supra* note 4, at 4.
94. Verchick, *supra* note 15, at 20.
95. Dimick, *supra* note 42.
96. OPIE ET AL., *supra* note 37, at xvii, 1; *see also* Little, *supra* note 26.
97. Dimick, *supra* note 41.
98. Little, *supra* note 26.
99. *Id.*

irrigate crops, and $20 billion worth of agricultural products depend on the Aquifer.[100] Through irrigation, farmers have operated as if they do not live in a dryland area, creating what Verchick calls a "climate free agricultural system."[101] Yearly groundwater withdrawals from the Ogallala Aquifer quintupled between 1949 and 1974.[102] In Kansas, 39,000 wells have been drilled into the Ogallala, and pumps withdraw 1,000 gallons per minute, seven days a week, withdrawing as much water as the flow in Niagara Falls for three weeks.[103] In Kansas, groundwater has dropped by over 150 feet, and many farmers have had to abandon their wells.[104] However, after years of plenty and habits to match, wells in Colorado, Kansas, and Texas overlying the Ogallala are increasingly running dry.

Groundwater depletion across the Ogallala Aquifer is not uniform. Whereas there is almost no depletion in the northern portion of the Aquifer system (Nebraska, South Dakota, and Wyoming), Kansas faces depletion of up to seven meters, and Texas faces depletion of up to eleven meters.[105] Texas experiences the highest groundwater volume loss.[106] Declining water levels may lead to reversion of irrigated farmland to dryland production, resulting in falling land values.[107] One inescapable conclusion is that if irrigators must comply with sustainable use rates, the usable life of the High Plains Aquifer could be extended into the next century or beyond.[108] Laws and regulations can help change farmers' behaviors and encourage reduction of water use.

I. CURRENT LEGAL APPROACHES TO THE PROBLEM OF GROUNDWATER DEPLETION ARE INADEQUATE

Current legal approaches to regulate groundwater are ill-equipped to sustainably manage groundwater supplies. Advances in agricultural irrigation not only occurred against a void

100. *Id.*
101. Verchick, *supra* note 15, at 20 (internal quotation omitted).
102. Little, *supra* note 26.
103. Frank Morris, *Wells Are Running Dry in Parts of Kansas*, NPR (Aug. 6, 2013, 5:10 PM), https://www.npr.org/2013/08/06/205546627/in-kansas-water-is-more-precious-than-gold [https://perma.cc/36H8-5JAW].
104. Tuholske, *supra* note 24, at 195.
105. *Id.*
106. Reilly et al., *supra* note 86, at 59.
107. Torell et al., *supra* note 21, at 163.
108. Hegeman, *supra* note 30.

of water regulatory law but also benefitted from this void.[109] The High Plains' great technological adaptation to wheat, corn, and sorghum monocultures was done with little regard for precipitation patterns. The result has been rapid groundwater withdrawals. Jack Tuholske, a renowned water law expert, observes that laws governing groundwater in the United States are outdated and ill-suited for today's problems.[110] Examining the management of the Ogallala Aquifer provides an opportunity to examine the problematic ways in which eight different states manage groundwater.[111]

A basic understanding of water law is helpful to understand the legal approaches implicated in the eight states overlying the Ogallala Aquifer. There are two basic doctrines of water law in the United States that govern surface water: riparianism and prior appropriation. [112] Generally, eastern states follow the British-based riparian system. Riparianism grants owners the right to use the water in the abutting natural waterway.[113] Under this system, water is a shared resource, and its use is governed by reasonableness.[114] By contrast, Western water law comes from the doctrine of prior appropriation, which states that the first to divert and use the water has the exclusive right to that water, under the concept of "first in time, first in right."[115] Therefore, water rights are a valuable private property interest that can be conveyed.[116] Unfortunately, despite the straightforwardness of surface water law, groundwater law is much more varied in this region, and currently, some aspects of groundwater law are contributing to the Ogallala Aquifer's depletion.

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109. John Opie, *Moral Geography in High Plains History*, 88 GEOGRAPHICAL REV. 241, 245 (2010).

110. Tuholske, *supra* note 24, at 192.

111. *See* Somma, *supra* note 79.

112. *See* NAT'L WATER COMM'N, WATER POLICIES FOR THE FUTURE: FINAL REPORT TO THE PRESIDENT AND TO CONGRESS OF THE UNITED STATES (1973), https://www.epw.senate.gov/public/_cache/files/0/9/09fa2cfd-e480-40e6-bdf6-fc9fc8b5b0e3/6A20EC2999F0441563294B9DFFCFDD6E.water-policies-for-the-future-final-report-1973.pdf [https://perma.cc/4HVF-QE47]. Groundwater law diverges from the law governing surface water, although, hydrologically, groundwater is often connected to surface water.

113. *Id.* at 271.

114. *Id.* at 300.

115. Water allocation in the west was developed through local custom. *See, e.g.*, Cal. Or. Power Co. v. Beaver Portland Cement Co., 295 U.S. 142 (1935).

116. Griggs, *supra* note 25, at 1281.

Western surface water rights, generally governed by the doctrine of prior appropriation, are property rights designed to balance the annual precipitation variability and assume that water represents a permanent property right. Somewhat less intuitively, given the lack of precipitation in the West, western water rights also assume the existence of a permanent water source.[117] As the second millennium matures, there is a growing disconnect between legal water rights and reality. As the amount of water in the Aquifer declines, the hydrological reality that emerges is that there is not enough water in the Aquifer to satisfy those rights.[118] Further complicating matters, prevailing water laws, such as prior appropriation and the law of capture, encourage "use it or lose it behavior" and counter sustainable development.[119]

A. *American Farm Policy Exacerbates Groundwater Withdrawals in the High Plains*

The Great Plains is no stranger to an agricultural model that disregards social and ecological sustainability. In the 1930s, large sections of the Great Plains experienced multiyear droughts[120] accompanied by dust storms, resulting in farm abandonment and distress migration away from the region.[121] The epicenter of the Dust Bowl was located in Colorado, Kansas, New Mexico, Oklahoma, Nebraska, and Texas[122]—states overlying the Ogallala Aquifer.[123] In the wake of the 2008 financial crisis, the population became more sensitive to land use and to how limited natural resources might generate new patterns of economic risk. As a result of this realization, there has been an increased interest in how the Dust Bowl should inform our understanding of the relationship between human activity and the earth. In the following Section, I examine the policies of the Dust

117. *Id.* at 1264.
118. *See id.*
119. OPIE ET AL., *supra* note 37, at 11.
120. McLeman et al., *supra* note 8, at 420 (observing that the destructive impacts of the Dust Bowl included the Dakotas, as well as portions of Canada, including Alberta and Saskatchewan).
121. *Id.* at 418 (providing a comprehensive review of literature spanning the ecological, meteorological, and atmospheric causes and impacts, as well as the socioeconomic impacts of the Dust Bowl).
122. *Id.* at 419.
123. Putney, *supra* note 6, at 1.

Bowl Era to show how flawed federal farming approaches resulted in ecological crisis.

1. Federal Policy and the 1930s Dust Bowl

Drought was the first proximate cause of the Dust Bowl. Never a place of excess, the Great Plains region averages under eighteen inches of annual rainfall.[124] Any reduction in that rainfall was certain to be noticed, and indeed, mapmakers in the 1800s referred to the region as "the Great American Desert" due to its cyclical regional droughts.[125] The central Great Plains is "a region of climate extremes but is most often a parched land buffeted by dry heat, wind, and limited rainfall."[126] Indeed, Walter Prescott Webb, native Texan and renowned historian of the Great Plains, observed that "[t]he distinguishing climatic characteristic of the Great Plains Environment . . . is a deficiency in the most essential climatic element—water."[127]

Although it was the proximate cause, drought in the Great Plains—a cyclical and recurring feature of the region—did not by itself lead to the Dust Bowl. Rather, many symptoms of the Dust Bowl, such as high soil erosion and severe dust storms, were largely caused by human action. Thoughtful agricultural practices in dryland areas recognize the ecosystem's fragility and adapt crop choices, animal breeding, and tilling techniques to those landscapes. Unfortunately, land in the Great Plains was not handled so delicately in the period leading up to the Dust Bowl. Overgrazing of grasslands in the nineteenth century, small allotments under homesteading programs, and the failure of both settlers and governments to recognize the region's aridity aggravated drought conditions.[128]

As with any natural disaster, however, a little bad planning can make nearly anything worse. Misguided federal policies regarding land management, particularly those that encouraged homesteading and overgrazing, magnified and contributed to the initial drought conditions, eventually causing the Dust

124. *Id.* at 4.
125. Ben Livneh & Martin P. Hoerling, *The Physics of Drought in the U.S. Central Great Plains*, 20 J. CLIMATE 6783 (2016).
126. *See* OPIE ET AL., *supra* note 37, at 1.
127. *See id.* at 350.
128. McLeman et al., *supra* note 8, at 426.

Bowl.[129] U.S. policy encouraged homesteading to establish family-operated farms.[130] Many Americans viewed settling the Great Plains as a culmination of Manifest Destiny and homesteaders flocked to the region from 1880 to 1920.[131] As farming expanded into unsuitable dryland areas, inexperienced farmers failed to adjust to their new limited water resources. As a result, farming practices contributed to soil erosion and dust storm occurrence. [132] Lacking fuel and unfettered by experience or government oversight, farmers plowed the sod, destroying the prairie grasses' long root systems which had kept a fragile ecosystem intact.[133] Tellingly, one of the period's worst mistakes was the inefficient use of water. The Great Plains Committee of 1936 found that the Dust Bowl's root causes included poor farming technologies and practices that failed to conserve soil moisture.[134] The Great Plains Committee recommended that the government develop systematic irrigation policies and institute laws to protect and conserve groundwater.[135]

An important outcome of the 1930s Dust Bowl was an expanded role for the government in land management and soil conservation.[136] In addition, the United States and state governments realized that they needed to communicate with farmers about their agricultural practices. Agencies including the Soil Conservation Service, the U.S. Forest Service (a component of the Department of Agriculture), and the Federal Emergency Relief Administration helped farmers change agricultural practices and also formed soil conservation districts.[137] As the government helped farmers change practices in the period immediately following the Dust Bowl, the government now must help farmers change practices to combat the aquifer depletion crisis.

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129. *See* Putney, *supra* note 6.

130. McLeman et al., *supra* note 8, at 419.

131. Opie, *supra* note 109, at 247.

132. Putney, *supra* note 6 (discussing the idea that another cause of the Dust Bowl was overgrazing and the placement of too many animals on these fragile lands).

133. OPIE ET AL., *supra* note 37, at 3.

134. U.S GREAT PLAINS COMM., THE FUTURE OF THE GREAT PLAINS: REPORT OF THE GREAT PLAINS COMMITTEE 50 (1936); Gilbert F. White, *The Future of the Great Plains Re-Visited*, 6 GREAT PLAINS Q. 84 (1986) (describing that the committee found that arable farming had been expanded into unsuitable areas and that range lands were overstocked).

135. McLeman et al., *supra* note 8, at 420.

136. *Id.* at 429.

137. *Id.* at 430.

2. Law at the Federal Level Simultaneously Promotes Conservation and Environmental Degradation

Federal policy both contributes to and helps resolve certain interplays between nature, technology, and management. To put it simply, farms deplete water resources.[138] Solutions to aquifer depletion must focus on farming, the sector using the most groundwater.[139] Yet, federal policy and law continue to contribute to groundwater depletion while simultaneously promoting some positive conservation approaches.

By 1976, Congress recognized the seriousness of the overpumping problem and requested that the Secretary of Commerce conduct an Ogallala Aquifer study.[140] The Secretary of Commerce was asked to work with the Secretary of the Army and other relevant state, federal, and local agencies to study the Ogallala's declining water levels and to report on issues including allocating and distributing water and the costs of inaction.[141]

In 1984, Congress mandated a water-level monitoring program for the Ogallala Aquifer.[142] In addition, Congress has more recently put in place some effective programs—like the National Resource Conservation Service—which are beginning to address the problem of overpumping and its consequences on aquifer depletion. Accordingly, Congress has made some progress on recognizing the overpumping problem and has attempted to address it through research and monitoring.

