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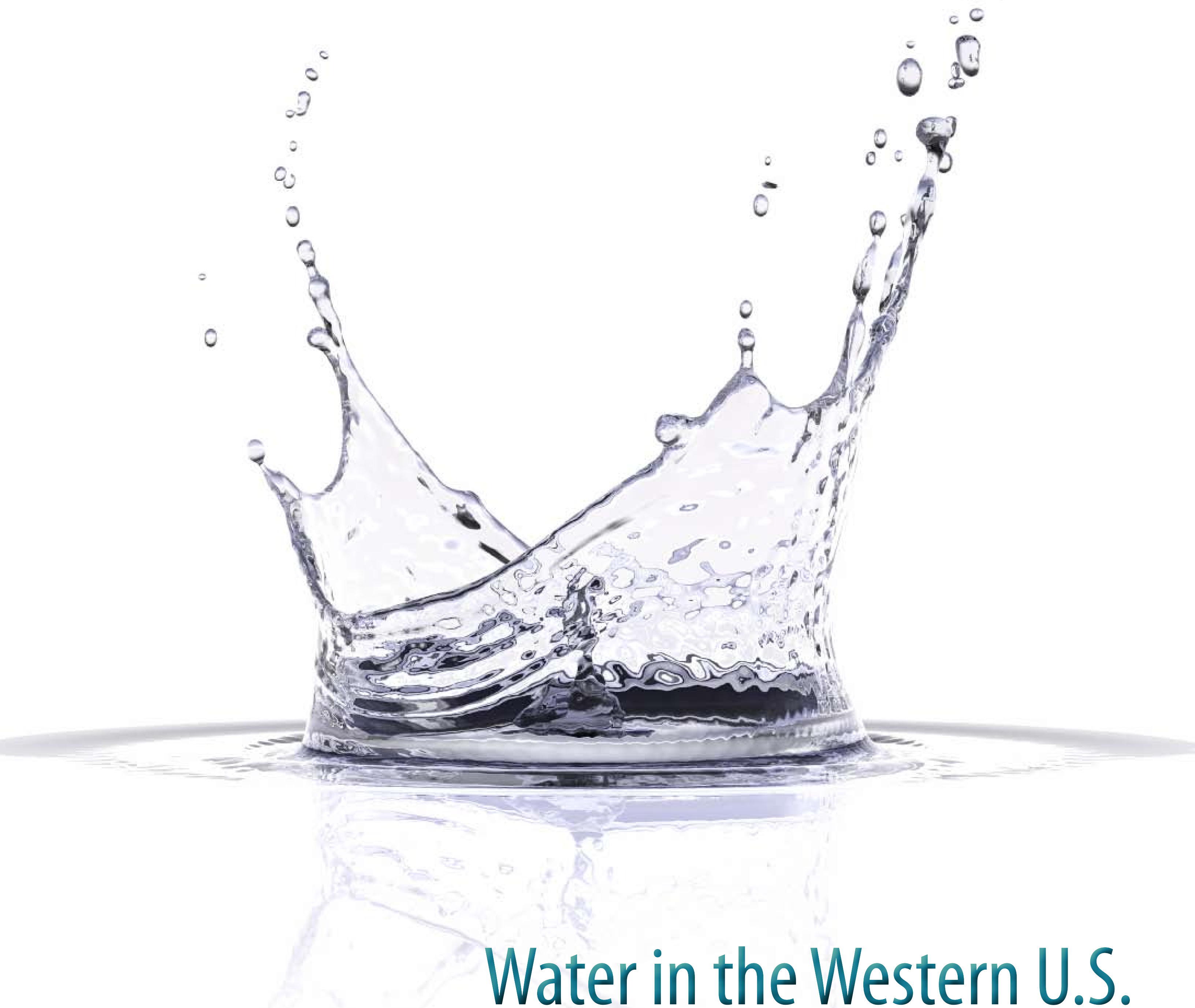

Water in the Western U.S.

Is there enough to meet the region's needs?

Rural Connections

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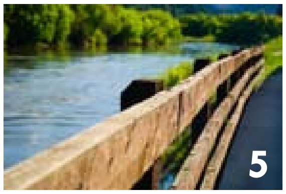


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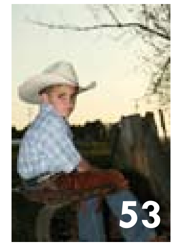

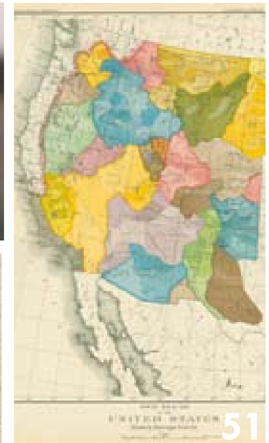

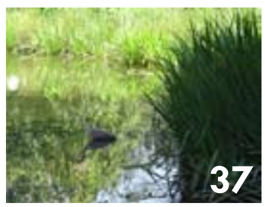

FROM *the* Director

Perhaps the most fundamental difference between the West and the rest of the country is water. Differences begin with precipitation. In non-western cities, average annual precipitation levels (in inches) include New Orleans–61.9; Atlanta–50.9; New York–47.3; Boston–41.5; Houston–46.1; and Chicago–35.8. In comparison, precipitation levels in western cities include Las Vegas–4.1; Phoenix–7.7; Albuquerque–8.8; San Diego–9.9; Los Angeles–12.0; Boise–12.2; Cheyenne–14.4; Denver–15.4; and Salt Lake City–16.5. The consequences are immense. Western rivers and lakes are few, far between, generally small and are often seasonal. Groundwater supplies, which could be used to augment scarce surface water, tend to diminish quickly and recharge slowly. Resource and especially water scarcity has resulted in western population densities being much lower than in the rest of the country. The West has even developed a set of water laws, based on prior appropriation, that are different from the rest of the U.S.

Through the years, Herculean efforts have been exerted and vast sums of money spent to cope with water shortage problems in the West. Massive dams have been built on western rivers to catch the spring runoff and thousands of miles of canals have been constructed to transport this water to western farms and communities. Tunnels have been drilled through mountains and water pumped uphill for hundreds of miles from the Colorado River to the desert cities of Phoenix and Tucson. As a result of these efforts, many western communities thrive and the West has been the nation's fastest growing region for several decades.

Yet, limitations imposed by water scarcity remain. One day while driving across the Arizona desert, I crossed a canal. This canal was carrying water from some distant source to farmers' fields and perhaps to other municipal and industrial uses. The canal was obviously not intended to provide life along its path, but simply to transport this life-giving water as efficiently as possible to its intended destination. Much of the canal was cement-lined to avoid water loss to seepage, and also to prevent plants from growing along the banks, which might then extract some of the precious liquid. Thus, there were no green plants along the banks of the canal. There were no fish or ducks or other animals splashing in the cool water. There were no fisherman standing on the bank, nor were any families camped by the water's edge. In fact, the canal was nothing more than a line of blue water surrounded by the reds and browns of the desert. After driving a few more miles, I reached the agricultural fields that were the destination for some of the canal's water. The transition from the desert to irrigated farmland was profound. The irrigated fields were luxuriant and the corn growing in these fields was tall and green. Yet, mere feet from the fields where the irrigation water did not reach, there was barely a living plant and the red and brown desert stretched to the far horizon. The absolute dependence of the arid west on transported water was striking. Take away the life-giving water for even a few weeks and the corn would wilt in the blistering desert sun; remove the water for a season and the land would quickly be reclaimed by the desert. From the luxuriant cornfields in the Arizona desert, one can drive for hours and see no other signs of viable agriculture and even little evidence of human habitation.

Rapid economic and population growth is making the water problems of the west even more pronounced. Simply put growing demand exceeds supply. Potential users desiring western water include farmers, utility companies, industry, residential users, and those desiring water for wildlife, biodiversity, amenity and recreation purposes. Farmers need water to grow crops because throughout much of the West, crop production is risky to impossible without irrigation. Resulting from past efforts, millions of acres in the West are now irrigated and western agriculture is a multi-billion dollar industry that employs thousands. Based largely on irrigated agriculture, California is the nation's most important farm state. With increased demand from other users, many farmers are now unsure if they will have irrigation water from one year to the next. The utility companies want water to turn their turbines to generate cheap and carbon-free power. However, if too much water is removed from reservoirs for agriculture, industry or residential purposes, their capacity to generate power is reduced. The rapidly growing population in the West means increased demand for water for industrial and residential purposes. More people mean more water for drinking, bathing, brushing teeth, flushing toilets, washing clothes and dishes, and keeping suburban lawns green. Additionally, there is growing pressure to retain water in lakes and streams for wildlife, biodiversity, amenity and recreational purposes. Biodiversity concerns have intensified with the recent listing of some species as threatened or endangered.

The already severe water problems of the west may be even worse in the future. Global climate change is projected by many to further reduce water supplies because of lower precipitation and increased evaporation. Thus, as James Powell discusses in this issue, the flow of water in the Colorado River for the past decade has averaged only 68 percent of normal. There are also concerns about the aging and eventual decline of the western hydrological system as reservoirs continue to fill with silt thus reducing their capacity; and infrastructure deteriorates. Furthermore, there are water quality concerns as intensive irrigated agriculture and suburban landscaping often leads to salinization and high levels of toxic chemicals in water supplies from fertilizers and pesticides.

There is no question that major changes are required relative to western water. In this issue, experts and scholars on western water issues help clarify issues and explore alternatives for addressing these issues. After reading these articles, two facts are clear. First, conservation is not an option but a necessity. If available water was used more efficiently by all users, there would be much more available for everyone. Some significant conservation strides have been made, and articles here discuss additional promising alternatives. Second, it is essential that all interested parties find a way to sit around the same table and work toward building a consensus. Historically, water law and decisions about the distribution of water have been made in courts of law where the decisions were often unsatisfactory to everyone. Open dialogue may be a better approach. Water scarcity is here to stay and we are all in this together. ■

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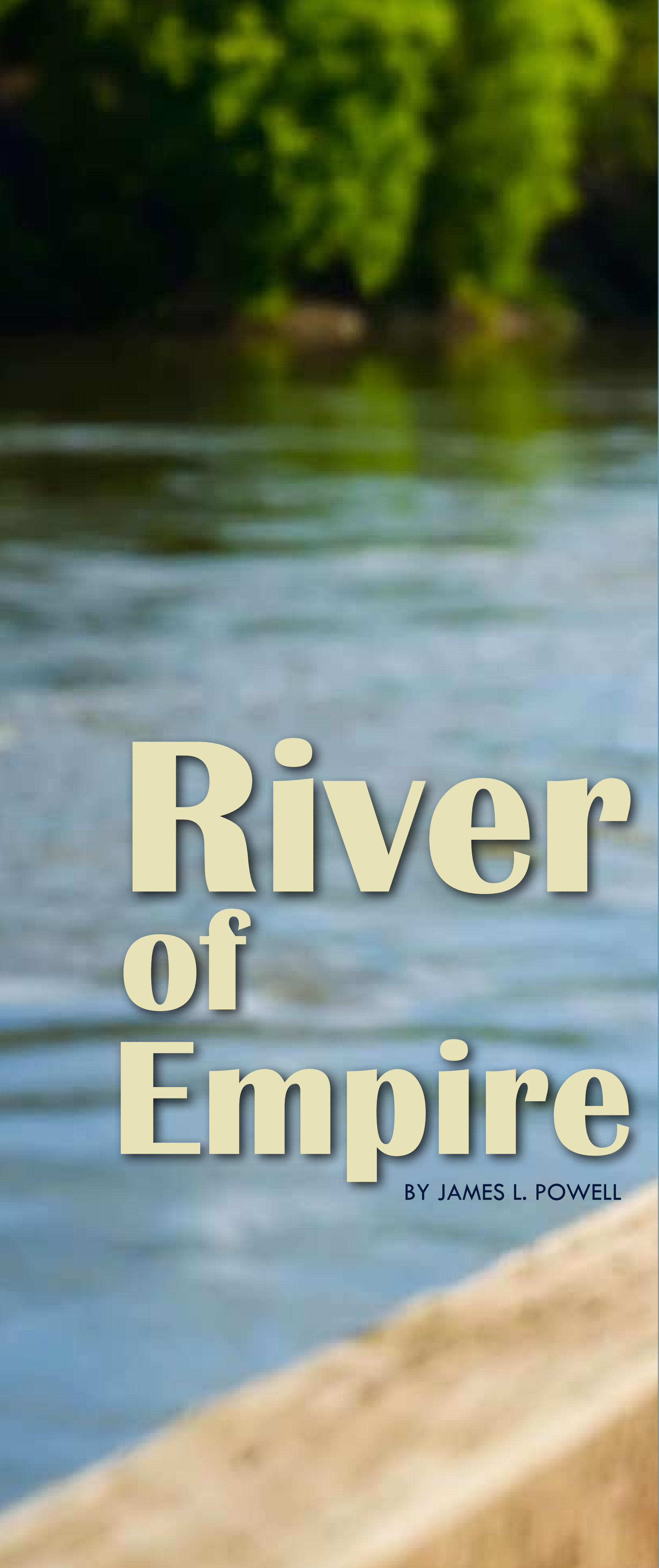

River of Empire

BY JAMES L. POWELL

In the West, 80% of the water goes for agriculture, much of it to agribusinesses to grow alfalfa, cotton, and rice, thirsty crops that cannot survive in an arid land without heavy irrigation.

In the American Southwest, growth has become a way of life. Take a warm, dry, and scenic land, add water, and you have instant civilization and population growth. But what happens when a region has no more water to add?

In 2008, Utah was the fastest growing state, followed by Arizona, Texas, Colorado, North Carolina, Idaho, Wyoming, and Nevada. Yet Nevada is also the driest state, with only seven inches of precipitation per year on average. Utah is close behind, followed by Wyoming, Arizona, and New Mexico. Topping the list of fastest growing cities between 2000 and 2006 was St. George, Utah at 40%, or about 5% per year. Las Vegas was fifth at 29% and the Phoenix megalopolis tenth at 24%. Note that a rate of 5% per year doubles in less than 15 years. The economic recession that began in 2008 led to a real estate bust that slowed or eliminated those growth rates, but when economic times turn better, the demand for growth will resume. Is there a city or state in the West that does not plan to grow? Where will they get the extra water? In the Southwest, up to now the answer would have been: from the Colorado River. But no longer.

The Colorado is the lifeblood of the American Southwest (Figure 1), supplying 30 million people with water and power through its system of dams and reservoirs. Without the river, there could be no Las Vegas, Phoenix, and Los Angeles, as we know them.

Since Hoover Dam went up in the 1930s, creating Lake Mead, and Glen Canyon Dam rose in the early 1960s, creating Lake Powell, demand for Colorado River water has risen inexorably until today, not a drop is left. As I show in my book, Dead Pool, add up the flow of the Colorado and its tributaries and you get a total supply of about 15.8 million acre-feet (an acre-foot is 325,851 gallons). Add up all consumption, including evaporation from the vast surfaces of Lake Powell and Lake Mead, and you get a total demand of 15.9 MAF. The Colorado River is tapped out.

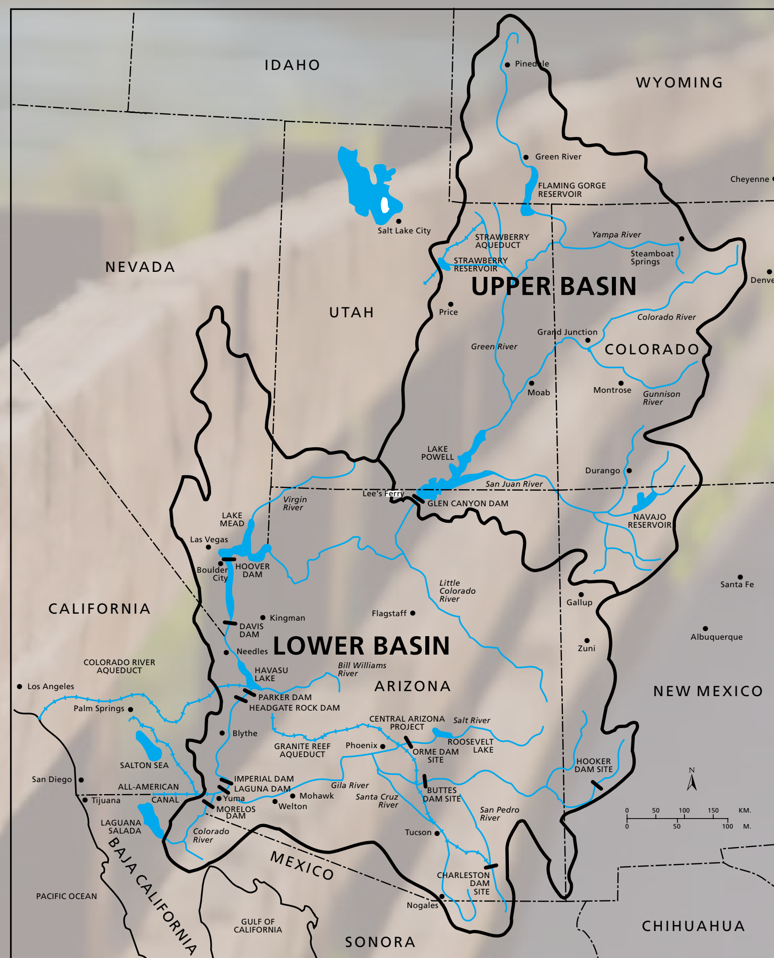

Figure 1. Colorado River Map. Pacific Institute.

Here's a specific example of what this means. Were Las Vegas to continue to grow as it did from 2000-2007, the neon metropolis would climb from 1.8 million to 3.2 million by 2030. If those extra 1.4 million people consumed water at the same rate as today, they would need nearly another 200,000 acre-feet. Las Vegas has done an admirable job of cutting consumption, so that in spite of the increase in population, the total water use today is about the same as in 1999. But conservation measures can only go so far. Cash for grass only works as long is there is grass to cash. More people will need more water and in the Southwest, we have run out of places to get it. The Colorado River has no surplus water; desalination is a problem when you are 500 miles from salt water; groundwater is fossil water that we always extract faster than nature can replenish and eventually use up. In a dry land, water is the ultimate limiting factor and if we want more, the only real choice is to change the way we use the water that Nature provides, which brings us to the issue for rural communities.

In the West, 80% of the water goes for agriculture, much of it to agribusinesses to grow alfalfa, cotton, and rice, thirsty crops that cannot survive in an arid land without heavy irrigation. It seems inevitable to this writer that politically powerful western cities will demand that governments reduce the share of water going to agriculture and send the difference to them and their residents. Government may not have to demand it: some water districts already sell part of their allocations to Los Angeles and San Diego.

