ANALYSIS OF WATER LAW AND WATER CONSERVATION IN ARIZONA

By

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Abstract

Arizona has a complex legal system governing its different sources of water (e.g., groundwater, surface water, rainwater, reclaimed water, etc.) This paper provides legal and historical context for the current practices governing water use in the state of Arizona, identifies ideal conservation practices to protect and preserve water resources, and recommends steps which could be taken to incentivize water conservation through new legal confines. Research on the current legal statutes and regulations that apply to water in Arizona as well as significant judicial decisions that shaped the interpretations of those laws are used to create a framework for understanding how water is managed in Arizona. Best practices for water conservation are explored based on scientific understanding of hydrology, ecology, and economics. Gaps between the current legal framework and best conservation practices are identified to highlight the downfalls of the current system of water appropriation. Drawing upon insight from the laws governing water in other western states and similarly situated geographic areas of the world and consulting professionals in various interest groups related to water use in Arizona, this paper proposes recommendations for the modification of our current water appropriation system (laws and their implementation) to better facilitate water conservation efforts while taking into account human interests.

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Statement of Relevance and Need

Water law in Arizona is the product of converging influences from traditional legal doctrine, history, politics, and geological/hydrological science. This complex web of laws has evolved over time to adapt to new knowledge and methods of managing water. However, it creates a margin for inefficient water allocation and damage to water conservation efforts when the current legal policy is not aligned with best water management practices. In a state with 113,594 square miles of surface land space (Open Data Network, 2018) and very little water, it is vital to understand how water is appropriated and improve water conservation practices. Water conservation is of particular importance given the current drought Arizona has been experiencing for over 20 years (Arizona State Climate Office, 2020) and climate change predictions which indicated hotter and drier weather in the future (Cayan et al., 2013). Water is a vital natural resource to support human life, but is also imperative for industry, especially agricultural operations.

Introduction

Overview of Water Appropriation in Arizona

The regulation and appropriation of water in Arizona can be broken into two main categories: surface water (e.g. lakes, rivers, etc.) and groundwater. Some states, such as Colorado, also have laws regulating rainwater, but Arizona does not regulate rainwater or rainwater collection. Groundwater is not regulated beyond "reasonable use," except in Active Management Areas. Active Management Areas are areas of the state in which severe groundwater overdrafts have occurred, meaning more water was being pumped out of the groundwater than was replenished each year (Lahmers & Eden, 2018). Surface water in Arizona is distributed based on the philosophy of prior appropriation, which means that the first people to put the water to a meaningful use have the senior right to that water so long as they maintain continuous use (Feitshans, 2016). A new water user cannot supersede the water claimed by a previous water user simply by establishing a claim upstream. Junior users are required to allow enough water to flow downstream to meet the rights of previous "senior" water users. In the case of a water shortage, water users receive their full water right in order of seniority. After all the water has been distributed, anyone with a lesser, unfulfilled water right receives nothing. However, a senior water user can lose their right (e.g., fifty acre-feet of water to irrigate an agricultural field) if they do not use that water for its claimed purpose for a period of time, typically 5 years. Most states west of the Mississippi use some form of a prior appropriation system. One major difference between the western states' prior appropriation system and the eastern states' riparian system is that a person does not have to own land physically touching the waterway (e.g. river, stream, etc.) to claim a right to the water. This allowed people to have a water right associated with remote land that they diverted water to through a pump or canal system.

A large-scale example of this type of surface water displacement is the Central Arizona Project (CAP). The CAP canal is 336 miles long, which allows it to deliver water to Active Management Areas through a series of pumps located throughout the state used to transport the water over mountains, which are each followed by a gradual slope allowing gravity to transport the water great distances to its final destination (CAP, 2016). CAP began in the early 1900s when Southwestern states negotiated how much water from the Colorado River each state would be entitled to use (August & Gammage, 2010). To make Arizona's water allotment available to the growing population that emerged from the agricultural community near the Salt River, President Johnson signed the Colorado River Basin Project Act in 1968. This act created the CAP as we know it today and authorized federal funds to build a canal system that would transport water from the Colorado River to other parts of the state (CAP, 2016).

One of the objectives of the CAP project was to provide an alternative source of water for irrigated agriculture, specifically in Southeast Arizona, where there was a major groundwater overdraft (meaning more water was being pumped out of the groundwater than was replenished each year). However, no new farmland was supposed to be irrigated with CAP water to prevent the use of CAP water from increasing the total demand for water (CAP, 2014). The CAP plays a vital role in preserving Arizona's water resources while sustaining its agricultural industry. Today, a majority of the water used for irrigated agriculture in Pinal County comes from CAP (Lahmers & Eden, 2018). However, the practice of diverting surface water to irrigate agricultural land in Arizona is not new. An American Indian group known as the Hohokam constructed an intricate network of canals near the Salt and Gila Rivers in South Central Arizona over 1,000 years ago (Lahmers & Eden, 2018). Despite being a traditional practice, this method of irrigated agriculture still poses some challenges, particularly to the environment.