In 1985, the Food Security Act recognized the crucial connection between conservation and agriculture.[143] The 1990 Farm Bill further acknowledged that water mining is fatal to farmland.[144] Yet, although the Farm Bill has included nods to conservation and thoughtful water management, the benefits of the Farm Bill's conservation programs have too often been counteracted by damaging commodity programs included in the exact

138. Ruhl, *supra* note 68, at 265; *see* Jesse Ratcliffe, *A Small Step Forward: Environmental Protection Provisions in the 2002 Farm Bill*, 30 ECOLOGY L.Q. 637, 638 (2003) (noting that farming creates environmental damage).

139. Shannon, *supra* note 17, at 11.

140. Torell et al., *supra* note 211, at 1.

141. 42 U.S.C. § 1962d-18 (2018).

142. Reilly et al., *supra* note 86, at 57.

143. Opie, *supra* note 109, at 251.

144. *Id.* at 252 (stating that, in line with the neoliberal Zeitgeist, the 1990s saw a move toward "efficiency" as the guiding force in farm policy, shifting agricultural risk from the government to the farmer).

same legislation. The 1985 Farm Bill resource conservation programs existed side-by-side with market-based farm commodity programs.[145] To qualify for the Bill's subsidy programs, farmers must grow certain crops, many of which are unsuitable for the High Plains' fragile drylands.[146] For example, federal subsidies support widespread irrigation of corn, which leads to excessive water use.[147] In addition, both the beef and the pork industries depend on grain feed and are therefore extremely water intensive. Such industries compound and worsen the impact on an already grain-intensive farm regime.[148] In fact, corn supplies ethanol-processing plants and feeds dairy cows, pigs, and cattle; all these uses are linked to an industrial agricultural system that overuses groundwater.[149] Further, federal subsidies for ethanol—a chemical compound requiring 1,700 gallons of water for every one gallon of ethanol created—represent a key culprit of excessive water use in the High Plains. [150] The Government Accountability Office (GAO) has expressed concerns that crop subsidies for plants like corn adversely affect conservation programs.[151] Accordingly, while it is laudable for the Farm Bill to acknowledge conservation, the bill not only falls short, it requires significant restructuring to actually promote conservation.

The 2002 Farm Bill also included provisions focusing on conservation, but it overlooked water resource health. While the 2002 Farm Bill moved to enhance environmental protection, the bulk of its provisions focused on "commodity programs," an overarching term for a collection of subsidies, income supports, and generous loan programs.[152] Despite this, the 2002 Farm Bill helped the Ogallala by establishing the Grasslands Reserve Program, which purchases permanent conservation easements.[153]

145. *Id.* Opie provides a detailed and extensive history of the relationship of the Farm Bill to the High Plains in this article.

146. *See* Ratcliffe, *supra* note 138, at 649.

147. OPIE ET AL., *supra* note 37, at 12.

148. P.W. Gerbens-Leenes et al., *The Water Footprint of Poultry, Pork and Beef: A Comparative Study in Different Countries and Production Systems*, 1 WATER RESOURCES & INDUSTRY 25, 25–36 (2013).

149. Morris, *supra* note 103.

150. David Pimentel, *Corn Ethanol as Energy*, 31 HARV. INT'L REV. 50, 51 (2009).

151. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 91, at 2–9.

152. Ratcliffe, *supra* note 138, at 638.

153. Grassland Reserve Program, 69 Fed. Reg. 29,173 (May 21, 2004) (codified at 7 C.F.R. 1415).

Tragically, the 2012 Farm Bill eliminated the Agricultural Water Enhancement Program which was funded at only $60 million in fiscal year 2012.[154] The 2018 Farm Bill goes in the wrong direction, cutting funding for the Conservation Stewardship Program, a program that encourages the environmental sustainability of farming operations.[155]

B. *Laws Regarding Groundwater Pumping Are Highly Variable, Both Between States and Inside States*

Although the law of prior appropriation regarding surface water is widespread in the West, laws regarding groundwater pumping in this region are highly variable, resulting in a diverse patchwork of policies and approaches to reduce groundwater depletion. Despite the significant impact federal laws and policies can have on groundwater conservation, federal law does not explicitly govern groundwater law.[156] The U.S. Supreme Court has ruled that Congress could regulate groundwater if it chose to do so.[157] However, as a matter of practice, Congress has effectively ceded this area to the states.[158] As a result of Congress's lack of intervention in the arena, groundwater remains a creature of state law.[159] In fact, each state in the High Plains region has a

154. Agricultural Reform, Food, and Jobs Act of 2012, S. 3240, 112th Cong. § 2706 (2012) (repealing the agricultural water enhancement program and stating that such repeal shall not affect contracts entered into before October 1, 2012).

155. MEGAN STUBBS, CONG. RESEARCH SERV., R45698, AGRICULTURAL CONSERVATION IN THE 2018 FARM BILL 6 (2019), https://fas.org/sgp/crs/misc/R45698.pdf [https://perma.cc/DT9R-2B2G] ("The new law shifts CSP from a program limited by acres (10 million acres annually under prior law; approximately $1.4 billion in FY2018) to one limited by total funding ($700 million in FY2019 in mandatory funding, increasing to $1 billion in FY2023). CBO projects this change from prior law will reduce the program by more than $12.4 billion total over ten years (see Table 2) for a total cost of $5.1 billion. Reduced spending from this reduction offset increased mandatory spending in other conservation programs (see Figure 3)."); Gracy Olmstead, *The Farm Bill Ignores the Real Troubles of US Agriculture*, N.Y. TIMES (Dec. 14, 2018), https://www.nytimes.com/2018/12/14/opinion/farm-bill-agriculture.html [https://perma.cc/8YVK-4SC3].

156. *See, e.g.*, Sporhase v. Nebraska *ex rel.* Douglas, 458 U.S 941 (1982).

157. *See, e.g.*, *id.*

158. PETER FOLGER ET AL., CONG. RESEARCH SERV., R45259, THE FEDERAL ROLE IN GROUNDWATER SUPPLY: OVERVIEW AND LEGISLATION IN THE 115TH CONGRESS 2 (2018), https://crsreports.congress.gov/product/pdf/R/R45259 [https://perma.cc/NWG6-9HUP] (observing that groundwater resources are generally the province of the states).

159. I wish to thank the students in my water law course in the Fall of 2018 for forcing me to have a more sophisticated understanding of the nuances of state groundwater law.

distinct groundwater regime.[160] To add to the confusion, many jurisdictions apply a different approach to groundwater than they apply to surface water.

There are five categories of common law groundwater doctrines that govern resolution of groundwater disputes in the United States. These are (1) the doctrine of capture or absolute dominion rule; (2) the "American" reasonable use doctrine; (3) the correlative rights doctrine;[161] (4) the Restatement (Second) of Torts section 858; and finally, (5) prior appropriation.[162] There is even variation among states following the same doctrine because states may apply the same groundwater rule differently. This Section explains the five doctrines and then discusses how the states underlying the Ogallala Aquifer have modified these doctrines within their boundaries. Finally, this Section evaluates which approaches have been most successful for encouraging aquifer sustainability.

C. *Overview of Laws Regulating Groundwater Withdrawals*

The common law doctrines of absolute ownership, reasonable use, correlative rights, and eastern correlative rights, which are based on state court decisions implemented through litigation or private negotiation, dominate the eastern United States.[163] As a general rule, U.S. groundwater law both undervalues water (broadly speaking) and values the present use of water over the future use of water. Western water law is somewhat more parsimonious with water use than eastern water law. Western surface water law generally fuses the doctrines of prior appropriation and beneficial use.[164] Groundwater rights, however, may be based on overlying land ownership, established uses, or the notion that water is a shared public resource. Groundwater feeds springs and surface streams while surface

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160. Dean Baxtresser, Note, *Antiques Roadshow: The Common Law and the Coming Age of Groundwater Marketing*, 108 MICH. L. REV. 773, 778 (2010).

161. Because the correlative rights doctrine applies to California and is not implicated in the management of the High Plains Aquifer, it is not discussed here. Katz v. Walkinshaw, 74 P. 766, 772 (Cal. 1903); *see also* Tuholske, *supra* note 24, at 209.

162. For an overview of the law of capture, the reasonable use doctrine, and the Second Restatement of Torts rule, see Wisconsin v. Michels Pipeline Constr., Inc., 217 N.W.2d 339 (Wis. 1974).

163. NAT'L RESEARCH COUNCIL, VALUING GROUND WATER 107 (1997).

164. Griggs, *supra* note 25, at 1313.

water recharges groundwater reservoirs. Surface water and groundwater are intimately connected, yet laws regulating groundwater are often insufficient because they fail to recognize this connection. Texas regulates groundwater using the common law of capture, which allows an unlimited use of water for nearly any purpose in the short term. Texas's approach to groundwater use is most likely to lead to aquifer depletion. By contrast, the groundwater laws of Colorado and Kansas envision longer time horizons and are more likely to lead to sustainable use.

1. English Rule or Law of Capture

A significant portion of the Ogallala Aquifer lies below Texas.[165] Yet, unfortunately for the Ogallala, in Texas, groundwater is viewed as private property connected to the parcel of land above it. Texas is the only remaining western state that adheres to the English common law doctrine of capture—a doctrine having a disastrous effect on preservation efforts.[166] The English rule of capture is partially based on an understanding that the amount of water below the ground is "unknowable." Unfortunately, this conception is extremely outdated, ignores science, and leads to dramatic overuse in the short term. The common law of capture provides that, absent malice or willful waste, landowners have the right to take as much water as they can capture under their land and do with it what they please. Furthermore, landowners are not liable to their neighbors even if they deprive their neighbors of using the water.[167] Put simply, in Texas, if a person can obtain possession over groundwater, it is theirs.[168] Most disconcertingly, Texas water law discourages efficient use and encourages immediate consumption.[169] Because Texas treats groundwater as an unregulated private property right, landowners are essentially free to use as much

165. FOLGER ET AL., *supra* note 158, at 15; Cruse et al., *supra* note 23.

166. Sipriano v. Great Spring Waters of Am., Inc., 1 S.W.3d 75 (Tex. 1999). Maine also follows the English doctrine of absolute ownership. Maddocks v. Giles, 728 A.2d 150 (Me. 1999).

167. Harry Grant Potter, III, *History and Evolution of the Rule of Capture, in* 100 YEARS OF RULE OF CAPTURE: FROM EAST TO GROUNDWATER MANAGEMENT 1 (William F. Mullican, III & Suzanne Schwartz eds., 2004).

168. Edwards Aquifer Auth. v. Day, 369 S.W.3d 814 (Tex. 2012); Gerald Torres, *Liquid Assets: Groundwater in Texas*, 122 YALE L.J. F. 143, 145 (2012).

169. Verchick, *supra* note 15; Baxtresser, *supra* note 160, at 780.

nonrenewable groundwater as they wish while facing minimal regulation.[170]

This doctrine of capture does not support sustainability, but rather promotes using the maximum amount of water possible without considering future consequences. For example, since Texas law grants landowners unrestricted rights to the water beneath their property, private landowners can sell groundwater from their ranches in the Panhandle to cities as far away as Dallas.[171] This doctrine adversely affects the Ogallala, as depletion is most severe in its southern portion—especially in Texas—where the water table has dropped at least one hundred feet, and in some places, more than 150 feet.[172] In fact, in 2013, the Ogallala suffered its second worst drop since at least 2000 in a large swath of the Texas Panhandle. The USGS released a study in 2013 showing that Ogallala levels have dropped more in Texas than in other states.[173]

Although Texas's policies of encouraging immediate use have disastrous effects on aquifer conservation, the law does not seem to be changing anytime soon. In 1999, in *Sipriano v. Great Spring Waters of America*,[174] the Texas Supreme Court (which is elected) declined to abandon the rule of capture in favor of reasonable use, deferring to the Texas Legislature.[175] In the 2012 case, *Edwards Aquifer v. Day*,[176] the Texas Supreme Court reaffirmed the absolute nature of groundwater rights, holding that landowners are entitled to compensation when their pumping volume is limited by regulatory authorities.[177] The court declared that landowners have real property interests in any groundwater underlying their land, analogous to landowners' interests in oil and gas.[178] Through these decisions, the Texas

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170. Ronald Kaiser & Frank F. Skillern, *Deep Trouble: Options for Managing the Hidden Threat of Aquifer Depletion in Texas*, 32 TEX. TECH. L. REV. 249, 250–51 (2001); *see also* Tuholske, *supra* note 24, at 211.