Suppose the percentage going to agriculture fell to, say, 60%. Could farmers and irrigators make up the difference? Many experts believe they could if they implemented stringent conservation measures such as drip irrigation, micro-sprinkler systems, laser-leveled fields, and soil-moisture monitors. The Pacific Institute estimates that in California, these measures could conserve five million acre-feet per year, allowing the state to double its population. A fundamental problem, however, is that if California were to implement those measures and the state's population did double, California would be right back where it started, with twice as many people but out of water again, fearing the next hard drought.

Conserving water will not be optional: the West is going to have to conserve, for rising demand for water is no longer the only problem: the supply is going to fall and may have already started doing so.

Although a river is always changing on a scale of months and years, until now it has been safe to assume that on a scale of decades, a river will continue to deliver the same amount of water that it has in the past. Without that assumption, there would have been no case for building megadams to impound a river and smooth out the annual fluctuations. But this assumption no longer holds, for the Earth is warming, affecting precipitation, evaporation, and therefore, river runoff.

Over the twentieth century, the flow of the mainstem Colorado River averaged 15.1 MAF (the figure above included the tributaries), but the higher flows came in the first two decades. The Commissioners who divided up the river's water among the seven basin states met in 1922, just after several years of what would turn out to be well-above average rainfall, leading them to allocate about 1.5 MAF more water than the river carries on average. Moreover, studies of tree-rings show that the centuries-long average is about 14.6 MAF: in other words, the twentieth century was unusually wet.

The twenty-first century so far gives even more cause for alarm. In 1999, just before Figure 2 begins, Lake Powell was brim full. The last thing any expert or government agency expected was that the first five years of the decade, 2000-2004, would see flows on average less than 50% of the historic ones. By the spring of 2005, Lake Powell was two-thirds empty. Fortunately, as shown in Figure 2, 2005 was a relatively wet year, though still only 5% above the long term average. At the time I am writing, Lake Powell and Lake Mead combined stand at 55% of their long term average. (The bar for 2010 in Figure 2 is the Bureau of Reclamation's projection for the "water year," which ends October 31.) To refill both reservoirs would take about 27 MAF, the equivalent of a second Lake Mead. Since the Southwest now consumes all the water that the mainstem Colorado River has reliably carried, how long might it take to regain that missing 27 MAF and refill the reservoirs? Suppose we aim to refill them by, say, 2025, 15 years from now. To refill reservoirs requires surplus water. The annual flow of the river would have to average 27/15 or 1.8 MAF above its long-term flow. That is virtually impossible in any century. Moreover, to refill the reservoirs would require that all parties agree to hold the surplus water back in the reservoirs, rather than let it flow downstream to irrigators and new subdivisions. That might be impossible politically. Thus I for one believe that at least one of the two giant reservoirs will never refill.

The West has had droughts before, though none in living memory that lasted a decade. The trouble is, there is scientific evidence that what we are witnessing in the Southwest is not just a drought, but also a change in the climate. The reason? Global warming.

Figure 3 shows that beginning around the year 1800, carbon emissions from fossil fuel burning and land use changes, atmospheric carbon dioxide, and global temperature all began to rise together and have kept on rising, the farther the faster. There are two possible explanations: one, the triple rise is a coincidence; two, it represents cause and effect. Appealing to coincidence is always a last resort. It is a fact of physics that carbon dioxide in the atmosphere traps heat and warms the surface. Without the greenhouse effect, the planet would be 57°F colder on average and none of us would be living on it. Thus by far the most logical explanation of Figure 3 is that as humans began to burn coal with the Industrial Revolution and then, in the twentieth century, oil and gas, the carbon dioxide emitted to the atmosphere caused global temperatures to rise. If you assume that the carbon emission curve can continue to rise but the temperature curve will turn down of its own accord, a Las Vegas casino has a spot reserved for you.

If this were merely an academic argument, we could let the scientists sort it out, as they always do. But it is not merely academic.

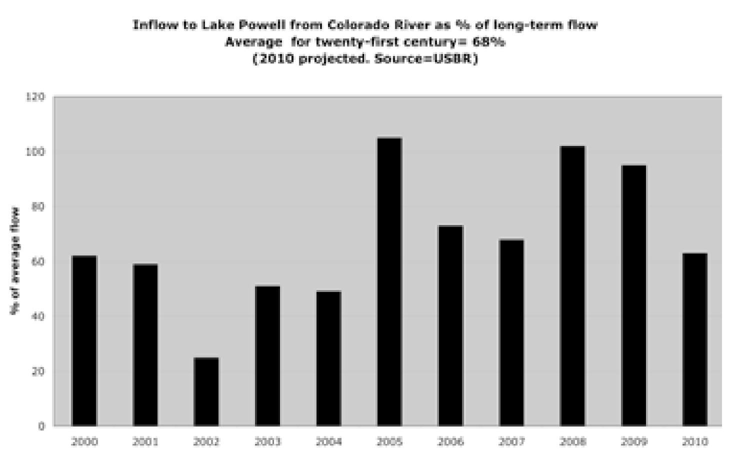

Figure 2. Inflow to Lake Powell from Colorado River.

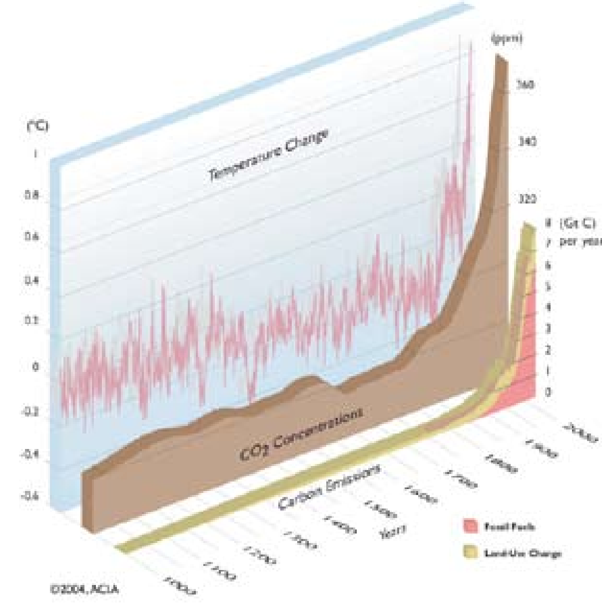

Figure 3. Changes in carbon emissions, CO2 concentrations, and temperature since AD 1000.

Almost all the water in the Colorado River comes from melting snow on the western slopes of the Rocky Mountains. (As early evidence that global warming has already begun, mountain snowfields in the west are melting earlier in the spring.) Higher temperatures cause more evaporation, which lowers river runoff. In a desert, evaporation is high: nearly 90% of the precipitation in the Colorado River basin evaporates, which means that small changes in evaporation can have a disproportionate effect on runoff. Calculations show that if evaporation increases by just 2%, runoff declines by 14%. How much water is 14% of the Colorado River? About 2 million acre feet, roughly half of California's allotment; or about seven times Las Vegas' allotment; or more water than Arizona receives from the river.

Several peer-reviewed studies have examined the possible effect of global warming on the runoff of the Colorado River and the status of its reservoir and water deliveries. One study from 2009 found that if global warming reduces inflow to Lake Powell 20%, by 2050 an annual shortfall of 2.2 MAF would result. Each study has found that the Colorado River reservoir system is vulnerable even to a 10% reduction in flow, the low end of the projected decreases due to global warming.

Figure 2 shows that inflow to Lake Powell is already down by almost one-third so far in the twenty-first century. None of the published studies assumed that the average flow going forward would be that low. We should hope that global warming has begun, for if we have yet to feel its effects, we start from unusually low flows and half-full reservoirs.

One reason runoff and river flow are down in the Colorado River basin may be because western temperatures have been rising steadily since the early 1970s (Figure 4). This is ominous, because previous droughts in the basin, like the one in the early 1950s, occurred at much lower temperatures.

The Rocky Mountain Climate Organization and the National Resources Defense Council report that "During the 2003 through 2007 period, the 11 western states averaged 1.7 degree Fahrenheit warmer than the region's 20th century average

The science of global warming is clear and strengthening. There is not a shred of evidence that scientists have fudged the data. Climategate, glaciergate, and all the "gates" have turned out to be tempests in teapots, changing not a single observational fact of global warming. Global warming is true, caused by humans, and dangerous. Long before rising temperatures lift sea level to dangerous levels, they will drop the Colorado River reservoirs to dangerous lows, or drain at least one of them. If we ignore the inevitable western water shortfall and fail to act, we and our grandchildren will have no one to blame but us. ■

About the Author

James L. Powell is the executive director of the National Physical Science Consortium. He holds a PhD in Geochemistry from the Massachusetts Institute of Technology and several honorary degrees, including Doctor of Science degrees from Berea College and from Oberlin College.

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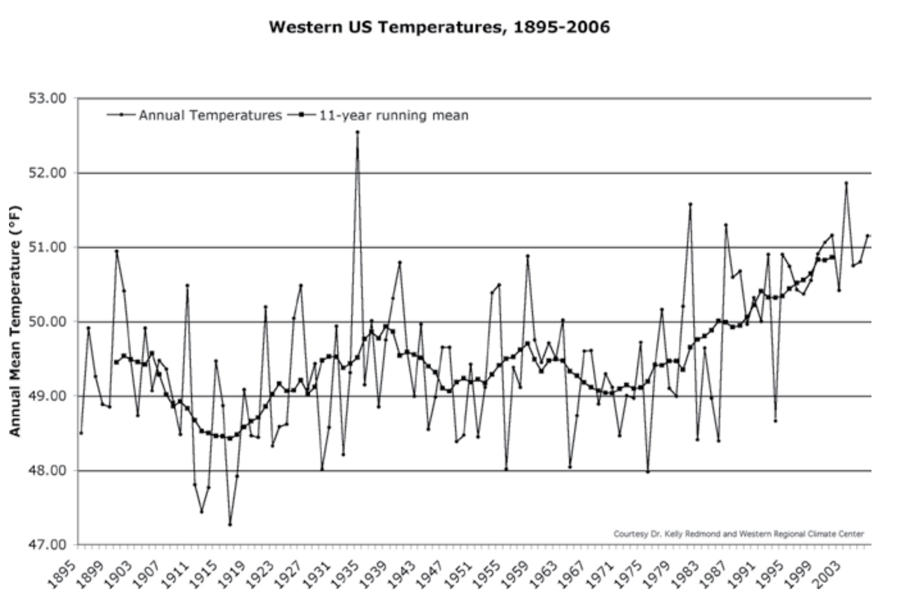

Figure 4. Western U.S. Temperatures 1895-2006.

The Future of Western Water Law:

Will Prior Appropriation Survive Changing Priorities in Western Water Use?

BY PETER D. MOHR

"Prior appropriation does not distinguish or show preference for one beneficial use over another.

More than 100 years ago, the increasing development of the arid West spurred the creation of informal rules to allocate the region's scarce water resources among competing users. These rules of local and regional custom were eventually incorporated by the courts into a common law doctrine that became known as "prior appropriation." The doctrine sought to achieve fairness and order in allocating water to those who had invested their efforts in the reclamation of arid lands through irrigation and other practices. For those who could show they had successfully diverted and applied the water to such uses, the doctrine provided some certainty in exchange for their labors, confirming in them a water right of a specified amount subject to the demands of older, or more "senior" water rights within the same basin. When water right demands among numerous users exceeded available flows within a particular stream or river, such a priority system allowed for curtailment of the more recently confirmed, or "junior" rights to satisfy the needs of the more senior priorities, thus the genesis of the maxim "first in time, first in right."

This principle of priority, however, did not entitle the holder of the right at the outset to the entirety of a stream or its remaining flows following the satisfaction of more senior priorities. Rather, such an amount was established subject to the doctrine's principle of "beneficial use" which limited the right to that necessary to achieve the "reasonable and economic use of the resource in consideration of other existing and future demands."[1] Beneficial use therefore determined the "basis, the measure, and the limit of the right" as a means to both maximize and avoid waste of the resource.[2]

By awarding a water right to be met in temporal priority in times of lesser flows, prior appropriation provided a level of risk management that is often credited with fueling the economic engine, which subsequently drove western development. The doctrine became so widely accepted that it would be codified in statute by most western states by the early part of the 20th century. Today, prior appropriation remains firmly entrenched within the laws administered by state courts and administrative agencies as they address the establishment, continued ownership and use of rights in surface water and (to a more limited extent) ground water throughout much of the west, approximately 75 to 80 percent of which remains dedicated to agricultural use.[3]

Although the last three decades have seen an increasing change of irrigation water rights to non-farming and largely urban uses, this transition is of little or no legal significance to the future of the doctrine itself. Unlike many state and local zoning laws which dictate preferred land use patterns, prior appropriation does not distinguish or show preference for one beneficial use over another. The type and place of use of a water right may typically be changed subject only to the limitation that the proposed use is both beneficial and will not diminish or result in "injury" to another water right.[4] And although the use and place of use of a water right may be altered, the original priority date—as the most valuable characteristic of the right—remains the same. Therefore, once having successfully changed a water right, and regardless of what the new use may be—industrial, commercial, instream use for the improvement of fish habitat, etc.—the entitlement to water under the original priority date remains and, with it, the market value associated with such a priority based on its relationship in time with other competing rights in the basin.

Given this ability to change water rights to a variety of non-farming uses, and that senior and junior rights alike may be bought and sold like other property for application to any beneficial use, proponents of prior appropriation argue the doctrine will remain viable well into the future. It is notable that such arguments are made in the face of a western economy showing an increasing reliance on more commercial and urban development and federal laws emphasizing the need for improved protections for endangered species. There are critics of course who advocate prior appropriation be stricken from the law altogether, often claiming that because the doctrine currently vests a large percentage of control and use of the water in a relatively small percentage of private interests, too little opportunity exists to dedicate such resources to more public interests such as the protection of endangered species. The same critics, however, fail to consider the orderly administration and certainty that prior appropriation affords compared to what might occur if the West were somehow compelled to proceed without it. Few if any reasonable alternatives exist that would maintain such a high level of orderly distribution in the management of western water supplies.[5]

History provides plenty of evidence that prior appropriation can accommodate the transition to uses that the modern West increasingly demands, including those uses dedicated to the protection of endangered species.[6] Still, many question how the doctrine can and will respond to federal laws which increasingly preempt it, thereby restricting vested water rights from diverting otherwise available flows. This article submits that there is no need for prior appropriation to be altered or changed to address existing and future western water supply issues. Rather, the past and the present show that prior appropriation "as-is" can accommodate such demands and will remain the foundation for allocation of the resource for the foreseeable future.

Currently, the most substantive challenge to any strict application of the doctrine is the Endangered Species Act (ESA) with its demand for instream flows sufficient to protect listed species. Therefore, particular consideration will be given to the ESA not because it is the only factor that will affect future allocations under prior appropriation, but because it has become the most significant to date.

With some exceptions,[7] prior appropriation has historically determined the allocation of water throughout much of the western United States. Entrenched as it has become, however, strict application of the doctrine has not fared well in response to water demands to protect listed species under the ESA. Most courts have held the ESA preempts any application of state authorized water rights, regardless of priority, in cases where such diversions would result in the "take" of a listed species.[8] See, e.g., United States v. Glenn-Colusa Irr. Dist., 788 F.Supp. 1126, 1134 (E.D. Cal. 1992)(stating in part that the ESA "provides no exemption from compliance to persons possessing state water rights, and thus . . . state water rights do not provide . . . a special privilege to ignore the Endangered Species Act [.]") Hence, while prior appropriation still governs the allocation of water throughout the West, it can be trumped by the ESA for a specified period of time to ensure necessary flows for endangered fish. However, such events should hardly be construed as evidence of the doctrine's future demise.

Significant conflicts continue to arise where water right diversions have either been subordinated to such "super priority" rights of the ESA, or diminished due to the intervention of federal reserved water rights in recognition of Native American tribal claims.[9] However, when evaluating options to resolve such disputes, it is prior appropriation that has provided solutions to meet both ESA and Tribal needs while still providing relative security for users' affected water rights interests. Two good examples of this exist in Idaho with the implementation of the Lemhi Conservation Plan and the 2004 Snake River Water Rights Agreement.[10]

In the case of the Lemhi Conservation Plan, an instream flow right and an accompanying water right leasing program were established to avoid further dewatering of the Lower Lemhi River and the resultant harm to salmon. As a result of the plan, legislation was enacted enabling the establishment of an instream water right for the affected portion of the Lemhi River and to allow senior water rights to be leased to the state water bank. Once leased to the state water bank, the senior water rights are then applied to maintenance of the state instream flow right. In doing so, the instream flow right also enjoys the protection of senior priority dates thus assuring the maintenance of sufficient flows for fish to the exclusion of more junior water interests. While the plan prevented the initiation of any ESA litigation, it has also provided security for senior water rights which users lease or, in some cases, permanently convey, to the state water bank in consideration of payments funded through a variety of different programs.[11]

The 2004 Snake River Water Rights Agreement addresses water demands for ESA listed species, federal reserved water rights to Nez Perce tribal claims, and existing and future demands for state and private water needs. The Agreement consists of three components – the Upper Snake River Component, the Salmon Clearwater Component, and the Tribal Component. In the Upper Snake River Component, the Bureau of Reclamation leases up to 427,000 acre-feet of water from willing sellers for flow augmentation for fish below Hells Canyon Dam. Similarly, under the Salmon Clearwater Component, the Bureau leases from the State of Idaho 60,000 acre-feet of water to create reliable flow augmentation to cover the 30-year biological opinion addressing the operation of Bureau projects under the ESA. The State of Idaho was able to lease the water as a result of its prior purchase of 75,000 acre-feet of direct flow water rights previously used to irrigate lands lying at an elevation more than 500 feet above the Snake River. And under the Tribal Component, the Nez Perce were assured of water under reserved rights possessing an 1855 priority date while also avoiding any adverse affect to existing water rights. As with the Lemhi plan, all three of the 2004 Snake River Agreement components demonstrate how the flexibility of prior appropriation can be used to address the water demands of the ESA and Tribal claims while still protecting private water rights.[12]

Finally, increasing restriction of water diversions to avoid harm to listed species has brought an increase in Fifth Amendment takings litigation. The success of any Fifth Amendment takings claim is often dependent on whether the government action at issue can be considered a "physical" or "regulatory" taking. Most simply stated, a physical taking requires evidence that the government has taken control of or seized property for its own use. A regulatory taking requires a different analysis altogether, instead considering the extent to which the economic and otherwise productive use of private property has been so diminished by regulation as to effectuate a taking of such interests.

