groundwater MARKETS

Managing a Critical, Hidden Resource

*Nearly all our usable freshwater comes from groundwater, so why is it mostly unregulated in the United States? **Yusuke Kuwayama** describes a market-based solution to better manage our nation's depleted aquifers.*

As California's three-year drought rages on, some communities are on the verge of running out of water. Ranchers are being forced to sell off cattle in fire sales, and the governor has urged residents to cut their water use by 20 percent. The California State Water Project—which has been pumping water from northern California to the arid southern end of the state since the 1960s—announced that for the first time, it would provide no supplemental water to the 25 million Californians and about 750,000 acres of irrigated farmland it normally serves. Instead, these customers will have to rely solely on local sources of water. The situation presents a catch-22 for the state and its residents: water shortages will increase reliance on declining groundwater supplies, but the unsustainable use of this resource has contributed to the severity of the drought.

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While extreme, the current drought in California demonstrates the importance of effective water resource management, including the prudent use of critical groundwater resources. Groundwater use is typically unmonitored and unregulated in the United States. Many states allow anyone to drill a new groundwater well, while a few western states have a priority system that ranks pumpers based on when they started pumping from the aquifer. In Texas, the law governing groundwater use is known as the "rule of capture," which allows a person the right to pump whatever groundwater is available. California follows the "reasonable use doctrine," which allows a user to pump an infinite quantity of water as long as the water is put to a "beneficial use." While this prevents many wasteful uses of groundwater, it allows continued pumping even if water tables decline in the underlying aquifer or if flows are reduced in connected streams and rivers.

The Consequences of Unregulated Pumping

On one hand, the lack of attention from policymakers and the general public is not surprising. Groundwater is located beneath the earth's surface in gaps between particles and chunks of soil, as well as spaces in the fractures of rock formations, so it's not immediately visible to us on a daily basis. On the other hand, groundwater is our most important freshwater resource, accounting for 95 percent of our usable freshwater, compared to 3.5 percent contained in lakes, swamps, reservoirs, and rivers.

Substantial pumping has resulted in large water table declines and the depletion of water stored in aquifers, requiring users to deepen their wells to reach increasingly scarce supplies or even shut down productive activities that rely on groundwater. In the Ogallala aquifer underneath the Great Plains, for example, pumping for irrigation since the 1940s has led to declines so large that the aquifer no longer supports irrigated agriculture in vast stretches of Texas and Kansas. According to a 2013 US Geological Survey study, about 32 percent of the depletion of this aquifer since the start of the twentieth century took place between 2001 and 2008.

In addition, the failure to manage ground-

Limiting Pumping from the Edwards Aquifer to Protect Endangered Species
The Edwards Aquifer supplies San Antonio, Texas, and its surrounding communities with water for agricultural, industrial, municipal, ecological, and recreational uses. Pumping that has frequently exceeded the natural recharge rate, coupled with periodic droughts, has reduced discharges at springs (sites where water flows naturally to the surface of the earth from underground). This, in turn, has affected habitats for several endangered and threatened species, including the San Marcos salamander, which is listed as threatened by the state of Texas.

In early 1993, a federal district court upheld an endangered species lawsuit and ordered that pumping limits be imposed to protect spring flow. This led to Texas Senate Bill 1477, which established the Edwards Aquifer Authority and charged it with managing the aquifer in order to reduce pumping, facilitate water markets, protect agricultural rights, and protect species habitats.

water and surface water as connected hydrologic systems has reduced water flow in nearby streams and associated ecosystems. Stream depletion has been litigated between local stakeholders and federal agencies over species protected under the Endangered Species Act in Idaho, Texas, and elsewhere, as well as species that are economically and culturally important, like Pacific Northwest salmon (see the box above). Stream depletion also has led to interstate conflict over the role of groundwater use in the fulfillment of compacts governing the distribution of water in transboundary rivers.

To resolve these conflicts, it will be necessary to curtail groundwater use in many regions of the United States. For a groundwater management policy to be cost-effective, it will have to achieve these reductions while also minimizing costs to groundwater users. Water resource economists often recommend groundwater markets as a tool for managers to promote this balance between the costs and benefits of regulation. Such markets can facilitate the movement of water to serve changing conditions and demands, providing price signals that encourage higher-valued uses and conservation.

Costs and Benefits of Groundwater Pumping

The benefits of groundwater pumping are usually pretty clear. A farmer or rancher makes revenue from irrigating crops or providing water to livestock; a residential user has access to water for drinking, bathing, landscaping, and so on. However, the costs of groundwater pumping can be more difficult to quantify. From an economic perspective, groundwater users face two types of costs. The first is the extraction cost, or the cost of getting the water out of the aquifer and conveying it to its point of use. Typically, energy costs make up the largest portion of groundwater extraction costs. If extraction costs are greater than the benefits generated by the water that is being pumped, then it doesn't make economic sense for the user to pump that groundwater.