171. Little, *supra* note 26.

172. Postel, *supra* note 20.

173. Kate Galbraith, *Continued Drought Means Another Big Drop for Ogallala Aquifer*, TEX. TRIB. (May 22, 2013, 6:00 AM), https://www.texastribune.org/2013/05/22/ogallala-aquifer-texas-panhandle-suffers-big-drop/ [https://perma.cc/4ZVD-VBE3].

174. Sipriano v. Great Spring Waters of Am., Inc., 1 S.W.3d 75 (Tex. 1999).

175. Pearl, *supra* note 24, at 1046.

176. Edwards Aquifer Auth. v. Day, 369 S.W.3d 814 (Tex. 2012).

177. *Id.*

178. *See* Torres, *supra* note 168.

Supreme Court chose to minimize political conflicts over groundwater pumping; this choice, however, exposed Texas aquifers to uncontrolled pumping.[179] Additionally, because Texas sits over only a small percentage of the Aquifer but adheres to a usage theory that encourages significant water usage with severely diminished accountability, this ruling set the stage for a state contest over the shared resource of the Ogallala. A battle of competing theories of use will play out in both the courts and future national elections, while regulatory rulemaking is also looming.

2. Reasonable Use and Correlative Rights

The reasonable use rule, also known as the "American Rule," requires balancing competing uses from the same aquifer.[180] Applying the "reasonable use" rule to groundwater creates a vertical riparian rights system but with the added requirement that the groundwater withdrawn be put to a reasonable use on the land overlying the water. The American Rule is increasingly falling out of favor in the West, although aspects of the rule remain in Nebraska, Arizona, and California.[181]

States, including Alabama and New York, differ as to which uses are considered "reasonable," but they often look to well location, the amount of withdrawal, and the proposed use for the withdrawn water.[182] Furthermore, because courts may restrict uses that cause unreasonable harm to other aquifer users, the American Rule is better at limiting excessive withdrawals than the rule of capture. Adjudication concerning reasonable use is fact-intensive, and reasonableness determinations are made on a case-by-case basis. In making their determination, courts will consider whether competing uses are causing other users unreasonable harm.[183]

From the standpoint of limiting wasteful groundwater withdrawals, an American Rule regime is difficult to manage. In the

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179. Kaiser & Skillern, *supra* note 170, at 251.

180. Tuholske, *supra* note 24, at 207–08.

181. Meeker v. City of E. Orange, 74 A. 379 (N.J. 1909) (discussing policy reasons for adopting the American Rule rather than the rule of capture); NAT'L RESEARCH COUNCIL, *supra* note 163, at 107.

182. The American reasonable use rule remains more prevalent in the East than in the West, and Alabama and New York are states that adopted reasonable use laws. In Alabama, for example, groundwater use must benefit the overlying land from which it is withdrawn. Adams v. Lang, 553 So. 2d 89 (Ala. 1989).

183. Tuholske, *supra* note 24, at 208.

absence of a state engineer, or a strict monitoring and withdrawal system, this approach may encourage wasteful groundwater use. Additionally, this approach is highly inefficient from a temporal standpoint. Because the courts determine whether competing uses are reasonable, excessive withdrawals may occur before the courts can adjudicate issues of reasonableness. In other words, while litigation determining the reasonableness of withdrawals is pending, the aquifer may be significantly overdrawn.

Under the western correlative rights doctrine, which originally took shape in California, each well owner is treated as having an equal right to groundwater regardless of when first use was initiated.[184] The western correlative rights doctrine allows landowners to withdraw as much water as they can "beneficially use on [their] land," subject to the correlative rights of neighboring landowners.[185] In times of scarcity, correlative rights are apportioned among neighboring land owners. "Under the correlative rights system, the pro rata share of each overlying landowner is determined based 'solely on his current reasonable and beneficial need for water.'"[186] If the groundwater supply is inadequate to meet the needs of all users and groundwater overdrafts are occurring, each user can be required to proportionally reduce use until the overdraft ends. This system has identical problems to the reasonable use system: it is litigation dependent, slow from a temporal standpoint, and groundwater withdrawals can occur while courts examine beneficial uses and determine reasonableness. However, the correlative rights doctrine is somewhat more parsimonious than either the American Rule or the law of capture because each overlying landowner may be forced to proportionately reduce water use. Again, the correlative rights doctrine was created when knowledge about aquifer capacity was much more limited than it is today. In a state facing chronic water shortages—like California—the correlative rights doctrine seems out of touch with the region's water use reality.

184. NAT'L RESEARCH COUNCIL, *supra* note 163, at 108.

185. Dale Ratliff, *A Proper Seat at the Table: Affirming a Broad Winters Right to Groundwater*, 19 U. DENV. WATER L. REV. 239, 243 (2016) (quoting Tehachapi-Cummings Cty. Water Dist. v. Armstrong, 122 Cal. Rptr. 918, 924 (Cal. Ct. App. 1975)).

186. *Id.* (quoting *Armstrong*, 122 Cal. Rptr. 918 at 924).

3. Prior Appropriation

The prior appropriation doctrine dominates the management of western surface water. Under this doctrine, the first person who begins using the water has the superior legal right to the resource. Twelve western states have adopted the prior appropriation doctrine for groundwater.[187] Under the doctrine of "first in time, first in right," groundwater rights are obtained by putting the water to "beneficial use."[188] Some states have a unified code for both surface water and groundwater, including Alaska, Kansas, Montana, North Dakota, and Utah.[189] Other states, like New Mexico, only apply the doctrine of prior appropriation to groundwater.[190] This doctrine protects well investments—land business ventures that are based on an expectation of a specific water supply. Some states such as Kansas and Colorado, have put institutional structures in place that help responsibly manage this shared resource. Indeed, among the eight states that overlie the Ogallala, Kansas and Colorado have the most sophisticated groundwater regulation regimes. Both states have adopted statutes modifying the prior appropriation doctrine that set reasonable pumping levels in accordance with the specific nature of various classes of groundwater aquifers.

States with statutory regulation schemes that jointly address both surface water and groundwater generally require a permit to appropriate groundwater. This is the case in New Mexico.[191] In New Mexico, groundwater reserves are in the public domain.[192] The New Mexico permit system requires that the water be put to a beneficial use and that it has a specified diversion point and quantity. Additionally, under the New Mexico system, water permits can be revoked if unused but can also be trans-

187. The states that have adopted the doctrine of prior appropriation for regulating groundwater include Idaho, Nevada, New Mexico, Oregon, South Dakota, Washington, and Wyoming. GREGORY S. WEBER, JENNIFER L. HARDER & BENNETT L. BEARDEN, CASES AND MATERIALS ON WATER LAW 369 (9th ed. 2014).

188. Tuholske, *supra* note 24, at 209. Beneficial use is a term of art in water law. Its explanation is somewhat complex.

189. WEBER ET AL., *supra* note 187, at 369.

190. State *ex rel.* Bliss v. Dority, 225 P.2d 1007 (N.M. 1950); Baxtresser, *supra* note 160, at 783.

191. N.M. STAT. § 72-12-20 (2019).

192. Lewis, *supra* note 16, at 44; State *ex rel.* Bliss, 225 P.2d 1007 (holding that the water of the state is public water subject to appropriation for beneficial use, and reaffirming that groundwater is subject to the doctrine of prior appropriation).

ferred so long as other water rights holders are not harmed. Using the prior appropriation doctrine to regulate groundwater presents certain problems. If there is a conflict between two or more users, temporal priority—"first in time, first in right"—is the determining factor in water allocation.[193] Additionally, granting groundwater permits for industrial uses can lead to aquifer depletion.[194] In *Mathers v. Texaco*, the New Mexico state engineer permitted a new industrial beneficial use that could potentially deplete the aquifer within forty years.[195] Further, if the aquifer's groundwater is being depleted faster than the recharge rate, it effectively becomes nonrenewable, rendering senior rights meaningless over time.[196]

All Colorado groundwater is regulated according to its geographical location and hydraulic connection to surface water, such as a stream, spring, or lake. Colorado also recognizes four different groundwater categories: tributary groundwater, or groundwater connected to a stream; designated groundwater; nontributary groundwater outside of a designated basin; and finally, Denver Basin groundwater, which has its own subcategories depending on whether an aquifer is tributary to a stream. First, tributary groundwater is considered part of the stream and is subject to the appropriation doctrine regulating the stream.[197] With regard to tributary groundwater, surface and groundwater are part of the same appropriation system. By contrast, for groundwater in a designated basin, Colorado allows administration in order to "permit the full economic development of designated groundwater resources."[198] For nontributary groundwater outside of a designated basin, Colorado applies the reasonable use doctrine. The water is deemed nontributary based on depletion rates to surface streams.[199] The right to pump groundwater in Colorado requires well permits.[200]

193. A. Dan Tarlock, *Prior Appropriation: Rule, Principle, or Rhetoric?*, 76 N.D. L. REV. 881, 881–82 (2000).

194. Mathers v. Texaco, Inc., 421 P. 2d 771 (N.M. 1966).

195. *Id.* at 777.

196. Tuholske, *supra* note 24, at 210.

197. *See* COLO. REV. STAT. §§ 37-92-101 to -602 (2019).

198. *Id.* § 37-90-102(1).

199. *See id.* If the water is outside a designated basin and "withdrawal of which will not, within one hundred years of continuous withdrawal, deplete the flow of a natural stream . . . at an annual rate of one tenth of one percent," then a landowner may withdraw groundwater from a groundwater source below his land. *Id.* § 37-90-103(10.5); *see id.* § 37-90-137(4).

200. Griggs, *supra* note 25, at 1288; Lewis, *supra* note 16, at 44.

The Kansas Legislature passed the Kansas Water Appropriation Act, which created an appropriation system for all water in the state, including groundwater.[201] The Kansas Legislature uses the appropriation doctrine for both streams and groundwater.[202] Kansas considers groundwater public property and manages it accordingly.[203] All nondomestic groundwater uses are subject to this appropriation system, while rights to use groundwater are created under a permit system that recognizes overlying landowners' interests and established uses.[204] Kansas's system promotes careful use of the aquifer and balances consumption and recharge.[205] In addition, unlike in Colorado, the Kansas regulatory approach does not distinguish between groundwater hydraulically connected to a stream or a lake and groundwater that is not.[206] Instead, Kansas effectively treats all water as part of the same system. In so doing, Kansas eliminates the artificial legal distinction that many states make between surface water and groundwater.