In 2008, a very much divided United States Court of Appeals for the Federal Circuit in *Casitas Municipal Water District v. United States, 543 F.3d 1276 (Fed. Cir. 2008), rehearing denied*, 556 F.3d 1329 (Fed. Cir. 2009), addressed the distinction between a physical and a regulatory taking when water and related water rights are at issue. In 2005, the district sued the United States in the Court of Federal Claims after having been compelled under a biological opinion issued by the National Marine Fisheries Service to annually forgo up to 3,200 acre-feet of the district's water right from the Ventura River that it otherwise would have stored in the Lake Casitas reservoir. Once the water in dispute was diverted, the biological opinion required that it not continue on throughout the length of the existing canal to then be stored into the reservoir, but rather be rerouted for the sole purpose of operating a fish ladder for listed steelhead trout. The *Casitas* majority held that by rerouting the water from the canal to the fish ladder, the government took exclusive possession of the water, which in turn amounted to a physical taking of the district's property. The dissent countered that the diversion of the water to the fish ladder could only be analyzed as a possible regulatory taking since the government did not "invade, seize, convey, or convert Casitas' property to a consumptive or proprietary use," but rather imposed regulatory operating criteria to ensure compliance with the ESA.

While the decision was sent back down to the Court of Federal Claims for further proceedings, it remains uncertain whether the majority's opinion in *Casitas* will be limited to the particular facts of that case. Some speculate that may be possible given the water to which the district was entitled was rerouted to the fish ladder as compared to the more typical ESA enforcement dispute where water rights are simply restricted from further diversion as a means of maintaining instream flows. It is also worth noting that there are two other water rights takings cases currently pending before the Federal Circuit, which may result in further clarification of the *Casitas* holding. *See, Klamath Irrigation District v. United States, 532 F.3d 1376 (Fed. Cir. 2008); and Stockton East Water Dist. v. United States, 583 F.3d 1344 (Fed. Cir. 2009), rehearing pet. pending.* Regardless, any compensation award resulting from a physical taking determined under any of these cases is apt to only further entrench rather than diminish the doctrine and the property interests vested thereunder. As aptly stated in a recent article by the attorney who argued the cause for the federal government in *Casitas*, "If construed more broadly to apply to any restrictions on water diversions, . . . Casitas' impact could be substantial, as the competition for water between fish protection and consumptive use grows."[13]

Conclusion

Prior appropriation will continue to provide for the orderly allocation of western water supplies as well as provide the necessary flexibility to accommodate the changing water needs of the West including those that seek to ensure the protection of endangered species. However, where negotiated solutions cannot be reached to address the increasing conflict between vested rights to divert water and the maintenance of instream flows, more Fifth Amendment takings claims can be expected to follow. With the *Casitas* decision presenting a significant yet somewhat uncertain marker in the development of takings jurisprudence related to water and water rights, it is too difficult to determine just how much affect this and other takings cases will have on the future relationship between prior appropriation and the ESA.


Hell's Canyon and the Snake River.

In addition, any existing challenges in meeting western water demands are apt to become even more pressing in the event of anticipated climate change. There is an expectation that climate change will more likely than not alter precipitation patterns that will produce basin flows appreciably different from what we experience today. Any future changes in climate that increasingly challenge year round access to surface and ground water supplies are apt to be accompanied by an ever-louder call for greater efficiencies to maximize the resource. If prior appropriation's own measure of a water right—as established under the principle of beneficial use—could be fully enforced, the resulting curtailment of wasteful practices could go a long way to achieving among the greatest of public interests in the West: the availability of a more certain water supply. ■

About the Author

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Endnotes

[1]F. Trelease, The Concept of Reasonable Beneficial Use in the Law of Surface Streams, 12 Wyoming L. J. 1, 6 (1956). Author's note: Although a core element of prior appropriation, such a principle is also commonly referred to as the "doctrine of beneficial use." See, note 2, infra.

[2]Id. See also, Janet C. Neuman, Beneficial Use, Waste and Forfeiture: The Inefficient Search for Efficiency in Western Water Use, 28 Envtl. L. 919, 978 (1998) for discussion about obtaining efficiencies under the doctrine of beneficial use.

[3]See Congressional Budget Office, Water Use Conflicts in the West: Implications of Reforming the Bureau of Reclamations Water Supply Policies (1997) at http://www.cbo.gov/doc.cfm?index=46&type=0&sequence=0.

[4]By example only, see Oregon Administrative Rule 690-380-0100(3) which defines "Injury" or "Injury to an existing water right" within a transfer or change of use proceeding to mean when a proposed change of use "would result in another, existing water right not receiving previously available water to which it is legally entitled."

[5]See Dan Tarlock, The Future of Prior Appropriation in the New West, 41 Natural Resources Journal 769, 778 (2001) (discussing the principles of riparian law, reliance on ad hoc judicial determinations, and the public trust doctrine as wholly ineffective substitutes to prior appropriation for allocating water in the West.)

[6]For example, Washington State among others has enacted statutes that fund water conservation in return for title to the water conserved, which is then held in the state trust water rights program where it can be applied for maintenance of instream flows. Wash. Rev. Code Ann. § 90-42-030(2) (2004).

[7]See Winters v. United States, 207 U.S. 564, 28 S.Ct. 207, 52 L.Ed. 340 (1908). This case further discussed at note 9, infra.

[8]The ESA prohibits any person from taking, possessing, selling, importing, exporting or transporting a protected species. The ESA also provides for identification of a critical habitat for each species and adoption of regulations which will conserve and enhance the population of the species. 16 U.S.C. § 1533(b)(2) and (d). Under the ESA, "take" means "to harass, harm, pursue, hunt, capture, shoot, wound, kill, trap, capture or collect or to attempt to engage in any such conduct." 16 U.S.C. § 1532(19).

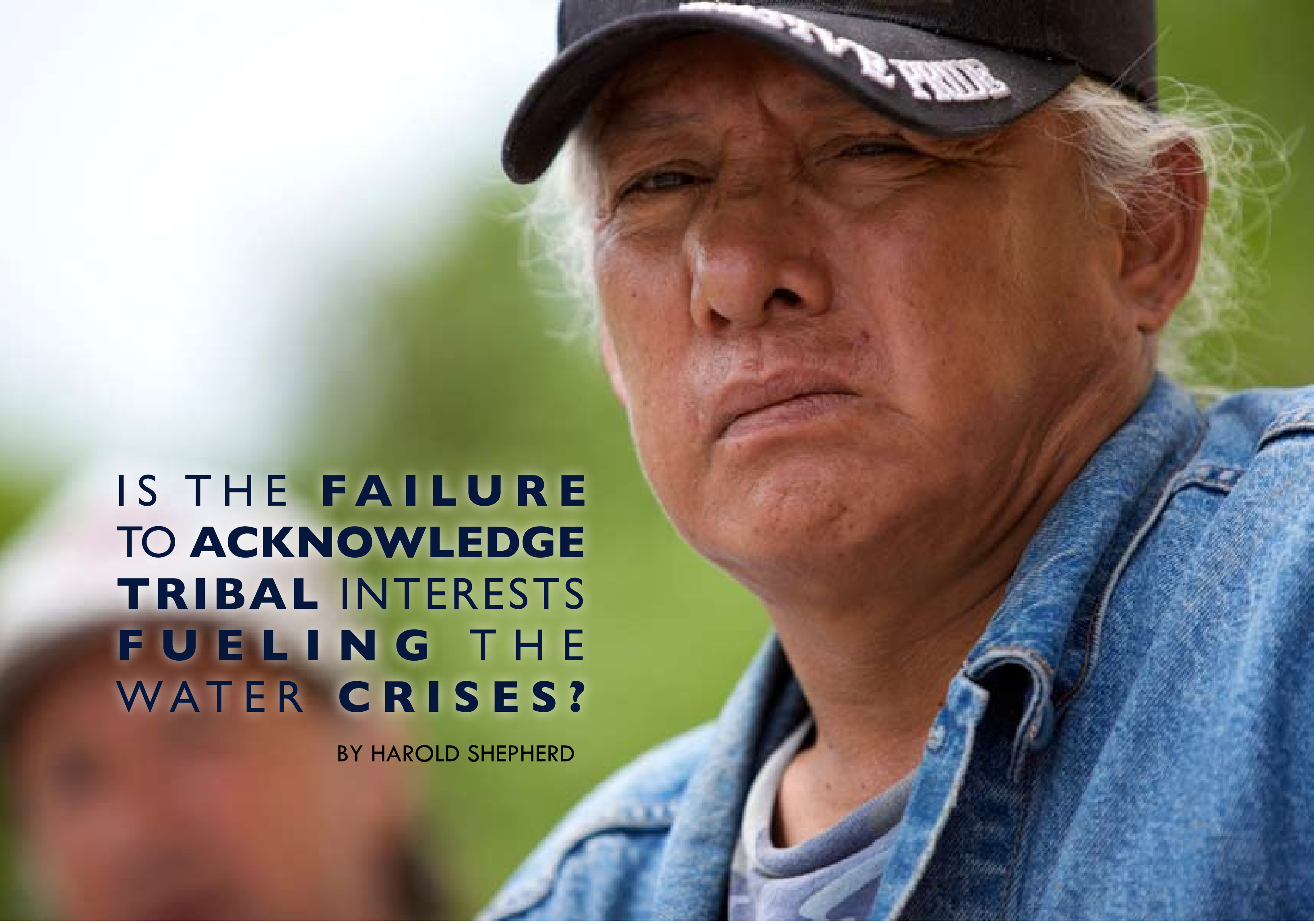
[9]See Winters v. United States, 207 U.S. 564, 28 S.Ct. 207, 52 L.Ed. 340 (1908)(holding held that federal reserved water rights, although not previously established under prior appropriation, nevertheless existed for future use in an amount necessary to fulfill the purpose of Native American reservation treaties and assumed a priority date equal to the date the reservation was initially established). Such rights are often vigorously contested since they typically assume among the most senior priority dates in any affected basin.

[10]The Klamath Basin Restoration Agreement entered into just this past February among the Klamath Basin Tribes, the federal service agencies, the States of California and Oregon, public interest groups, and private water users may prove to be yet another example of such effective cooperation among the traditionally divergent interests of species protection and the diversion of water for consumptive use.

[11]Of the 35 c.f.s. that is required to maintain minimum flows for fish, 14 c.f.s. has been permanently committed to such use through outright acquisition of senior water rights. Phone conversations with the Idaho Dept. of Water Resources Staff (April 27, 2010).

[12]Such an approach also coincides with the congressional policy directive of the ESA "that Federal agencies shall cooperate with State and local agencies to resolve water resource issues in concert with conservation of endangered species." 16 U.S.C.A. § 1531(c)(2). See also, Clive Strong, Is the Prior Appropriation Doctrine a Relic of the Past or the Foundation for Resolving 21st Century Water Supply Demands?, paper submitted to the ABA 24th Annual Water Law Conference (Feb. 2006).

[13]For a summary discussion of Casitas, see Katherine J. Barton, Takings and water rights: Casitas Municipal Water District v. United States, TRENDS, ABA Section of Env., Energy, and Resources Newsletter, at p. 6 (March/April 2010).



IS THE **FAILURE** TO **ACKNOWLEDGE** **TRIBAL** INTERESTS **FUELING** THE WATER **CRISES?**

BY HAROLD SHEPHERD

Although tribes comprise a large percentage of many rural communities in the West, most of the water in these areas has been allocated to non-Indian users.

The history of water use in the West is characterized by a reluctance of water management agencies and the general public to come to terms with the finite nature of this precious resource. This attitude is best illustrated by a recent lawsuit in which several Western Slope communities in Colorado sued the City of Denver to prevent it from securing new rights from the already over tapped Colorado River. During the trial, Colorado Conservation District Manager Eric Kuhn, who was a witness for the communities, testified that the amount of water the state can reliably count on from the 1922 Colorado River Compact is no more than 150,000 acre-feet—considerably less than half of what would be needed for the 2.9 million people projected to arrive in the state over the next quarter century. While attorneys for the state immediately pounced on Kuhn's remarks as being too "pessimistic," just before the trial, an attorney for the Plaintiffs secured a copy of an internal document prepared by the state only eight days earlier which showed that Colorado had almost exactly the same amount of water available for development as Kuhn suggested and only about one-tenth of what the state, up until then, had been publicly saying was available.

Another reason for Colorado's rather optimistic predictions of available water for growth and development is the fact that not only did the commission that created the Compact over estimate the amount of water available in the River but even though they knew that Mexico, the Navajo and other tribes had rights to the river, when it divvied up the presumed 15 million acre-feet annual flow, it didn't define the claims. There was still no mention of the claims of Indian tribes in 1944, when the assumed baseline was reset to 16.5 million acre-feet so that Mexico would get 1.5 million acre-feet per year, nor four years later, when the commission set the Upper Basin states' shares on a percentage basis rather than an absolute allocation.

The slight to the Tribes in the Compact occurred even though an 1850 treaty with the Navajo Nation, reinforced by a 1908 Supreme Court ruling, guaranteed water rights necessary for a permanent homeland. In 2003, the Navajo Nation sued the U.S. Department of the Interior seeking to force the U.S. government to, at last, quantify its rights. Some Navajos say a strict interpretation of the treaty and ruling in *Winters v. United States*[1] shows the tribe's rights trump all others because they were affirmed before the Compact came into existence.

The lack of attention to tribal water rights in the development of state and federal water policies takes many forms. Under the Columbia River Water Management Project (CWRMP), for example, the Washington State legislature directed the Department of Ecology to secure adequate water supplies from the River for irrigation, municipal, industrial and instream flows.[2] The CWRMP's reference to instream flows, however, is over shadowed by the legislature's declaration "that a Columbia river basin water supply development program is needed, and directs the Department of Ecology to aggressively pursue the development of water supplies…"[3] The interests of tribes in the protection of subsistence and cultural practices in the state, therefore, have been getting lost in the fervor to divert water for consumptive uses.

Recently, for example, the Federal Bureau of Reclamation applied to Washington State for 82,500 acre-feet of water from Lake Roosevelt near the Colville Tribe Reservation in part to bolster municipal and industrial supplies and provide supplemental water to farmers. As part of the CWRMP, the state signed agreements with the Colville and Spokane tribal governments in which the state agreed to provide annual payments to the Tribes in exchange for their support for the project.

Although the applicable tribal governments officially support the Drawdown, Vision for Our Future (VFOF), a local conservation organization made up of members of the Colville Tribe, has joined others in challenging the Bureau's failure to analyze the impacts of the Lake Roosevelt Project in federal court. In general, VFOF claims the Bureau violated the National Environmental Policy Act (NEPA)[4] by failing to conduct timely environmental analysis of such impacts and to draft a full Environmental Impact Statement (EIS).

Challenges to the Drawdown are based on federal regulations which require that the NEPA process must occur "early enough so that it can serve practically as an important contribution to the decision making process and will not be used to rationalize or justify decisions already made"[5] and that this should have occurred before the Bureau applied for and then received water rights from the state for the water in question. In addition, the federal government's trust duty to Indian Tribes higher standard of protection, potentially, enhances the obligation of federal agencies in relation to management of water, because while NEPA applies only to "major federal actions"[6] the trust obligation applies to any federal action potentially impacting tribal interests.[7] Therefore, when tribal water rights are affected the trust duty requires the Secretary to "ensure to the extent of his power" that all available water is used to satisfy the tribe's interest.[8]

As in the case of Lake Roosevelt, a common NEPA issue regarding DOI irrigation projects is the application of project water to irrigation or other purposes that may reduce instream flows needed by fish upon which the members of a tribe depend for subsistence and other uses. In many such cases, because the irrigator, as the requesting party, must pay for the NEPA analysis, the agency may be under a lot of pressure not to conduct a full environmental analysis even though the project may involve significant impacts.

Similarly, disproportionate impacts related to the development of water resources to the Winnemem Wintu Tribe of Northern California began back in 1933 when Congress adopted the Central Valley Project. This project directed the construction of Shasta Dam and authorized the government to acquire tribal lands, sacred sites, ancestral villages and burial grounds along the lower McCloud River that would be flooded by the construction of the dam. Promises by the U.S. government to compensate tribal members for the 4,400 plus acres of allotment land inundated by the dam and to provide a cemetery for the relocation of 183 burials, were never fulfilled.

Now, the Federal Bureau of Reclamation wants to raise Shasta Dam another six feet which would sacrifice more of the free-flowing McCloud River, already flooded for 15 of its 35 miles, destroy more than 780 acres of land along the part of the McCloud River that still flows free, drown more WWT sacred sites, including graves and a rock used for sacred rituals, and flood McCloud canyon endangering wildlife and forests.

In addition, based on the State of California's desire to cut back on carbon producing sources of energy due to the effects such sources have on climate change, it has called on increased production of hydropower. One such project relates to Pacific General Electric's recent filing of an application for re-licensing of the McCloud-Pit Hydroelectric project located on the McCloud River near the Winnemem Wintu Village. However, the current operation of the Project, which focuses primarily on the maximization of profit to the company, has resulted in centralized control and impacts to: traditional and cultural uses; aquatic habitat and water rights that excludes the interest of the native community; a bureaucratic governmental regulation of water resources; and disconnected communities from responsibility and control over energy.

Finally, the Federal Bureau of Indian Affairs recently canceled an EIS for the proposed operation and maintenance of the Flathead Indian Irrigation Project located on the Flathead Indian Reservation in northwestern Montana. The Secretary of the Interior is required to transfer the operations and management of the Project under the Flathead Indian Allotment Act, which authorized allotments of land to members of the Confederated Salish and Kootenai Tribes and construction of the Project for "the benefit of Indians" within the Flathead Reservation.[9]

When the Act was amended in 1908 it also authorized the construction of irrigation systems to serve homestead lands with the Reservation and provided for turnover of the operation and management of irrigation works serving non-Indian lands when certain Project construction repayment conditions had been met.[10] Upon turnover of the Project, the 1948 Act called for the operation and management of the Project under rules and regulations approved by the Secretary. The BIA, Tribes and non-Indian irrigators are developing proposed standard operating procedures for the Project and are proposing to contract the management of the Project under a Cooperating Management entity made up of representatives of non-Indian irrigators and the Tribes, with BIA providing oversight functions and maintaining its role as trustee. Some members of the Tribe believe, however, the assertion of the BIA that non-Indian irrigators should share co-management of the Flathead Irrigation Project, incorrectly, implies that the Project, somehow, nullified the Tribe's guarantee of territorial jurisdiction in the Hellgate Treaty, and that it accepted as legal the taking of land when settlers moved onto the Reservation during the federal era of assimilation and termination.

Indeed, as in the case of the Hellgate and other treaty rights, the Department of Interior's approach to protection of tribal water resources has been the result of political bargaining, which has often overshadowed the rational need for individual projects. The evolution of water management by the DOI has created a conflict of interest for the government that continues to significantly affect tribal interests. The agency has encouraged appropriation of water and development of water projects by non-Indians at the same time that it was suppose to be preserving the same water for the needs of tribes.[11] Therefore, while Indian water rights are protected on paper by the courts and have been occasionally enforced by the Department of Justice, historically, tribes have had little support from DOI.[12] Without political power to secure appropriations for tribal reclamation programs, tribes have been largely unable to realize the same access to water as non-Indian communities.[13]

As a result, although tribes comprise a large percentage of many rural communities in the West, most of the water in these areas has been allocated to non-Indian users. Recognizing this dilemma several years ago, the Interior's Report of the Working Group on the Endangered Species Act and Indian Water Rights proposed several measures to ensure that tribal water rights are not unfairly hampered by application of the federal Endangered Species Act (ESA).[14] In an effort to address looming conflicts caused by unrecognized treaty water rights in water management decisions related to the ESA, the Working Group Report recommends limiting future distribution of water rights to non-Indians, when endangered species and tribal water rights may be impacted, in order to prevent the appropriation of water needed for survival of listed species even before tribal rights can be exercised. Unfortunately, to date, the Department of Interior has taken no action to implement the Recommendations.