The second cost associated with groundwater pumping arises from the fact that any unit of groundwater pumped today will not be available for use in the future. This is known as the scarcity value of water. Quantifying scarcity values can be tricky, especially if multiple users share an aquifer, which is often the case. Scarcity values for an individual user tend to be lower in multi-user aquifers because attempts by one user to increase his or her future welfare by saving groundwater in the aquifer are futile: other users may end up withdrawing it. As a result, users are compelled to pump groundwater from the aquifer at a higher rate. Users also may pump groundwater at a relatively high rate because they are simply not aware of the degree to which they are depleting the resource, thus perceiving the scarcity value of water to be lower than its actual value. Finally, if users do not account for the value of groundwater to future generations, their high pumping rates may be optimal for them but not for society as a whole.

Further complicating matters, in addition to incurring extraction costs and losses in scarcity value, groundwater pumping lowers the height of the water table, increasing extraction costs for other nearby users. In this case, users may withdraw groundwater too quickly because, although reducing their pumping rate lowers the future pumping cost of all users, they are not compensated for this conservation. Groundwater pumping can also impose costs on third parties by reducing flows to connected rivers, springs, and other surface water bodies. These depletions can affect other entities that hold rights to the surface waters that are being depleted, or damage ecological systems that depend on high surface water flows.

Thus, for users to pump groundwater at a socially optimal rate, they must weigh the benefits of groundwater pumping not only against the associated extraction costs and scarcity value, but also against the costs that they may impose on other groundwater users, surface water users, and individuals who experience a loss in value from damaged ecosystems. In reality, individual users will tend to account only for their private costs. Thus, governments can play a role by providing incentives that bring pumping rates closer to the socially optimal level, such as encouraging the development of groundwater markets.

Creating a Groundwater Market

To establish groundwater markets, the aquifer's regulating body must first quantify groundwater rights by determining the optimal total volume of pumping from the aquifer. Those rights are then allocated to users under a predetermined scheme. The regulator can then separate the water rights from parcels of land and make the rights transferrable, creating a market for groundwater. Such a market would function as many others do—transactions take place if one user is willing to pay a larger sum of money for a unit of groundwater than another user is willing to sell it for. Both the buyer and the seller are better off after this transaction. For the buyer, the groundwater he purchased is more valuable to him than what he paid for it; for the seller, the payment she received exceeded the value that she placed on the groundwater.

However, mutually beneficial transactions may be difficult to realize if potential sellers are unable to find willing buyers, and vice versa. Centralized entities, such as brokers or clearinghouses, can encourage transfers in a groundwater market by collecting bids from all potential buyers and sellers. Once all bids are collected, the broker or clearinghouse can take each buyer and try to find a seller who is willing to sell water at a lower price than what the buyer is willing to pay. Thus, these centralized institutions act as "matchmakers" for buyers and sellers who

Groundwater Trading in the Platte River Basin

The Platte River Basin overlies the High Plains aquifer and supports extensive groundwater-fed irrigation. At the same time, it is in the middle of a primary North–South corridor for migratory birds, including whooping cranes, which have been listed as federally endangered since 1970. Due to concerns that groundwater pumping has lowered water levels in the Platte River and its tributaries, management districts within the basin have placed limits on irrigation and introduced moratoria on new wells.

Limiting groundwater pumping in order to maintain stream flow may impose significant costs on water rights holders, and it is important to understand the trade-off between maintaining stream flow and maintaining the activities supported by pumping. As part of a project funded by the US Department of Agriculture and National Science Foundation, researchers from the University of Illinois, University of Nebraska, RFF, the Desert Research Institute, and the National Oceanic and Atmospheric Administration have been working to understand how ecological, economic, and hydrologic processes interact in connected surface water–groundwater systems. Based on the research results, University of Illinois professor Nick Brozović, his master's student Richael Young, and their collaborators have been working to implement a pilot groundwater trading program in the Twin Platte Natural Resources District in the Platte River Basin in Nebraska. The pilot program works within the existing regulations of the district but automates the otherwise complicated process of matching buyers and sellers and allows for confidential, anonymous bidding.

may otherwise not have found each other (see the box on page 23).

Markets also have the benefit of allowing more flexible movement of water to serve changing conditions and demands. Over time, they encourage users to evaluate conservation strategies because any water that is saved can be sold on the market. As a result, groundwater markets, and water markets in general, can help water-stressed regions better cope with decreased and uncertain water supplies in the face of climate change.

The rapid depletion of aquifers in the United States has significant impacts on users and the environment, requiring stakeholders across the country to look for creative and effective policy solutions. Decades of research by economists have shown that markets hold the potential to provide incentives for conservation, stewardship, and efficient reallocation of natural resources. While small-scale groundwater markets have begun to emerge in the United States, this policy instrument can be applied more broadly in groundwater management in order to protect our most important freshwater resource. ●

FURTHER READING

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