Kansas only issues groundwater use permits if water is available and the proposed use does not interfere with other water rights, minimum desirable stream flows, or the public interest.[207] This approach implies that before groundwater permits are issued, the state will consider the connection between groundwater and surface water. One of the most important aspects of the Kansas groundwater system is that metering is required. Additionally, users must submit annual reports showing that the water is being applied to a "beneficial use" and that users are pumping only their allotted amount.[208] In Kansas, irrigators often choose not to make groundwater calls, because they know that it may shut down junior rights for a long time.[209] As a result, many farmers operating in states like Kansas—states that have an appropriation system with senior appropriation rights—make contractual agreements with junior rights holders

201. KAN. STAT. §§ 82a-701, -702 (2019).
202. John C. Peck, *Protecting the Ogallala Aquifer in Kansas from Depletion: The Teaching Perspective*, 24 J. LAND RESOURCES & ENVTL. L. 349, 349 (2004).
203. KAN. STAT. ANN. § 82a-702.
204. *Id.* § 82a-705; *see also* Williams v. City of Wichita, 374 P.2d 578, 595 (Kan. 1962).
205. Verchick, *supra* note 15.
206. KAN. STAT. ANN. §§ 82a-702, -703, -706.
207. *See id.* § 82a-703a.
208. *Id.* §§ 82a-702, -703, -706.
209. *See* Griggs, *supra* note 25, at 1281.

instead of invoking groundwater doctrine.[210] Overall, the Kansas approach to water management seems relatively judicious. Kansas stopped new development on parts of the Ogallala Aquifer in the 1970s.[211]

4. Restatement (Second) of Torts Section 858

The approach outlined in the Restatement (Second) of Torts combines a property law rule similar to the law of capture with a tort rule. In 1978, the American Law Institute addressed the issue of groundwater for the Restatement (Second) of Torts. The Restatement's drafters focused on imposing tort liability for pumping groundwater that was distinct from property law. The basic property rule remains that a pumper owns the water that he withdraws and "captures." Importantly, the Restatement is not a water law doctrine and imposes liability for withdrawing groundwater resulting in injury to others. A user who puts withdrawn groundwater to beneficial use will generally not be liable if their withdrawals harm others. Under many doctrines, liability only occurs if the withdrawal *unreasonably* harms a neighboring landowner through lowering the water table, reducing artesian pressure, or withdrawing an amount exceeding the proprietor's reasonable share; another form of unreasonable harm occurs if the withdrawal has a direct and substantial effect upon a watercourse or lake and harms a person entitled to use its water.[212]

One drawback of this approach is that it may be difficult to determine who caused "unreasonable harm" when multiple individuals or entities are withdrawing water simultaneously. Several pumpers withdrawing a moderate amount of water concurrently can lower the water table significantly. This doctrine does not adequately limit withdrawals to amounts that do not exhaust the aquifer. This may be, in part, because scholars have only recently been able to accurately estimate how much water aquifers contain.

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210. *See id.*

211. Morris, *supra* note 103.

212. The principles of section 858 have been adopted by Wisconsin and Nebraska. TARLOCK ET AL., *supra* note 23, at 312 (noting that surprisingly few courts have adopted the Restatement rule).

Nebraska combines the doctrine of reasonable use on overlying land with the correlative rights rule for groundwater.[213] Furthermore, Nebraska has a well-established doctrine of prior appropriation for determining surface water rights.[214] Nebraska has some combination of a correlative approach and a Restatement (Second) of Torts reasonable use approach.[215] Nebraska does not recognize an absolute ownership interest in groundwater. Rather, it grants landowners rights to use groundwater on the land from which it has been extracted. Further, those extraction rights are limited to reasonable amounts and cannot be "injurious to others who have substantial rights to the waters . . . ."[216] Courts exercise broad discretion and rely on many factors when deciding groundwater allocation disputes.

Oklahoma's groundwater law combines elements of the American Rule with a permitting system. The Oklahoma Legislature enacted the Oklahoma Groundwater Act of 1973 to govern groundwater withdrawal and use.[217] Prior appropriation governs groundwater that is a tributary to a surface stream; by contrast, the landowner owns any water flowing under the surface (but not forming a definite stream).[218] In other words, groundwater is essentially the surface owner's private property, although it is subject to reasonable regulation by the Oklahoma Water Resources Board.[219] Therefore, Oklahoma has adopted the American Rule for nontributary groundwater, which allows landowners to use groundwater even if it interferes with a neighbor's water supply, as long as the use is "reasonable."[220] For tributary groundwater, Oklahoma grants water rights or well permits in proportion to the amount of land irrigated, and water

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213. NEB. REV. STAT. § 46-702 (2019); *see also* Spear T Ranch, Inc. v. Knaub, 691 N.W.2d 116 (Neb. 2005).

214. Griggs, *supra* note 25, at 1273.

215. *Id.* at 1288.

216. Sporhase v. Nebraska *ex rel.* Douglas, 458 U.S. 941, 964 (1982) (Rehnquist, J., dissenting) (noting that groundwater is an article of commerce and therefore subject to congressional regulation).

217. OKLA. STAT. ANN. tit. 82, §§ 1020.1-1020.22 (2019).

218. Gary D. Allison, *Oklahoma Water Rights. What Good Are They?*, 64 OKLA. L. REV. 469, 507 (2012).

219. OKLA. WATER RES. BD., WATER LAW AND MANAGEMENT IN OKLAHOMA (2012), https://www.owrb.ok.gov/supply/ocwp/pdf_ocwp/WaterPlanUpdate/joint_committee/WATER%20LAW_MANAGEMENT%20IN%20OKLAHOMA.pdf [https://perma.cc/824J-WNLV]; OKLA. WATER RES. BD., OKLAHOMA GROUNDWATER LAW AND WATER RIGHTS ADMINISTRATION (2012), https://www.owrb.ok.gov/news/news2/pdf_news2/pres/GWLawPermitting.pdf [https://perma.cc/VM3D-YRF2].

220. *See* Canada v. City of Shawnee, 64 P.2d 694 (Okla. 1936).

users must apply to the Oklahoma Water Resources Board for a permit to use groundwater.[221] By law, Oklahoma will approve withdrawals so long as those withdrawals do not result in a depletion of the aquifer in less than twenty years.[222]

D. *Current Economic and Legal Incentives Encourage Aquifer Depletion*

While these competing and often incompatible water rights doctrines have set the stage for political battles between states, this conflict also implicates legal and economic theories. Aquifers present a classic tragedy of the commons because water's mobility makes it fungible and nonexcludable.[223] The classic property law example illustrating the tragedy of the commons begins with a pasture open to all.[224] Each herdsman tries to keep as many cattle as possible on the commons while also seeking to maximize individual gain.[225] The herdsman receives a positive utility, accruing only to him, each time he adds an incremental animal.[226] However, the entire community receives a negative utility because of each individual's overgrazing.[227] Each individual is locked in a system that compels him to overuse the resource without limit, even though it is a limited resource.[228] In addition, the commons tends to be particularly prone to free riding: if a few herdsmen behave responsibly, those behaving irresponsibly benefit from the temperate behavior of the few.

While the herdsmen example provides a discrete, concrete example of the tragedy of the commons, this problem can be writ both large and small. Examples of the commons range from smaller-scale national parks to much larger-scale groundwater concerns.[229] In general, farmers whose land overlies aquifers are

221. OKLA. STAT. ANN. tit. 82, §§ 1020.7, 1020.9.

222. Allison, *supra* note 218, at 511 ("The OWRB is instructed to regulate the withdrawal of water from Oklahoma's major aquifers by establishing a Maximum Annual Yield (MAY) 'based upon a minimum basin or subbasin life of twenty (20) years.'" (quoting OKLA. STAT. ANN. tit. 82, § 1020.5(B) (2019)).

223. *See generally* Garrett Hardin, *The Tragedy of the Commons*, 162 SCI. 1243 (1968).

224. *Id.* at 1244.

225. *Id.*

226. *Id.*

227. *Id.*

228. *Id.*

229. *Id.* at 1245.

faced with a similar dilemma: like fishermen in depleted cod fisheries on the East Coast, they rely on a finite resource for their livelihood. On the one hand, if they pump water and ignore long-term consequences, they can optimize their short-term profits. On the other hand, if they keep pumping at unsustainable rates, they will "kill the goose that laid the golden egg," destroying the very resource they depend on.[230] When farmers overpump the aquifers, their behavior causes a negative externality for other users by reducing the amount of water available to all users. In addition, like the herdsmen example, groundwater and aquifers tend to be particularly prone to free riding: if only a few users behave responsibly, those behaving irresponsibly benefit from the temperate behavior of the few.

Presently, legal and financial incentives promote a rapid, unsustainable, and short-term use of the Ogallala. Federal farm policies currently provides subsidies to farmers who grow crops that tend to deplete the Ogallala Aquifer.[231] Further, state law—particularly in Texas—encourages landowners to maximize their withdrawals without considering the impacts those withdrawals have on the larger resource. Additionally, the less rapacious prior appropriation doctrine encourages senior property rights holders to use their complete water allocation, even when doing so is inefficient and may damage the common pool resource.

Alexander Pearl, Director of the Center for Water Law at the Texas Tech University School of Law, argues that policymakers should give special consideration to common pool resources, such as groundwater aquifers, to prevent the worst consequences of unregulated commons use. Pearl provides a helpful taxonomy, noting that common pool resources suffering from a tragedy of the commons share three characteristics: (1) resource scarcity, (2) internalization of benefits, and (3) externalization of costs.[232] He develops the model of the vital commons as a method to determine the degree of harm done by resource overuse or underuse. He also argues that a vital common pool resource is necessary for sustenance, and damage of the common pool resource is non-remediable. He defines both earth's atmosphere and groundwater aquifers as vital common

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230. *See generally* Little, *supra* note 26.
231. U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 91; Little, *supra* note 26.
232. Pearl, *supra* note 24, at 1040.

pool resources.[233] Pearl's work draws our attention to the parallels between groundwater depletion and climate change: both suffer from policymakers' neglect because it is so easy to lose sight of the problem when the effects appear to be merely the cumulative tangled ends of so many disparate programs. Like climate change, depleting groundwater resources will lead to the eventual decline of the human species, and if the matter is not rapidly addressed, it may become impossible to remedy the destruction.

E. What Remedies Are Being Attempted on the Ground?

In the absence of effective federal oversight, states have tried several solutions to reduce over-pumping. Some of these approaches focus on voluntary participation. While the Texas Legislature has attempted to facilitate groundwater management districts, other states have focused on mandatory restrictions and fines, and still others—like Kansas—have tried the most coercive measures, including fines, individual farm meters, and pumping restriction agreements. In an absence of legislative agreement, some states have resorted to litigation. While litigation has the potential to protect portions of aquifers, it cannot protect an entire aquifer and is unlikely to be effective over large areas. Wisely using tax incentives may help facilitate technological solutions, which can effectively help farmers conserve water. In general, the federal government has focused on a cooperative approach. Voluntary participation is extremely effective, in that it includes the aquifer's users in the process of designing a solution to protect a resource on which they depend. However, voluntary participation may not be a strong enough remedy, given the size of groundwater withdrawals that are currently taking place.

1. Pumping Restrictions and Fines

Portions of the Ogallala Aquifer underlying west-central Kansas have experienced the highest levels of aquifer depletion to date.[234] A promising pilot program in northwest Kansas's

233. *Id.* at 1041.

234. *A Vanishing Aquifer*, NAT'L GEOGRAPHIC, https://www.nationalgeographic.com/magazine/2016/08/vanishing-aquifer-interactive-map/ (last visited Feb. 10, 2020) [https://perma.cc/WFM5-TGLY].

Sheridan County was enacted to prolong the Aquifer's life. The Northwest Kansas Groundwater Management District No. 4 limits pumping for the next five years. Also, this mandatory program fines irrigators who pump more and suspends their water use for two years.[235] In 2012, Kansas began implementing stiff penalties in response to overpumping. These efforts met significant resistance.[236] In 2015, Governor Sam Brownback of Kansas assembled stakeholders, conducted five hundred meetings regarding local water use, and tallied over fourteen thousand comments.[237] Stakeholders broadly supported penalties for overpumping and for failure to submit water use reports, as well as giving the state engineer the authority to seal the meters and prevent further pumping. Further, in response to overpumping concerns, Kansas has established categories of overpumping and corresponding levels of penalties. For example, overpumping for more than seventy-two hours can result in fines of up to $1,000 a day and a reduction in water use.

However, these state-down regulation approaches may not be easily implemented across the entire Aquifer. In west Texas, an area of high groundwater withdrawal, farmers are suspicious of and dislike central government.[238] Indeed, Kaiser and Skillern note that in Texas, any attempt to regulate groundwater pumping provokes significant political and legal opposition.[239] Accordingly, while a "stick-based" approach seems to work well in some states, such as Kansas, it may not be as effective in Texas, where farmers yearn to avoid state control. Nevertheless, as discussed below, Texan farmers are increasingly working together to voluntarily reduce water use.

The next Section explores litigation-based strategies for groundwater regulation and management. Because some western states have groundwater policies that do not effectively address depletion or apportionment of groundwater use, litigation has filled the interstices. However, as the next Section argues, litigation is no substitute for coherent, aquifer-wide management.

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235. Hegeman, *supra* note 30.