Using CAP to supplement Arizona's water needs has important implications for conservation. As groundwater is removed, the water table (level of underground water) drops. If too much water is withdrawn, empty space takes the place of the water and the soil can no longer support the weight of the land above it which leads to collapse. Once the land above has compacted the spaces, they are no longer available for water storage (National Oceanic and Atmospheric Administration, 2018). The CAP was instrumental in protecting groundwater storage that could not have been reclaimed if it had been lost in the 1960's when water overdraft was most severe. However, in recent years, the water levels in Lake Mead, where a large portion of the Colorado River water (i.e. the source of CAP water) have lowered. This has sparked debate among both politicians and the scientific community over how sustainable CAP will be as a source of water in the future.

Another environmental challenge posed by the CAP is the disruption of natural wildlife habitat. According to the CAP website (2016), the entire length of the canal is fenced. This poses challenges to migratory wildlife populations that would traditionally cross the area now restricted by the long canal and surrounding fence. This restricts gene flow between populations, which is a vital survival feature of adaptation within wildlife populations. The U.S. Bureau of Reclamation sought to mitigate these environmental issues by contracting environmental teams from the University of Arizona and the Arizona Game and Fish Department to perform wildlife studies and determine their migration patterns. According to the CAP website, wildlife bridges were built at strategic locations according to the recommendations of the study to minimize interference with the natural migration patterns of wildlife by enabling them to cross the canal. Additional design features incorporated into the design of the canal as a result of the study include: fences, watering holes, escape ramps in distribution canals, and a roughened concrete finish that allows smaller animals to climb in and out of the canals (CAP, 2016).

Evolution of Water Law in Arizona

Surface Water

Before the Arizona Surface Water Code was enacted on June 12, 1919, a person claiming a water right simply had to post a notice of appropriation at the site of water collection (such as the edge of a river) and then put that water to beneficial use. After the law was made (which today is known as the Public Water Code) a person must apply for and obtain a permit in order to appropriate surface water, and document the volume, use, and date of right to access that water.

The State of Arizona defines surface water as "waters of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, flood, waste or surplus water, and of lakes, ponds and springs on the surface…" Surface water became a topic of national interest in 1944 when Arizona and several other western states signed the Colorado River Compact which partitioned the water from the Colorado river equally between the Upper Basin- Wyoming, Colorado, Utah, New Mexico- and the Lower Basin-California, Arizona, and Nevada (U.S. Bureau of Reclamation, 2020).

The signing of this agreement was followed by years of legal disputes over the allocation of water between Lower Basin states, particularly Arizona and California. The disputes were finally settled in 1963 by the Supreme Court decision in *Arizona v. California.* The Supreme Court allotted 4,400,000 acre-feet to California, 2,800,000 to Arizona, and 300,000 to Nevada, and it gave Arizona and California each half of any surplus. Additionally, the court held that the U.S. also reserved water rights for Native American Reservations at the time the reservations were created, although it did not specify how much water they were entitled to. This was settled by later cases, some of which are still on-going negotiations such as the Upper Gila River dispute with the San Carlos Apache Tribe (Layton, 2019). The Tribe chose not to sign a negotiated water settlement in 2004, and the continued litigation since then was topic of discussion at the Arizona Department of Agriculture's Arizona Agribusiness Roundtable event in December, 2019. The court also ruled that Congress intended to give the power to make contracts for the delivery of water to the Secretary of the Interior to accomplish this division. No state/entity could have the water without a contract. Another important takeaway from the decision is that each state reserved exclusive use of the waters of her own tributaries. Exclusive use means that water from Arizona's tributaries, such as the Gila River, would not be subtracted from its Colorado River allocation (*Arizona v. California,* 1963). Securing water rights to access this water made the CAP possible.

