Colorado Foundation for Water Education

December 2015

# Managing Agriculture and Water Scarcity in Colorado (and Beyond)

by Joshua Zaffos

## Key Points:

- *Colorado's overall existing water rights – from the most senior, to the most junior – exceed the available supply of water during many years and in most regions across the state.*
- *Colorado's water laws under the Doctrine of Prior Appropriation prioritize water allocations among water rights holders and help to mediate potential conflicts among them.*
- *Colorado's water laws, policies and programs provide a stable yet adaptive framework that continues to evolve for managing water resources amidst scarcity.*
- *Colorado agriculture is a major $40 billion industry and is also the dominant water user. Irrigated farmland covers just 9 percent of the state's privately owned land area, but accounts for 86 percent of its total water diversions.*
- *Growing demands from competing water users – reflecting population growth, energy development, and recreational and environmental needs – threaten to reduce irrigated farming and ranching in coming decades.*
- *The continued variability of water supplies due to drought, groundwater overdraft, and other factors may impact future water availability, delivery and timing for agricultural and other water uses.*
- *In the face of water scarcity, Colorado growers are adapting their farming practices to use less water – e.g., changing the mix of crops, adopting innovative irrigation techniques, and relying on strip-tilling or no-till practices.*
- *Colorado water managers, agricultural producers, and ditch companies are addressing water scarcity challenges through existing water law and statutes and also by exploring and developing new legal, policy and technical solutions to address scarcity at local and statewide levels.*

## Inside this Issue…

*Overview of Colorado Agriculture and Water Management* .....2
*Water Development for Agriculture*....2
*Agriculture and Water Reallocation*....3
*Managing Water Scarcity*.....4
*Buy and Dry* .....6
*Living with Drought*.....8
*Adaptive Strategies for Now and the Future*.....9
*Alternative Transfers*.....10
*The Push for Efficiency*.....11
*Farming Adaptations*.....11
*Conclusion: Building On More Than a Century Of Water Law*.....13
*Endnotes* .....14

CoBANK KNOWLEDGE EXCHANGE

*This report was prepared jointly by the Colorado Foundation for Water Education and CoBank, and it was funded by CoBank.*

*The Colorado Foundation for Water Education promotes increased understanding of water resource issues so Coloradans can make informed decisions. CFWE is a non-advocacy organization committed to providing educational opportunities that consider diverse perspectives in order to advance the conversation on Colorado water.*

## *Overview of Colorado Agriculture and Water Management*

Colorado agriculture is a $40 billion industry that includes farming, ranching and fruit growing.[1] Irrigated agriculture covers only about 9 percent of the state's privately owned land area, but accounts for about 86 percent of total water diversions made from surface streams and groundwater aquifers.[2] Farmers and ranchers have been beneficially using Colorado's water to supply food to a constantly growing population. These farms and ranches own many of the oldest water rights in the state. Municipalities in turn are looking to purchase or lease these rights to secure water supplies for their own growing populations. Consequently, agriculture's share of water rights faces multiple pressures and potential reductions due to drought, population growth and competition from municipal and industrial water users, interstate legal obligations, and other factors. All of the state's water users, including agriculture, have had to adapt to the worsening scarcity.

> *All of the state's water users, including agriculture, have had to adapt to the worsening scarcity.*

Colorado water law plays an essential role in managing these challenges and protecting legal water rights. Specifically, under Colorado water law, water is considered a public resource; the rights to use that resource are allocated under a system of "first in time, first in right" that guides its beneficial use; and these are considered personal property rights. This legal framework, known as the Colorado Doctrine of Prior Appropriation, dates back more than 150 years to miners' and farmers' first diversions and uses of water within the state. The Doctrine developed to support the allocation of scarce surface water and groundwater that is tributary to a surface stream. The legal rights governing the use of those resources give water users certainty that the available water they have relied upon will continue to support investments in their livelihood. Over time, the set of laws and regulations governing prior appropriation in Colorado has evolved along with the customs and values of its people to include water rights for environmental and recreational flows.

### Water Development for Agriculture

Colorado's oldest water rights belong to the People's Ditch in south-central Colorado's San Luis Valley, which Hispanic settlers initially constructed in 1852.[3] Through the 19th and early 20th centuries, farmers and laborers built dirt-lined canals using shovels, oxen, and explosives to divert and redirect flows toward farms, where growers used flood irrigation to water row crops.

Today, Colorado's top agricultural commodities are corn, cattle, dairy products, wheat, hay, potatoes, pigs, sheep and poultry, according to the Colorado Farm Bureau. Other major crops include beans, millet, sunflower and fruit crops, particularly peaches and apples, grown in orchards on the state's Western Slope.[4] Variations in water availability, commodity prices, and farming practices have altered the mix of crops in the state over time. Sugar beets, for example, used to be a dominant crop in much of eastern Colorado farming, but have given way to corn, grown primarily as animal feed, and other crops.[5]

To cope with water scarcity, early farmers built reservoirs to store water during periods of heightened runoff for use later in the year. With developments in technology and engineering, water delivery and storage systems also advanced significantly in size and scale, with new projects designed and built to move water across the state. That's because while approximately 80 percent of Colorado's precipitation and natural streams flow on the west side of the Continental Divide, which passes through the center of the state, around 90 percent of Colorado's growing population lives along the drier Eastern Slope, or Front Range, between the cities of Fort Collins and Pueblo, including metro Denver.[6] Moreover, the majority of the state's agricultural acreage is also situated in the Eastern Plains. As a result, Colorado's water users divert an average of nearly 600,000 acre-feet of water annually

across the Continental Divide from the Colorado River Basin and its tributaries to supplement the native, in-basin water supply.[7]

The state's largest transbasin diversion is the Colorado-Big Thompson Project, authorized by President Franklin D. Roosevelt in 1937 to pipe flows from the upper Colorado River across the Continental Divide for storage in Front Range reservoirs and use by eastern Colorado agriculture and communities. Known as the C-BT, the project was the largest ever of its kind at the time and allowed sugar beet farms and other agriculture to flourish in northeastern Colorado.[8]

In those areas of Colorado with limited access to surface water or groundwater, some growers have relied on dryland farming techniques, using only what water falls from the sky to grow crops. Dryland farming continues today in Colorado's central High Plains, with farmers growing mostly winter wheat, corn, and sorghum – without the benefit of irrigation and at the mercy of yearly precipitation or drought. As groundwater tables in regionalized areas relying on the vast Ogallala aquifer decline, some growers are adopting dryland techniques provided that their land is suitable.[9] During extremely dry years or following severe weather events, dryland farmers may turn to crop insurance to offset losses.

## Agriculture and Water Reallocation

Today, Colorado faces continuing reallocation of water use in the state. While agriculture remains an economic and cultural driver in Colorado, the combination of volatile commodity prices, farm consolidation, the rising cost of inputs such as equipment and seed, and the declining inclinations among younger generations to farm or remain in rural communities has resulted in population losses across many rural agricultural communities.[10]

Mounting pressures on Colorado's scarce water supply have also played a role in the state's reallocation of water use. Swelling water demands from cities experiencing rapid population growth, compounded by the difficulty in permitting new water storage projects, have spurred municipalities to increasingly pursue acquisitions of senior agricultural water rights from willing sellers,

*Built between 1938 and 1957, the Colorado-Big Thompson Project collects and moves water eastward across the Continental Divide, providing supplemental water for 30 cities and towns and 640,000 acres of irrigated farmland in northeastern Colorado. © 2012 Northern Colorado Water Conservancy District. All rights reserved.*

followed by the removal of that water from the farms for use by municipalities – a process colloquially known as "buy and dry." These transactions can be profitable for an individual farmer but threaten to undermine the viability of rural communities as their economic engines – the farmers and supporting businesses – cease operations and move out of the area.