236. Morris, *supra* note 103.

237. Amy Bickel, *Kansas Water Law: Pumped-Up Penalties for Violators Gain Steam*, HUTCHINSON NEWS (Dec. 30, 2015, 5:00 PM), https://www.hutchnews.com/38b727d7-9bd7-5ba8-94ac-b9d84939eae2.html [https://perma.cc/ZTD9-X5U3].

238. Somma, *supra* note 79, at 2.

239. Kaiser & Skillern, *supra* note 170, at 251.

2. Litigation

Although litigation can help adjudicate the parties' rights on a case-by-case basis, it usually results in an indirect and inefficient solution to a longer-term problem. However, one rather clever case brought under the Endangered Species Act (ESA) may have carved a new path for effective litigation. In *WildEarth Guardians v. Salazar*, litigants creatively attempted to reduce pumping by having part of Kansas's aquifer named as a habitat for the Scott's Riffle Beetle, an endangered species.[240] The plaintiff pursued an endangered species listing and argued that the beetle population was being threatened by aquifer dewatering, contamination, and habitat destruction due to its confinement to one site—a fifty-foot stretch of stream fed by a single spring in Kansas's Lake Scott State Park.[241] That single spring is fed by the Ogallala Aquifer.[242] However, as the Aquifer is being depleted, groundwater levels are falling there.[243] The spring's reported yield has declined from 400 gallons per minute in 1974 to 350 gallons per minute in 1998.[244] Despite these realities, the Fish and Wildlife Service (FWS) made a negative ninety-day finding determining that a listing of the Scott's Riffle Beetle was not warranted.[245] The court denied plaintiff's motion to review the FWS's action, holding that WildEarth failed to establish that the FWS's decision was arbitrary and capricious.[246]

Although ultimately unsuccessful, this case suggests an intriguing litigation strategy for preventing aquifer depletion. In addition, it shows that aquifer depletion has wide-ranging effects, like further harming threatened and endangered species. If the plaintiff had been successful, it most likely could have protected a portion of the Aquifer. However, litigation under the ESA is not likely to be effective as a global strategy. At best, it is piecemeal and would likely only result in discrete, small areas of the Aquifer being protected, without solving the fundamental problem of aquifer depletion.

240. WildEarth Guardians v. Salazar (*WildEarth Guardians*), No. 10-cv-00091-WYD, 2011 WL 4102283 (D. Colo. Sept. 14, 2011); 16 U.S.C. § 1533 (2018).

241. *WildEarth Guardians*, 2011 WL 4102283 at *1.

242. *Id.*

243. *Id.*

244. *Id.*

245. *Id.*

246. *Id.* at *7.

3. Water Saving Irrigation Techniques

Technological advances in irrigation can play a key role in reducing groundwater use. University of California, Irvine Hydrologist Alexandra Richey is a proponent for preserving aquifers through a variety of nonlegal strategies, including recycling wastewater and adopting water-saving irrigation techniques.[247] Likewise, in response to the crisis facing the Ogallala, the USDA Natural Resources Conservation Service (NRCS) has launched the Ogallala Aquifer Initiative. The Ogallala Aquifer Initiative's specific goals include improving irrigation efficiency, converting operations to dryland farming, installing irrigation water management systems, and applying nutrient management.[248] In support of this program, the NRCS provides agricultural producers with technical and financial assistance to implement a variety of conservation practices, including improving irrigation efficiency, managing nutrients, and implementing prescribed grazing, among other things.

Computer-aided irrigation practices can save 10 to 15 percent of water per crop per season.[249] Infrared sensors on the arm of a center pivot irrigation system sense leaf temperatures as well as evaporation rates and turn on when a given temperature threshold is reached.[250] More than half of the West's irrigated cropland acres continue to be irrigated with more traditional, less-efficient application systems. In addition, USDA data indicates that the potential exists for increased irrigation efficiency through more extensive use of improved on-farm water-management practices. According to the USDA, fewer than 10 percent of irrigators make use of soil- or plant-moisture sensing devices.[251] Additionally, fewer than 2 percent of irrigators use computer-based simulation models.[252] These models calculate irrigation requirements by gauging where the crop is in the growing cycle under local weather conditions.[253]

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247. James, *supra* note 53.

248. NAT. RES. CONSERVATION SERV., *supra* note 24, at 2.

249. Somma, *supra* note 79, at 10.

250. Little, *supra* note 26.

251. Econ. Research Serv., *Irrigation & Water Use*, U.S. DEP'T AGRIC., https://www.ers.usda.gov/topics/farm-practices-management/irrigation-water-use/ (last visited Jan. 28, 2020) [https://perma.cc/JAV7-98KR].

252. *Id.*

253. *Irrigation & Water Use*, U.S. DEP'T AGRIC., https://www.ers.usda.gov/topics/farm-practices-management/irrigation-water-use/ (last visited Jan. 28, 2020) [https://perma.cc/JAV7-98KR].

Moving into the twenty-first century, irrigated agriculture can only succeed if producers are able to improve water management for crop production at the individual unit: the farm itself. Advancements in irrigation technologies and improved water-management practices can enhance water-use efficiency at the farm. In addition, coordinating water management at the farm as well as watershed levels may help increase the efficiency of allocating water among competing users.[254] The majority of U.S. irrigation investment, however, is financed privately. About 90 percent of farms reporting irrigation improvements in 2013 received no public financial assistance. Farms receiving public assistance represented fewer than 5 percent of all irrigated farms that made irrigation investments in 2013.[255]

4. Promotion of Conservation-Related Behavior by Farmers

When considering what steps can be taken to preserve the groundwater supplies stored in the Ogallala Aquifer, it should be noted that this problem has received some—although insufficient—attention from Congress. Congress directed the U.S. Geological Survey to begin monitoring water-level changes in the Ogallala Aquifer in response to these reductions.[256] The Farm Bill's national conservation programs, including the national resources conservation programs, are an important component of effective, voluntary, farm-level conservation practices that can help protect water quantity.[257] Specific goals of NRCS include improving irrigation efficiency, converting operations to dryland farming, installing irrigation water management systems, and applying nutrient management.[258]

There are three main programs funded by the Farm Bill that promote conservation-related farmer behaviors. These three programs include the Environmental Quality Incentives Program (EQIP), the Conservation Stewardship Program, and

254. *Id.*

255. *Id.* About 30 percent of the farms receiving public assistance for irrigation investments made use of USDA's Environmental Quality Incentives Program (EQIP).

256. TAGHVAEIAN ET AL., *supra* note 2.

257. ENVTL. & ENERGY STUDY INST., FACT SHEET: CONSERVATION MEASURES AND THE FARM BILL (2017), https://www.eesi.org/files/FactSheet_Farm_Bill_Conservation_Measures_0317.pdf [https://perma.cc/SD8R-7D9].

258. NAT. RES. CONSERVATION SERV., *supra* note 24, at 2.

the Agricultural Management Assistance Program. EQIP provides assistance and payment to farmers, ranchers, and other agricultural producers who complete eligible conservation practices on their land.[259] This Program takes a cooperative approach that focuses on voluntary action. The Program essentially views farmers and ranchers as partners in conservation and managers of natural resources.[260] One explicit objective of the NRCS is to extend the useful life of the High Plains Aquifer. In fiscal year 2016, NRCS provided $13,737,891 in financial assistance for contracts under the "Ogallala Aquifer Initiative." These are excellent programs, but do not go far enough.

Further, farming is not the only way to make a living on the Great Plains. The Great Plains was traditionally home to native grasslands which supported pronghorn antelope, lesser prairie chickens, buffaloes, and swift foxes.[261] Grassland restoration, with an emphasis on indigenous plants such as blue grama and green needlegrass, can provide wildlife habitat and excellent fodder for cattle or buffalo. Such efforts could also open up opportunities for hunting and ecotourism.[262]

5. Promotion of Improved Plant Selection and Planting Techniques

Although some High Plains farmers are shifting to crops that require less water, the High Plains continues to produce crops that require high levels of water and are unsustainable for the long term. In addition, cattle and pork production—two water-intensive industries—are popular farm items in this region. Accordingly, farmers should move away from water-intensive crops like corn and cotton,[263] and toward crops that require less water, like wheat, sunflowers, or sorghum. Many farmers are also moving to something called "dryland farming," eschewing water-intensive corn in favor of crops that are less

259. *Id.* EQIP was funded at $1.35 billion in 2014, with incremental increases for each following year.

260. EQIP is a voluntary conservation program that provides farmers and ranchers with financial cost-share assistance and technical assistance to implement conservation practices on working agricultural land. Environmental Quality Incentives Program (EQIP), 79 Fed. Reg. 73,954 (Dec. 12, 2014) (codified at 7 C.F.R. pt. 1466).

261. Little, *supra* note 26.

262. *Id.*

263. *See* TAGHVAEIAN ET AL., *supra* note 2.

water intensive. In addition, careful planting techniques, such as leaving the crop stubble in the ground and planting a new crop in the residue, can decrease erosion and evaporation.[264] This technique captures blowing snow thereby increasing precipitation absorption.[265] Furthermore, low-till, or no-till techniques, like leaving crop residue to decompose, can increase moisture retention. One strategy is to let dry fields sit fallow for a full year between plantings to collect moisture.[266]

Several federal programs provide economic incentives for conserving existing grasslands. The grasslands overlying the Ogallala Aquifer play a crucial role in reducing erosion, sequestering carbon, and providing habitat for a variety of endangered species. Institutional measures—such as conserved water rights, groundwater and surface-water withdrawal restrictions, and drought water banks—can encourage agricultural producers to reduce water consumption for crops, while facilitating the reallocation of water to higher-value uses.

6. Creation of Groundwater Management Districts

Despite the fact that the common law in Texas is leading to groundwater depletion, farmers are beginning to adapt. Some areas facing steep declines in the southern High Plains have responded by creating local districts to monitor water levels, which are also effective in helping stakeholders become more involved in groundwater conservation.[267] As a response, many states have created groundwater management areas that provide special protective rules in a limited geographic area.[268] In some states—like Texas—these groundwater protection areas are created by local entities, and in some states—like Colorado and Kansas—they are managed by the State Engineer. Still other states have implemented regulatory schemes that require the permitting of wells.

264. Little, *supra* note 26.

265. NAT'L RES. CONSERVATION SERV., U.S. DEP'T OF AGRIC., CONSERVATION PRACTICES THAT SAVE: CROP RESIDUE MANAGEMENT (2005), https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_023624.pdf [https://perma.cc/VJ72-LGUK]; Mutiu Abolanle Busari et al., *Conservation Tillage Impacts on Soil, Crop and the Environment*, 3 INT'L SOIL & WATER CONSERVATION RES. 119 (2015).

266. Morris, *supra* note 103.

267. TAGHVAEIAN ET AL., *supra* note 2.

268. *Id.*

In her Nobel Prize winning work, Elinor Ostrom uses the game theory concept of the prisoner's dilemma to explain individuals' inability to manage a resource.[269] Within this framework, Ostrom explores the effectiveness of cooperative solutions governing common resources, identifying eight characteristics of successful long-term sustainability.[270] Supplementing Ostrom's work, economist Carol A. Rose urges scholars to acknowledge the history of commons resources and the communities that use them.[271] Ostrom and Rose identify attributes of effective informally-managed commons.[272] These characteristics include: (1) clearly defined households that have rights to withdraw resources from the commons, (2) appropriation rules that are connected to local conditions, (3) graduated sanctions for appropriators who violate operational rules, and (4) conflict-resolution mechanisms.

Against a historic backdrop of under-regulation, the potential for groundwater management districts, with clearly defined stakeholders, sanctions, operational rules, and detailed histories, holds promise. Applied to a culture that is deeply suspicious of centralized power, such a program nevertheless promises to create accountability even among strongly individualistic agricultural communities like those in Texas. In 1997, the Texas Legislature enacted Senate Bill 1 to create local groundwater conservation districts in areas expected to experience groundwater problems.[273] The Texas Legislature also enacted a bill that designates priority groundwater management areas.[274] Groundwater conservation districts in Texas may regulate the spacing of wells and limit groundwater production based on tract size to minimize well interference.[275]

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269. *See generally* ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION (1990).

270. *Id.* at 90.

