Market-based Groundwater Allocation: 
Considerations for Arizona from the Texas Edwards Aquifer Cap 
and Trade System

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Arizona water issue: persistent groundwater overdraft

As highlighted in a recent New York Times article (Healy, 2013), changing climatic conditions in the Western U.S. are likely to cause more drastic fluctuations in Rocky Mountain snowpack, with winters of little snow forcing hard allocation challenges in the spring and summer, and problematizing the “renewableness” of Arizona’s allocation of the Colorado River. While groundwater is only one part of Arizona’s water portfolio, a less predictable surface water supply ensures that it will remain a critically important one into the future regardless of “new” sources such as reclaimed and desalinated water. More than 30 years after its passage, the Arizona Groundwater Management Act (GMA) remains the major regulatory legislation for meeting the state’s water conservation goals. For the Phoenix, Tucson, and Prescott Active Management Areas (AMA), this goal was “safe yield” for aquifers by 2025. In 2013, just 12 years away from that target, major challenges remain.

One challenge identified in a recent assessment (Smith, 2011) is that despite the replacement of groundwater withdrawals in some cases with Colorado River supplies via the Central Arizona Project canal, groundwater is still being pumped faster than it can be replenished in many places. Per capita water use has declined but overall consumption has not. Consequently, overdraft is projected to continue in most AMAs based on Arizona DWR’s estimates (Table 1). Overdraft causes well-known problems, both physical (subsidence and fissuring, lowering of quality due to higher amounts of salts and minerals at deeper depths) and economic (increased costs of pumping from lower depths as the water table declines).

Another perceived problem related to reducing overdraft is the complex regulatory system that has evolved over time. The GMA rules centralized administrative and regulatory authority with the state. The increasingly complicated body of rules and regulations to conserve water has been lamented (Glennon, 2004), and the allocation mechanisms they have set up have been criticized as “arcane” (Smith, 2011). Along with the bureaucratic complexity is a perception of incoherence: “Our institutions for managing water are so fragmented, we can't cooperate in shortages” (Patricia Gober, quoted in McKinnon, 2009). These factors tie in to a second challenge, which is emerging conflict between urban and rural demands, “between those who have water and those who need it (Smith, 2011, p. 3).”

Market-based governance as an alternative

Market-based governance approaches to water allocation are thought by proponents to achieve a more economically efficient allocation of water, simplify regulation and the bureaucratic apparatus, and head off emerging conflicts between rural and urban demands (Anderson & Hill, 1997; Howe, 2002). For these reasons, market-based allocation approaches have been proposed as reforms for centralized regulatory systems such as Arizona’s (Glennon, 2004; Robb, 2011; Smith, 2011). A recent Grand Canyon Institute report calls on the Arizona Legislature to create a commission to investigate market-based water allocation approaches and make recommendations about legal changes needed to enable their implementation (Smith, 2011).

In practice, market-based water governance implies an argument for moving water from inefficient historically-based agricultural uses to more efficient, newer
municipal and industrial sector uses. Yet a fully economically “efficient” allocation, followed to its logical conclusion, could mean a total shift of groundwater rights from agriculture to cities. However, agricultural water can be an important source of flexibility or “buffer” during drought years, as William DeBuys (2011, p. 172) points out in his prognostication for central Arizona:

“Things will be fine for the roughly 3.5 million people who drink, cook, and wash with CAP water only for as long as…the cities of central Arizona don’t grow so much that they consume their agricultural buffer, which is their main protection against the uncertain years ahead.”

Since it unclear what might happen if market-oriented reforms were introduced in Arizona in the future, this analysis investigated an existing groundwater market in order to inform debates about introducing more market-based allocation policies in Arizona. Specifically, it reports findings about groundwater governance via a cap and trade system in the Edwards Aquifer in south-central Texas.

Methods

In this analysis I quantitatively analyzed 14 years (1998-2012) of groundwater rights transfer records obtained by public records request to the Edwards Aquifer Authority (EAA), the agency created to implement and oversee the cap and trade system. The database contains over 5,634 individual records, though some were administrative actions other than actual sales or leases of groundwater rights, such as modifications to existing permits. Records of sales and leases were evaluated in terms of frequency of transfers over time; the proportions of sales versus leases; volumes of water transferred; and the changes in purpose of use, e.g. from agricultural to industrial. The year 2011 was the most severe drought year in the Texas historical record, and so it was singled out to determine whether transfer activity increased concurrently. The analysis of transfer records was supplemented with a review of agency reports and documents, peer-reviewed literature, and information on agency websites to understand the basic institutional structure of the trading system and the EAA.