Overall water appropriations have resulted in the over-allocation of many of Colorado's river systems, leaving little if any opportunity for development of new water supplies that could be reliably depended upon. It is not uncommon, especially in the South Platte River, Arkansas River, and Rio Grande Basins, for water demand to exceed the supply during the summer months and during severe drought conditions such those in 2002 and 2012.[11] In contrast, in 2011, 2014, and 2015, the "free river" conditions that existed during significant portions of the year on the South Platte River constituted missed opportunities for utilizing water storage facilities to help offset the dry years. Colorado's Doctrine of Prior Appropriation is very effective in allocating water during times of scarcity, and it protects the senior water right holders – a benefit to them – even as it also creates incentives for other interests to seek to acquire those valuable benefits.

In addition, legal obligations, such as interstate water compacts, U.S. Supreme Court equitable apportionment decrees, and Endangered Species Act recovery stipulations, also limit water use within the state. Interstate pacts dictate that Colorado must deliver allocated flows to downstream states and users. Complying with those agreements can be viewed as Colorado's top water right administrative priority.[12] Recovery programs targeted toward endangered species, often through multi-state agreements, protect water right holders' ability to continue to divert while ensuring flows reach critical river reaches. Extended drought and other climatic fluctuations also impact water availability on a year-to-year basis.

## *Managing Water Scarcity*

Between 2000 and 2014, Colorado's population grew from 4.3 million to 5.4 million people, one of the fastest state growth rates in the country.[16] According to the Colorado State Demography Office, those trends will continue: New residents are expected to increase by roughly 1.5 percent per year through 2020, outpacing national averages, and the state could have 6 million citizens by 2020 and 9 million by 2050.[17]

Propelled by that growth spurt, Colorado is transitioning from a more rural and sparsely populated state to one dominated by an urban and suburban corridor around metro Denver and along Colorado's urban Front Range. The Colorado Water Conservation Board projects that the

### The Republican River: A Case Study in Interstate Compact Compliance

The Republican River flows from eastern Colorado into Nebraska and Kansas across the High Plains region, and the three states divide and share the river's flows based on the 1942 Republican River Compact.[13] Such interstate river compacts are legal obligations to administer water between states and ensure that downstream states receive a specific volume or flow-rate of water for their legal users.

The 2002 Final Settlement Stipulation is an agreement among the three states following a complaint filed by Kansas protesting that it was not receiving its legal share due to groundwater pumping in the other two states. The Colorado Legislature created the Republican River Water Conservation (RRWC) District in 2004 to assist the state in complying with the compact.

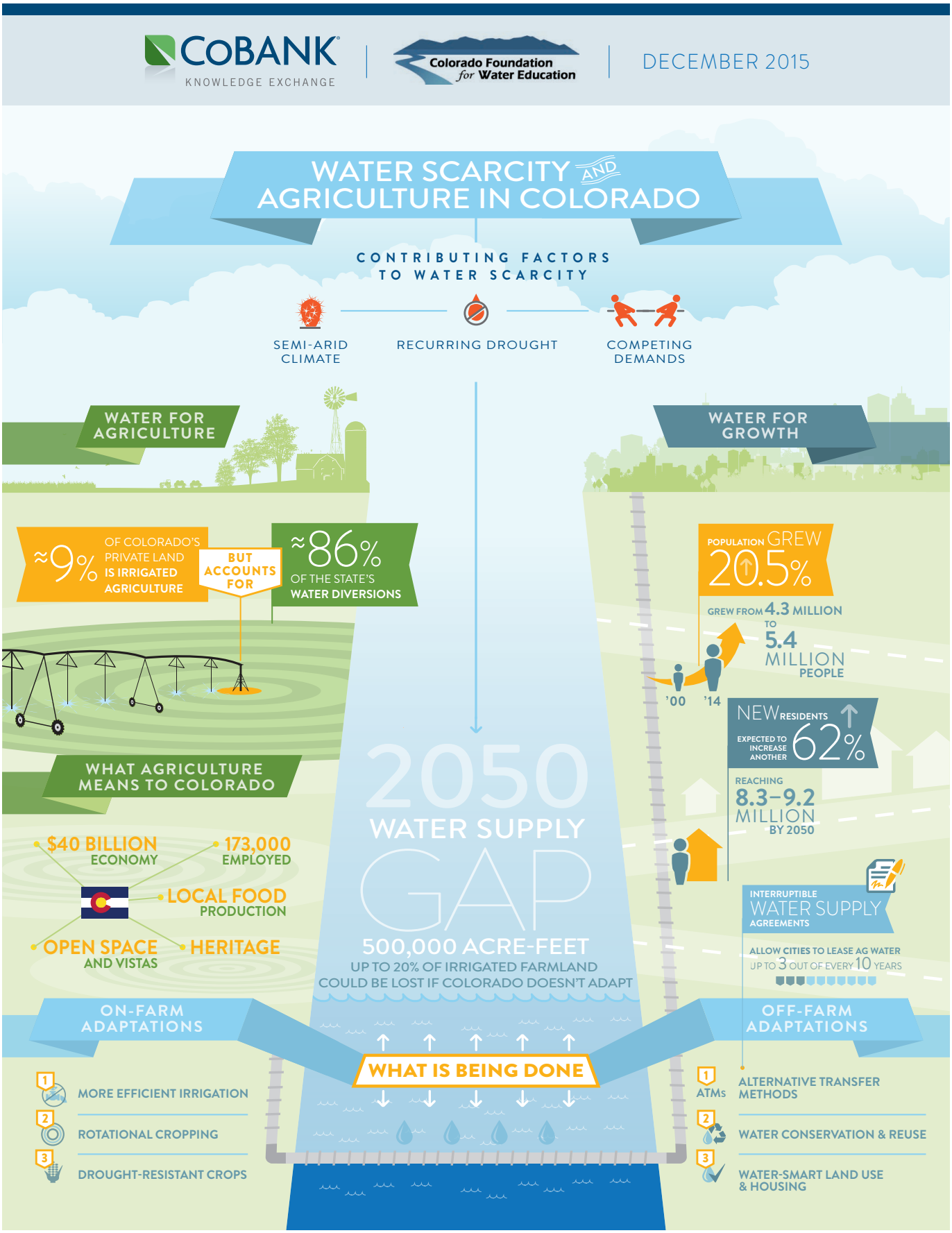
"About 90 percent of our economy here is ag-based, and a huge amount of money is contributed from irrigated agriculture," said Deb Daniel, the RRWC district general manager. "Water is the lifeblood of our area."