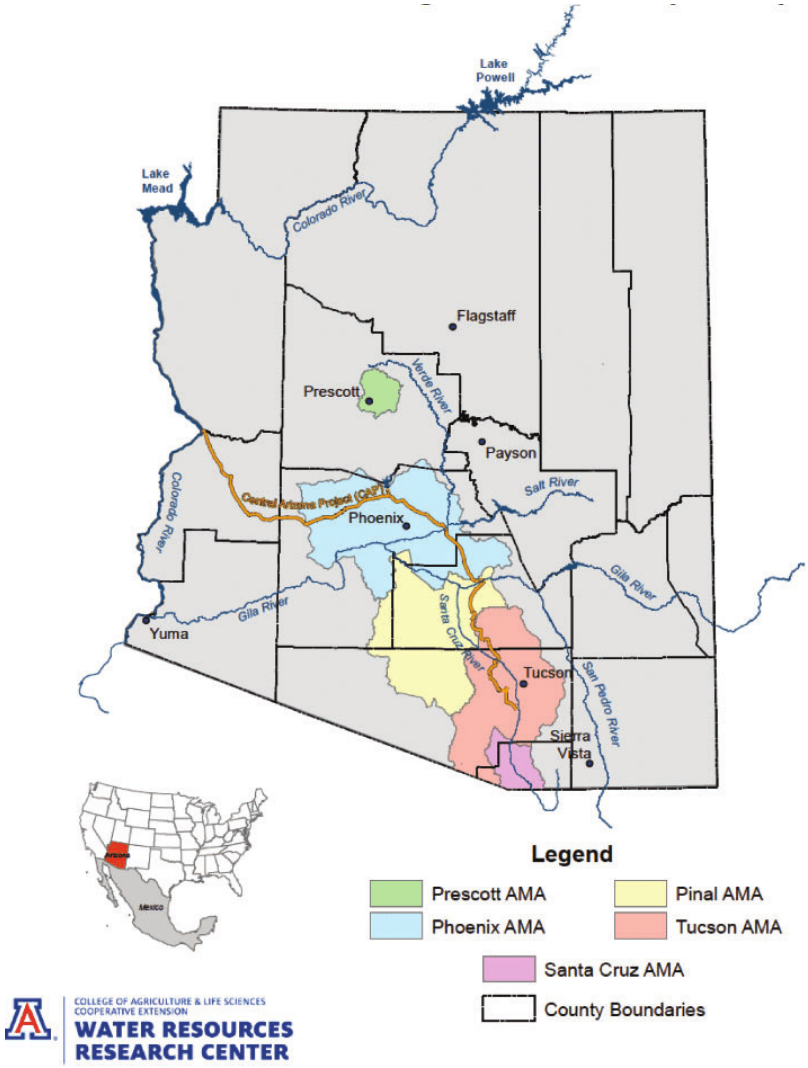
Groundwater

The Groundwater Management Act of 1980 created the Groundwater Management Code (Code) that governs groundwater use in Arizona which is not subject to the appropriation doctrine. The Code has been a subject of division as seen in the split rulings on *Bristor v. Cheatham* and *Bristor v. Cheatham ("Bristor II")* by the Arizona Supreme Court in 1952 and 1953 (McGinnis & Heilman, 2014). Further complicating the rules of water regulation is the fact that, hydrologically, all water systems are connected, and removing water from one source will have some impact on another (Brodie, Sundram, Tottenham, Hostetler & Ransley, 2007). This issue has been accounted for, to an extent, through litigation over the source of water (groundwater versus surface water) since the Arizona Supreme Court ruled in 1932 that "underflow, subflow or undercurrent…of a surface stream…" counted as surface water and was subject to appropriation doctrine (*Southwest Cotton,* 1932). The definition of "subflow" was further clarified by Judge Stanley Goodfarb in the *Gila River General Stream Adjudication* trial who established a new test to determine if a well was pumping appropriable surface water or non-appropriable groundwater. This test used a geological unit called the "saturated floodplain Holocene alluvium," to establish the boundaries of the subflow zone. However, wells outside the subflow zone may be found to be pumping subflow if their actions result in a measurable decrease of subsurface water levels (called the "cone of depression") that reaches the subflow zone, affecting its volume (McGinnis & Heilman, 2014).

Groundwater is subject to the "reasonable use doctrine," which, according to Hutchins and Steele (1957), is an American standard that was developed to recognize that the landowner has the right to *use* the water underlying their land, but not unlimited rights because the water is a public good, not a privately owned one. The use of the water must bear some reasonable relationship to the use of the overlying land (Hutchins & Steele, 1957). Most wells in Arizona that are determined to be pumping groundwater are subject to very few regulations (although all wells must be registered) unless they are located in an Irrigation Non-expansion Areas (INAs) or Active Management Areas (AMAs) as provided for in the Groundwater Code. The locations of the AMAs and INAs can be seen in Figure 1. The main restriction that applies to Irrigation Non-expansions areas is that no new acreage that was not irrigated between 1975 and 1980 can be irrigated. AMAs are subject to much more stringent regulation. Instead of applying the common-law reasonable use doctrine, a person must obtain one of the following "groundwater rights" to withdraw or use groundwater: grandfathered rights, groundwater withdrawal permits, or exempt withdrawals. Furthermore, the use of this water is monitored by the Arizona Department of Water Resources.

Figure 1

Active Management Areas (AMAs) in Arizona (map created by the Water Resources Research Center)



Current Water Conservation Law in Arizona

While laws that apply to appropriable surface water, wastewater, and water quality impact water conservation, laws specifically related to water conservation concerns in Arizona focus mainly on groundwater since this resource makes up the highest percentage of Arizona's supply (Arizona Department of Water Resources). A supply which, in many areas, has been significantly depleted.

Active Management Areas

The AMAs determined by the Groundwater Management Act are each subject to their own set of goals and limitations set to enforce those goals. This legislation is a key part of conserving Arizona's water resources because the AMAs encompass more than 80 percent of the state's population, the majority of the state's economic activity, and more than 50 percent of Arizona's total water use (Jacobs & Megdal, 2004). The cities within AMAs areas are also expected to experience significant population growth. To protect the water resources in the face of this growth the Assured Water Supply program was created. Under AWS mandates, either the water supply company or developer for any new subdivisions in AMAs must be able to show sufficient water supplies to serve the proposed development are physically, continuously and legally available for 100 years and that the water supply meets applicable water quality standards. The proposed water source and use must be consistent with the management goal of its AMA, demonstrating that it will not use more water than can be replenished.