Findings

Institutional design of the Edwards Aquifer Authority and cap and trade system

The Edwards Aquifer (Fig. 1) is a karstic aquifer with springflows that feed streams that are home to endangered species. Several years of highly contentious political wrangling stemming from an early 1990s Endangered Species Act suit ensued which eventually culminated in a then-groundbreaking policy reform in order to limit withdrawals such that springflows from the aquifer are sustained enough to maintain a minimum stream flow in order to preserve the habitat for endangered aquatic organisms.

The authorizing legislation was comprised of three main features: (1) a cap on total withdrawals (2) the conversion of legally unlimited groundwater withdrawal rights under the rule of capture legal doctrine to private, tradable, permitted ones; and (3) the creation of a state bureaucratic entity, the Edwards Aquifer Authority (EAA) responsible
for management and administration. The EAA is a state agency with a $33.5 million comprehensive budget that imposes duties on permit holders, who have to pay aquifer management fees, periodically file status and annual groundwater use reports, and implement conservation plans. The EAA has a multi-county jurisdiction (shown in red in Fig. 1) that corresponds with county boundaries and not hydrogeological ones. The EAA is set apart from the rest of the groundwater conservation districts in the state by its additional and specific regulatory authority and responsibilities, primarily that it is limited in the number of permits it may grant under the cap (Kaiser, 2010).

The cap enumerated in the authorizing legislation was 400,000 ac-ft per year, which was the scientifically recommended maximum amount that could be withdrawn during a drought of record (in this case the 1950s drought) and still preserve spring flows to protect endangered species. However, the EAA wound up allocating 549,000 ac-ft in permits. The permits were allocated based on historical use rates through an adjudication process with an appointed Special Master. The 400,000 ac-ft mark was supposed to be achieved by 2008, 15 years after the court ruling, but legislation was passed in 2007 raising the cap to 572,000 ac-ft (Votteler, 2008).

The San Antonio Water System has access to approximately 52% of the permitted volume of the Edwards Aquifer, about 295,000 ac-ft (San Antonio Water System, 2013). Over 90% of the drinking water used by San Antonio Water System comes from the Edwards Aquifer. The city lacks any significant alternate water sources, and is using the relatively low prices of water on the market to purchase rights. The sources reviewed indicate that most of the rest of the permitted groundwater extraction rights are allocated to irrigation, based on historical usage.

**Frequency and volume of groundwater withdrawal rights transfers**

Analysis of the EAA transfer records showed that leases and not sales accounted for the largest number of transactions (76%) during 1998-2012 (Fig. 1). As previously reported by Colby (2000), transfers were relatively few during the first years of the program. They then show a marked increase in 2006 and sustained higher levels thereafter, though with interannual variability. The mean number of transfers (sales and leases combined) for the period 2006-2012 (445.57) was over three times higher than during the prior period 1998-2005. Future work will seek to explain this shift in trading frequency.

Leases also accounted for the largest volume (Fig. 2) (75.8%) of the total amount transferred during the study period. The average transfer was found to be about 37,500 ac-ft in volume, and 24% of the total volume transacted was through sales; 76% were leases. Less than 8% of the permitted pumping volume has been sold or leased annually on average over the period 1998-2012, though it was as high as 12.5% in 2006. In terms of pricing, a 2007 study reported lease prices as low as $80 per ac-ft (Boadu, McCarl, & Gillig, 2007), while more recent transactions have fetched as much as $6000 per ac-ft (Griffin, 2010). Unfortunately price data were infrequently and unevenly reported in the records analyzed in this study.
Groundwater withdrawal permits are classified by the EAA into three types according to the purpose of the water right: irrigation, municipal, and industrial. Transfers of water rights from irrigation to municipal and industrial (M&I) accounted for approximately 43% of all transfers 1998-2012 (Fig. 4). Another 40% were transfers among irrigators. The vast majority (83%) of all trades were either within agriculture or from agriculture to M&I. Only 2% were transfers to agriculture, and the remainder was comprised of trades within and between M&I uses.

Transfer activity during the 2011 drought

An argument for market-based water allocation is that it introduces greater short-term flexibility through leasing arrangements, which is valuable during drought-induced shortages. Since 2011 was the worst drought year on record in Texas, it was expected that the number of leases would increase. The records show that this was the case (Fig. 5). 2011 tied 2009, also a bad drought year, for the most total transfers at 536. 85% of the total volume transferred in 2011 was done through 454 leases, for about 39,000 ac-ft. However, this is only a small percentage (6.7%) of the total permitted volume under the cap. Some water was transferred from irrigation to M&I (21% combined), but the vast bulk of transfer quantity (73%) consisted of transfers among agricultural users (Fig. 6). Explaining this difference will be a task for future investigation.