As a result, in 2008, the Colorado State Engineer's Office approved measurement rules for all large-capacity wells within the district's boundaries, using flow meters and other equipment to measure the amount of water that was pumped annually from the system. "Previously, we had no way to get accurate data," Daniel said.[14]

"The measurement rules were (initially) met with a sizable amount of resistance from the growers," Daniel said, partly because they had to pay installation costs. "But once equipment was installed and growers could see and document how much water the wells were pumping, that information was extremely valuable to those growers. That has really helped them make better informed decisions on an annual basis."

Voluntary retirement of wells, with compensatory payments coming through federal conservation programs along with supplemental payments from the RRWC district, has helped offset river depletions and meet compact obligations. The measurement program has also triggered changes that have led to more efficient water use, such as the use of underground drip-irrigation systems or other upgrades to existing irrigation systems using newer technology. Some growers have also replaced cornfields with sorghum and wheat crops that require less water.[15]

"Growers are paying a lot more attention to the efficiency of their irrigation systems," Daniel said. "They are recognizing the fact that we need to continue to search for more ways to conserve water in this area."

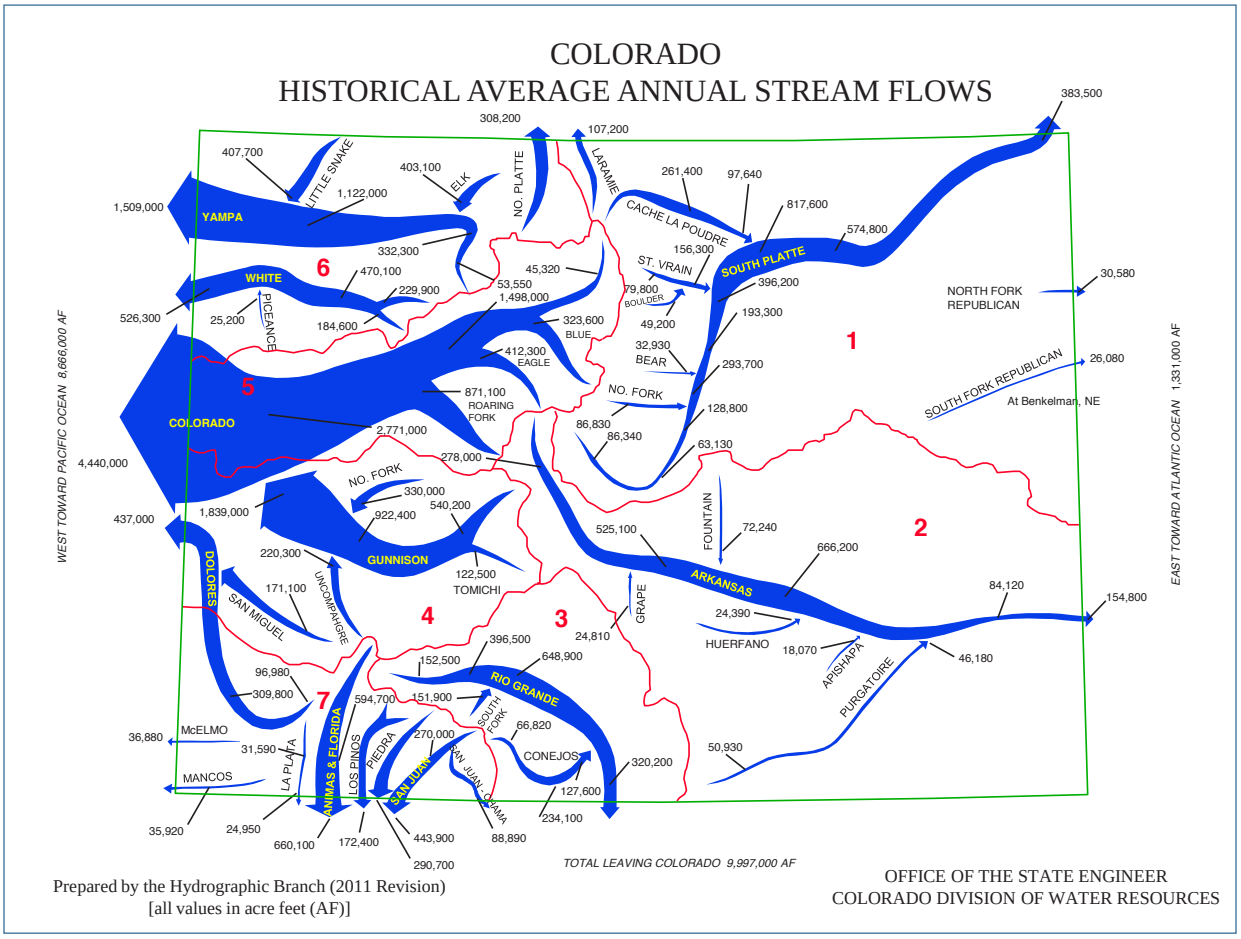

CoBANK
KNOWLEDGE EXCHANGE
Colorado Foundation for Water Education
DECEMBER 2015
WATER SCARCITY AND AGRICULTURE IN COLORADO
CONTRIBUTING FACTORS TO WATER SCARCITY
SEMI-ARID CLIMATE
RECURRING DROUGHT
COMPETING DEMANDS
WATER FOR AGRICULTURE
≈9% OF COLORADO'S PRIVATE LAND IS IRRIGATED AGRICULTURE
BUT ACCOUNTS FOR
≈86% OF THE STATE'S WATER DIVERSIONS
WHAT AGRICULTURE MEANS TO COLORADO
$40 BILLION ECONOMY
173,000 EMPLOYED
LOCAL FOOD PRODUCTION
OPEN SPACE AND VISTAS
HERITAGE
WATER FOR GROWTH
POPULATION GREW 20.5%
GREW FROM 4.3 MILLION TO 5.4 MILLION PEOPLE
'00
'14
NEW RESIDENTS EXPECTED TO INCREASE ANOTHER 62%
REACHING 8.3–9.2 MILLION BY 2050
INTERRUPTIBLE WATER SUPPLY AGREEMENTS
ALLOW CITIES TO LEASE AG WATER UP TO 3 OUT OF EVERY 10 YEARS
2050 WATER SUPPLY GAP
500,000 ACRE-FEET
UP TO 20% OF IRRIGATED FARMLAND COULD BE LOST IF COLORADO DOESN'T ADAPT
WHAT IS BEING DONE
ON-FARM ADAPTATIONS
1 MORE EFFICIENT IRRIGATION
2 ROTATIONAL CROPPING
3 DROUGHT-RESISTANT CROPS
OFF-FARM ADAPTATIONS
1 ATMs ALTERNATIVE TRANSFER METHODS
2 WATER CONSERVATION & REUSE
3 WATER-SMART LAND USE & HOUSING

state's municipalities could experience a water supply gap of up to 500,000 acre-feet by 2050 unless the state's water suppliers and users can all work together to address the shortfall.[18] Absent an effective solution, the equivalent of some 2.5 million people would be left with unmet water needs. To provide for their growing customer bases, municipalities will step up their efforts to secure an adequate water supply, and will likely approach Colorado's irrigators with increasingly lucrative offers to sell or lease the senior water rights they own while also outcompeting irrigators in the water market.