Surface water such as CAP water was an important solution to the groundwater overdraft issue. Unfortunately, although CAP was successful as an engineering project, it was an economic and financial failure (Sternberg, 2016). CAP couldn't compete with the price of groundwater and farmers weren't able to afford the higher price of CAP water. As a result, a large portion of CAP water was diverted to municipal use where urban dwellers could be charged a higher price for the water. Arizona made significant adjustments to its pricing policy for CAP water to make it more affordable, creating an agricultural incentive pricing system which lowered the cost of CAP water for agricultural use. Through government subsidies for agriculturists designed to encourage the use of CAP water, the amount of groundwater used for agriculture was still able to be significantly reduced (CAP, 2016). The solution also lowered Arizona's overall repayment obligation to the federal government who loaned it the money to build the CAP canal, because low interest payments are made on the portion of the debt for CAP water used by agriculture (Jacobs & Megdal, 2004).

Arizona also makes use of its CAP water by storing some of it in Groundwater Savings Facilities (i.e., aquifers) to be accessed at a later date, a plan developed by the Groundwater Savings recharge program. When the water is recovered it is legally accounted for as the type of water that was stored–not groundwater. The Central Arizona Groundwater Replenishment District (CAGRD) has a program that allows landowners in AMAs who do not have access to CAP infrastructure to purchase water from them according to "replenishment assessment costs" and then pump that water out of the ground while the CAGRD stores water in recharge facilities. This storage is considered "replenishment" because it is intended to replace the groundwater pumped by users. Despite the somewhat expensive water cost, this model has been popular, experiencing a higher-than-predicted enrollment rate. There is some concern over the process because the CAGRD itself does not currently have, and is not statutorily required to have, a firm, 100-year supply of water for replenishment the way individual municipal providers are (Jacobs & Megdal, 2004).

Beneficial Use Doctrine

One of the restrictions prior appropriation applies to surface water in Arizona is that it also ascribes to the beneficial use doctrine, which requires continual, beneficial use of the water or the right to use it is forfeited. This results in a "use it or lose it" mentality which "creates incentives for the owner of a water right to exercise that right every year regardless of efficiency or the consequences to other uses, simply to avoid losing it..." (Culp, Glennon, & Libecap, 2014, p. 16). This doctrine has been upheld by the Arizona Court of Appeal in 1966 case *Salt River Water Users' Association v. Kovacovich.* Under the doctrine of beneficial use, the court held that landowners are "not entitled under all circumstances to appropriate a given number of acre-feet of water per year." Rather, "beneficial use is the measure and the limit to the use of water" (*Salt River Water Users' Association v. Kovacovich,* 1966, p. 201), which means that reducing the amount of water used does not allow you use that extra water as a marketable commodity or use it to irrigate adjacent land that is not part of the original water right. Any water saved through conservation efforts is simply made available to other users with junior (lower ranking) water rights. A water user only has the right to use the amount of water needed for the original beneficial use stated when a claim for that water use was made.

Reclaimed Water and Rainwater

Reclaimed water is highly treated wastewater from a wastewater treatment plant (A.R.S. § 49-201(32)). Reclaimed water can conserve potable (i.e., safe to drink) water for human consumption and domestic purposes when used as a substitute for other water uses such as agriculture. Gray water is wastewater that has been collected separately from a sewage flow and that originates from a clothes washer or a bathroom tub, shower or sink but that does not include wastewater from a kitchen sink, dishwasher, or toilet (A.R.S. § 49-201(18)). Gray water can be used directly as a substitute for water uses such as landscape irrigation. Arizona has taken advantage of wastewater within the Phoenix, Pinal, and Tucson AMAs where 95 percent of its wastewater is reclaimed for beneficial use (U.S. Bureau of Reclamation, 2015). Beneficial use can include a number of applications including: agriculture, underground storage, power generation, industrial uses, turf irrigation, and aquatic and riparian habitat. The Arizona

Department of Environmental Quality has established detailed rules governing the treatment of reclaimed water (Water Pollution Control, 2019). Each use has different standards of quality that it must meet in order to be used for that purpose. Treating wastewater can be especially useful for AMAs that are required to prove that they are returning as much water into the groundwater aquifers as they pump out (Tucker & Wilhelmi, 2015). Releasing the treated water underground is a useful way to meet this goal, and recycling the water for reuse in landscaping, agriculture, or even in homes will reduce the overall demand on additional water sources. This is particularly relevant since most of the state's AMAs contain highly populated cities such as Phoenix, Tucson, and Prescott. The concentrated population leads to high volumes of wastewater that makes treating it an economical option. Reclaimed water is cheaper than potable water (drinking water), making it an attractive choice for water users, and it is a cost-saving and convenient method for wastewater utilities to dispose of treated wastewater (Tucker & Wilhelmi, 2015).

In the state of Arizona, rainwater that falls on land you own may be legally collected in Arizona without a permit (Water Resources Research Center, 2017). Rainwater may be harvested and stored for future use. It is not regulated by the state of Arizona.