Based, in part, on the failure of the federal government to implement studies and recommendations like that of the Working Group Report, tribes are finding that once off-reservation users obtain a federal or state permit to appropriate water, the process is very difficult to reverse, even though the permits may violate tribal water rights or other laws. This is particularly true when additional interests are affected, or where requirements have been imposed, such as those stemming from the listing of threatened and endangered fish species. When combined, therefore, with the race to service non-Indian water projects at the expense of tribal needs, such policies have all but completely excluded tribes from enjoying the benefits others receive from federal irrigation projects.

There may, however, be consequences to non-Indian water interests also for the failure of state and federal agencies to figure tribal rights into the water management equation. In the case of the Colorado River, for example, if the Upper Basin states violate their "delivery obligation" under the Compact, those making up the Lower Basin could make a legal "call" on the river causing the Upper Basin parties to shut down their own water users until river flows come back up. Under the doctrine of prior appropriation, this would mean that more junior users within the upper basin states would be shut down first; followed by increasingly senior rights until the delivery obligation was met.

The situation could get worse when, and if, tribal water claims are finally asserted. The Navajo Nation, for example, could claim up to 800,000 acre-feet of water from the Colorado River, which could have dramatic impacts on storage in Lake Powell and the Upper Basin State water allocations.

Similarly, the dramatic implications of the Nez Perce Tribe's water rights demands as part of the Snake River Basin Adjudication (SRBA), which began in 1993, include the potential abdication of no less than virtually every other existing use of water within the Basin. Consequently, in almost every case, the filing of tribal claims represents the point of no return, because they automatically label all other water related concerns in the affected area as 'junior appropriators.'

However, based on an understanding that the Winter's Doctrine is merely court-made law and not backed by any statute or treaty and at the risk of appearing, ultimately, in front of an increasingly unsympathetic U.S. Supreme Court, most tribal leaders are pursuing negotiations to assert their water rights rather than litigating. At the same time, satisfaction of tribal water rights rarely significantly impacts local water needs. The federal government, for example, is soon expected to sign an agreement with the Gila River Indian Community, which will be the largest Indian water settlement in U.S. history, affecting the rights of a dozen Arizona tribes.[15] Even though the water included in the agreement is equivalent to the total need for future growth in the cities of Phoenix and Tucson, through the use of leasing tribal water and other options, the arrangement between the Tribe and the Cities does not substantially hamper municipal needs or even signify the end of urban growth.

Tribal settlement agreements may not only be applied to provide assurances to non-Indian agricultural interest, but can protect stream flows needed for fisheries. A prime example is the SRBA in which the turning point in the negotiations occurred when non-Indian water right holders discovered that if they prevailed against the Nez Perce in the adjudication process, they would likely eventually have to leave undiverted the same water claimed by the Tribe in order to fulfill a federal biological opinion requiring instream flows for endangered species in the Snake River. In addition to providing water to agricultural interests while satisfying tribal water rights, therefore, the resulting SRBA settlement satisfies tribal treaty rights and needs for water to protect fishery habitat.

Many experts suggest that conflicts over water will become the greatest global crises over the next century. Such predictions make the responsibility of state and federal water managers to prevent conflict and catastrophic results of their actions all the more pertinent. Therefore, rather than ignoring or contesting tribal water rights when making water distribution decisions, governmental agencies should acknowledge the existence of tribal water rights and implement studies and recommendations suggesting that these tribal rights be quantified before water diversions are authorized. Further, agencies should recognize the ability of using treaty water rights; to not only satisfy tribal and non-Indian water right disputes, but to address the public interest in the protection of fish and wildlife habitat. This will produce a much more desirable outcome than putting off the inevitable.

About the Author

Harold Shepherd is the executive director for Red Rock Forests in Moab, Utah.

Endnotes

1 207 U.S. 564 (1908).

2 RCW 90.90.005, et seq.

3 RCW 90.90.005. (emphasis added).

4 42 U.S.C. §§ 4321-4370e (1994 & Supp. III 1997); See also, 40 C.F.R. § 1502.2.

5 40 C.F.R. § 1502.5 (1987)

6 42 U.S.C. § 4332(2)(c).

7 Pyramid Lake Paiute Tribe of Indians v. United States Navy, 898 F.2d 1410, 1420 (9th Cir. 1990).

8 40 C.F.R. § 1506.6 (1999).

9 33 Stat. 302.

10 35 Stat. 450.

11 See Harold Shepherd, Conflict Comes to Roost! The Bureau of Reclamation and the Federal Indian Trust Responsibility, 31 Envtl. L. 4, 901, 914 (2001).

12 Id.

13 Id.

14 Final Report and Recommendations of The Working Group on the Endangered Species Act and Indian Water Rights, 65 Fed. Reg. 41,709-01 (July 6, 2000) (Working Group Report).

15 http://www.gilariver.org/index.php/about-tribe/46-water-settlement/118-water-settlement

Glen Canyon Dam, Arizona.

The Klamath Solution:

Certainty *for* Farmers *and* Electricity Consumers

BY DEAN S. BROCKBANK

Collaboration, not litigation, worked to reach a settlement in the Klamath Basin.

PacifiCorp has provided electricity to customers in the Klamath Basin for nearly 100 years. This Southern Oregon and Northern California community is one of the more than 200 rural communities we now serve.

Through our Northwest operating utility, Pacific Power and through our Intermountain West operating utility, Rocky Mountain Power we provide over a billion kilowatt hours of electricity per year to more than 23,000 irrigation customers in six Western states. The largest share of those irrigation customers is in Oregon. Of those, Pacific Power serves more than 3,200 irrigation customers in the Klamath Basin. Our role as a partner in these rural communities is just as important to us as running an efficient business and delivering safe, reasonably priced power.

Over the past two decades, many of the Klamath Basin's stakeholders including PacifiCorp have found themselves in a courtroom fighting over natural resource issues. In short, at issue in the Klamath Basin is a familiar controversy found throughout the Western United States, which stems from a lack of the most precious of natural resources—water. Fundamentally, these controversies, wherever they occur follow roughly the same script, with the names, rivers and specific players changing from community to community.

The generic plot line goes something like this: farmers and ranchers primarily want to ensure that sufficient, cost-effective water is available for their crops and livestock. Sometimes, like here, a power company is involved. The power company wants to run water through turbines to generate clean, cost-effective electricity to the communities it serves. Federal regulators are charged with enforcing the various resource-related laws, such as the Clean Water Act and the Endangered Species Act, and state regulators are enforcing the state corollaries to those statutes. Enforcement of these laws often conflicts with the goals and interests of the farmers, ranchers and industry. Environmental organizations and other groups such as Native American Tribes want to keep the water in the river for the fish and to keep the environment as close to its natural landscape as possible. Recreationalists have different interests depending on their respective activities. All of these interests are represented zealously, working to achieve their preferred outcomes. When all of these players do not get what they want, controversy ensues and they typically end up in a courtroom.

The Klamath Basin water wars have been no different. Although certain parties may have won small battles over the decades, this has been a war that nobody could ever win. In fact, for years all of us have been missing an opportunity for mutually beneficial outcomes. So as a stakeholder group, we tried something new—working together in collaboration.

Although the Federal Energy Regulatory Commission has jurisdiction over and grants licenses for hydroelectric facilities, state and federal resource agencies play a key role in the development of a license. As a result of this decades-old Klamath Basin controversy, our effort to relicense our Klamath Hydroelectric Project has faced ever-growing opposition from the federal and state resource agencies in both California and Oregon. Given the strong public policy direction from the governments, we elected to move from a litigation stance to one of collaboration. But first and foremost we needed to reach a good business deal for our customers.

In the wake of various government agencies advocating for dam removal–and the rising costs associated with relicensing the dams, not to mention the risks of the numerous unknown costs of litigation to environmental mitigation—we recently negotiated a settlement agreement on behalf of our customers with the governors from Oregon and California and the Secretary of the Interior.

Within the framework of these negotiations, we established a potential transfer process for the dams that ensures our customers will not be saddled with unknown risks and liabilities associated with dam removal. The Secretary of the Interior himself will make the determination in 2012 on whether to order transfer of the dams to a third party, most likely the federal government. The Secretary's decision will be based on independent scientific review and will determine if the benefits of removal outweigh the risks.

If the Secretary determines that it is in the public interest to remove the dams, then PacifiCorp and its customers will be protected from liabilities and lawsuits associated with dam removal. Moreover, in collaboration with the Oregon legislature, we achieved a cost cap for our customers on how much they would be required to contribute to the process should removal occur. The State of Oregon passed a law that directs us to set aside a less-than 2% surcharge for Oregon customers. Weighing all of the risks and unknown costs, this surcharge is a better option than the costs our customers would normally bear if we continued down the traditional path of relicensing the Klamath dams and incurred the costs of nearly $400 million in fish ladders alone, not to mention other environmental mitigation and increased costs for power, due to likely reduced water flows.

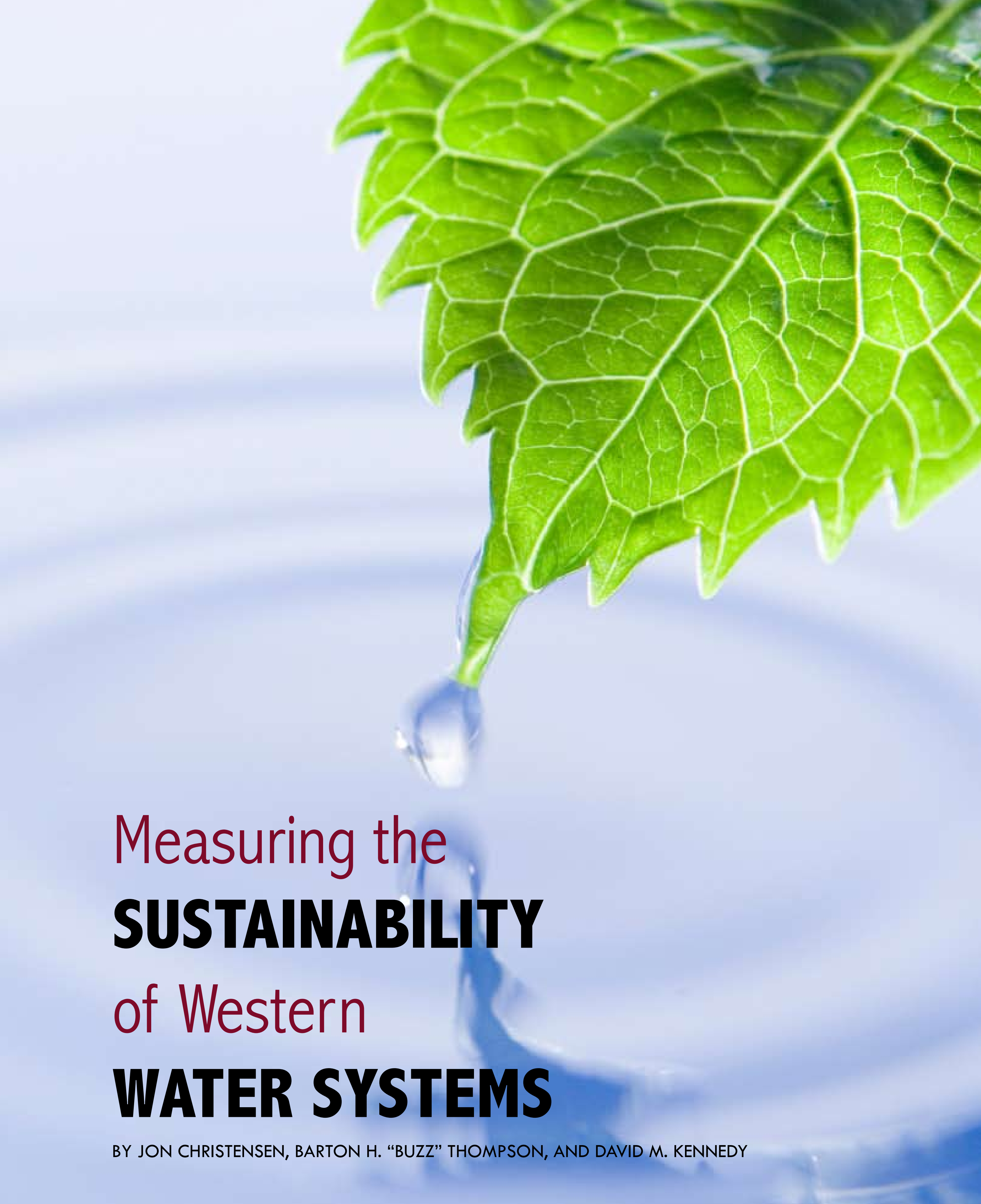
The agreement also ensures that our Oregon and California customers continue to benefit from the low-cost, carbon-free electricity from the Klamath dams for at least the next decade. Finally the agreement also establishes a mechanism to save a portion of their rates to fund possible dam removal while we identify clean, reasonably priced replacement power.

Just because we signed a settlement agreement does not mean that we are done solving this problem. Several key milestones must still be achieved for this settlement. First, we must get Congressional approval for the Klamath settlement and the State of California must pass a proposed water bond to cover its agreed upon $250 million commitment—both of these objectives will be challenging, but achievable.

So we are a long way from completion, but without collaboration and listening to a lot of different voices along the way, our customers would not be looking at a very fair deal that protects their interests and wallets -- in the wake of an unprecedented and historic dam removal determination. The Klamath settlement represents compromise on all fronts; it represents collaboration and coordination; talking instead of suing; trying to solve problems by working with those with whom you disagree. Is this settlement an optimal solution for any single party or interest? No. However, it represents a solution that all participants can live with; it represents a solution crafted by the parties themselves for themselves rather than imposed by a judge. That alone should motivate others to pursue collaboration over litigation.

About the Author

Dean S. Brockbank is the vice president and general counsel for PacifiCorp Energy.



Measuring the **SUSTAINABILITY** of Western **WATER SYSTEMS**

BY JON CHRISTENSEN, BARTON H. “BUZZ” THOMPSON, AND DAVID M. KENNEDY

Few, if any problems are more important to the future of the West than solving this formidable accumulation of water problems.

Introduction

Our water systems in the American West are old-fashioned hybrids. Combinations of natural and engineered systems, they are largely the products of archaic political and institutional structures, some dating back centuries, late nineteenth-century scientific assumptions, and mid-twentieth-century engineering technologies. All of these foundational fixtures of the West's water system are showing severe signs of obsolescing rapidly.

Few water managers, moreover, are able to think beyond their basins or operate with a regional or watershed-wide mandate. The West's astonishingly fragmented water management systems—numbering more than 1,100 water districts, as well as hundreds of mutual water companies and other entities – have never been well articulated and are now approaching intolerable incoherence. Entrenched jurisdictional deadlocks chronically frustrate attempts to allocate and manage water efficiently and price it rationally. Everywhere challenges arise from the age-old competition among agricultural and urban users, but also from new threats like aging water infrastructure, soaring population growth, intra-regional population shifts, growing local and global demand for food, unanticipated climate change, and the increasingly compelling claims of aquatic ecosystems.

Policy makers desperately seek new water sources, even as they struggle with inadequate tools for assessing risk and uncertainty, surprising ignorance of one another's practices, lack of public or even scientific consensus regarding health and safety standards, scant understanding of how to put a value on "natural capital" or "ecosystem services" to balance human and environmental water needs, and virtually no capacity to integrate the management of groundwater and surface water. Few, if any problems are more important to the future of the West than solving this formidable accumulation of water problems.

Background

To gain a better understanding of the water challenges facing the West and how a major western research university might best contribute to solving them, the Joint Program on Water in the West at Stanford University held four major dialogues in 2008 and 2009. The Program is a collaboration between the Bill Lane Center for the American West, the Woods Institute for the Environment at Stanford, and numerous other researchers, government agencies, water purveyors, and nongovernmental organizations. The dialogues engaged private and public leaders and academics from both Stanford and other major western research institutions to identify the principal challenges and potential solutions.

Based on these dialogues and other consultations with public and private decision makers and experts, we concluded that our research could best contribute to improving the sustainability of western water resources by focusing initially on three major opportunities to achieve dramatic, immediate, and measurable improvements in water management in the West:

1. Through better management of groundwater, including groundwater banking, and of integrated management of surface and groundwater interactions;
2. Through development of metrics and performance measurement systems or "dashboards" needed to effectively guide efforts to move toward more sustainable water systems in the West; and
3. Through developing methods to expand and improve water reuse, including use of reclaimed water for irrigation and watershed restoration.

Participants in our dialogues consistently identified these three challenges as among the most important facing the western United States, so the Joint Program on Water in the West is now embarking on a five-year program of research, technology development, and policy initiatives focused on these three areas. The Program will not only engage in research and development, but will also test solutions and approaches at a variety of scales (from the level of a single building to the level of a campus, farm, or small community, to the level of municipal systems and water districts, and finally states and regions), and work with private and public decision makers to disseminate and implement the solutions and approaches.

Figure 1 details the conceptual model of our approach. (See page 21).

The goal of the Joint Program on Water in the West is to address and help overcome the major challenges facing western water and to help create water systems in the western United States that are sustainable from economic, ecological, political, institutional, and equitable perspectives.

The Program's work has particularly important implications for water management in agriculture, which accounts for about 80 percent of water withdrawn for human use throughout the region. In California alone, agriculture is a $30 billion-a-year enterprise. But studies suggest that the state's agricultural sector can continue to thrive only if aggressive steps are taken to increase water-use efficiency. The Program's research on water reuse and monitoring, and managing contaminants of emerging concern will help ensure the safety, reliability, and public understanding of water reuse for irrigation of food crops. The Program's research on groundwater recharge and storage will improve technology for sustainably managing aquifers as irrigation reservoirs and preventing saltwater intrusion in coastal farmlands. The Program's evaluation of water banking practices will provide economic and policy decision-support tools for smoothing supply, moderating price fluctuations, putting water to its highest and best use, and implementing water transfers within and beyond irrigation districts. The Program's assessment of best institutional practices for groundwater management will identify obstacles to the creation of local groundwater authorities and recommend politically viable solutions for groundwater regulation, which is a key to sustainable water management in places like California's Central Valley.