## Buy and Dry

As urban communities have grown, they have invested in water development projects, large and small, to increase their water storage and supplies, but transmountain diversion projects and other complex delivery and storage systems have become increasingly difficult to fund and permit.[19] Regulations to ensure that projects have the least possible enviromental impact have slowed and even halted approval of planned projects. Most notably, the rejection of the Two Forks Dam in 1990, which would have stored water for metro Denver and more than a dozen neighboring communities, left urban utilities seeking alternatives to secure municipal supplies.[20] Since then, numerous other projects to build or expand reservoirs have taken years to move through federal permitting processes, and for many of those projects, the outcomes remain uncertain.

Cities and industrial users, such as energy companies, that now need expanded and reliable supplies of water have responded by acquiring senior water rights from




Prepared by the Hydrographic Branch (2011 Revision)
[all values in acre feet (AF)]

OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES

irrigators. These entities may buy farms to acquire their water rights and then formally apply through water court to change the rights' use for municipal or industrial purposes. This strategy, known as buy and dry, contributed to the loss of at least 850,000 acres – about 25 percent – of the state's irrigated farmland during the period from 1997-2012, though other factors, such as housing developments, have also played a role.[21] Not only is the state losing irrigated farmland, but some of its rural communities are struggling to remain viable.

This scenario is in motion throughout eastern Colorado. The South Platte Basin, which covers much of northeastern Colorado and the Denver metro area, counts nine of the state's top 10 counties for agricultural production, while the southeastern Arkansas Basin is the state's next most significant agricultural region.[22] These same two regions are also home to the fastest-growing populations in the state. The South Platte Basin faces projected losses of up to 234,000 acres of irrigated agriculture by 2050 if Front Range cities are successful with current identified water projects and rely exclusively on buy and dry to meet the remainder of their projected water needs. If current municipal water supply projects are unsuccessful, this loss could be even greater.[23]

Already, within the service area of the Northern Colorado Water Conservancy District which covers much of the South Platte Basin, this shift is apparent. Farmers owned about 85 percent of Northern Water's Colorado-Big

## Case Study: Lessons in "Buy and Dry"

In the mid 1980s, the north Denver suburban community of Thornton began looking for future water supplies to meet projected growth. With the Two Forks Dam project in doubt, city managers acquired nearly 50 percent of the water rights and 20,000 farmland acres along the Water Supply and Storage Company irrigation ditch, which diverts water from the Cache la Poudre River, 60 miles north of Thornton.[26]

When the city went through Colorado water court to legally repurpose the water rights for municipal use, objectors, including the Northern Colorado Water Conservancy District, expressed concerns that the transfer would permanently dry up farmland and diminish regional agriculture.

The most notable case of buy and dry in Colorado comes from Crowley County, bordered by the Arkansas River in southeastern Colorado, which served as a cautionary tale as Thornton pursued its deal. Starting in the 1960s, investors began buying up water rights from Twin Lakes Reservoir, which supplied Crowley County's irrigation farmers. By the 1980s, the Front Range cities of Pueblo, Colorado Springs and Aurora held most of the water rights in Twin Lakes. As a result, Crowley County's irrigated farmland plummeted from 50,000 acres to just 5,000 acres, and several local communities virtually vanished.[27]

Thornton and the objectors to its water-rights transfer sought to avoid a similar worst-case scenario. Instead, while finalizing its water-court decree, Thornton leased its water and farmland back to local growers, and will continue this arrangement until the city is ready to divert the flows for its own use.[28]

"Both the city of Thornton and the folks who were objecting in our water-court case saw the situation down there [in Crowley County] and wanted to make sure that wasn't repeated," said Mark Koleber, Thornton's water supply director. "From the beginning, Thornton made voluntary tax payments so the local school districts, fire districts and library districts were not impacted by our properties being taken off the tax rolls. We lease to local farmers and we lease excess water for augmentation plans to ensure that well users on the nearby South Platte River can continue to pump."

The court decree also requires Thornton to convert the farmland parcels to a non-irrigated self-sustaining crop or groundcover as it prepares to move some of its water. The city is now moving forward with plans to pipe a portion of its water for municipal use by 2025, and meeting with communities along a proposed pipeline corridor. "We're trying to be a good neighbor," Koleber said.

Thompson Project water shares in 1957 when the project first began operating. Today, just 34 percent of water in the district is owned by farmers, although agriculture still uses about 50 percent of the water through lease agreements.[24] Meanwhile the area's population has skyrocketed from 150,000 to 850,000 people, and other competing uses, such as the natural gas industry, are also in the market for water supplies.[25]

## Living with Drought

Drought conditions underscore the need to manage for water scarcity. Drought has always been a recurring phenomenon in Colorado. The recent, severe drought in the early 2000s highlighted the difficulties accompanying periods of prolonged water shortage. However, the drought conditions that occurred in the 1930s, 1950s, and 1970s were even more devastating for agricultural producers, with some of the reservoirs along the South Platte River remaining unfilled for years. In fact, the Prewitt Reservoir in northeast Colorado, even with its 1910 water right, was completely dry and received no water for two years during the mid-1950s.[29]

> *Drought conditions underscore the need to manage for water scarcity.*

Drought typically reduces streamflows but, unless accompanied by warmer temperatures, does not increase crops' evapotranspiration or affect the timing of mountain snowmelt and runoff.[30] While irrigators can still divert water at the onset of the farming season, there is less overall volume in streams. As a result, senior water rights holders can often still use their legal shares, but more junior irrigators may face curtailment and must plan accordingly to reduce the area of irrigated crops planted.

### Colorado's Water Rights Determination Act

In 1969, the Colorado legislature recognized the connection between surface water and groundwater that is tributary to the surface stream by enacting the Colorado Water Rights Determination Act. This landmark legislation required that any junior users of surface water or groundwater from a tributary aquifer must replace or "augment" their depletions to the river in time and place according to the priority of their water rights.[31] In other words, if a farmer pumps a well and the water removed affects the river during times of demand from other users who are senior to the farmer's well, he must replace that water.

Junior well owners were allowed to operate for nearly 30 years by simply obtaining annual approvals of their temporary substitute water supply plans from the State Engineer. However, following the drought of 2002-03, the Colorado Supreme Court ruled in the 2003 *Simpson vs. Bijou* case that the State Engineer did not have the authority to grant annual augmentation plan approvals unless an official augmentation plan application was pending in water court. This ruling affected the operation of junior priority wells, particularly in the South Platte Basin.[32] As a result of this ruling, junior well owners were required to obtain water court-approved augmentation plans, but the state legislature immediately stepped in to allow the use of temporary substitute water supply plans while their augmentation plans were pending in court, as originally contemplated in the 1969 Act. After these well owners were required to prove to the water court and to senior water users that they had sufficient water to offset the depletions caused by their pumping, it became evident that some augmentation plans were not providing adequate replacement water to prevent injury to other water rights. Hence, the water court required that some wells had to be either partially or completely curtailed until sufficient water was supplied.[33]

Although requiring junior water rights owners to mitigate their effects on the river can be cumbersome and, at times, controversial, it has made Colorado's surface and tributary groundwater system a sustainable method for water allocation and administration. This method stands in contrast to California's, for example, where devastating drought and unregulated pumping have significantly diminished groundwater supplies that are interconnected with surface water flows in some areas.[34]

In addition to reducing streamflows, drought has contributed to groundwater declines. Falling groundwater tables in the Rio Grande and Republican basins have forced cutbacks on pumping to irrigate farms and ranches.[35 36] And along the South Platte River, many irrigators who rely on groundwater wells were ordered to cease pumping in 2006 after water courts determined that their wells, lacking replacement water plans, were depleting water that would otherwise flow to the river to be accessed by downstream senior water users.[37] A 2003 Colorado Supreme Court case, *Simpson vs. Bijou,* determined that diverters with junior water rights, whether for surface or tributary groundwater, must develop a court-approved augmentation plan, which details how a water user will offset or augment their out-of-priority water diversions so that senior surface water rights are not diminished.[38] These augmentation plans, as recognized through the prior appropriation system and related laws, provide some flexibility for irrigators and are an important and somewhat unique element of Colorado water management and law.