Water Quality

The quality of water is also an important aspect of the water conservation topic because water that is available but unfit for use in agriculture, such as drinking water, etc. is not helpful. The quality of water is commonly evaluated based on the pH, conductivity, phosphorus, stream flow, nitrogen, bacteria, total dissolved solids, turbidity, dissolved oxygen, temperature, and suspended solid contents (Farrell-Poe, Payne, & Emanuel, 2005). Water quality standards in Arizona are set and monitored by the Arizona Department of Environmental Quality according to the rules published in the Arizona Administrative Code § R18-11-101-122 (2019). Surface runoff from agricultural fields that have used fertilizers and/or pesticides have also been a source of water quality concern, and the rules in Chapter 6, Pesticides and Water Pollution Control, of the Environmental Quality title of the Arizona Administrative Code regulate their use.

Best Practices for Water Conservation in Arizona

The most straightforward solution to conserving current water resources would be to stop using it and let the underground aquifers recharge naturally. However, such a proposition is grossly impractical considering the millions of Arizona residents, and it might not necessarily be effective. There is no guarantee that sufficient quantities of water would end up in groundwater aquifers that have been depleted without targeted recharge and monitoring. Reducing overall water consumption is just one of several strategies that should be employed in order to efficiently and effectively conserve water in Arizona. Based on environmental research and economic analysis the best practices for protecting and sustainably utilizing our water resources in Arizona are eliminating unnecessary water use, raising the cost of water (R. Glennon, personal interview, February 14, 2020), preserving the quality of available water (DiNapoli, 2018), and utilizing additional water sources (Glennon, 2009).

Reducing Water Use

Simply cutting off people's access to water would be economically and socially crippling, and without targeted recharge of the most severely over-drafted aquifers, the water that is saved might not reach the places it is needed most. However, cutting back water consumption by using water more efficiently to reduce the overall demand is a vital component of water conservation. While cities, municipal water facilities, and individual homeowners can all take actions to reduce their overall water use and avoid waste, the topic of reducing water use almost immediately turns to agriculture. This is because agriculture accounts for 68% of Arizona water use (Lahmers & Eden, 2018). As the largest consumer of water, agricultural operations are sometimes accused of dominating and wasting Arizona's water (Murphree, 2015). However, it is important to view this water consumption in light of the global perspective. The world-wide average consumption of water for agricultural use is approximately 70 percent (Lahmers & Eden, 2018). Based on the previous statistics, agricultural water use in Arizona is comparable to the global agricultural water use average.

Agriculture in general has high water use because it produces the world’s food supply, and plants and animals require water to grow. However, the relative efficiency of Arizona’s water use does not mean room for improvement does not exist. Because agriculture is such a significant consumer of water, it stands to have the greatest overall impact in reducing water consumption by making minor changes to increase water efficiency. This is already taking form in some places where water is expensive through irrigation methods that use less water such as drip irrigation, sprinkler systems, and laser-leveling fields before flood irrigating. The Arizona Department of Water Resources recommends the following methods of agricultural conservation as the best management practices: canal lining, laser technology to grade land, level basin irrigation, sprinkler irrigation, drip or trickle irrigation, tailwater re-use system, crop rotations, soil and water analysis, flow rate measurement, bed and furrow shaping, irrigation scheduling (refer to Table 1 for definitions).

Table 1

Arizona Department of Water Resources (2020) Best Management Practices for Water Conservation in Arizona

Practice	Definition	Benefits
Canal Lining	Lining conveyance channels with concrete	• Significantly reduces seepage losses • Prevents waterlogging of surrounding lands • Maintains water quality
Laser Technology To Grade Land	Grading the land to slope specific to soil type and field layout with assistance from laser-guided technology	• Improves uniform application of water • Minimizes or eliminates losses caused by tailwater runoff • Minimizes percolation of water past the crop root zone
Level Basin Irrigation	Level basin irrigation systems are small field units (five to ten acres) comprised of level, closed basins. Level basins	• Improve uniform application of water • Eliminate losses caused by tailwater runoff • Minimize percolation of water past the crop root zone
Sprinkler Irrigation	The efficient use of irrigation sprinklers to meet the water demands of a crop	• Improves uniform distribution of water • Prevents excessive runoff and percolation of water past the crop root zone • Increases efficiency of fertilizer applications
Drip Or Trickle Irrigation	Drip irrigation systems use many low-volume, low-pressure water emitters to deliver water to a precise location. May be an above- or below-ground system	• Improves uniform distribution of water • Minimizes percolation of water past the crop root zone • Maintains soil nutrients in the root zone • Reduces water loss due to soil evaporation
Tailwater Re-Use System	Collects and reuses irrigation water that did not percolate into the soil before reaching the end of the field during irrigation	• Increases irrigation efficiency • Reduces water loss • Maintains water quality

However, a bigger impact could be achieved simply by growing a different crop that doesn't require as much water in the first place. One example of this is hay production in Yuma. Forages such as hay and, especially, alfalfa use significantly more water than crops such as tepary beans or melons (Myers, 2019). The number of acres in Arizona used for forage decreased while those used for vegetables and melons increased between 2012 and 2017 (see Figure 2). This has taken place mainly in Yuma where, according to Professor of Law at the University of Arizona and one of the nation's experts on water policy and law, Robert Glennon, alfalfa which was once the primary crop in the region has been replaced in some cases with high dollar vegetable/melon crops (R. Glennon, personal interview, February 14, 2020). This allows farmers to reduce water use and remain economically competitive.