Five principles guide the work of the Joint Program on Water in the West:

- Only a holistic, integrated approach is likely to yield solutions commensurate with the variety, complexity, and urgency of the challenges facing the West. The Program systematically integrates "institutional" analyses of the historical, legal, political, and economic dimensions of western water issues with cutting-edge science, engineering, and the development, promotion, and transfer of innovative technologies to water managers.
- Water challenges are best examined by thinking about the region as a whole. Many challenges cannot be solved by individual states or locales alone. By thinking integrally about the entire region, researchers and practitioners in one area can help inform their colleagues in other areas.
- Solutions require not only sound science but also pilot projects that test and demonstrate the technical feasibility, efficacy, cost, and political viability of solutions on both small and large scales.
- Even the best solutions will not be effective if they are confined to academic journals. The Program will engage strategically with both public and private sector decision makers to ensure that its work is responsive to their needs and actively contributes to implementing solutions.
- Measuring results is crucial for success, but few metrics exist for improving the sustainability of water management systems. As noted above, we will develop metrics to measure the success of our own work and broadly promote the development and use of reliable metrics for sustainable water systems in the West.

Measuring the Success of Reform Efforts and Sustainable Water Systems

In the coming years, major investments must be made in reforming the West's rapidly obsolescing water systems. This presents an historic challenge and opportunity to create an adaptable dashboard of metrics that can inform, help drive, and measure the success of water reform efforts and the sustainability of water systems in the West. This performance measurement system will draw from best practices around the region, and even overseas, particularly in other arid regions such as Australia, and in other sectors, particularly business.

Although there is a plenitude of data available on such questions as water supplies, use, and treatment, most western states have crucial data gaps on important questions such as groundwater supplies, groundwater-surface water interactions, and water quality. States, moreover, have spent little if any time addressing the fundamental question of what defines an efficacious water system. For example, is the percentage of endemic fish species on the federal endangered or threatened species lists a good measure of the ecological health of a water system?

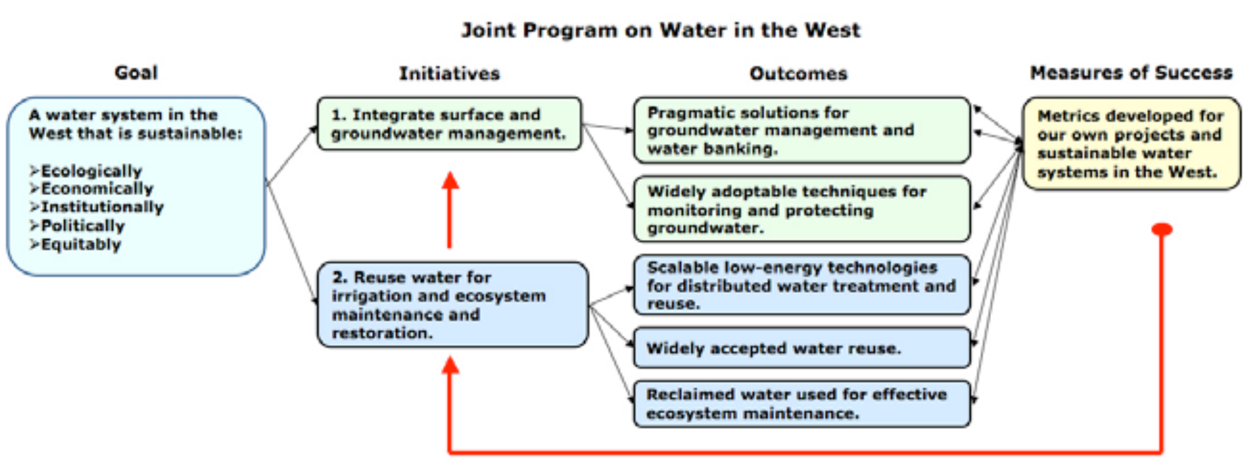


Figure 1. Conceptional Model of Joint Program on Water in the West.

Performance measurement in any field is a crucial challenge. Defining metrics for success can be particularly challenging in reform efforts that are necessarily tied to theories of change. Metrics and performance measurement systems must identify key actionable metrics that deserve the attention of decision makers and be adaptable as the environment for reform changes, successes change what needs to be measured, and people adapt their behavior to perform to measurement systems.

Defining performance metrics, however, is critical both to states seeking to evaluate the status of their water systems and to reform efforts wishing to evaluate their success. The Program is working to develop an improved set of metrics, along with recommendations on the type of information needed to implement the metrics, by bringing experts in the discipline of performance measurement together with experts in water law, biology, water institutions, political reform, databases, and data visualization.

Together, these experts are helping us identify the broad goals for sustainable water systems and define metrics that can serve as indicators for making progress toward those goals. The Program is working with visualization specialists to create a set of interrelated dashboards for measuring the success of efforts to reform California's water system. Key audiences may require different metrics, and the Program's work will reflect this key fact. Measurement of progress toward broad goals statewide, and specific goals on a local level, can help build public support for reform. But reform efforts will require metrics for measuring progress on intermediate goals, whether on groundwater management and water banking, for instance, or freshwater flows for ecosystem health, or even support for key legislation. Policy makers may require a different dashboard. In each case, important decisions will have to be made about conserving and focusing the attention of key audiences on the metrics that matter for success in driving reform. The Program will also identify and work to fill data gaps and address information asymmetries that hamper reform efforts. Finally, the Program will practice what it preaches, defining metrics for its own success, measuring results, and sharing what we learn with collaborators.

Conclusion

Since before the publication in 1879 of John Wesley Powell's "Report on the Lands of the Arid Region of the United States," water—or more precisely, its scarcity, has defined the identity and character of the American West. Coping with aridity deeply shaped the cultures of western indigenous peoples from the parched mid-continental prairies to the sere flats of the Great Basin and the dusty pueblos of the Sonora Desert and desiccated arroyos of coastal California. The novelty of the West's great thirst challenged and confounded the earliest American pioneers—and often broke them.

Powell was among the first to understand that the fabled "westward movement" could not proceed on the sunset side of the Hundredth Meridian as it had proceeded across the eastern half of the continent. Here the land was dry. Its settlement would depend crucially not just on the frontiersman's gumption and grit but on scientifically informed, daringly ambitious efforts to capture, store, move, manage, and allocate water on unprecedented scales.

Powell's recommendations led eventually to colossal dams on the Colorado, Columbia, and Sacramento River systems, as well as elaborate water management schemes like the Colorado River Compact, the Bonneville Power Authority, California's Central Valley Project, and the California State Water Project. Those epic engineering achievements are the stuff of legend. They literally made the desert bloom and caused cities to arise from the plains. In the decades after World War II, they transformed Powell's arid West into the nation's most populated, prosperous, and dynamic region.

But those achievements are no longer adequate to sustain the West's water needs. The West now faces an urgently mounting water crisis. In the years to come we must find new solutions through innovations in science, technology, policy, law, economics, institutions, and rigorously measuring our results as we move toward sustainable water systems in the West.

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Time *and* NATURE

BY JOSEPH E. TAYLOR III

What role do academic historians play in natural resource management?

If you have read this far, then you care about natural resources; if you care about nature, then you should care about the discipline of history. I know this is a hard sell. Most Americans regard academic historians as esoteric and boring. Some have merit, yet like most Americans through time, they toss the baby with the bathwater. When Alexis de Tocqueville toured the United States in 1831, he observed that the average American man disregarded "his ancestors," ignored "his descendants," and separated himself from "his contemporaries." At times he seemed confined "entirely within the solitude of his own heart." Tocqueville was so disturbed by this that he coined a new word: "Individualism." That label stuck, and ever since legions of prophets have, like Ralph Waldo Emerson, counseled Americans to "Trust thyself," "Insist on yourself," that nothing "can bring you peace but yourself." This is empowering, yet believing we are the architects of our own fate has also led us to believe that the past does not matter. This is the cultural backdrop I and other historians face when we try to teach bright, energetic souls who are nevertheless convinced that academic history is quaint and irrelevant. Even sage business, scientific, and political leaders express these assumptions.[1]

One notable exception is in the field of natural resource politics, where competing interests regularly invoke the past to persuade policy makers. All pay considerable attention to the implications of legislative and judicial precedence, and all follow the long-term trends of science, technology, and nature. In these ways historical analysis does inform forestry, grazing, irrigation, and hydroelectric politics, especially in the West where most battles revolve around access to public resources. No issue is more freighted by the past than Pacific salmon. As the National Research Council noted in a 1996 report, "the life history of salmon is intertwined with human history," and because salmon migrate vast distances, they have historically linked habitat to water in ways that now affect nearly every Westerner. Thus most residents of the region are steeped in and vexed by the competing narratives about declines in salmon and the communities that depend upon them and their environments.[2]

This broad awareness of salmon's history might seem hopeful to historians, but this is not the case. Certainly the rising consciousness of the past's relevance is welcome, but how people in the natural resource community engage the past still diverges significantly from the disciplined methodology of my profession. From the historians' perspective, what we see is an instrumental approach, a tendency by advocates, scientists, and managers to sift the documentary evidence for those bits which best support a particular position or model. Sheila Jasanoff, a leading scholar in science and technologies studies, calls this an "adversarial structure." The litigious context in which history and science are invoked encourages participants to bias their presentations and let panels, agencies, and courts adjudicate the differences. This is not how academic historians practice their craft, and the disparities are important.[3]

Although we share with advocates, scientists, and others an interest in the past, academic historians take a disciplined approach that diverges significantly from other modes of story telling. As historian William Cronon notes, we hew religiously to a few crucially conservative and distinguishing rules. While we are highly creative in our use of sources and methodologies, we cannot, like novelists, "contravene known facts about the past." We must deal with all of life's messy and contradictory details, which also means that we cannot, like advocates, "be arbitrary in deciding whether a fact does or does not belong." The result is a form of narrative that is less amenable to the advocacy approach to policy making but, in exchange, far more comprehensive and nuanced. Finally, to the extent that we tell tales about human relations with nature, we must heed the strictures of science and "make ecological sense." The result is an approach to story telling that can annoy. Historians' fealty to the complexity and ambiguity of life dissuades us from the prosecutorial tones of the grey papers and briefs that frame public discourse. We are by training and familiarity with the evidence resistant to the adversarial structure, and our respect for the contingencies of life makes us balk when asked to predict the future because we know from deep research how seldom our species has ever understood what was coming next.[4]

It is no wonder we seem useless in policy forums, yet the dismissals are shortsighted. Historians' disciplined approach is crucial to natural resource management because of what we have learned about environmental relations. Although North Americans yearn for pristine nature, locating that pure and separate world is difficult. Wherever we look, at whatever period in the last millennium, we see the human hand. Well before 1492 people were burning landscapes, diverting waters, and reshaping ecologies. Thus establishing a natural condition is not simply an ecological but a cultural equation. This is especially true in the Pacific Northwest, where ideas about wild salmon, and their implications on stream management, collide not only with the material impacts of aboriginal, industrial, and angler fisheries but also with the cultural framing of fish as food or game or pest. As historians note over and over, every conservation battle has been a struggle over which nature and whose nature would be conserved. The historian's approach can clarify issues in ways no adversarial narrative will.[5]

Technology raises different historical problems. The FERC relicensing process has launched heated debates about moribund dams. Partisans focus selectively on impacts, emphasizing the benefits or costs of impounded conditions in support of their particular solution. Often lost is the history dams themselves create in terms of toxins and heavy metals that accumulate in backed-up sediment. A discussion of breaching thus requires a broad, often ambiguous historical consideration of activities that have occurred in upstream landscapes for sometimes decades or even centuries. Fish hatcheries show similar complications. ESA listings have become a key driver in salmon management by placing tremendous emphasis on protecting "wild" genetic stock. But as the ruling in Alsea Valley Alliance v. Evans revealed, "wild" is not a priori the same thing as "primordial" because of how transplanting programs homogenized hatchery and non-hatchery stocks over time, thus mooting claims that protecting naturally-reproducing stock is always warranted. As the ESA's opponents learned in Oregon Trollers v. Gutierrez, however, transplanting was haphazard, and many runs do remain genetically distinct.[6]

If these messy, complicating details require us to study the human history of nature, it is equally true that we should examine the environmental contexts of society. There has always been a tendency in natural resource politics to simplify and dismiss opponents. During the battle over Hetch Hetchy, San Franciscans cast the Sierra Club as tools of monopolists. A century later a Sierra Club chairman portrayed local watershed councils as dupes of industry. Neither was accurate, but the caricatures shaped listeners who did not know these communities. The Sierra Club was actually divided by the proposal to dam the Tuolumne River and in no simple way aligned with power and water interests, and even tiny watersheds such as California's Mattole River or Oregon's Nestucca River contain kaleidoscopic material and cultural divisions depending on the location, tenure, and livelihood of residents. More vexingly, the lessons of one basin are only applicable to the next to the degree we recognize the inherently local dynamics of natural resource politics, yet as a recent pact to breach four Klamath River dams illustrated, local participation is crucial to achieving workable solutions.[7]

Many natural resource scientists and advocates do realize the past matters to the present and future, but how they engage history is problematic. A National Research Council committee tried to establish a baseline for a native oyster species on Point Reyes by extrapolating historical remarks about estuaries sometimes hundreds of miles away. A group at the University of British Columbia quantified marine ecology around the Falkland Islands by compiling three centuries' worth of anecdotes from passing ships. A team at the University of New Hampshire modeled cod biomass on the Scotian shelf in 1852 by quantifying conversations among ship captains. These examples of historical ecology are admirable for their ambition, yet their methods are woeful. All take an instrumental approach to evidence, and all try to transform qualitative remarks into quantitative data by converting nominal evidence into ordinal information and then assigning interval values. The resulting assertions mask any sense that historical documents are not transparent, that biases of authors and intended audiences are inherently relevant to the interpretation of evidence.[8]

The study of western water cannot be abstracted from the things that live and inhere in it because fish, opportunity, recreation, and wildness are central to people's lives and to the stories they tell about themselves and their environments. Water matters in all its parts, not just the bits that seem most relevant or most easily quantified.

Such analytical slippages suggest massive flaws in how the natural resource community practices history. In the quest for numbers, we see systemic misunderstandings about what documents can reveal. This is where the historians' discipline matters. As historian Katharine Anderson notes, researchers stumble when they ignore or devalue "evidence about changes in how and why human beings have observed and counted in different times and places." Put another way, data is produced in time and space, and it always reflects its context. Thus before researchers can interpret a document they must learn its social and cultural history. This is what academically-trained historians do. We study both the specific details and the general contexts, and that is why the natural resource community needs us. We are crucial resources for understanding human perceptions of nature.[9]

The study of western water cannot be abstracted from the things that live and inhere in it because fish, opportunity, recreation, and wildness are central to people's lives and to the stories they tell about themselves and their environments. Water matters in all its parts, not just the bits that seem most relevant or most easily quantified. We need a nuanced view of the material and cultural history of western water because we live in time as well as space. Even though natural resource politics is about the future, there is no part of this subject that is not deeply influenced by the past. Thus doing policy well means doing history well, and doing history well entails more than crunching numbers and prosecuting opponents. A disciplined approach to the past requires attending to all the evidence, considering all the material and cultural contexts, and viewing events from all of its angles. It also requires humility and acknowledging the limits of what can be known.

I believe academically-trained historians are better at this than other scholars, but my intent is less to create jobs than to sell the discipline. It would be chauvinistic to insist that scholarly historians are the only ones who can do history well, partly because criticisms about opaque writing have merit and partly because holding a PhD is no guarantee of wisdom, but ultimately the distinction is not the PhD but the discipline. Among the most nuanced recent contributions in historical ecology is the work of the World Whaling Project, a research group directed by a biologist. The team includes no historians, but they took pains to learn historical methodology before wading into a vast documentary trove on nineteenth-century whaling. Rather than simply extract population and location data, though, they cross-checked federal abstracts with the original captains' logs. The result was a smaller but more robust dataset that limits their ability to estimate populations but has enabled them to correct species range maps, some dating to the 1850s. This is by any metric very sophisticated history, and it helps underscore my point that some people do history better than others. The key is to take seriously the discipline of history.[10] ■

About the Author

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Western Households' Water Values, Knowledge and Preferences for Meeting Future Scarcity

What is the public's view of western water issues?

BY JAMES PRITCHETT, ALAN BRIGHT, ANDREA SHORTSLEEVE, JENNIFER THORVALDSON, TROY BAUDER, AND REAGAN WASKOM

Western agriculture has blossomed with the development of water resources that are used in growing crops, which in turn spurs the growth of value-added industries like meat, sugar and dairy products. Economic activity is generated directly by these industries when inputs are purchased and wages are spent. Without other viable local base industries to generate revenues and provide employment, a reduction in agricultural revenue seriously impedes a rural regional economy.

Yet, population growth is driving a reallocation of agricultural water resources from rural areas to burgeoning municipalities. By 2030, an estimated 33 million additional people are projected to be living in the West, requiring approximately 30 billion more gallons of water for consumption (Western Governors' Association, 2006). Growth and subsequent water conflicts are often focused in agricultural areas where key water resources are fragile and scarce, as pointed out in the Bureau of Reclamation's Water 2025 Report.

In the face of increasing water scarcity, decisions must be made about how future demands for water resources will be met, the "acceptable" strategies for addressing scarcity in short term droughts and where public investment should be made in water development, infrastructure and mitigation. In particular, water providers seek costumer preferences for water initiatives because of an implicit notion that policy decisions should also be consistent with public attitudes and preferences. After all, households are the likely source of funds for water development, firming and relocation. Do western households want water to come from agriculture? Little has been researched or written on this question.

Western household perceptions, preferences and values for water are the subject of a Colorado Water Institute survey of households (Pritchett et al 2009) that was completed in 2009 . The purpose of the study is to benchmark the public's view of many western water issues, and particular attention is focused on households' perceptions of water scarcity, how municipal households view water in agriculture and trade-offs among alternatives for meeting future water demands. Survey responses from 6,250 individuals provide several water-related themes, and a subset of these themes is discussed in this article.

Respondents first addressed short-term scarcity. It's true that the West can experience temporary (less than 2 years) water shortages for a variety of reasons such as drought or over-allocation to certain uses. During these times, there may not be enough water to adequately provide for all water uses, and respondents were asked to prioritize water demands among the eight uses listed below:

1. For the natural environment (e.g., as part of fish and wildlife habitat, forest health and other natural uses.
2. For natural resource management (e.g., in-stream management, fire suppression, stream banks and wetland management)
3. For household use (e.g., drinking, cooking, showers, laundry, dishwashing, and toilets)
4. For private landscaping (e.g., lawns and gardens for private homes and businesses)
5. For industrial use (e.g., commercial manufacturing, mining and power plants)
6. For irrigated farmland (e.g., food or energy crop production, livestock)
7. For municipal landscaping (e.g., community parks, golf courses
8. For recreation (e.g., rafting, fishing, swimming, skiing, scenic viewing)

In this ranking question, if a respondent chose a category as the top priority, it is given a weight of 3, the second most water priority a 2, the third priority a 1 and if unranked the use category received a 0.