Many geophysicists and other earth scientists are concerned that, in addition to drier weather conditions, warmer temperatures could be the new normal in Colorado and the West. Warmer year-round temperatures would alter the timing of the spring runoff from mountain snowpack, making it occur earlier in the year. Earlier runoff poses an additional trial for irrigators and the fulfillment of their water rights because less water is available later in the year to finish their crops.

A recent study, commissioned by the Colorado Water Conservation Board (CWCB) and updated in 2014, found that Colorado's average temperature has already risen by around 2 degrees Fahrenheit over the last 30 years.[39] By mid-century, the study projects, the average temperature may rise another 2.5 to 5 degrees, compared with the 1971-2000 average. Such changes could result in some areas receiving more precipitation while others get less, but most studies suggest that natural streamflows are more likely to decline than increase, particularly in the southern half of Colorado. This is due not only to reduced precipitation, but also to the increased uptake of water by plants faced with warmer temperatures and a longer growing season. The CWCB study also found that Colorado's peak spring runoff now takes place between one and four weeks earlier than it did 30 years ago.

*Colorado's growing population is concentrated in its metropolitan areas. As those areas grow, so do their needs for water, housing, and land. Colorado's irrigated farmland has shrunk nearly 900,000 acres during the past 20 years.*

During such times of drought and scarcity, Colorado water law and its prior appropriation system help to prioritize water allocation and mediate potential conflicts among water rights holders. Prior appropriation ensures that senior water rights are protected while junior rights will be curtailed. Prior appropriation and subsequent case law also uphold that water is put to beneficial use and not wasted; that is, users cannot take more water than they need or are legally entitled to use. Augmentation and substitute water supply plans provide flexibility to optimize water use among rights holders – so long as they offset out-of-priority depletions that would harm senior water rights.[40] In addition to the legal underpinnings, cooperation among water users within a river system can also play a key role in mediating conflicts.[41]

## Adaptive Strategies for Now and the Future

Faced with pressures from competing water demands, drought and legal obligations, Colorado water users, researchers and policy makers are developing innovative strategies, new policies, and agreements designed to

improve water conservation and efficiency and introduce flexibility into water law. But at the same time, they also are stirring up new challenges for agricultural and other users.

Much progress has been made through comprehensive planning and strategy programs during the past decade. The Colorado Water Conservation Board initiated the Statewide Water Supply Initiative in 2004 to identify Colorado's current and future water needs through 2030. The statewide Interbasin Compact Committee also facilitates dialogue between different parts of the state, while basin roundtables in each of the eight major river basins in the state, plus one in the Denver metro area, serve as local grassroots forums. Since 2005, the roundtables have brought together regional water stakeholders to work on identifying local consumptive and nonconsumptive water needs and to propose projects and strategies designed to address the gaps between demand and supply while limiting any reductions in agricultural water rights and use. This process has culminated in the development of Basin Implementation Plans for each roundtable, which have been incorporated into Colorado's first state water plan, finalized in November 2015.[42]

The state's water plan emphasizes the importance of protecting the viability of Colorado agriculture into the future, and lays the groundwork for projects, policies and programs that could help minimize losses from buy and dry and other water scarcity factors.

## Alternative Transfers

The Colorado General Assembly has passed various bills designed to make water law more responsive and flexible to the changes and challenges of water allocation today. On one hand, new laws and programs offer new incentives and revenue streams to support agricultural operations. On the other hand, any change to a water right also opens up that water decree to objections or decisions that could result in a re-quantification, and potential reduction, in that water right. Any project that repurposes water rights – to enable water to be sold or leased to different uses and industries, for example – is subject to approval by the State Engineer or water court.[43] This legal process includes an analysis of a water right holder's historical use, because the measure and limit of any prior appropriation water right is its beneficial consumptive use of water over a representative historical time period. This process protects against the expansion of water rights that can cause injury to other water rights.[44]

A major area of focus for new policies has been the initiation of programs that enable and encourage **alternative transfer methods (ATMs)**, which are alternatives to buy and dry and the permanent transfer of water rights. These ATMs generally allow agricultural producers to maintain ownership of their water.

One prominent example that has received funding is the Arkansas Valley Super Ditch, which began a pilot project phase in 2015.[45] The Super Ditch is not an actual ditch; rather, it's an alternative transfer method known as an **interruptible water supply agreement** that allows temporary water transfers between willing parties during drought. Participating irrigators lease water to cities in up to three out of every 10 years. These irrigators receive payment for their leased water and reduce their own consumptive water use through rotational cropping where non-irrigated crops are planted or through temporary fallowing of their fields. While these ATMs are beneficial to the individual producers and can help reduce the permanent transfer of water out of the area, local rural communities and ancillary businesses will still experience a reduction in economic activity during those periods of temporary exchange.

Notably, interruptible supply agreements and other emerging ATMs allow farmers to maintain legal ownership of their water rights, even as the water is redirected temporarily to municipal or industrial uses. Related changes to state law also allow the establishment of **water banks** within each state water division and other exchanges that don't require adjudication of water rights or leave irrigators vulnerable to loss, or injury, of their water rights.[46] Many efforts are still proceeding through trial runs, and program adoption has been gradual, due to would-be lessors' lingering concerns about diminishment of their water rights. Potential lessees, such as cities or industrial users, also have misgivings

and concerns as their overriding goal is to build a reliable water supply, and a 30-year interruptible supply agreement could be a tenuous basis for planning and building a community of full-time residents.[47]

## The Push for Efficiency

Agricultural researchers and regional pilot projects are developing ways for growers to use water more efficiently in order to better respond to drought and also make water available for alternative transfers. These efforts are tapping precision-agriculture tools and software and new technology to alter inefficient farming practices that, in some cases, have been used for generations.

On both sides of the Continental Divide, farmers historically used flood irrigation, channeling ditch water into open furrows between rows of crops to saturate the ground. This practice is less efficient than other methods because much of the water applied is not used by crops, runs off the field, percolates through the ground, or is lost to evaporation.