271. Carol M. Rose, *Left Brain, Right Brain and History in the New Law and Economics of Property*, 79 OR. L. REV. 479, 488 (2000).

272. Pearl, *supra* note 24, at 1040.

273. Texas water law provides that "[i]n order to provide for the conservation, preservation, protection, recharging, and prevention of waste of groundwater, and of groundwater reservoirs or their subdivisions, and to control subsidence caused by withdrawal of water from those groundwater reservoirs . . . groundwater conservation districts may be created . . . ." TEX. WATER CODE ANN. § 36.0015 (2019).

274. *Id.* § 35.008.

275. Texas water law allows the spacing of water wells and allows controls on the production of groundwater. It also allows the district to adopt different rules

Despite resistance, some Texas farmers realize that they must take action or else risk running out of water.[276] These farmers have changed their behavior in many ways: They have moved from flood-style irrigation to more efficient low-pressure, drip-line sprinklers. In addition, the High Plains Underground Water Conservation District, based in Lubbock, has declared that water pumped in excess of the "allowable production rate" is illegal.[277] Texas has nearly one hundred local groundwater conservation districts, which voluntarily regulate well spacing and pumping rates within their boundaries to encourage long-term groundwater protection.[278] Local districts employ a variety of techniques including education, loans, and peer pressure to encourage farmers to fulfill their conservation responsibilities.[279] This approach is a form of voluntary self-management by water users themselves and perfectly illustrates Ostrom's theory of self-governance in the absence of regulation. Although this approach represents an improvement to the common law rule of capture, which would otherwise prevail in Texas, the solution is currently a piecemeal approach, leaving groundwater management in many areas of the state unregulated.

Groundwater management districts in other states see similar parallels between the comprehensiveness of the implemented regime and the effectiveness of handling and accounting for competing demands. For example, Colorado and Kansas also use Groundwater Conservation Districts.[280] Colorado's groundwater law defers to local groundwater management districts and gives other groundwater appropriation powers to both the Colorado Ground Water Commission and the state engineer, who issue well permits for the designated basin.[281] Further, as stated earlier, Colorado recognizes four distinct groundwater categories: tributary groundwater, designated groundwater,

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from one geographic area to another for different aquifers or geographic areas. *Id.* § 36.116.

276. Postel, *supra* note 20, at 2.

277. *Id.* at 1.

278. Pearl, *supra* note 24, at 1056.

279. Somma, *supra* note 79, at 2.

280. Stephen E. White & David E. Kromm, *Local Groundwater Management Effectiveness in the Colorado and Kansas Ogallala Region*, 35 NAT. RES. J. 275, 275 (1995).

281. Griggs, *supra* note 25, at 1292–93.

non-tributary groundwater outside of a designated basin, and Denver Basin groundwater.[282]

Kansas illustrates how strong resource management can result in better practices that create sustainable groundwater yields. Southern Kansas was one of the areas overlying the Ogallala that was hardest hit by the Aquifer's decline. Groundwater levels dropped more than 150 feet in some areas in this region.[283] Luckily, the Kansas government's conservation response has been extremely strong. Kansas has powerful local bodies called "groundwater management districts" that have some autonomy over groundwater management.[284] The Kansas system also allows the state chief engineer to impose substantial reductions in groundwater use, particularly in Intensive Groundwater Use Control Areas.[285] Further, in making such a reduction order, the chief engineer asked water users to employ "efficient, nonwasteful water practices" and to administer the aquifer on a "safe yield basis."[286] Kansas farmers have gotten on board by voluntarily agreeing to cut usage by 20 percent over a five-year period; failure to do so will result in sanctions.[287]

II. TOWARD A NATIONWIDE MODIFICATION OF INCENTIVES

Solutions to aquifer depletion in general, and to the Ogallala Aquifer's depletion specifically, have been elusive. Because the Aquifer underlies so many states, I argue that successful solutions should contain three elements: they must (1) explicitly consider the role of farmers as key stakeholders, (2) start thinking of aquifers as collectively managed public resources, and (3) align financial incentives and legal incentives in the direction of sustainability.

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282. Colo. Ground Water Comm'n v. N. Kiowa-Bijou Groundwater Mgmt. Dist., 77 P.3d 62 (Colo. 2003).

283. Little, *supra* note 26.

284. Peck, *supra* note 202, at 350.

285. *Id.*

286. *Id.* "Safe-yield" is a key concept with regard to aquifer management: it refers to the pumpage of water that can be sustained without continued withdrawal from aquifer storage. More abstractly, safe-yield represents pumping levels for which consequences are socially tolerable. TARLOCK ET AL., *supra* note 23, at 332.

287. Brett Walton, *Kansas Farmers Cut Ogallala Water Use—And Still Make Money*, CIRCLE OF BLUE (Mar. 6, 2018), https://www.circleofblue.org/2018/world/kansas-farmers-cut-ogallala-water-use-and-still-make-money/ [https://perma.cc/W9Y6-H3R8] (noting that, in taking advantage of a new state law, Kansas farmers agreed to cut water withdrawals by 20 percent through 2017).

Denise Fort and Summer McKean note that groundwater as a nonrenewable resource has received minimal attention in the political arena, and observe that aquifer depletion is occurring as an implicit consequence of water law rather than as a consequence of deliberate water decisions.[288] America's law today seems to accept current levels of irrigation and depletion. Regulatory and legislative solutions are needed to correct doctrinal problems and to change incentives. At the present time, no federal legislation governs the Ogallala Aquifer, the Central Valley Aquifer, the Mississippi Embayment, the Arizona Alluvial Basins, or any of the aquifers underlying the territory of the United States.[289] Although the federal government has the power to legislate in this area, they have effectively ceded this power to the states.[290] As discussed earlier, state law regimes are inadequate to have any real effect on groundwater quantity conservation. As a result, water law regimes are reduced to varied effect on groundwater quantity conservation, with a failure of uniformity triggering all of the usual commons pitfalls.

In order to protect the aquifer commons, lawmakers' and policymakers' goals should be to discourage undesirable behavior (overpumping) and to encourage desirable behavior (more efficient water use). The remedies available to prevent aquifer depletion lie along a continuum and range from the voluntary to the mandatory, and from the less-effective to the more-effective. Solutions to aquifer depletion can be placed into two categories. One group of solutions is easy to implement and is politically feasible. These solutions will have a positive impact on aquifer depletion, but by themselves are insufficient to dramatically change outcomes. Another group of solutions will be harder to implement politically but when implemented may provide faster, more visible signs of progress.

A. *Align Economic Incentives with Laws and Conservation Goals*

Federal and state lawmakers need to take immediate steps to align available economic incentives to promote, encourage,

288. Denise Fort & Summer McKean, *Groundwater Policy in the Western United States*, 47 IDAHO L. REV. 325, 325 (2011).

289. *See* Verchick, *supra* note 15.

290. Sporhase v. Nebraska, 458 U.S 941, 950 (1982) (holding that groundwater is an article of commerce and therefore subject to congressional regulation).

and expand behavior that will save America's aquifers. It is possible to change incentives in a few different ways. First, farmers and state agencies can be encouraged to pursue voluntary approaches. Second, legislatures and agency administrators can give farmers incentives to change their farming practices and their water use in the form of tax deductions from the state and federal government. Third, legislators can impose tax penalties or fines when farmers behave in ways deleterious to groundwater management. Finally, agencies can implement very strict limits on withdrawals, water rationing, or bans on groundwater withdrawals.

In addition, federal and state lawmakers should recognize the history of their common pool resource: namely, that until recently, groundwater has been managed as a private resource.[291] A sea change is required: instead of managing the groundwater as a private resource, it must be managed as a regional and intrastate resource. Groundwater mining in arid regions—including California, Arizona, and the High Plains Region—affects far more people than the farmers making water withdrawals. As aquifers decline, numerous stakeholders will be affected. These stakeholders include state governments; residents in arid states who rely on aquifers for groundwater; consumers who rely on the agricultural products produced with groundwater; politicians who will face pressure to send state and federal money to mitigate the effects of groundwater depletion; neighbors affected by ground subsidence; advocates for endangered species like the silvery minnow which faces extinction due to dropping water levels; and residents of regions who will be pressured to send limited and over-appropriated supplies of surface water to replace depleted groundwater stores.[292] Scholars Fort and McKean note that groundwater withdrawals are presently managed as a conversation between those who have property rights and water management agencies.[293] Instead, the conversation over groundwater must include all affected stakeholders, and management decisions should be made regionally while also considering national effects.

291. *See* Fort & McKean, *supra* note 288, at 326.
292. *Id.* at 337.
293. *Id.* at 326.

B. *Use Tax Deductions to Gradually Introduce Regulatory Schemes for Reducing Groundwater Withdrawals*

One proposed approach, which should be implemented immediately, is to change the Farm Bill's tax deductions to encourage farmers to both monitor and reduce their aquifer withdrawals and start using water-saving technology. This approach benefits from being incremental and politically feasible, as well as from applying a voluntary model of conservation. This gradual approach, starting with voluntarily changing behaviors to receive tax benefits, would result in farmers being more likely to self-select management plans, reduce resistance, and increase stakeholder buy-in. This approach draws on the natural overlap that researchers say exists between the conservationists' need to manage demand on depleted aquifers, and farmers' own tendency to favor management plans that utilize technical authority and rely on the expertise of irrigation experts and economists.[294] From an economics standpoint, the proposed approach shows the greatest chance of success among the various theories that attempt to reduce demand and encourage water conservation.[295]

Additionally, existing federal programs already promote conservation of sustainable aquifer yields. Indeed, EQIP funding has had an important cumulative impact on irrigation investments, contributing to farm profitability through improved yields and water and energy conservation, as well as potentially enhancing local and regional water quality and environmental resources.

Five percent of the 2014 Farm Bill's total funding was dedicated to conservation programs.[296] Unfortunately, the 2014 Farm Bill repealed funding for the Agricultural Water Enhancement Program, which was a voluntary conservation initiative that provided financial and technical assistance to conserve surface and groundwater.[297]

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294. TAGHVAEIAN ET AL., *supra* note 2, at 3.

295. Somma, *supra* note 79, at 9.

296. *Path to the 2018 Farm Bill: Conservation*, NAT'L SUSTAINABLE AGRIC. COALITION: NSAC'S BLOG (Mar. 14, 2017), http://sustainableagriculture.net/blog/path-to-2018-farm-bill-conservation [https://perma.cc/7B64-HUMK].

297. *See Agricultural Water Enhancement Program (AWEP)*, U.S. DEP'T AGRIC., https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/?cid=nrcs144p2_068627 (last visited Feb. 10, 2020) [https://perma.cc/JLC4-PZ49].

The 2018 Farm Bill has both beneficial and less conservation-focused changes. For example, the 2018 Farm Bill made changes to conservation programs that provide funding for technical assistance; helped farmers and ranchers maintain, improve, and expand activities to benefit natural resources; and made changes to the Conservation Reserve Program, such as allowing nonprofits to be eligible partners in the Conservation Reserve Enhancement Program.[298] The 2018 Farm Bill Slowly increased funding for EQIP from $1.75 billion in Fiscal Year 2019 to $2.023 billion in Fiscal Year 2023. This program helps groundwater reduction in two key ways. First, the program authorizes increased payments for "incentive practices" that address one or more priority resource concerns.[299] Second, the program allows irrigation districts and acequias to participate in certain EQIP projects. The Conservation Stewardship Program was funded at about $700 million in Fiscal Year 2019. This program adds the concept of a comprehensive conservation plan and encourages such plans to account for increased weather volatility.[300] The National Resources Conservation Service already works directly with farmers to design and implement a conservation plan and to conserve water, particularly through improving irrigation practices.

The 2020 Farm Bill should build on these successes by allowing landowners to earn federal tax benefits upon agreeing to (1) annual water monitoring, and (2) reducing water withdrawals according to goals set in conjunction with the USDA, the USGS, and state entities. The payment mechanism enhances deductions and accelerates depreciation on specific types of conservation and irrigation-related equipment.

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298. *Agriculture Improvement Act of 2018: Summary of Key Conservation Programs*, LAND TRUST ALLIANCE, https://www.landtrustalliance.org/topics/federal-programs/farm-bill-conservation-programs (last visited Jan. 21, 2019) [https://perma.cc/234D-2U59].