Table 2

Number of irrigated acres in Arizona by crop types

	Irrigated Acres	
Crop	2012*	2017†
Forage (e.g. hay or alfalfa, excluding sorghum)	322,816	315,000
Cotton	197,455	175,000
Vegetables/melons	130,345	134,600
Wheat	102,581	115,000

Sources: *USDA 2012 Census of Agriculture;
†USDA 2017 State Agriculture Overview. Created by Lahmers & Eden (2018)

Simply refraining from farming, or fallowing the land, during summer months when plants require the most water is another way to preserve water resources. In the summer, alfalfa may consume four times as much water to grow than it would during the cooler months, and still produce yields that are lower in quality and quantity (Glennon, 2009). One way to motivate farmers and other water users to use less water is to raise the cost of water in the summer

Capturing and Reusing Water

Capturing, cleaning, and reusing wastewater is an excellent way to recycle water. However, there are potential environmental concerns with the practice. Combined sewer systems in which wastewater from human use and storm waters collect from a cities drains are collected in the same system pose a water quality risk if the systems cannot contain the volume of water produced by the rainstorm and untreated sewage water overflows into nearby rivers or other ecosystems (DiNapoli, 2018). The City of Phoenix has two separate systems to avoid this problem: one for sanitary sewer and a storm drain sewer. The stormwater sewer does not transport water to the sanitation facility, instead depositing the water in a retention basin or waterway (City of Phoenix, 2020). However, stormwater still has the potential to carry pollutants and flood communities. Some Phoenix neighborhoods were flooded by stormwater in 2014, prompting the city to build additional retention basins in the city to contain the stormwater generated by Arizona's intense monsoon rains (Cline, 2016). Other cities, such as New York City, Portland, and Denver have incorporated a practice known as "green infrastructure" into their water management systems. Examples of green infrastructure include Green Roofs, Rain Gardens, Detention/Retention Ponds, and Porous Pavements.

According to the U.S. Environmental Protection Agency (EPA), green infrastructure slows the flow and reduces the speed of stormwater, reducing the danger of flooding and erosion. It also provides an opportunity for the ground to absorb the stormwater, filtering it and recharging underground aquifers (U.S. Environmental Protection Agency, 2019). For cities that transport and treat stormwater before returning it to an underground aquifer or repurpose it for another use, green infrastructure can simplify the process and piping system needed for managing stormwater saving the city money. According to the U.S. Environmental Protection

Agency (2020), green infrastructure can save cities money by reducing the construction costs associated with site grading, paving, and landscaping and by eliminating or diminishing the size of piping and detention facilities. Green infrastructure also provides other benefits such as reduced energy expenses for buildings with green roofs (i.e., a roof that has been waterproof and covered, at least partly by a growing medium and vegetation) by providing insulation that reduces heating/cooling costs (U.S. Environmental Protection Agency, 2019). The Montana State Fund building (Figure 2) is Leadership in Energy and Environmental Design certified Gold due, in part, to its green infrastructure such a green roof that harvests rainwater to irrigate vegetation (U.S. Environmental Protection Agency, 2019).

Figure 2

A green roof built on the Montana State Fund building in Helena, MT (EPA, 2019)

Utilizing Additional Water Sources

As Arizona's population grows, additional sources of accessible water become increasingly valuable. Two new sources that have gained popularity in recent years are rainwater harvesting and desalination. While both of these sources, rain and saline water, were present previously, they have been under-utilized as water sources that can be collected and used for human purposes such as agriculture, landscape irrigation, and even drinking water.

Rainwater Harvesting

Rainwater harvesting is beneficial for cities like Tucson, Arizona where the climate is exceptionally hot and dry, risking rainfall loss to evaporation. The Department of Interior estimated that "more than 95 percent of the precipitation falling on Arizona is consumed by evaporation and by transpiration (Harshbarger, 1966)." Dr. Glennon reaffirmed this phenomenon emphasizing the idea that states who impose regulations on rainwater operate under the mistaken assumption that "if it [rainwater] hits the ground it's on the way to the river… but that's not the way it works. In Tucson, 98% of the water that comes down goes right back up (personal communication, February 14, 2020)." Rainwater harvesting typically comes in two forms: rainwater collected off of a roof or other structure and stored in a cistern/barrel or rainwater collected through earthworks and stored in the soil (Lancaster, 2008). Tucson Water, a local water utility, has promoted the use of rainwater harvesting through its "City of Tucson Water Harvesting Guidance Manual" which "offers developers, engineers, designers, and contractors detailed, illustrated information about [water] harvesting principles, site design, and techniques (Glennon, 2009, p. 190)." Continued adoption of rainwater harvesting technique poses great opportunity for securing supplementary water sources for Arizona's future.