In recent years, some farmers in the South Platte, Republican, Arkansas, and Rio Grande River basins have implemented more efficient irrigation systems like sprinklers to cope with drought and diminishing groundwater resources, and to reduce pumping and labor costs.[48] Sprinklers are more efficient than flood irrigation, but the increased efficiency can have unintended consequences. As farmers install new, more efficient sprinkler systems, less water percolates into the ground, thus reducing the return flows that replenish streams and that downstream water users rely on. At the same time, a greater proportion of the irrigation water is absorbed by the crops. Paradoxically, ditch and reservoir systems that are water short may end up consuming more water as local farmers install more efficient irrigation equipment.[49]

Improved efficiency and the resulting reduction in return flows can also complicate compliance with interstate water compacts and efforts to send certain volumes of water downstream. Along the Arkansas River, irrigators now pay to seasonally buy water stored in reservoirs

*“In the face of water scarcity and tightening water restrictions around groundwater pumping, Colorado growers realize that business as usual is no longer an option.*

and have it delivered to the river to boost flows and fulfill augmentation plans to offset their irrigation improvements. These purchases are done to comply with new irrigation efficiency rules developed by the State Engineer and stemming from the Arkansas River Compact and a related lawsuit from Kansas.[50] With the support of organizations like the Lower Arkansas Water Management Association, farmers are complying – but they also point out that the rules discourage them from installing more efficient sprinkler systems in all of their fields.[51]

## Farming Adaptations

In the face of water scarcity and tightening water restrictions around groundwater pumping, Colorado growers realize that business as usual is no longer an option. And they’re adapting accordingly. Many growers, for example, are adjusting the mix of crops that they grow in favor of those that require less water. In the San Luis Valley, pumping restrictions to maintain the aquifer have led potato farmers not only to fallow fields, but also to introduce less thirsty cover crops including Sudan grass and radishes, in place of alfalfa, to limit their water use.[52] Northeastern Colorado farmers have also tried growing more sorghum, soybeans and sunflowers and less alfalfa and corn to reduce their water use, better withstand drought, and minimize the cost of groundwater augmentation.[53] Farmers have also turned to new, drought-tolerant crop strains to better weather low-flow seasons. The new mix of crops and use of fallowing can provide alternatives for farmers and even allow them to enter new markets. However, depending on the value of

the crop grown, these changes may impair the earnings of the individual grower as well as the amount of revenue flowing into the local economy.

Researchers from Colorado State University and the U.S. Department of Agriculture are also testing how farmers can maintain production while carefully managing water consumption through **regulated deficit irrigation**.[54] This strategy seeks to optimize crop yields with limited water by using a set of precision instruments to monitor crop stress and time irrigation. Such instruments as infrared

## Case Study: Innovations in Irrigation

Fruit growers and vineyard owners along the Orchard Mesa Irrigation District on Colorado's Western Slope benefit from a favorable microclimate, consistent moisture and minimal freezing temperatures. "We don't know about drought unless we read about it," said Max Schmidt, irrigation district manager. Local growers also benefit from owning senior water rights within the Colorado River Basin that pre-date the seven-state, 1922 Colorado River Compact, which could spur more curtailments for more junior water users if regional flows continue their downward trend.[55]

Many fruit growers there have invested in sprinklers and, in some cases, drip systems to improve irrigation efficiency, receiving some federal cost-share support. The newer systems offer "more efficient and uniform irrigation for a better quality crop," Schmidt said. Such advances have occurred in part through the Grand Valley Salinity Project, which operates to control soil salinity and reduce salt loading into the Colorado.[56]

The Orchard Mesa district, which includes a hydroelectric plant that needs minimum flows to operate, also coordinates with the Upper Colorado Endangered Fish Recovery Program. Thirty-three "check" dams within the ditch and a reservoir at the end of the canal – improvements made through the federal recovery program – help to maintain functioning levels for irrigators and the power plant, but also allow for the release of timed flows during the year that benefit several endangered fish species.[57] This arrangement eliminates conflicts between irrigators and the fish, which need water at different times of year. "It's one of those programs where everybody wins," Schmidt said.

Along the Eastern Slope in northeastern Colorado, as many as 75 percent of farmers have installed sprinkler irrigation systems in place of flood irrigation within the last 15 to 20 years, according to Charlie Bartlett, a farmer in the small town of Merino and chairman of the Colorado Ag Water Alliance, a producer-led partnership to promote agriculture.[58]

Bartlett is also a member of the South Platte Ditch Company, which began an aquifer recharge pilot program in 1974 when some surface water rights holders were already seeing declines in the river. Other water users' groups used annual replacement or substitute water supply plans to offset pumping effects on the river and downstream users, but as demands increased, so did calls on the river.[59] A 2001 lawsuit in the Arkansas Basin known as the *Empire Lodge* case initially ruled that the State Engineer's Office could no longer approve replacement plans on a year-by-year basis, and ultimately led to the establishment of more stringent, court-approved augmentation plans.[60]

The onset of severe drought conditions in 2002 and subsequent years led to the shutdown of 400 wells within the South Platte basin while water managers worked to set up court-approved augmentation plans.[61] Since then, those plans have eased some of the tensions within the basin while also protecting surface water-rights holders. "The transition was painful but I think the river is better," Bartlett said. "We don't have as many calls as we once had. So, it's working."

Farming practices have also "completely changed" in recent decades, Bartlett added. Growers now use strip and conservation tilling to better maintain soil moisture year-round, which also makes more efficient use of water. Technology, such as monitoring meters and automated ditches, has also played a role in providing more accurate data and precise management.

Farmers are "pretty open but pretty cautious because of the economics and costs," Bartlett said. "When you change farming practices or techniques, it's a learning curve."

thermometers, weather stations, moisture gauges, and other tools can be used to measure field temperatures, soil moisture, sunlight, wind and humidity while monitoring crop conditions and requirements. These precision instruments also provide data on how different crop mixes and rotations affect productivity.

Deficit irrigation is now being employed in parts of the High Plains, while researchers continue to refine and develop best practices. For now, management and monitoring remain intensive and also require extensive below-ground instrumentation, and some farmers may find the technologically driven approach daunting.[62] However, deficit irrigation studies have identified other approaches that farmers are adapting.

Strip tilling, for example, is a practice that disturbs a small percentage of the soil while leaving most of the past season's crop residue behind in the form of cornstalks and wheat stubble. Prior to the 2002 drought, most Colorado farmers carried out conventional tillage programs, fully clearing fields of leftover vegetation. Although thorough tilling was easier for controlling weeds, preparing seed beds, and managing ditches, deficit irrigation studies have shown that strip tilling or no-till practices save labor and reduce fuel consumption and equipment wear, protect against erosion and crop stress, and increase crop yields.[63] The leftover organic materials temper the sun's heat and reduce evaporation and runoff while increasing soil health. Strip tilling also captures and retains field moisture from snow in the winter and rain in the spring, which supports early season crop growth, so farmers can save their allocated water for use later in the season.[64]

*In the face of water scarcity, Colorado's growers have adapted their farming practices to use less water. One adaptation is to stop tilling their land, leaving most of the past growing season's residue behind in the form of corn stalks and wheat stubble.*

## Conclusion: Building On More Than a Century Of Water Law

The expanding toolbox of alternative strategies and policies to manage in the context of scarce water conditions in Colorado offers solutions that can avoid negative outcomes for farmers, food growers, and consumers in the state and beyond. Implementing new projects and policies will require not only regular evaluations and revision of these programs, but also managing their unintended consequences or tradeoffs.