299. *Id.*

300. Average global temperatures have increased steadily since the mid-twentieth Century. British researchers have established that warming from human emissions has increased the likelihood of extreme weather events. *See* Kyle Frischkorn, *Does Climate Change Cause Extreme Weather Events?*, SMITHSONIAN MAG. (Aug. 15, 2017), https://www.smithsonianmag.com/science-nature/does-climate-change-cause-extreme-weather-events-180964506/ [https://perma.cc/M7UQ-DS9M]. According to the EPA, the rising global average temperature is associated with widespread changes in weather patterns. *See Climate Change Indicators: Weather and Climate*, U.S. ENVTL. PROTECTION AGENCY, https://www.epa.gov/climate-indicators/weather-climate (last visited Jan. 21, 2019) [https://perma.cc/53U8-C5NW].

First, under Internal Revenue Code section 175, individuals in the farming business can choose to deduct certain expenses for soil or water conservation efforts, preventing farmland from eroding, or working to recover endangered species. The conservation practices have to be implemented as part of a plan approved by the Natural Resource Conservation Service of the USDA, or a comparable state-approved plan.[301] Currently, the deduction for conservation expenses cannot be more than 25 percent of an individual's gross income from farming.[302] This deduction should be increased to an amount sufficient to make it more attractive for farmers located above aquifers to conserve than to move grasslands to croplands. This percentage could be determined by economists at the GAO and the USDA working together.

Second, according to the Farmer's Tax Guide, farmers cannot currently deduct the cost of drilling a water well, for irrigation and other agricultural purposes, as a soil and water conservation expense.[303] It is a capital expense. Farmers recover their costs through depreciation. This clause should be amended to allow farmers who voluntarily agree to monitor their wells and reduce their groundwater withdrawals to take a special depreciation allowance for conservation-related farm equipment, like equipment used in irrigation and water wells. This depreciation allowance should be determined according to a reduction schedule published by the Natural Resource Conservation Service of the USDA in conjunction with the USGS National Water Information System.[304]

Currently, for qualified property acquired after 2007 and placed in service before 2016, farmers can take an additional 50 percent depreciation allowance.[305] The allowance is an additional deduction that can be taken before figuring regular depreciation under the modified accelerated cost recovery system (MACRS). Right now, this property includes certain aircraft, property with a long production period, and certain specified

301. Kristine A. Tidgren, *Deducting Farm Expenses: An Overview*, IOWA ST. UNIV. CTR. AGRIC. L. & TAX'N (July 30, 2017), https://www.calt.iastate.edu/article/deducting-farm-expenses-overview [https://perma.cc/73CC-E32E].

302. *Publication 225 (2019), Farmer's Tax Guide*, IRS (2019), https://www.irs.gov/publications/p225#en_US_2016_publink1000217935 [https://perma.cc/6VTE-K986].

303. *Id.*

304. *Id.*

305. *Id.*

plants. The 2020 Farm Bill should be amended to ensure that if farmers can comply with the USDA's schedule for voluntary well monitoring and withdrawal reductions, they should be allowed to use the additional 50 percent depreciation allowance. In addition, the 2020 Farm Bill should completely reinstate and fund the Agricultural Water Enhancement Program. This incentive system should be subject to a quadrennial program evaluation, which could be conducted by the GAO, to measure the extent to which target populations are adopting desired forms of behavior.

C. Change Legal Doctrine to Be More Uniform Across the Aquifer

What can states do to limit groundwater depletion? Doctrinally, changes to state law are required. The various existing state law regimes for managing groundwater are too distinct to provide any long-term solution; therefore, state laws need to be modified to promote cohesion among the aquifer states. The Texas Law of Capture is clear from a regulatory perspective. However, it is very destructive, and will rapidly deplete shared aquifers, including the Ogallala Aquifer, and state-specific aquifers like the Trinity Aquifer. Texas and Oklahoma should be strongly encouraged to adopt a system that employs a state engineer with strong enforcement powers, similar to the systems utilized in Kansas and Colorado. In addition, all states overlying the Ogallala Aquifer should move to a permitting system, with permits approved by the state engineer. The Kansas system allows the state chief engineer to impose substantial reductions in groundwater use, particularly in Intensive Groundwater Use Control Areas. If all states overlying the Ogallala Aquifer moved to a combination of a "reasonable use" system in conjunction with a "strong permitting system," such restrictions could be implemented across all states facing imminent groundwater depletion.

Scholarly approaches to doctrinal changes similarly depend on uniformity. Robert Verchick advocates for planned sustainability with regard to groundwater use.[306] Scholars Kaiser and Skillern observe that the law should promote safe and sustainable groundwater yields. Kaiser and Skillern suggest that while

306. Verchick, *supra* note 15, at 22.

much of the recent groundwater law debate has focused on protecting private property rights, creating additional local groundwater districts, or stopping cities from pumping groundwater from rural areas, we must wait for core groundwater management solutions that evince community support and agreement on (1) how to resolve the conflicts over domestic well interference caused by high-capacity wells; (2) how to prevent aquifer overdrafting and promote safe, sustainable aquifer yields; and (3) how to address aquifer mining.[307]

D. *Change Doctrine to Reflect the Values of Intergenerational Sustainability*

In line with this recommendation, the idea of "reasonable use" and "safe-yield" should be redefined doctrinally to include the sustainable use of the groundwater, preferably over an extended time horizon. Looking at the policy and doctrinal changes over a potential range of time, two hundred years for example, would encourage communities to anticipate variable factors in planning for yield and collection standards. Currently, state systems limiting the amount of water that can be withdrawn from a basin or aquifer rely on annual yield and recharge rates, which fail to account for variability. This short time horizon means that the policy nearly exclusively emphasizes outtake, rather than recharge, of water resources. Idaho and South Dakota employ a "safe-yield" standard for groundwater withdrawal that limits withdrawal to the average annual recharge rate. This is a more conservative policy, which allows a certain amount of water to stay in the aquifer. Oregon has enacted a sustained-yield policy in certain geographical areas that limits the amount of water withdrawn from a designated basin to "the amount of water that can be withdrawn from it annually without exceeding the long-term mean annual water supply to the reservoir."[308]

In Oklahoma, by contrast, a landowner or landowner's lessee may withdraw water for reasonable use up to but not exceeding a basin or sub-basin's maximum annual yield. The maximum annual yield is set by the Oklahoma Water Resources Board.[309]

307. Kaiser & Skillern, *supra* note 170, at 294–95.

308. Doherty v. Or. Water Res. Dir., 783 P.2d 519 (Or. 1989).

309. MAXIMUM ANNUAL YIELD FACT SHEET, OKLA. WATER RES. BD. (2012), https://www.owrb.ok.gov/about/about_pdf/Fact-MAY.pdf [https://perma.cc.BD95-EKKJ]. According to the OWRB, the "maximum annual yield" of a groundwater

Having the Oklahoma Water Resources Board set the maximum annual yield provides flexibility, but it may result in undue political pressure and uncertainty. Again, the procedures and approaches of Colorado and Kansas provide best practices in this area. For example, Colorado will tolerate groundwater depletion of up to 40 percent over a timeframe of one hundred years.[310] Kansas allows controlled mining in certain designated geographical of up to 40 percent deletion over a shorter period: namely, twenty-five years.[311] Redefining "reasonable use" to account for an extended time period could be achieved by promulgating a uniform code for groundwater management and lobbying state legislatures to adopt it. If the already-severe groundwater depletion situation worsens, a case can be made that Congress should require states to adopt such legislation.

E. Improve Information Sharing Between States and the Federal Government

Some solutions for reducing aquifer depletion are based on increasing the amount of information available to scientists, farmers, and state and federal agencies. Such solutions can be implemented in a manner that ranges from voluntary to mandatory. Information-based solutions include encouraging agencies to share information, educating farmers about the state of the aquifer, and creating national commissions. Information-based solutions can also include imposition of requirements on state agencies, such as mandatory information sharing with both federal and local agencies and requiring metering for all wells.

Burke Griggs points out that, at least in Kansas, detailed records for nondomestic water rights exist. He argues that the local groundwater units adopt all of the hydrological data generated by the Kansas Geological Survey and the USGS concerning the state of the Aquifer, including groundwater models that evaluate the hydrological consequences of pumping.[312] This approach is sound and will reduce uncertainty in future litigation.

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basin is a term used to describe the total amount of fresh groundwater that can be withdrawn while allowing a minimum twenty-year life of the basin. *Id.*

310. COLO REV. STAT. § 37-90-137(4)(b)(I), (II) (2019).

311. KAN. ADMIN. REGS. § 5-23-4a (2019).

312. Griggs, *supra* note 25, at 1319.

It also resolves the problem of "paper water rights," where appropriations far exceed the actual amount of water in the ground.

At a minimum, states should adopt the uniform data model of the USGS in an effort to improve groundwater management and ensure uniform reporting and analysis.[313] Griggs's recommendation should be taken a step further by ensuring that federal, state, and local entities involved in groundwater management share information with each other. This is a straightforward, low-cost suggestion that should be implemented. After September 11, 2001, sharing information between agencies at different levels working on similar problems became increasingly popular.[314] This approach reduces silos between agencies conducting similar work. Importantly, data sharing is highly effective in situations where valuable data is being recorded at multiple levels in multiple dispersed locations, but no single unit is effectively consolidating that data. Improving information sharing among states and water districts would enhance comprehension of groundwater management issues, permitting more effective problem-solving of a highly dispersed common pool resource. Such information sharing would prove even more valuable if state agencies were required to share information in their possession on groundwater withdrawals in their jurisdiction with the USGS. Data sharing and analysis increases coordination between units working on similar problems while also reducing costs.[315] Such strategies have been used to good effect in public health, water infrastructure, worker protection, and for combating organized crime. Effective data sharing approaches focus on identifying available data, setting priorities, identifying a lead agency, addressing a lead agency, and drafting rules for data sharing.[316]

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313. *See id.*

314. *See* Brian Z. Tamanaha, *Are We Safer from Terrorism? No, but We Can Be*, 28 YALE L. & POL'Y REV. 419 (2010). During 9/11, critical information was spread among several individuals within the intelligence community. The community was divided by institutional barriers, however, and no unit existed to put all the information together.

315. *See* Sara Cherico-Hsii et al., *Sharing Overdose Data Across State Agencies to Inform Public Health Strategies: A Case Study*, 131 PUB. HEALTH REPS. 258 (2016).

316. *Id.*

F. Establish a National Aquifer Protection Commission

While other scholars have suggested a national aquifer protection commission, I suggest two ways for improving that commission to better preserve water quantities. First, in agreement with Verchick, I propose a system that looks beyond parochial state borders and that recognizes the role of geography.[317] Second, I join Pearl in advocating for the creation of an Ogallala Aquifer Commission.[318] Additionally, an interstate Ogallala Aquifer Commission could benefit from a national platform with the power to address the depletion problems facing other aquifers. A National Aquifer Protection Commission would be particularly effective if it addresses concerns regarding depletion in all critically endangered aquifers, not just the High Plains Aquifer. Such a commission would bring federal attention to the problem of aquifer depletion. In addition, such a commission could catalogue and assess the steps that the federal government is already taking to protect aquifers, particularly under the auspices of the USDA. Creating a National Aquifer Protection Commission gives the matter much needed political and media attention and may increase the quality and quantity of research on the problem. Indeed, such a Commission has historical precedent. In 1936, while the Dust Bowl was suffering from the most severe drought in its history, President Roosevelt created a Great Plains Drought Area Committee to formulate long-range plans for remedial action. This committee was composed of representatives of various federal agencies and of state agriculture experiment stations and land-grant colleges.[319]

G. Require Well Metering

Well metering, another information-based solution, would ensure that farmers—and indeed state agencies in high withdrawal areas—receive and conduct education in concert with the USDA regarding the consequences of withdrawal rates. In essence, all farmers are operating under uncertain conditions regarding groundwater withdrawals.[320] Particularly because in-

317. Verchick, *supra* note 15, at 22.
318. Pearl, *supra* note 24.
319. Putney, *supra* note 6.
320. In her article, Erin Baker explores decision-making in the presence of increased information in a climate change context. She finds that learning may

formation on aquifer depletion rates is disaggregated and incomplete, farmers are not aware of the impact that their personal withdrawals have on the greater resource. They are also not aware that groundwater is being depleted rapidly enough to threaten their livelihoods.