The weights given by all respondents to a particular category are summed. The sum is divided by the sum of total weights from all categories. The result is a percentage, and the percentage represents the proportion of total weights that a category has received. The percentage is called the relative importance statistic. Figure 1 summarizes these relative rankings.

Irrigated farmland was second only to household use (not including landscape watering) as a high priority among the eight categories. Note that the column bars sum to 100 percent, so the priority of one use may be measured relative to another. The lowest priorities are found for municipal landscaping and for recreation.

Respondents were then asked to choose among strategies to alleviate short-term scarcity. Options to rank 1st, 2nd , or 3rd included:

1. Restricting the amount of water that can be used on private lawns and landscapes.
2. Restricting the amount of water than can be used on public landscapes (e.g., parks and golf courses
3. Permanently transferring water from farms to the city.
4. Temporarily renting water from farms to the city.
5. Restricting the amount of water that can be used by industry (e.g., commercial manufacturing, mining or power plants).
6. Draining reservoirs and lakes.
7. Increasing water rates (bills) paid by private households.
8. Putting a limit on water projects that help protect wildlife and fish habitat.

These responses are summarized in Figure 2 using the relative importance statistic.

Consistent with the priorities of the previous question, respondents dislike transferring and leasing water from agriculture, but instead prefer restricting outdoor watering on public and private landscapes. Given the responses in Figures 1 and 2, it appears that households would prefer to meet short-term scarcity without impinging the performance of irrigated agriculture.

Respondents are also keenly aware of the potential for long-term water scarcity. In contrast to short-term water strategies, the opportunities to develop water for long-term use are more capital and construction intensive and require longer term planning. Opportunities include:

1. Reusing waste water on private lawns and landscapes (e.g., homes and private businesses)
2. Reusing waste water on public landscapes (e.g., parks and golf courses)
3. Building reservoirs and other storage projects
4. Limiting the growth of cities to a level that is supported by a sustainable water supply.
5. Requiring that households take steps to conserve water (e.g., use low-flow toilets)
6. Constructing pipelines
7. Reusing waste water, after it is treated, for use within the home.
8. Buying water from farmers

The first, second and third best option for meeting long-term water needs were ranked by survey respondents as indicated in Figure 3.

Buying water from farms is the least desirable alternative among the long-term strategies that include reusing water in various forms, limiting growth and building storage projects. Notably, the question does not include a location for alternatives; thus survey respondents might not support reservoir construction near their home or in an ecologically sensitive area.

The previous discussion suggests that households value water in agriculture, but are these households willing to pay a fee to this end? To gain insight, respondents were asked whether they were willing to pay a fee—which varied randomly across respondents from $5 to $25 in five-dollar increments—on their water bill during the

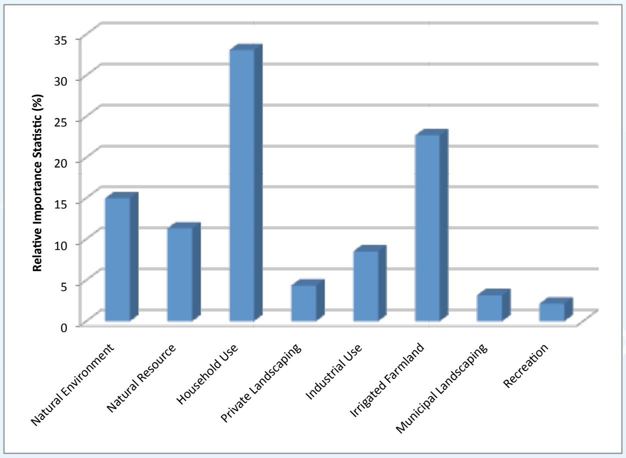

Figure 1. Relative priority rankings for water use in short-term scarcity.

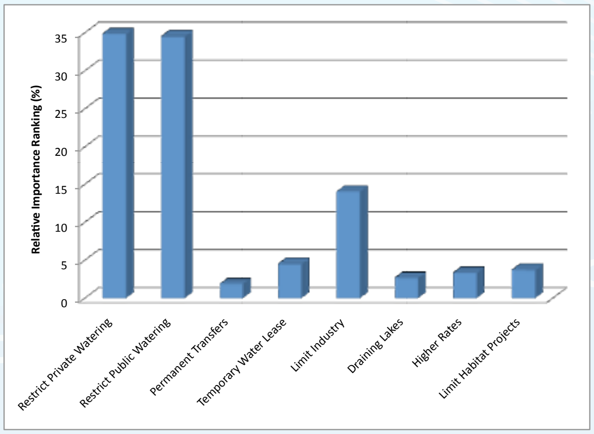

Figure 2. Relative rankings of strategies for meeting demand during short-term scarcity.

By 2030, an estimated 33 million additional people are projected to be living in the West, requiring approximately 30 billion more gallons of water for consumption (Western Governors' Association, 2006).

summer months to fund programs designed to increase the supply of water and reduce the demand for water. Respondents were told this fee would be used to support eight such water initiatives, but the cost of the eight initiatives and how the fee might be divided among these initiatives was not specified. Mores specifically the question asked:

> "Water providers might consider increasing water rates in order to find new sources of water, to pay for water conservation programs, or to help with problems that may arise as water is shifted to cities from other areas. Would you pay an additional $___ per month on your water bill during the summer months if the fee was divided among the following programs?"

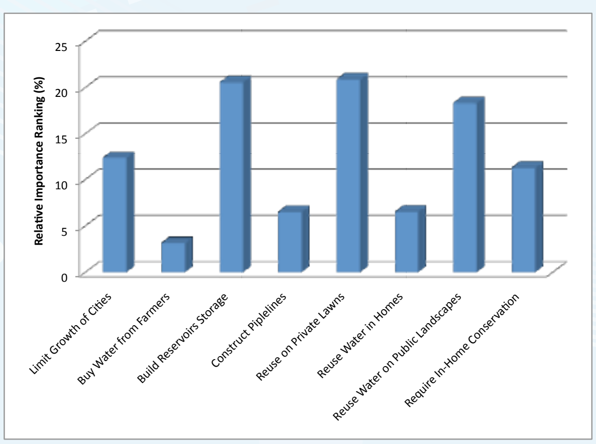

Figure 3. Relative ranking of long-term water strategies by survey respondents.

1. To implement programs and technology to reduce household water consumption.
2. To construct a reservoir for water storage.
3. To create a system to reuse household waste water for watering public landscapes.
4. To set aside water for wildlife habitat in and around nearby streams.
5. To help keep irrigated farms in production.
6. To make infrastructure improvements in rural communities as compensation for water being transferred to cities.
7. To set aside water for public water-based recreation.
8. To provide subsidies on water-efficient appliances.

Just over half (52.1%) of all respondents stated a willingness to pay a fee on their summer water bill in support of eight listed programs. What drives the decision to pay the water fee? Insight comes from a statistical procedure described in Thorvaldson, Pritchett and Goemans (2010). Simply put, the size of the fee tends to decrease the likelihood of a decision to pay. Homeowners are less supportive of the fee than renters, and households with higher incomes are more likely to support the fee. Attitudes of the respondents toward growth also make a difference. If respondents' agree that new growth and development should pay for its own water resources, they are less supportive of the fee. Nearly a quarter of respondents list either "Increase fees on new homes and new housing developments" or "Increase water rates for new housing developments" as their first choice for funding new water supplies. These respondents' couple land use planning and water resource planning. A pair of strategies might assist in confronting water scarcity—encouraging voluntary restrictions on water use, and the implementation of regional planning. Respondents that supported voluntary restrictions generally did not want to pay a fee in support of the eight initiatives. In contrast, respondents encouraging regional planning of water resources supported the administration of a fee. The opposing results might be grounded in perceptions of individual vs. collective responsibility. Households who feel that water restrictions should be voluntary rather than mandated by the government may not see water scarcity as a problem that will affect them, or if it does affect them, they desire independence in addressing the issue. In contrast, households who feel that regional planning is needed to address water scarcity likely recognize that water scarcity is an issue that will affect everyone and that the best solutions will likely need to involve entire communities.

Simple demographics also play a role in support for the fee. The longer a resident has lived in the West, the less support exists for the fee. Although there is little correlation between the length of time a respondent lived in the West and an awareness of water scarcity, if newer residents to the West are perceived as having a diminished sense of water scarcity, this could further perpetuate the general view that newer residents to the West should bear a greater portion of the burden of securing water supplies for the future.

Homeowners were less likely to give a "yes" response to the fee, perhaps because homeowners are more likely than renters to have greater awareness of water use and costs, and may thus be more sensitive to increasing fees. Moreover, because some renters do not pay a separate water bill, they may not have to bear the burden of a water fee, at least in the short term. Thus, it may not be that renters are more supportive of the fee so much as they are less likely to have to pay the fee and are thus less opposed to it.

The age and income of respondents explains the willingness to support a fee to fund water initiatives. The youngest category of respondents and the oldest respondents tend to support the fee, a finding consistent with Deller et al (1997)—who found that younger individuals and retirees are more likely to support economic development efforts—which may be due in part to older individuals having higher discretionary income. Indeed, higher levels of household income increased the likelihood that a respondent would support the fee. Income also tended to influence the decision to support the fee more than other demographic and attitudinal variables, perhaps suggesting that higher income households can share a larger burden of supporting water initiatives, a revenue-generating model that is consistent with property tax collection to support public utility efforts and progressively-tiered water rates.

Respondents were then asked to allocate the fee across the eight programs in any way they wished, even if they did not support the fee. The average allocations are shown in Table 1. It is striking that, while much of the water policy literature emphasizes the need for demand management and a reallocation of some water from existing uses, respondents prefer to allocate the largest proportions of the fee toward reservoir construction and keeping irrigated farms in production. It may be that these two activities are perceived as benefitting a greater portion of the population.

Averages are just one of many ways to describe respondents' preferences for allocating the proposed water fee. Additional insight can be provided by determining the number of respondents that allocated the majority of the fee toward one particular program, and the number of respondents that allocated 100 percent of the fee toward one program. These data are also displayed in Table 1, and while largely in agreement with the average allocations, there are a few exceptions, namely among those respondents who seek to devote all of their fee to water efficient appliances. Once again, households seek to keep irrigated farms in production.

Conclusions

Water scarcity will increase in the West in no small part due to increasing demands for a resource that is already largely appropriated. Reallocation of water resources is likely, but these results suggest that municipal households would prefer that irrigated agriculture remain vibrant. This is of practical importance to water managers seeking to acquire resources and to the rural communities who find irrigated cropping is an important base industry. A logical next step is to develop innovative water sharing opportunities

Table 1. Average Fee Allocations among Eight Water Programs

Program	Average Allocation	# of Respondents Allocating Majority of Fee to Program	# of Respondents Allocating 100% of Fee to Program
Construct a reservoir for storage.	17.2%	902	82
Keep irrigated farms in production	16.2%	710	83
Create a system to reuse household water for public landscapes.	16.2%	638	70
Implement programs to reduce household water consumption.	13.9%	471	45
Set aside water for wildlife habitat in nearby streams.	12.1%	165	43
Provide subsidies for water-efficient appliances	10.9%	237	84
Make infrastructure improvements in rural communities	6.9%	59	22
Set aside water for public based recreation.	6.6%	37	17

between agricultural and urban interests. Examples of water sharing are limited in the West, but include the use of interruptible supply agreements, rotational fallowing that spreads lost economic activity over a greater geography and time, and innovative water exchanges.

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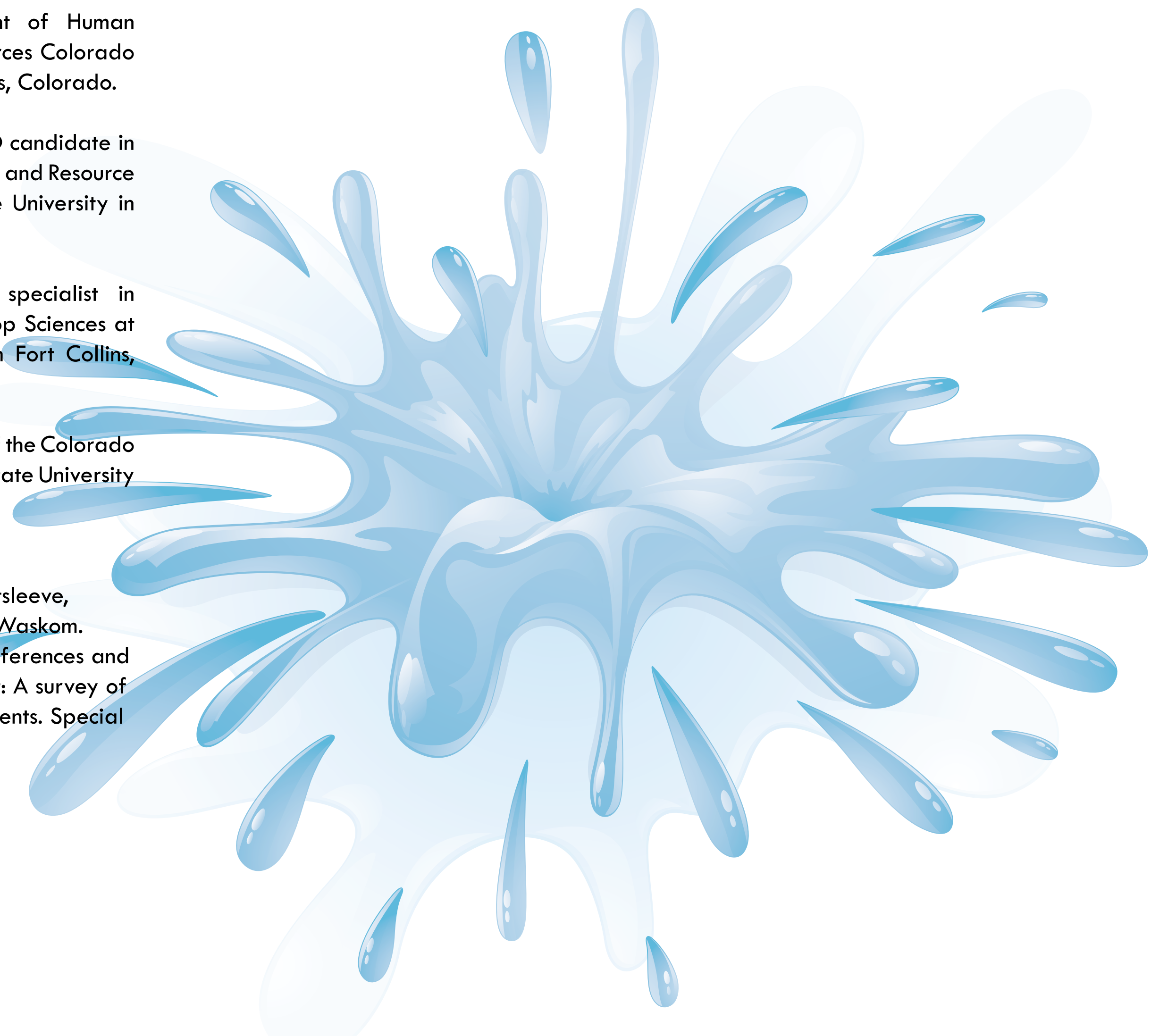

HYDROLOGICAL IMPACTS *of* Traditional Community Irrigation Systems *in* NEW MEXICO

BY ALEXANDER G. FERNALD,
STEVEN J. GULDAN,
AND CARLOS G. OCHOA

This article compiles recent research results to describe new perspectives on hydrology of traditional community irrigation systems (Figure 1). In New Mexico, these irrigation systems have been in use for centuries, and at least 800 operating ditches exist in the state (OSE, 1991). For the most part, these are unlined earthen canals and convey water to fields that are flood irrigated. Studies have shown that these two aspects can result in significant amounts of water that seep out of the bed and banks of the ditch and below root zones in crop fields, particularly if ditches and fields are composed of sandy or coarse soils (Ochoa et al., 2007). Historically, some water managers have considered this seepage as water that is lost and have encouraged irrigation water delivery and application methods that minimize seepage. Many community ditch irrigators and residents, however, recognize benefits from this seepage: recharging groundwater, keeping shallow wells functioning, and supporting riparian vegetation along the ditches and fields. In situations where it is difficult to have enough flow in the ditch to adequately deliver water to all irrigators, ditches can be lined with impervious materials such as concrete, plastic, or other materials. Where availability of irrigation water is low for individual irrigators or an entire community ditch, sprinkler or drip irrigation methods can be used to conserve water at the field scale.

Our research indicates that in some community ditch-irrigated landscapes, a large-scale reduction in irrigation seepage may lead to unintended negative effects on local aquifers and river flows.

Figure 1. Two traditional community irrigation ditches.

Research on the Hydrology of Community Irrigation Systems

In order to better understand the hydrology of community irrigation systems (Figure 2), in 2002 we began studying water flows in one community ditch system, the Acequia de Alcalde, located in the northern portion of the Espanola Valley in north central New Mexico.

Study results indicate that two key hydrologic functions are provided by these irrigation systems: contributing to shallow aquifer recharge; and providing groundwater return flow to the river. Measurements of shallow groundwater showed that during the 2007 irrigation season, the water table rose about two feet (0.6 meter). Also, a significant amount of this transient water table rise remained past the irrigation season, and because the river is gaining flow from the connected shallow aquifer, it was assumed that this additional water would become return flow to the river. Of river water diverted into the Alcalde community ditch, an average of 33% returned to the river as groundwater return flow—12% originated as seepage from the ditch and 21% originated as seepage from the irrigated fields (Figure 3).

These results indicate that large flows are rapidly being exchanged between the river, irrigation system, and fluvial aquifer.

Past and Present Hydrograph

Prior to large human impacts on parts of the upper Rio Grande, natural features of the river basin resulted in spring snowmelt and storm event runoff being held upstream. These features included river channel meandering, flooding, and even beaver dams. Surface water held upstream would seep into the soil and slowly make its way towards, and then enter, the river as groundwater return flow. During the last two centuries, human alterations and impacts to the river and river flow that counteract these natural features and processes included channelization, levee construction, and beaver trapping.

Aquifer and river connections function to supply stream flow, and the traditional irrigation systems appear to maintain these connections in the upper Rio Grande. Our research indicates that in some community ditch-irrigated landscapes, a large-scale reduction in irrigation seepage may lead to unintended negative effects on local aquifers and river flows.

Figure 4 illustrates a simulation using a system dynamics model, under a scenario in which there are no diversions into community irrigation ditches (as would be the case, for example, if fields are no longer used for irrigated agriculture). In this hypothetical situation, there is less recharge of the aquifer, and so less groundwater return flow to the river. The current irrigation systems actually conserve water by keeping it underground, and the water that seeps from fields and ditches is stored temporarily then released into the river. We have termed this phenomenon "hydrograph retransmission" in which river runoff is stored and released later in the year (Fernald et al., 2010). The spring snowmelt hydrograph is delayed, and much like beaver dams of the past, this storage and release function provides water to downstream users during drier periods when it is most needed.