Desalination

Although desalination, or removing salts and minerals from saline water, is usually proposed as a solution for water crises in coastal states, it also has conservation applications for the landlocked state of Arizona. Arizona already has a desalination plant in Yuma, Arizona the Yuma Desalting Plant. This plant reduces the salt content of the Colorado River water the U.S. delivers to Mexico and could potentially make additional usable water available to California and Arizona. However, running the desalination plant is very expensive and would cost several million more dollars than simply paying farmers to fallow their land in exchange for their water (Glennon, 2009). Again, it is important to look at the big picture. Simply fallowing farmland during times of water shortage due to drought is not an ideal solution because it will greatly increase the cost of food. Currently Americans spend a lower percentage of their budget on food than any other country (Wolfe, 2014). If increased incrementally, U.S. consumers would be able to afford small increases in the price of their food if water prices increased, but an abrupt change could negatively impact consumers.

Desalination also has practical implications for freeing up new sources of water for Arizona through deals with California to access the Colorado River water. The CAP is currently not operating at full capacity and could transport an additional 0.7 million acre-feet of water (CAP, 2016). If a sustainable desalination plant could be built and maintained along California's Pacific coast it would alleviate California's water demand and potentially make more Colorado River water available for Arizona to purchase from California, expanding Arizona's access to renewable water sources. However, in addition to being incredibly expensive and not yet cost effective, desalination also presents environmental concerns related to how excess salts removed from the water should be disposed of. Many environmental groups are concerned about the effects of super concentrated sublime seawater being released back into the ocean where it could have a negative impact on marine life and fisheries.

Bridging the Gap Between Law and Practice

When comparing Arizona's laws governing water rights and the best practices for water conservation, several themes emerge to highlight the lack of continuity between these two topics. Some areas of water law, such as the requirements for AMAs to produce proof that they replace the amount of groundwater removed from the aquifer and the lack of restrictions on rainwater harvesting, and in line with conservation efforts. However, some laws fail to incentivize water conservation practices, such as the beneficial use doctrine.

Water Classification

The most obvious inconsistency between Arizona water law and the hydrological reality of Arizona's water system is its division between surface water and groundwater. While there are distinct characteristics and concerns related to each broad grouping of water categories, ultimately, water is all part of one system. This division is a historical relic born out of the evolution of water law and irrigation practices. Recognizing the connectedness of both surface water and groundwater, in 2007 the Australian government, developed a report establishing a new framework for managing "Connected Groundwater-Surface Water Resources in Australia."

The report, created by Australia's Department of Agriculture, Fisheries, and Forestry seeks to correct problematic divisions between the designation of groundwater versus surface water. Australia has been subject to water designation disparities similar to those observed in Arizona and has a similar climate due to relatively reflexive latitudinal locations in relation to the equator. The framework utilizes the principles of conjunctive water management which it outlines as:

1. Where physically connected, surface water (including overland flows) and groundwater should be managed as one resource.
2. Water management regimes should assume connectivity between surface water (including overland flows) and groundwater unless proven otherwise.
3. Water users (groundwater and surface water) should be treated equally.
4. Jurisdictional boundaries should not prevent management actions. (Brodie, et al., 2007, p. 6)

The principles were developed by a group of Australian water experts, managers, and users, and they were used to inform that aims of the frameworks created by the ADAF which are to provide a consistent national approach to conjunctive water management in Australia in line with the principles of the National Water Initiative:

1. To promote decision-making based on an understanding of both the hydrological and hydrogeological characteristics of a catchment;
2. To provide a common understanding of groundwater-surface water connectivity;
3. To catalogue the available tools for assessing connectivity;
4. To raise awareness of the value of numerical models and other predictive tools in setting management targets and options;
5. To promote the coordinated monitoring of groundwater and surface water resources;
6. To identify sources for the key datasets required for management decisions.

Adapting a similar strategy with Arizona stakeholders could be very effective and help set a more realistic trajectory for water management in Arizona. However, in a personal interview with Robert Glennon, a professor of Law who has spoken on the current water policy landscape in more than 30 states as well as to Europe, Asia, Australia, and the Middle East, he expressed his doubts that such a policy could be implemented in Arizona. When asked if the standards governing surface water and groundwater might become more aligned in the future, Glennon replied, “Not in Arizona. This bifurcated craziness started in 1931 and has been reaffirmed twice by the Arizona Supreme Court. We just have to live with it” (personal communication, February 14, 2020).

Proactive Groundwater Regulation

More regulation of groundwater is necessary to preserve and replenish this valuable public resource. It should be tracked and accounted for similar to surface water in Arizona. Careful monitoring of groundwater use provides an opportunity for new INAs to be designated in a timely manner, before damage is done to the groundwater aquifers.