Within this context, Colorado water law provides the guiding framework to allocate scarce water resources as it has done since the 1860s. Dominant uses and applications of water may change, drought may persist or diminish, but scarcity remains a constant. While recent changes to Colorado water law have brought new levels of flexibility to enable water sharing among different uses, the system endures to protect senior water rights through prior appropriation.[65] This remains a key principle for water allocation in Colorado amid growing competition and demands for flows. Colorado's agricultural sector may flourish, withstand or wither amid population growth and drought in the state, but water law will continue to uphold senior water rights as long as producers choose to maintain their use. ■

## Endnotes


[1] U.S. Department of Agriculture National Agricultural Statistics Service, "Colorado Agricultural Statistics 2014," September 2014, p. 4. http://www.nass.usda.gov/Statistics_by_State/Colorado/Publications/Annual_Statistical_Bulletin/Bulletin2014.pdf

[2] Colorado Division of Water Resources, Diversion record data provided by Tracy Kosloff to Headwaters Magazine, June 2015.

[3] Colorado Foundation for Water Education, "Citizen's Guide to Colorado Water Law, Fourth Edition," 2015, p. 5.

[4] Colorado Farm Bureau, "Colorado Ag Facts," Accessed July 2015. https://www.coloradofarmbureau.com/sites/default/files/ckfinder/files/Co_agfacts.pdf

[5] Colorado Brownfields Foundation, "Colorado Sugar Beet Factory Initiative," 2012, p. 1-2.

[6] Estabrook, Rachel, Colorado Public Radio, "Colorado Water Plan's Big Hurdle: Uniting Western Slope, Front Range," December 10, 2014. http://www.cpr.org/news/story/colorado-water-plans-big-hurdle-uniting-western-slope-front-range

[7] Colorado Foundation for Water Education, "Citizen's Guide to Transbasin Diversions," 2014, p. 5. http://issuu.com/cfwe/docs/cfwe_cgtb_web

[8] Tyler, Daniel, "The Last Water Hole in the West: The Colorado-Big Thompson Project and the Northern Colorado Water Conservancy District, University Press of Colorado, 1992.

[9] Best, Allen, Headwaters Magazine, "Making the Ogallala Last," Fall 2014. https://www.yourwatercolorado.org/cfwe-education/headwaters-magazine/archive/305-headwaters-magazine/headwaters-fall-2014-eastern-plains/703-the-ogallala

[10] Graff, Gregory D., Annabelle Berklund, and Kathay Rennels, Colorado State University, "The Emergence of an Innovation Cluster in the Agricultural Value Chain along Colorado's Front Range," November 2014. http://outreach.colostate.edu/econ-dev/econ-docs/Colorado-Ag-Innovation-Cluster-CSU-Nov-2014.pdf

[11] Waskom, Reagan, Colorado Water, "Surface Water Diversions and Administration," January/February 2014, p. 22-23. http://wsnet.colostate.edu/cwis31/ColoradoWater/Images/Newsletters/2014/CW_31_1.pdf

[12] Colorado Foundation for Water Education, "Citizen's Guide to Colorado Water Law, Fourth Edition," 2015, p. 22. http://issuu.com/cfwe/docs/wl4_r9_web

[13] Republican River Water Conservation District, "About the Compact," Accessed October 2015. http://www.republicanriver.com/CompactInfo/RepublicanRiverCompact/tabid/159/Default.aspx

[14] Interview with Deb Daniel, Republican River Water Conservation District, September 28, 2015.

[15] Interview with Deb Daniel, Republican River Water Conservation District, September 28, 2015.

[16] U.S. Census Bureau, "Colorado: State & County QuickFacts," 2015. http://quickfacts.census.gov/qfd/states/08000.html

[17] Colorado State Demography Office, "Population Totals for Colorado and Sub-state Regions: Population Forecasts." https://drive.google.com/file/d/0B-vz6H4k4SESWkFIeW5VWHRzMFE/view

[18] Colorado Water Conservation Board, "Colorado's Water Plan," July 2015, p. 14. http://coloradowaterplan.com/

[19] Zaffos, Joshua, BizWest, "Water projects stuck in regulatory limbo," September 6, 2013. http://bizwest.com/water-projects-stuck-in-regulatory-limbo/

[20] Marston, Ed, High Country News, "Water pressure," November 20, 2000. http://www.hcn.org/issues/191/10100

[21] U.S. Department of Agriculture, 2012 Census of Agriculture, "Historical Highlights: 2012 and Earlier Census Years." http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_State_Level/Colorado/st08_1_001_001.pdf

[22] Zaffos, Joshua, Headwaters Magazine, "The Ever-Evolving Farmer," Fall 2012. https://www.yourwatercolorado.org/component/content/article/130-headwaters-magazine/headwaters-fall-2012-rooted-in-colorado/551-the-ever-evolving-farmer

[23] South Platte Basin Roundtable, "South Platte Basin Implementation Plan," April 2015, p. 2-29. https://www.colorado.gov/pacific/sites/default/files/SouthPlatteBasinImplementationPlan-04172015.pdf

[24] Brown, Eric, Greeley Tribune, "C-BT water unit price doubles in recent months," July 7, 2013. http://www.northernwater.org/docs/NISP/NISPNews/MediaCov2013/CBTpriceDoublesGreeleyTribJuly72013.pdf

[25] Northern Colorado Water Conservancy District, Northern Water WaterNews, "Water reflects changes," September 2012, p. 9. http://www.northernwater.org/docs/Waternews/WnSep2012.pdf

[26] Interview with Mark Koleber, Thornton Water, October 2, 2015.

[27] Goodland, Marianne, The Colorado Independent, "Buying and drying: lessons from Crowley County," July 9, 2015. http://www.coloradoindependent.com/154354/buying-and-drying-water-lessons-from-crowley-county

[28] Interview with Mark Koleber, October 2, 2015.

[29] North Sterling Irrigation District, "Storage in Prewitt Reservoir" historical records.

[30] Interview with Reagan Waskom, Colorado Water Institute, September 21, 2015.

[31] Colorado Foundation for Water Education, "Citizen's Guide to Colorado Water Law, Fourth Edition," 2015, p. 16-17. http://issuu.com/cfwe/docs/wl4_r9_web

[32] Zaffos, Josh, Headwaters Magazine, "Out on the Eastern Plains," Fall 2014. https://www.yourwatercolorado.org/component/content/article/305-headwaters-magazine/headwaters-fall-2014-eastern-plains/704-on-the-eastern-plains

[33] Zaffos, Josh, Headwaters Magazine, "Out on the Eastern Plains," Fall 2014. https://www.yourwatercolorado.org/component/content/article/305-headwaters-magazine/headwaters-fall-2014-eastern-plains/704-on-the-eastern-plains

[34] Public Policy Institute of California, "Reforming California's Groundwater Management," Accessed November 2015. http://www.ppic.org/main/publication_show.asp?i=1106.