Water Quality and Riparian Benefits

In addition to effects on water quantity, research has shown that seepage of irrigation water in these systems is beneficial to water quality and riparian vegetation. In one study, water analyses show that ditch and crop field seepage dilute nutrients and salts in resident groundwater, improving the quality of water drawn from shallow wells (Helmus et al., 2009). In another study, it was found that cottonwood poles planted near the ditch survived and were successful, indicating that there is sufficient lateral seepage from the ditch to support riparian plantings (Cusack, 2009). These ditch-side areas could be used to provide additional valuable habitat for wildlife.

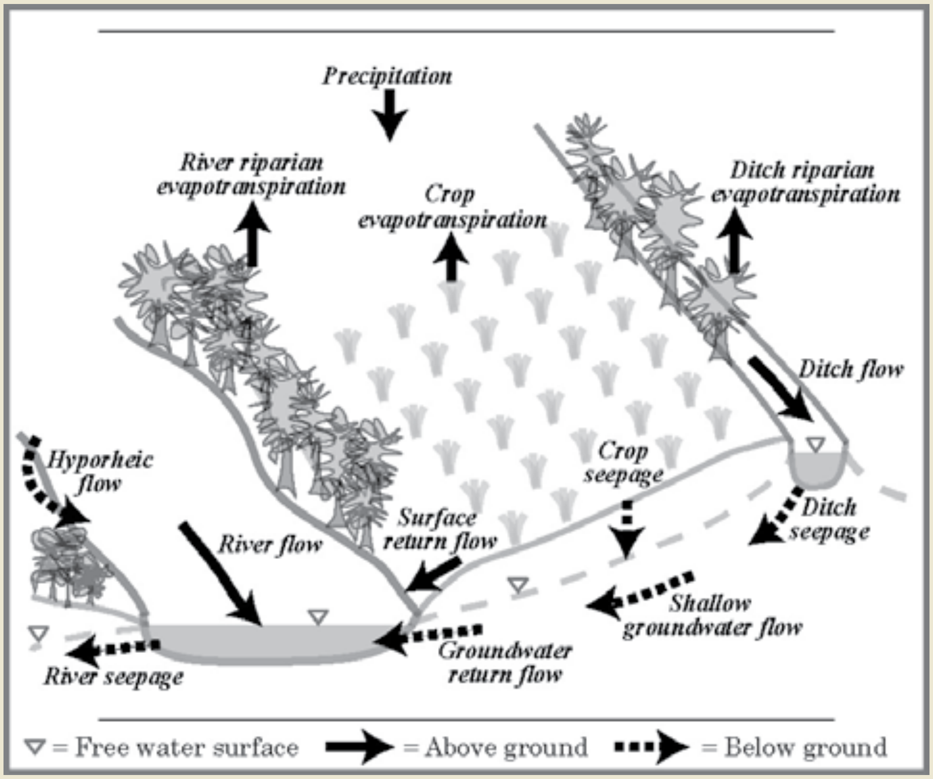

Figure 2. Water flows (indicated by arrows) in a typical irrigated agricultural river valley. Relative magnitudes of flows vary by time and location.

Conclusions

Besides providing for agricultural production, traditional community irrigation systems in New Mexico provide critical hydrologic functions that may be lost if significant amounts of water are transferred out of these systems to non-agricultural uses. Research indicates that a significant amount of water being diverted into the valley irrigation systems returns back to the river. Through seepage into the shallow aquifer, storage in the aquifer for 1-3 months, and then release to the river as groundwater return flow, these systems effectively take spring and summer runoff from the river and retransmit this flow to the river later in the year. ■

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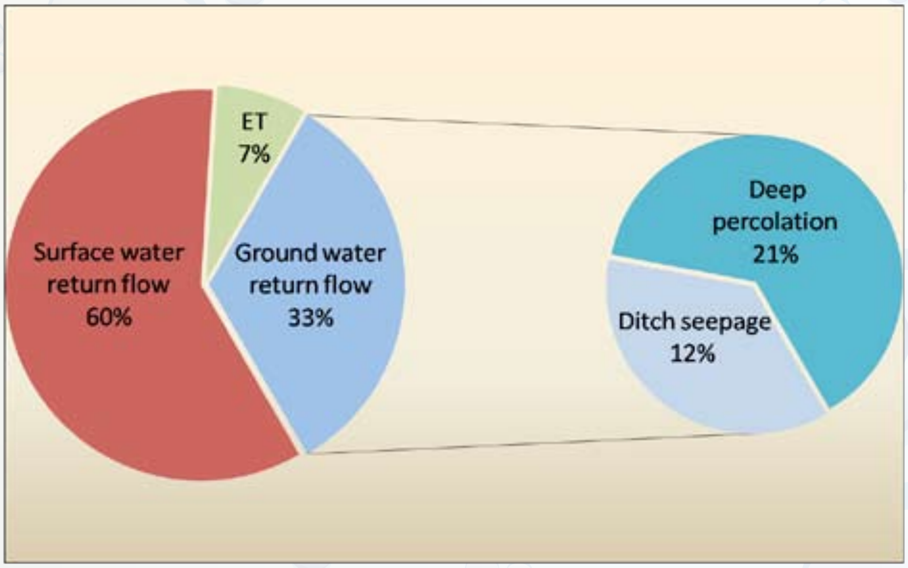

Figure 3. Three-year averaged water budget of the Alcalde community ditch.

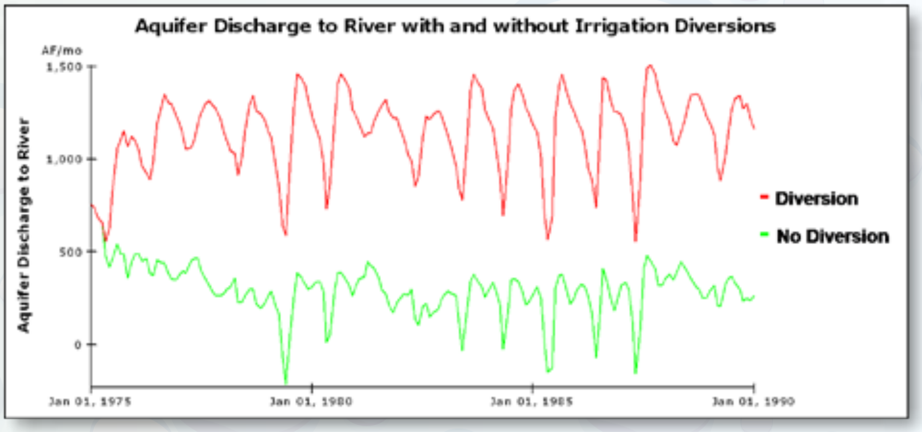

Figure 4. Effects of diversion on groundwater return flow to river. This figure is posted ahead of print (with permission from the American Society of Civil Engineers) (Fernald et al., 2010).

Constructed WETLANDS FOR Wastewater TREATMENT AND AS Landscape AMENITIES IN *Rural Communities*

BY GARY AUSTIN

Unlike conventional facilities in cities, sewage treatment in rural towns can take advantage of biological methods. This kind of treatment is less expensive to build, operate and maintain for towns with populations of a few thousand people.

Small communities have the opportunity to take a multi-functional approach to gaining water quality, open space and recreation benefits when they need to expand or upgrade their sewage facilities to meet more stringent quality requirements. Unlike conventional facilities in cities, sewage treatment in rural towns can take advantage of biological methods. This kind of treatment is less expensive to build, operate and maintain for towns with populations of a few thousand people.
Conventional sewage treatment requires large inputs of energy and chemicals. These systems are always more expensive than the "natural" treatment systems that depend on gravity to move water while gravel filters, microorganism and plants clean it (Kadlec, 2009). Design, engineering and assessment of biological treatment of sewage has advanced dramatically in just the last 15 years. Now these methods can be confidently applied to institutions like schools, residential subdivisions as well as small communities, in both warm and cold winter climates.

There are really two wastewater treatment goals. The first is protecting human health and the second is cleaning water enough to discharge into the environment without harming the ecosystem. This article advocates that the final treatment step employ a pond type wetland to add scenic, wildlife and recreation benefits to the practical need to clean wastewater.

Primary Wastewater Treatment

Biological wastewater treatment requires pretreatment (primary), secondary and tertiary stages. The first stage is very simple. It involves a screen followed by a set of tanks or ponds that let the water sit so the solids can settle out. The solids (sludge) are periodically collected for disposal either in a landfill, an incinerator or methane digester. Sewage lagoons that are common to rural towns can be designed or upgraded to provide primary treatment by providing 108 square feet (10m2) per person. They are not very effective at removing some contaminants nor are they aesthetic elements, but can be upgraded by adding a planted gravel filter dam at the outlet to greatly improve water treatment (Steinmann and Melzer, 2003). Of course, public access to sewage lagoons must not be allowed due to unhealthy water quality.

Primary treatment really is a treatment step, since it improves the water quality by about 50%. Enormous populations of bacteria consume the waste even though there is typically no oxygen or light present. The primary tanks or ponds should have two or more chambers and filters to prevent suspended solids from entering the next stage.

Secondary Treatment

The secondary treatment stage in a biological system uses a constructed wetland to continue the purification process. In this stage removal of biological oxygen demand (BOD) and total suspended solids (TSS) are the two main EPA standards. In raw sewage they can both be 300 mg/L (milligrams per liter) or more, while at the end of secondary treatment they must not exceed 30 mg/L.

Oxygen is used by living organisms and to breakdown organic and inorganic matter. If the BOD demand is too high, it removes the oxygen that fish and microorganisms in the natural environment need to survive. It is also a rough measure of microbes (including disease causing ones like viruses and E. coli, etc.) in the wastewater. TSS are organic or inorganic particles that make the water cloudy and more importantly serve as sites for harmful bacteria to grow.

There are options for the secondary treatment stage. The common choices are a free water surface flow wetland (FWS), a horizontal subsurface flow wetland (HSF) and a vertical subsurface flow wetland (VSF). The HSF is the most common type in the U.S. but there are many FWS wetlands too. Communities would choose one or another based on local conditions, such as availability of materials, the winter temperatures and the stringency of water quality standards.

Free Water Surface Flow

The free water surface wetland is a series of marsh and open water cells that are heavily planted with wetland plants. As the water flows through the vegetation, bacteria growing on the plant stems and the soil surface clean the water.

Figure 2 shows the plan of a FWS wetland (in addition to two subsurface wetland cells). The FWS and the HSF are equally effective at meeting secondary treatment standards according to recent analysis of hundreds of wetlands (Kadlec, 2009). For secondary treatment public access and perhaps animal access to the water in the FWS wetland must be prohibited. There is also the problem of mosquito control and some problems in locations that experience severe winters. In severe winter areas of northern U.S. and southern Canada the size of the wetland may need to double to achieve the required standards during winter. Monitoring of existing wetlands has established a sizing rule of thumb. The area required for a FWS or HSF wetland to accomplish secondary treatment is 54 to 48 square feet (5-4.5 m2) per person (Cooper, 2009). This equals about one acre for every 850 people the system serves. For accurate wetland sizing matched to the target contaminants or nutrient reduction communities need to consult an environmental engineer.

Horizontal and Vertical Subsurface Flow

Another wetland treatment choice is the subsurface flow (HSF) type where water flows through a bed of gravel planted with cattail, bullrush or other wetland plants. The HSF wetland is about three times more costly to install than the FWS type (unless the FWS is enlarged to accommodate a cold climate).

About 50 square feet of the horizontal flow gravel bed per person served is required to meet EPA secondary treatment standards in summer and winter (Vymazal, 2005). The HSF wetland is less sensitive to cold weather than the FWS and is easier to insulate. A Minnesota HFW is insulated with 6” (15 cm) of mulch to protect it from freezing at temperatures as low as -45°F (Kadlec, 2009). In Norway HSF systems preceded by a buried bio-filter have proven to be very effective (Jenssen et al., 2005).

In the subsurface flow wetland there is no standing water on the surface, so there is no odor or contact hazard, but, like the FWS wetland, the bed is densely planted making it an open space feature. The water flows slowly through the gravel that is 12”-18” deep. Beneficial bacteria growing on the gravel and roots consume many contaminants in the water. Several factors are critical to the effectiveness of subsurface flow wetlands. The plant roots must reach all the way to the bottom of the bed. If they do, then the amount of ammonia removed will be greatly increased (Vymazal, 2005). If water can flow below the roots the amount of ammonia can actually increase. The horizontal subsurface flow wetland is very effective at reducing biological oxygen demand and total suspended solids and moderately able to convert nitrates to nitrogen gas but is ineffective at converting ammonia to nitrate and removing phosphorus. Secondary treatment can be accomplished if the water moves through a gravel bed for two days. Three days of residency time is generally required to achieve the maximum removal of pathogens.

There are two kinds of subsurface flow wetlands (Figure 1). In one the water flows horizontally through the gravel bed while in the other the water drains vertically through the bed. Either method can be used to meet secondary treatment goals but in combination they begin to achieve tertiary goals too.

The vertical subsurface flow (VSF) wetland receives periodic doses of pretreated water over its entire top surface. Then the water flows down through the gravel and out of the wetland through a bottom drain. Air replaces water in the gravel pore spaces after it flows through. This system creates an oxygen rich environment where bacteria reduce BOD, TSS and convert ammonia to nitrates. VSF wetlands require only 21.5 square feet (2 m2) per person but they do require energy input, pumps, and more regular attention from an operator (Tuncsiper, 2009).

The VSF wetland is more efficient at removing most contaminants including, BOD, TSS and converting ammonia to nitrates but is ineffective at converting nitrates to nitrogen gas or removing phosphorus. To take full advantage of the capacity of the VSF wetland to convert ammonia to nitrates and the HSF wetland capacity to convert nitrates to nitrogen gas the two types should be used in combination. Figures 1 and 2 show a configuration that would be very effective for secondary and some tertiary treatment.

Tertiary Treatment

Once the primary threats to human health are addressed in secondary treatment, attention shifts to nitrogen and phosphorus that harm aquatic environments when they are in excess. Ammonia (a type of nitrogen) is toxic to fish and shellfish and should be reduced to 0.26 mg /L if shellfish are present or 1.8 mg /L if they are absent (EPA. 2009). Nitrogen, especially as nitrate is toxic to fish, other aquatic life and people. The standard for drinking water for babies is 1.0 mg/L (10 mg/L for adults).
As illustrated in Figure 2, a sequence of low oxygen (HSF), high oxygen (VSF), low oxygen (HSF) and then high oxygen FWS environments can be provided by a series of wetlands and ponds (Langergraber et al,, 2009; Tuncsiper, 2009) to achieve high reductions in BOD, TSS, ammonia, nitrates, coliform bacteria and total nitrogen.

An ammonia removal rate of 97% and a total nitrogen removal of 61% were achieved by a horizontal and vertical subsurface flow wetland configuration similar to that shown in Figures 1 and 2. Note that water from the vertical flow wetland is pumped to the horizontal flow wetland to complete the nitrogen conversion process (Vymazal, 2005).

Phosphorus is often the most difficult EPA nutrient standard for conventional and biological sewage treatment to meet since a small amount has a large negative impact. Only about 60% of phosphorus is removed by subsurface flow wetlands unless the gravel has high calcium, manganese or iron content, in which case 90% removal is possible (Jenssen et al., 2005). Providing these instead of locally available crushed rock could add significant installation costs. Exacerbating the removal problem is the excessively high loads of phosphorus in raw sewage. The county of Spokane, Washington, banned dishwashing detergent with more that .05% of phosphorus. After one year this has resulted in a 14% reduction in phosphorus in the main sewage treatment plant outflow (Murphy, 2009). Fertilizer is another major source of phosphorus that impacts natural streams and lakes but it is often unregulated.

High Water Quality and Landscape Amenities

In the sequence shown in Figure 2, the marsh and pond stages are the most multi-functional. These constructed wetlands are usually square or rectangular to make engineering calculations and construction simple. However, a little extra effort could greatly improve their aesthetic value (Figure 2) and provide communities with added benefits including:

1. Tertiary polishing of the water

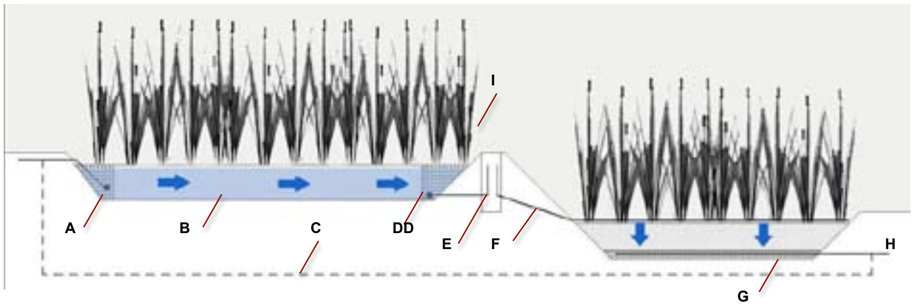

Figure 1 - Horizontal Subsurface Flow Wetland (left), Vertical Flow Subsurface Wetland (right)
A – Inlet from septic tank; B – Horizontal flow through medium to fine gravel; C – Recirculate 50% of flow from VSF to HSF wetland for denitrification; D – Collection zone, coarse gravel; E – Water level control; F – Intermittent dosing of VSF; G – Water drains vertically through gravel to bottom drain; H – Outflow to free water wetland; I – Dense planting. For the plan view of the HSF and the VSF wetland see Figure 2.

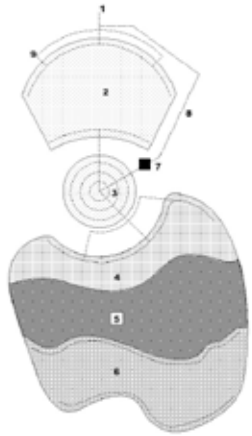

Figure 2 - Wetland System Plan
1 – Inlet from septic tank or lagoon; 2 – Horizontal subsurface flow wetland; 3 – Vertical subsurface flow wetland (drains vertically through gravel to bottom drain); 4 – Deep marsh (18" deep); 5 – Open water (4' deep); 6 – Shallow marsh (12" deep); 7 – Optional pump; 8 – Optional pipe to return 50% of water from VSF to HSF wetland for denitrification; 9 – Distribution, inlet and outlet pipes. All zones are densely planted except for the open water zone.

from the subsurface wetlands (especially phosphorus reduction).

2. Water quality that is high enough to support fish and a wide range of aquatic organisms and terrestrial wildlife. This capability along with high visual character attracts people too.
3. Trails around or boardwalks over the free water wetland shown in Figure 2 would provide opportunities to educate with fish and wildlife interpretive signs, to walk or bicycle and to picnic on the adjacent lands.
4. Water that is clean enough for human contact and reuse for irrigation and fishing. However, additional purification would be necessary for swimming, reuse in buildings, and especially for drinking.