In summary, this analysis of the Edwards Aquifer cap and trade system for groundwater withdrawal rights showed that:

- Leases and not sales accounted for most transfers and as well as the total volume.
- Temporary increases in transfers suggest that the ability to trade through leases under the cap allowed some flexibility in allocation during severe drought years 2009 and 2011.
- The majority of groundwater rights transfers were between agricultural users and not from agricultural to municipal or industrial purposes.
- A relatively small percentage of the total permitted volume under the cap was actually sold or leased, about 8%, from 1998-2012 on average and in the 2011 drought year.

Observations and considerations for market-based reforms in Arizona

As Arizona’s water demands increase, reallocation of water rights among competing users is likely to become increasingly important, setting the stage for rural-urban antagonisms over water. The specific set of rules and regulations determining how exactly reallocation may occur will likely change in some ways in the future, perhaps significantly. However, in many locations, not just Arizona and Texas, the conservation district seems likely to be the primary political entity for management and governance. Policy reforms in Arizona will be implemented at the level of the AMA in Arizona. Based on this analysis, I draw several observations and conclusions relevant to the AMA-based governance system in Arizona.

First, unlike the Texas groundwater districts, the Arizona AMAs are already jurisdictionally suitable for cap and trade because the boundaries correspond with hydrogeologic features instead of counties. This implies a better institutional “fit” to the
Groundwater overdraft has been reduced within the AMAs to a large extent by offsetting pumping with CAP surface supplies. But it’s been projected that all CAP supplies will have direct delivery demands by 2030 (ADWR, 2011). Much of future unmet municipal demand in the AMAs is expected to be met through retirement of surrounding agricultural land. Reallocation of groundwater rights from agriculture to M&I may occur through the extinguishment and transfer of an Irrigation Grandfathered Right (IGFR) when agricultural land is permanently retired. The retirement requirement may preclude more short-term temporary reallocations, e.g. via land falling, that could be useful during severe drought shortage periods that occur before landowners wish to permanently retire from farming. A cap and trade system or other reform could potentially introduce some short-term intra- and inter-sectoral reallocation flexibility by allowing for temporary leases. For this to happen would require reconsideration of the laws and rules determining what may be done with IGFRs. Specifically, they would need to allow for short-term leases of IGFRs, separate from land ownership.

Establishing a cap in an AMA could force addressing the overdraft problem sooner than later, though it could be designed to ratchet down in stages over time, as was the original intent in Texas.

It was not clear from the Edwards Aquifer what the local hydrological effects of changing points of withdrawal through transfers might be, and this should be a key consideration for Arizona as well when assessing the physical and spatial implications of leasing or selling water rights. Recent research on groundwater trading schemes in Australia has identified important hydrological, and “hydro-economic” challenges associated with the redistribution of temporal and spatial impacts of pumping in a groundwater trading system (Skurray, Roberts, & Pannell, 2012). However, relatively little work has been done in the area of groundwater cap and trade systems and more should be carried out.

This analysis of the EAA shows that creation of a cap and trade market for groundwater rights does not equate to minimal bureaucracy and regulation. If a similar system were to be implemented in Arizona in the future, it should not be assumed that the size or complexity of the administrative apparatus would automatically be lessened. Although the specific duties and activities of the DWR with respect to the AMAs would have to be altered somewhat under a cap and trade regime, monitoring is a vital function that would still be required from an underfunded agency already struggling with oversight.

Finally, based on the Edwards Aquifer case, it should not be assumed that if a groundwater cap and trade system were implemented that trading would be active, especially in the first few years. It should also not be expected that there will be some large scale shift from agriculture to M&I uses, even during drought years, given the relatively small volumes of water transferred during 2009 and 2011 as a percentage of total permitted rights. If there is to be a continuing trend of reallocating water from rural to urban use, a cap and trade system may not necessarily hasten it. More research should be done to understand the factors affecting farmers’ decisions to sell or lease groundwater rights under such a system.
References


Tables and Figures

Table 1. Groundwater overdraft anticipated by Arizona Department of Water Resources in Active Management Areas by 2025.

<table>
<thead>
<tr>
<th>Active Management Area</th>
<th>Overdraft with groundwater allowance (ac-ft)</th>
<th>Overdraft without groundwater allowance (ac-ft)</th>
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Adapted from Smith, 2011
Source: ADWR Active Management Area Assessments
http://www.azwater.gov/AzDWR/WaterManagement/Assessments/default.htm
Figure 1. Edwards Aquifer region and Edwards Aquifer Authority jurisdiction.

Source: Edwards Aquifer Authority
Figure 2. Edwards Aquifer Transfer Frequencies, 1998-2012

Figure 3. Edwards Aquifer Transfer Volumes (ac-ft), 1998-2012
Figure 4. Transfers by Type of Use 1998-2012 (a) frequency and (b) quantity (ac-ft)

Figure 5. Number of groundwater permit leases per year.
Figure 6. Volume of transfers (ac-ft) in 2011 by purpose.