[35] Smith, Jerd, Headwaters Magazine, "Aquifers in Free Fall," Summer 2013. https://www.yourwatercolorado.org/component/content/article/279-headwaters-magazine/hw-summer-2013-the-rio-grande/592-aquifers-in-free-fall

[36] Best, Allen, Headwaters Magazine, "Making the Ogallala Last," Fall 2014. https://www.yourwatercolorado.org/cfwe-education/headwaters-magazine/archive/305-headwaters-magazine/headwaters-fall-2014-eastern-plains/703-the-ogallala

[37] Waskom, Reagan, Colorado Water Institute, "A Brief Timeline of Groundwater Management in the South Platte Basin," February 2013. http://www.cwi.colostate.edu/southplatte/files/Reagan's%20SP%20timeline%20%28brief%20history%29%20revised%202-5-13.pdf

[38] Colorado Foundation for Water Education, "Citizen's Guide to Colorado Water Law, Fourth Edition," 2015, p. 30. http://issuu.com/cfwe/docs/wl4_r9_web

[39] Colorado Water Conservation Board, "Climate Change in Colorado," August 2014. http://cwcbweblink.state.co.us/WebLink/ElectronicFile.aspx?docid=191995&searchid=e3c463e8-569c-4359-8ddd-ed50e755d3b7&dbid=0

[40] Colorado Foundation for Water Education, "Citizen's Guide to Colorado Water Law, Fourth Edition," 2015, p. 16. http://issuu.com/cfwe/docs/wl4_r9_web

[41] Interview with Gregory J. Hobbs, Jr., Retired Colorado Supreme Court Justice, October 12, 2015.

[42] Colorado Water Conservation Board, "Colorado's Water Plan," November 2015. http://coloradowaterplan.com/

[43] Zaffos, Joshua, High Country News, "Can leasing irrigation water keep Colorado farms alive?" June 8, 2015 https://www.hcn.org/issues/47.10/can-leasing-irrigation-water-to-keep-colorado-farms-alive

[44] Colorado Foundation for Water Education, "Citizen's Guide to Colorado Water Law, Fourth Edition," 2015, p. 15-16. http://issuu.com/cfwe/docs/wl4_r9_web

[45] Zaffos, Joshua, High Country News, "Can leasing irrigation water keep Colorado farms alive?" June 8, 2015 https://www.hcn.org/issues/47.10/can-leasing-irrigation-water-to-keep-colorado-farms-alive

[46] Colorado Water Conservation Board, "Colorado's Water Supply Future, Alternative Agricultural Water Transfer Methods Grant Program Summary," May 2011, p. 5-7. http://www.coagwater.colostate.edu/docs/ATM_Final_Report_5_3_11.pdf

[47] Zaffos, Joshua, High Country News, "Can leasing irrigation water keep Colorado farms alive?" June 8, 2015 https://www.hcn.org/issues/47.10/can-leasing-irrigation-water-to-keep-colorado-farms-alive

[48] Harvey, Nelson, Headwaters Magazine, "The Efficiency Dilemma," Fall 2014. https://www.yourwatercolorado.org/cfwe-education/headwaters-magazine/archive/305-headwaters-magazine/headwaters-fall-2014-eastern-plains/702-efficiency

[49] Rachel Barta, Israel Broner, Joel Schneekloth and Reagan Waskom, Colorado Water Institute, "Colorado Water High Plains Irrigation Practices Guide: Water Saving Options for Irrigators in Eastern Colorado," Spring 2004. http://www.cwi.colostate.edu/publications/sr/14.pdf

[50] Colorado Division of Water Resources, "Arkansas River Irrigation Improvement Rules," 2011. http://water.state.co.us/SurfaceWater/RulemakingAndAdvising/ArkRiverAC/Pages/ArkSWIrrigImpRules.aspx

[51] Harvey, Nelson, Headwaters Magazine, "The Efficiency Dilemma," Fall 2014. https://www.yourwatercolorado.org/cfwe-education/headwaters-magazine/archive/305-headwaters-magazine/headwaters-fall-2014-eastern-plains/702-efficiency

[52] Zaffos, Joshua, Headwaters Magazine, "The Ever-Evolving Farmer," Fall 2012. https://www.yourwatercolorado.org/component/content/article/130-headwaters-magazine/headwaters-fall-2012-rooted-in-colorado/551-the-ever-evolving-farmer

[53] Interview with Reagan Waskom, Colorado Water Institute, September 21, 2015.

[54] Smith, Jerd, Headwaters Magazine, "Bound by a River," Fall 2015 https://www.yourwatercolorado.org/cfwe-education/headwaters-magazine/fall-2015-colorado-basin/776-bound-by-a-river

[55] Interview with Max Schmidt, Orchard Mesa Irrigation District, October 12, 2015.

[56] U.S. Department of Agriculture Natural Resources Conservation Service, "Salinity in the Grand Valley, Celebrating 30+ Years, 1979-2012," Accessed October 2015. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_060826.pdf

[57] MacIlroy, Kelsea, Your Water Colorado Blog, "From Vine to Wine on tour in Palisade, Colorado," September 14, 2015. http://blog.yourwatercolorado.org/2015/09/14/from-vine-to-wine-on-tour-in-palisade-colorado/

[58] Interview with Charlie Bartlett, Colorado Ag Water Alliance, September 24, 2015.

[59] Howe, Chuck, "Water Law and Economic Efficiency: Conflicts Under the Priority Doctrine of Water Property Rights," January 2009. http://www.cwi.colostate.edu/southplatte/files/Howe%20-%20Water%20Law%20Economic%20Efficiency%20-%20Conflicts%20Under%20Priority%20Doctrine%20of%20Water.pdf

[60] Hobbs, Greg, Headwaters Magazine, "A Decade of Colorado Supreme Court Water Decisions: 1996-2006," Fall 2006. https://www.yourwatercolorado.org/cfwe-education/water-is/water-law/85-headwaters-magazine/headwaters-fall-2006special-report-law/186-a-decade-of-colorado-supreme-court-water-decisions-1996-2006

[61] Simpson, Hal, Colorado State Engineer's Office, "History of Well Regulation, South Platte Basin," September 2006. http://water.state.co.us/DWRIPub/DWR%20Presentations/hsimpson_history_090606.pdf

[62] Interview with Charlie Bartlett, Colorado Ag Water Alliance, September 24, 2015.

[63] Colorado State University Soil & Crop Sciences, "Conservation Tillage Demonstration an Outreach Project," Accessed August 2015. http://www.conservationtillage.colostate.edu/fieldwork.shtml

[64] Smith, MaryLou and James Pritchett, Colorado Water Institute SR-22, "Agricultural/Urban/Environmental Water Sharing: Innovative Strategies for the Colorado River Basin and the West" 2011. http://www.cwi.colostate.edu/publications/SR/22.pdf

[65] Interview with Gregory J. Hobbs, Jr., Retired Colorado Supreme Court Justice, October 12, 2015.

***Disclaimer:*** *This report is intended solely for the initial recipients to whom this report is distributed and shall not be distributed to any other person or persons without the express written consent of CoBank, ACB, which may be withheld in its sole and absolute discretion. The information contained in this report is not intended to be investment, tax, or legal advice and should not be relied upon by the recipients for such purposes. The information contained in this report represents the opinions of the author or authors and not of CoBank, ACB, its subsidiaries, affiliates, officers, or employees. While CoBank respects the opinions of the author or authors and believes that this article has been compiled from what CoBank regards as reliable sources, this report is provided for general informational purposes only and is not advice provided or sanctioned by CoBank. CoBank has not verified the accuracy of the information in this report and does not make any representation or warranty regarding the content, and disclaims any responsibility for the information, materials, third-party opinions, and data included in this article. In no event will CoBank be liable for any decision made or actions taken by the user while relying on information contained in this article.*