Making Water Marketable

Ultimately, every effort needs to be made to conserve excess water and reduce the amount of water used, especially in agriculture. However, a major disconnect exists between current water law in Arizona and the best practices for water conservation: the lack of incentive to conserve water. The current policy of beneficial use actually discourages water conservation practices because it provides no economic value for reducing water consumption and installing irrigation improvements is expensive. “The costs of modern sprinkler or drip irrigation systems, concrete ditch lining, laser leveling of fields, and other water-saving improvements,” according to the National Research Council (1992), “can be high in relation to the low profits in much of western agriculture” (p. 83). If the farmer could use the water saved by these investments for another purpose or sell it to others to use, it would provide a compelling reason to invest in water-saving technology. Arizona’s method of handling water is very similar to that of Colorado where the "salvaged water doctrine" holds that other appropriators receive the right to use any conserved waters (*Southeastern Colorado Water Conservancy District v. Shelton Farms, Inc.,* 1974). As highlighted by Cupt et al. (2014).the salvaged water doctrine "effectively encourages overuse of water because it does not allow farmers and others who reduce their water use to use lease, or sell the conserved water" (p. 16). A first hand example of this disincentive can be seen in the *Salt River Water Users' Association v. Kovacovich* (1966) case when agriculturists holding water rights from the Verde River were penalized for using the water saved by making irrigation improvements to irrigate a nearby piece of land. This is not legal under the beneficial use and salvaged water doctrines, even though they weren't using any more water than they had previously been using on their original field. While the court recognized the value of their conservation and fallowing practices to maintain the land's productivity, it was firm in the fact that "Although this may be a commendable practice, this is not sufficient to alter the established doctrine with respect to use of water." Beneficial use gives right to the specific use of water, not an amount of it. An alternative to the salvaged water doctrine can be seen in California's Water Code [§ 1241]. This law allows conserved water to be sold, leased, or exchanged, and water rights are not retracted (i.e., taken away if not used in 5 years) for water made available through conservation (Cupt, et al., 2014). Currently, California, Montana, Oregon, and Washington have laws that allow the right to use salvaged waters saved through conservation improvement to remain with the original holder of the water right or to be transferred to other users (Woodard, 2016).

However, carefully planning would need to be integrated into the process of legalizing water transfer on a larger scale. If a larger percentage of a community's farmers choose to fallow their land at the same time and for an extended period of time, it could negatively impact rural economies for whom agricultural operations are the primary employers and economic drivers. While it might be beneficial for farmers and those receiving access to the saved water, it can have a negative effect on the community. A prime example highlighted by the New York Times is Palo Verde Valley, California where, in 2011, agricultural business suppliers and farm workers suffered as a result of nearly one third of agricultural land being taken out of production to sell the water to urban communities (Barringer, 2011). They were able to sell the water for a higher price than they would have received for the crops that they could have used the water to produce. Cases like this are cause for concern for the community of Imperial Valley, where half the jobs held by its 174,000 residents are tied to agriculture (Barringer, 2011). The concern is also valid for many parts of Arizona considering Arizona agriculture is a $23 billion industry employing more than 162,000 unique workers (Bickel, Duval, & Frisvold, 2017).

Expansion of Desalination

Another solution to the diminishing quality and quantity of water in Arizona, desalination, is limited by technological, rather than political, development. Despite the challenges, desalination poses many potential solutions to the lack of freshwater among a growing population in the West, and it should continue to be the subject of more funding and research. However, it is not currently the most effective method for addressing the current water crisis in a timely manner.

Recommendations for Arizona

In order to incentivize frugal use of water resources, I suggest the following actions:

1.1) the beneficial use doctrine which governs all appropriable water resources should be altered so that land can be temporarily or seasonally fallowed without irrigation for conservation purposes and retain all applicable water rights. Furthermore, the water saved from fallow practices, irrigation improvements, or other conservation practices should be able to be repurposed or sold to other users, in a manner similar to the California Water Code § 1241

OR

1.2) Alternatively, due to the highly politicized nature of the issue and the long history of the beneficial use doctrine that renders it difficult to change, the beneficial use doctrine could be maintained, but a system of government incentives, such as subsidies, should be created to reward agriculturists and others who measurably decrease their water consumption through water-saving irrigation technology or fallow periods. While there are currently no specific government (state or federal) program of this nature that I am aware of, it could be modeled (on a state level) after the United State Department of Agriculture land conservation programs such as the Conservation Reserve Program (CRP) and other similar programs that provide varying benefits to farmers who use soil and environmental conservation practices such as no-till farming or even complete fallowing of their land to improve water quality, prevent soil erosion, and provide habitat for wildlife. The right to future use of the full amount of water originally established by their water right should not be forfeited on account of their participation in the program.

This will be done, in part, to minimize the effects of my second recommendation:

2) A tiered increase in all water prices, including groundwater. Exemptions will be made according to existing guidelines in non-agricultural expansion districts. Special

programs will be established for farmers similar to the tiered prices for agricultural water purchased through CAP. Lower-income communities should also be protected when increasing overall water costs. To ensure access to necessary water, the EPA recommends "low-income households should be charged lower rates on non-discretionary water consumption (the minimum sanitary requirement, e.g., 6,000 gallons a month), and higher rates on water consumed beyond that amount

3) Meters should be placed on all wells with a pumping capacity greater than 35 gallons per minutes, including those outside AMAs and INAs, to provide better conservation data for the Arizona Department of Water Resources. This threshold is in-line with the standards used to categorize wells in agricultural non-expansion districts. The data from the wells should be reviewed every 5 years to evaluate if a need to establish additional INAs exist.

4) Cities should be encouraged to build green infrastructure and, if located in an AMA, the estimated amount of water rechanged into the groundwater by the green infrastructure should count toward the total amount of water the AMA is required to replenish. Rainwater collected by individuals to off-set water consumption from traditional sources should also remain legal and promoted.

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