One simple solution that would dramatically increase the available amount of information would be to require that every well in the nation be metered. As noted above, hydrologists have insufficient information about the amount of water left in aquifers. Requiring metering would help to close this informational gap. In addition, state agencies do not actually know how much water farmers are withdrawing from wells on a state-by-state basis. Requiring metering would help both farmers and state agencies understand the withdrawal quantities on a state-by-state basis.

For aquifers that cross state boundaries, such as the Ogallala Aquifer or the Mississippi Embayment, requiring metering would help state agencies, as well as federal agencies, understand how withdrawal rates differ across borders, and would help these entities move toward withdrawal rates appropriate to their groundwater conditions. This solution can be adopted on a state-by-state basis, or it could be imposed by Congress in multistate aquifer regions, such as the High Plains Aquifer and the Mississippi Embayment. Some states, like Kansas, already require metering.

In other states, like Oklahoma, water metering is not required, and the Oklahoma Farm Bureau has aggressively and successfully opposed all attempted water-metering mandates. Arguably, voluntary metering is an option, but that will make the available information more fragmented and, thus, less useful. Beginning voluntary metering with tax incentives may be a less painful way to get farmers used to the eventuality of mandatory metering. Yet, voluntary metering is a mere stopgap measure. Realistically, mandatory metering will be required by 2030 if our nation's aquifers are to be saved.

If farmers were more aware of how their individual behavior affects the aquifer in the long run, as well as their ability to keep farming effectively in the medium run, such information might

cause individuals to pursue a "go slow" policy. Erin Baker, *Increasing Risk, Increasing Informativeness: Equivalence Theorems*, 54 OPERATIONS RES. 26, 26 (2006).

encourage them to change their behavior. Information-based solutions are an important way to reduce the deficit of information with regard to groundwater stores in the United States. Although information-based solutions may change behavior in some small way, they are probably disproportionate to the scale of the problem. Moreover, information-based solutions are slow: although they are effective in the medium and long run, they will not immediately address the dramatic effects of depletion.

H. Continue to Support Local Management Institutions Such as Groundwater Management Districts

A federal and state infrastructure need not ignore the abilities of local communities to self-regulate. As noted above, Elinor Ostrom's research has demonstrated the success that can be had by local communities that avoid the tragedy of the commons by developing local management institutions. There is, in fact, empirical evidence that farmers are willing to change their behavior.[321] While federal and state regulations can provide a structural framework for self-regulation among communities without such traditions or history, local communities that do have this history should be encouraged to continue developing management institutions and theories based on their shared history and knowledge of which methods work and which methods fail.

Here, Ostrom's theories are well borne out by the increasing popularity of groundwater management districts in several states, including Arizona, Nebraska, Texas, Colorado, and California. Although there is an increased popularity among states, farmers are not homogenous. Some are very willing to participate in conservation, whereas others have a more short-term approach to water usage. Yet, throughout the Ogallala, some farmers have shown an interest in extending the life of the resource they depend on. In essence, local farmers in communities

321. *See, e.g.*, Walton, *supra* note 287; Amy Bickel, *Kansas Water Law: Pumped-up Penalties for Violators Gain Steam*, HUTCHINSON NEWS (Dec. 30, 2015), https://www.hutchnews.com/38b727d7-9bd7-5ba8-94ac-b9d84939eae2.html [https://perma.cc/6KJ4-KNM9]; Brett Walton, *Texas and Kansas Farmers Take Different Paths to Saving Water*, CIRCLE OF BLUE (Jan. 19, 2014), https://www.circleofblue.org/cpx/ogallala-aquifer/texas-and-kansas-farmers-take-different-paths-to-saving-water/ [https://perma.cc/A4VA-ZXT4] (observing that the North Plains Groundwater Conservation District in Texas set an annual pumping limit of 18 inches).

that have curated lessons from their shared history are often very aware of what steps need to be taken to manage aquifers in a sustainable manner. Voluntary local efforts have been shown to be effective at reducing water withdrawals and irrigation amounts. In fact, from 2007 to 2012, the largest decreases in irrigated acres occurred in Texas (521,000 acres), Colorado (351,000 acres), Nebraska (262,000 acres), and Oregon (215,000 acres), with smaller declines in California and New Mexico.[322] Most of these states lie above aquifers threatened by depletion. Although groundwater management districts are effective at a local level, they are neither large enough nor powerful enough, to manage a regional aquifer such as the Ogallala, which spans eight states. However, the federal government can build on this concept in two possible ways. One is a regional groundwater management district spanning the entire Ogallala. This approach could be used for other cross-regional aquifers, like the Atlantic Aquifer and the Mississippi Embayment. Another approach is utilization of an interstate compact.

The approaches to aquifer depletion outlined up to this point are politically feasible, avoid political confrontation, and do not really require state governments or politicians to make hard decisions. In addition, they build on existing success and look to expand programs that have already been shown to be effective. Indeed, the 2014 Farm Bill solved one conservation problem by linking conservation and crop insurance subsidies after the GAO highlighted the problem. The downside of this approach is that it has limited effectiveness given the severity of the problem. Critics might argue that this approach is too modest and that more drastic steps should be taken. They would be correct. More effective approaches will have to rely more on the stick than the carrot.

I. Impose Pumping Limitations and Fines

Where community history and self-regulation do not promote change, regulations over pumping volume and an imposed fine schedule may be more helpful. In order to make significant progress on reducing aquifer depletion, increasing levels of coercion will be required. States, like Kansas, have demonstrated

322. *Irrigation & Water Use*, *supra* note 253.

success with convening stakeholder groups who support increasing pumping limitations. After states or Congress implement mandatory metering, setting pumping restrictions for aquifers facing rapid depletion would be the next step. A promising pilot program enacted in northwest Kansas's Sheridan County aimed at prolonging the life of the Ogallala Aquifer.[323] The Northwest Kansas Groundwater Management District No. 4 instituted a mandatory water management program that limited pumping for the next five years. Irrigators who pump more than the amount allowed by the limit face fines and a suspension of their water use for two years.[324] Because mandatory metering would improve information about groundwater stores, the USDA could more effectively work with state agencies to determine pumping limitations and sustainable yield goals on a state-by-state, and even region-by-region, basis.

CONCLUSION

Eighty-three years after the Dust Bowl, America's High Plains face a dire threat. Entire sections of the country could run out of groundwater supplies by the end of the century, or even sooner. Legal experts, lawyers, judges, legislators, and policymakers across the nation should be concerned about the nationwide impact that depletion of this precious resource will have on the availability of drinking water and the agricultural productivity of the country.[325] The problem of aquifer depletion will affect all Americans in one way or another within the next generation and could even revive the conditions created by the 1930s Dust Bowl. As one observer noted, "Far too few people realize the present gravity of the situation, and probably no one appreciates the full significance of the threat to future generations."[326] Can we apply unselfish, effective action to prevent catastrophe for the next generation's?

Like climate change, no single silver bullet adequately addresses the problem of aquifer depletion. Instead, a variety of changes must be made ranging from the incremental to the grand, from the voluntary to the coercive. The solution will require changes in irrigation technology, crop choice, consumer

323. Walton, *supra* note 287.
324. Hegeman, *supra* note 30.
325. Verchick, *supra* note 15, at 13.
326. Putney, *supra* note 6.

and farmer behavior, legal doctrine, and legislation. National and statewide policymakers must begin paying attention to groundwater management in the Ogallala Aquifer, as well as in other aquifers.[327] Currently, the Ogallala Aquifer is being managed in a piecemeal manner. In effect, policymakers are observing an unsuccessful and dangerous natural experiment taking place at the state level. In some states overlying the Ogallala—such as Colorado, Kansas, and New Mexico—significant focus is being placed on sustainable groundwater management. In other states—such as Texas—groundwater is managed with reckless disregard for the long-term consequences or the cross-border implications.

The 2020 Farm Bill should dramatically incentivize water conservation efforts. A few ways this can be achieved include encouraging voluntary metering, adhering to voluntary withdrawal limits, investing in improved irrigation equipment, and eliminating subsidies for high water commodities like corn and pork. The Bill already contains conservation provisions, as well as a variety of tax deductions and subsidies designed to adjust farmer behavior. The task now is to use those existing provisions in a way that reduces subsidies for high water use crops and farm products. These changes are feasible and incremental and should find significant support on both sides of the aisle.

This Article has presented a variety of moderate solutions, including: supporting subsidies for improved irrigation technology, eliminating subsidies for water-depleting crops, improving information sharing between the federal government and state governments, imposing mandatory well-metering, and changing the doctrinal definitions of "safe-yield" to have a longer time horizon. Finally, it is time for Congress to create a National Aquifer Commission, which will begin the process of managing the High Plains Aquifer, as well as other aquifers, in a way that recognizes the fact that aquifers are national resources with national impacts that must be managed collectively.

The most contentious solution is the one that will have the greatest and most efficient effect at slowing aquifer depletion. The water in the High Plains Aquifer is running out and will be gone within two generations unless water-use patterns change.

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327. *See* Fort & McKean, *supra* note 288, at 325 (asserting that policymakers should pay greater attention to groundwater management in the western United States).

Numerous federal studies have considered the problem of aquifer depletion in the High Plains Aquifer.[328] This shows the national scope of the problem. Nebraska, Wyoming, New Mexico, Colorado, and South Dakota should follow Kansas's lead to mandate limits on groundwater withdrawals over the Aquifer and impose strict penalties on those who violate limits. The Texas Supreme Court has created a problem by suggesting that limiting withdrawals may amount to a taking, but significant pressure from neighboring jurisdictions, and indeed, Congress, is just what is needed to eradicate the outdated law of capture.

Writing for the Soil Conservation Service in 1936, Arthur H. Joel observed,

> The conditions around innumerable farmsteads are pathetic. A common farm scene is one with high sand drifts filling yards, banked high against buildings, and partly or wholly covering farm machinery, wood piles, tanks, troughs, shrubs, and young trees. . . . Numerous livestock have died as the result of strangling, eating excessive amounts of grit, and from starvation, all associated directly or indirectly with wind erosion and drought. . . . Numerous roads become impassable after a few serious dust storms, and many cars have been ruined or badly damaged. . . . To all of this add poverty, heavy indebtedness, enormous relief costs, and other social and economic difficulties, and the picture in many localities is a most discouraging one.[329]

Mr. Joel concluded his observations with the following insight:

> It is . . . no exaggeration to say that . . . difficulties [related to the Dust Bowl] have become problems of national importance, problems demanding careful study and unselfish,

328. *See* Water Resources Research Act of 1984, 42 U.S.C. § 10301 note (2018) (Ogallala Aquifer Research and Development) ("The Secretary, acting through the United States Geological Survey and in cooperation with the States of the High Plains region, is authorized and directed to monitor the levels of the Ogallala aquifer, and report biennially to Congress."); High Plains States Groundwater Demonstration Program Act of 1983, 43 U.S.C. § 390g (stating that the Secretary of the Interior shall investigate and establish demonstration projects for groundwater recharge of aquifers in "High Plains States"); U.S. GEOLOGICAL SURVEY, NATIONAL WATER QUALITY ASSESSMENT PROGRAM: HIGH PLAINS REGIONAL GROUND-WATER STUDY (2008), https://pubs.usgs.gov/fs/2000/0091/report.pdf [https://perma.cc/P23J-6AKV].

329. Putney, *supra* note 6.

> effective action at an early date in order to prevent their continued development to catastrophic proportions.[330]

We must heed this call and implement unselfish, effective, and collective action. Groundwater depletion represents a crisis for American farming and, by extension, for American consumers. Without rapid action, the reckoning will come soon, and it will be severe. Solutions for reducing aquifer depletion in the High Plains Aquifer represent a testing ground for the rest of the nation, and the rest of the planet. [331]

330. *Id.*
331. Little, *supra* note 26.