Compact High Rate Systems

In addition to the subsurface and free water wetlands discussed above, another biological treatment option is available to small communities. This is a high rate, compact treatment system invented by John and Nancy Todd. The proprietary names of the system are Living Machine™ and Eco Machine™. The Todd's used the same natural purification process discussed above but utilized a wider range of bacteria, microorganisms, snails and plants in tanks within a greenhouse. The greenhouse keeps air and water temperatures high and allows tropical and subtropical plants to flourish as you can see in the image of the IslandWood Living Machine™ on Bainbridge Island, Washington. This system requires more energy for water and air pumps, winter heating and lighting. The most recent project designed by John Todd is the Omega Center for Sustainable Living (http://www.eomega.org/omega/about/ocsl/) in Rhinebeck, New York. The system is capable of treating 52,000 gallons of wastewater per day using a sequence of septic tanks, a subsurface horizontal flow wetland, an interior aerobic lagoon and a re-circulating sand filter. While installation, operation and maintenance costs are higher for this system than others presented here, the amount of land required is small. The cost is competitive with traditional sewage treatment plants for small communities but eliminates chemical and some energy inputs required of conventional systems. In warm climates, where solar panels are incorporated, or where municipal infrastructure doesn't exist this natural process system is very attractive. The environment inside the greenhouse is very pleasant and can be designed to serve more than the engineering function, as you can see by visiting the Omega Center website.

Conclusion

Biological wastewater treatment systems have improved significantly during the last 15 years. The design and engineering of new systems feature reliable, low cost secondary and tertiary water quality. The landscape characteristics of the systems make them features in rural communities rather than infrastructure blight. The streams and ponds can be integrated into the community park or greenway system to enhance the character and quality of life.

About the Author

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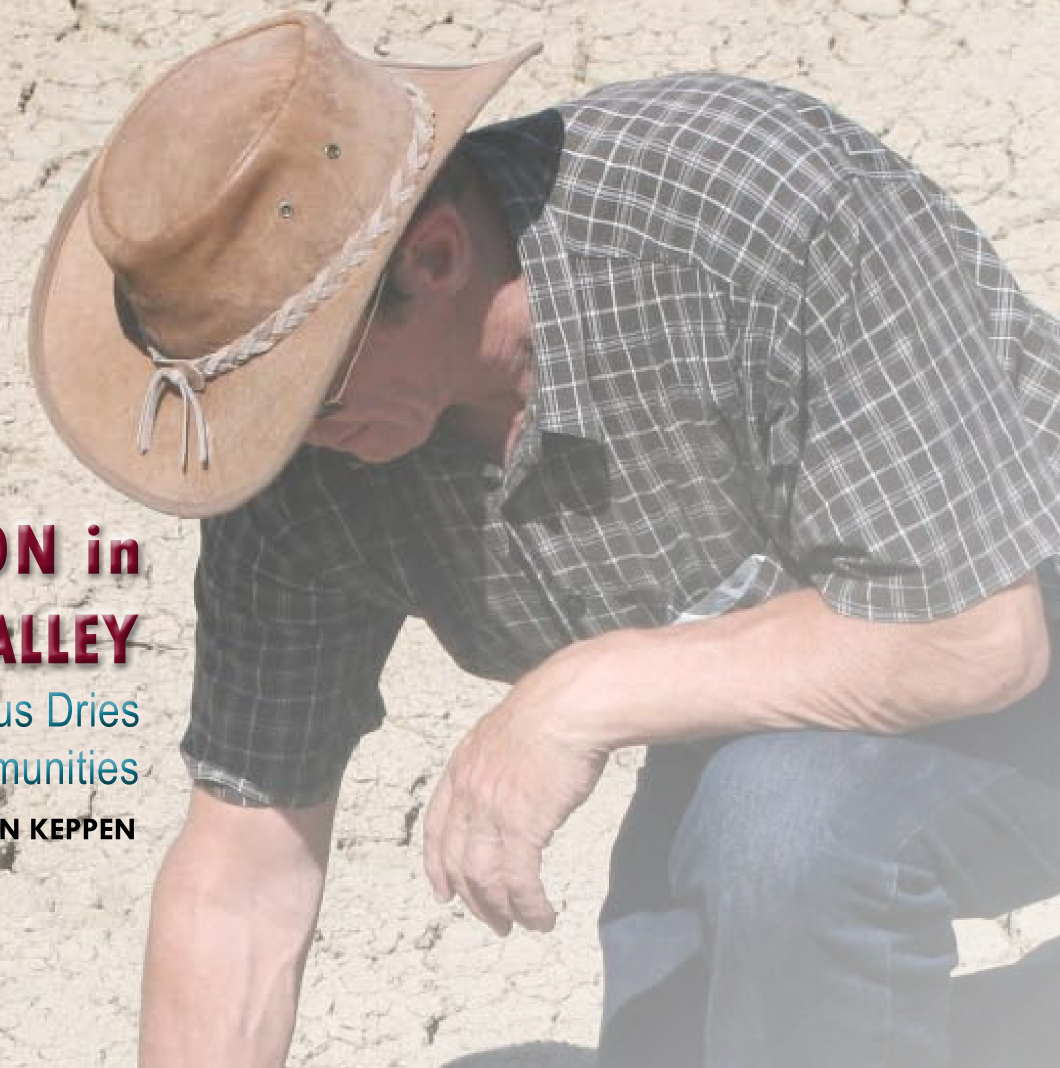

TUNNEL VISION in the CENTRAL VALLEY

Narrow Regulatory Focus Dries up Western Rural Communities

BY DAN KEPPEN

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Introduction

Western agriculture has become one of the most highly regulated industries in the world. Over the past few decades, the Clean Water Act (CWA), Endangered Species Act (ESA), and a host of other statutes have significantly impacted irrigation water supplies. Water beneficially used for decades by farmers is now being taken to meet the asserted needs of species listed under the ESA without any due process. These federally mandated reallocations have had significant adverse impacts on the West and its ability to meet the challenges of competing demands for water supplies. The increasingly complex federal regulatory structure, and the increasingly expensive and protracted processes which this structure encourages, makes obtaining and sustaining water supplies increasingly difficult on both agricultural and municipal users alike. For the farmer or rancher, the current water allocation and reallocation schemes often create economic conditions, a sense of disillusionment and resignation, and uncertainty. Nowhere is the uncertainty of water supplies greater than in California's San Joaquin Valley.

Impacts to Rural Communities

Severe water shortages caused by the combination of federal fisheries restrictions and drought on water supplies to the western side of the Valley forced hundreds of thousands of farmland to be fallowed last year. University of California experts estimate that the combined effects of these restrictions on the water supply have cost Central Valley agriculture nearly $1 billion in lost income and more than 20,000 lost jobs. In 2009, water users that depend on the federal Central Valley Project (CVP) received only 10% of the water they contracted to receive, the lowest allocation in the history of the project. Without these federal restrictions, the allocation would have been 30%. Earlier this year, the U.S. Department of the Interior announced an increased allocation of water for south-of-Delta CVP agricultural water service contractors in 2010 to a whopping 25% of their contract.

A Call for Sound Science in Agency Decision Making

The Family Farm Alliance—a grassroots organization representing farmers and ranchers in the 17 Western states—in July 2009 filed a lawsuit in federal district court challenging the science and decision-making used by the federal government to justify taking water away from farmers and letting it flow out through the Golden Gate. The Alliance challenged a "biological opinion" issued by the U.S. Fish and Wildlife Service (USFWS), which said a 3-inch fish, called the Delta smelt need that water. This marked the first time since the Alliance was formed over 20 years ago that it has filed a lawsuit, and this action was not taken lightly. In December 2008, attorneys for the Alliance raised concerns with the adequacy of the scientific data used to develop the opinion to the attention of the government, using the federal agency's own administrative procedures to seek correction of the opinion. The government refused to address the problems that were raised or correct the opinion. The Alliance was forced to file the lawsuit to compel the government to respond.

The Alliance wants the court to order the government to revise the opinion to comply with the fundamental requirements of the ESA and the Information Quality Act (IQA) regarding the quality, objectivity, and integrity of scientific decision-making by federal agencies. Among other reasons, the mandated Independent Peer Review of the smelt biological opinion was not performed properly under the ESA. The Alliance also believes the biological opinion is based on assumptions and speculation, not actual scientific data. For the past 15 years, federal regulators have ordered more and more stringent restrictions on the water supplies pumped through the Delta to serve California's farms and cities. But instead of showing any benefit from these measures, the populations of delta smelt and other fish have continued to decline.

Many Stressors, One Regulatory Focus

There are many reasons for the decline in the fish population that are not related to the water pumping that are being ignored by the government, including urban water pollutants, increases in non-native fish that feed on the smelt, and climate changes. Predation of juvenile salmon by other fish species is especially troublesome. Predators are killing nine-out-of-ten juvenile salmon before ever reaching the Delta. Nearly one million striped bass live in the Delta and the watershed and catch of large-mouth bass has quadrupled since the 1980s. Both are non-native fish that prey on young salmon and smelt. Research last year estimated that striped bass consumed 21% to 42% of endangered winter- and spring-run juvenile salmon, respectively. Other studies show the water projects—which have been the sole focus of federal fisheries agencies and some environmental activists—took less than 3%.

Bigger Picture Impacts

The water cutbacks that have already occurred are not increasing the populations of salmon and smelt. Further cutbacks will only serve to harm agriculture and other water users. San Joaquin Valley farmers cannot afford any more cutbacks in the water deliveries. The region cannot sustain more fallowed crops and further unemployment for the workers that will result. More cutbacks will also add to unemployment that already has reached Depression-era levels in agricultural towns up and down the Valley.

In the bigger picture, fewer crops coming out of the San Joaquin Valley will increase the need for imported fruits, vegetables, and nuts from other countries. Increased dependence upon imported produce leads to increased vulnerability to food safety problems such as toxins, exotic pests, diseases, not to mention terrorism. That is because other countries produce food ingredients that are being grown and processed under conditions that would violate our public safety standards in the U.S.

Conclusion

Water use is a critical issue throughout California and the other Western states, especially in areas served by federal water projects like the CVP or the Klamath Project. Federal involvement has grown exponentially over the past several decades through legislative enactments such as the ESA and the CWA. The increased control exerted by federal agencies through a variety of means has increasingly led to gridlock in the management of water supplies in the West. Worse – it is crippling Western rural communities supported by agriculture and once-reliable irrigation supplies.

The Alliance IQA litigation and other suits brought on by San Joaquin water users demonstrate the harm and likely continued decline of Delta smelt are due to ill conceived and misplaced regulation. Meanwhile, desperate agriculture, water, and business communities are working with elected officials to try to formulate a temporary emergency plan to restore pumping so that the economic crisis that occurred last year is not repeated again.

The time has come to stop the unnecessary harm. Now is the time for leadership at all levels—local, state, and federal—to face the challenges and create the opportunities that will define the future of the San Joaquin Valley, the Klamath Basin, and the rest of the rural West. ■

About the Author

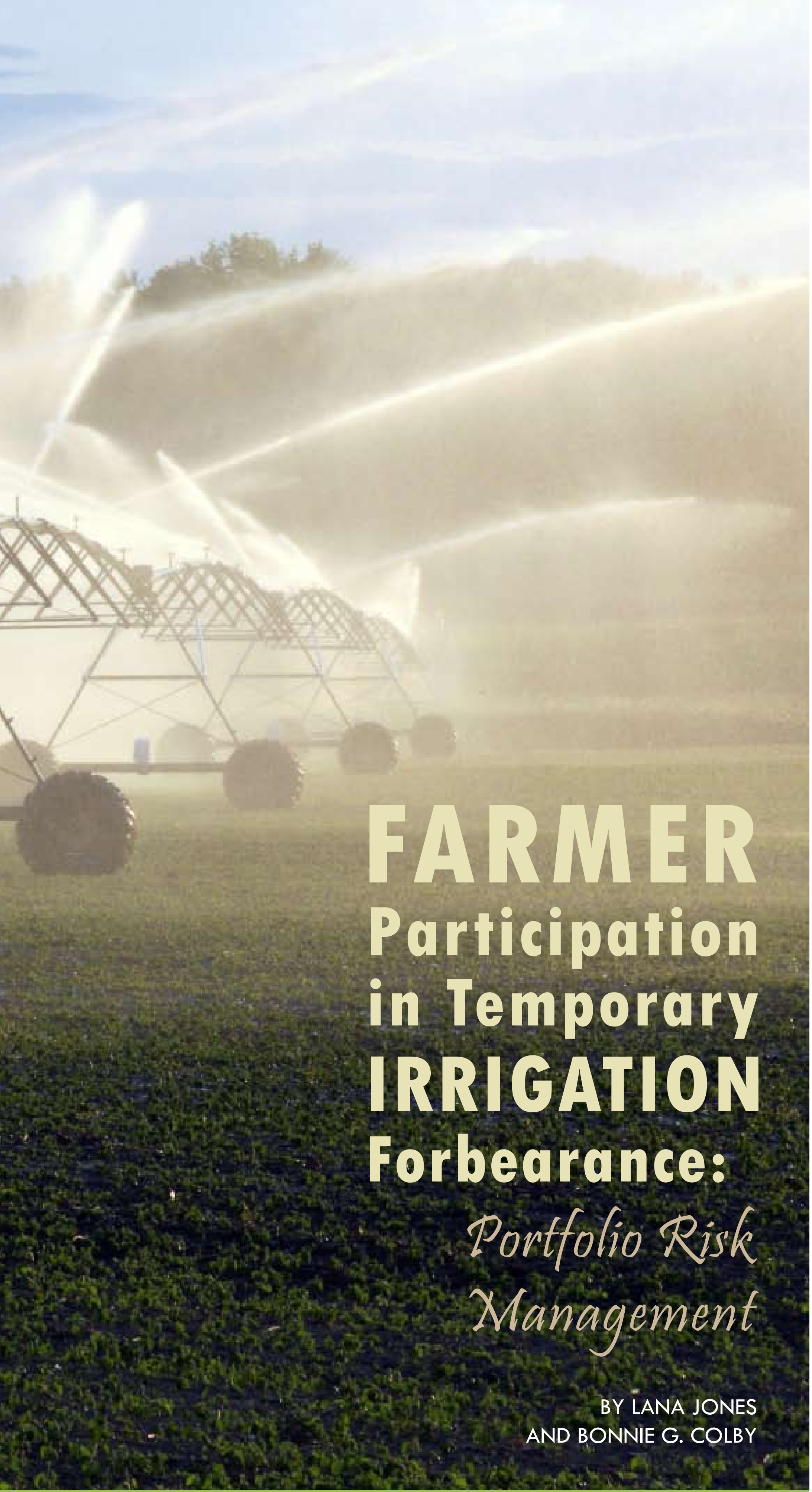
Dan Keppen is executive director of the Family Farm Alliance, a non-profit grassroots organization that represents family farmers and ranchers, irrigation districts and allied industries in 17 Western states.

Additional Resources

The California Farm Water Coalition
www.farmwater.org.
Formed in 1989 in the midst of a six-year drought. CFWC was formed to increase public awareness of agriculture's efficient use of water and promote the industry's environmental sensitivity regarding water.

Why California is Running Dry
CBS' 60 Minutes 2009
http://www.cbsnews.com/stories/2009/12/23/60minutes/main6014897.shtml?tag=co

Family Farm Alliance
www.familyfarmalliance.org
"Western Water Policy: The Challenges and Opportunities of our Times - Our Legacy for the Next Generation"
Farmer Participation in Temporary Irrigation Forbearance: Portfolio Risk Management



FARMER Participation in Temporary IRRIGATION Forbearance: *Portfolio Risk Management*

BY LANA JONES
AND BONNIE G. COLBY

Introduction

The regular occurrence of extended drought in the West, combined with future prospects of more extreme drought episodes associated with climate change, particularly in the Southwest (Seager et al., 2007), imply that interest in water transfers from agricultural to municipal and environmental uses will remain high. Cities and conservation groups continue to look to agriculture for water because farmers and irrigation districts hold entitlements to large shares of reliable water. Permanent transfers of agricultural water ("buy and dry", like those from Owens Valley to Los Angeles in the early 20th century), were once the norm (Libecap, 2007). However, temporary transfers have become more common. Temporary water transfers put a smaller financial burden on the purchaser, who may only need the water to fill in gaps in urban supply reliability or water for fish recovery programs during dry years. Temporary transfers have lower negative impacts on agricultural communities because land is not permanently retired from agriculture. A potential drawback of temporary transfers is their inability to provide long-term water supply assurance. Dry-year option agreements that span multiple years or decades can solve this problem, providing farmers with a stable stream of revenue for their participation while filling in drought-related gaps in water needs of cities and habitat restoration programs.

The terms of dry-year option agreements (DYOs) vary with local needs. Typically, the buyer (a city, conservation organization or wildlife management agency) pays farmers to enroll some of their acreage in the DYO and then pays an annual fee per acre enrolled for the life of the agreement. When water is needed, the buyer notifies farmers to refrain from irrigating their enrolled land (irrigation forbearance or fallowing) and takes delivery of the water. The buyer uses it for their purposes and participating farmers receive an additional payment based on the amount of water transferred. The allowed timing, magnitude, or number of fallowing requests is generally specified in the agreement and limited over its life.

Cropland fallowing is not uncommon in agriculture. Farmers may periodically fallow fields to build up soil moisture and nutrients, discourage pests, or participate in USDA programs, such as the Conservation Reserve Program. DYOs provide income for fallowing. The willingness of cities or conservation organizations to pay more to use agricultural water during drought than some farmers provides incentive for these agreements.

Two DYOs are currently operating in southern California. In 2005, The Metropolitan Water District and the Palo Verde Irrigation District entered into a 35-year agreement (PVID-MWD). Farmers enrolling in the program receive a one-time payment of $3,170 per acre for each acre enrolled plus a payment each year fallowing is requested. Payments start at $602 per acre and are escalated annually by 2.5% for the first five years and 2.5-5% each of the remaining 30 years (PVID-MWD, 2004). In 2003, San Diego County Water Authority entered into a similar 15-year agreement with Imperial Irrigation District (IID, 2008). Fallowing payments are based on acre-foot of water conserved instead of acre. In 2005 payments were $60 per acre-foot conserved up to a maximum of $360 per acre (IID, 2005). Unlike the PVID-MWD agreement, where landowners enroll a portion of their land for potential fallowing over the life of the agreement, eligible IID farmers apply each year. Several smaller pilot programs have occurred in western Arizona, with the U.S. Bureau of Reclamation paying irrigation districts to arrange with member farmers to fallow a specific number of acres for a year in order to provide water for instream needs in the Lower Colorado River Basin (US Bureau of Reclamation, 2006, 2008ab, 2009). Voluntary, temporary fallowing also has been used in Oregon's Klamath Basin as part of the Klamath Water Bank. That program, which began in 2001 and has operated under various names ("Demand Reduction Program" in 2001), has gone through considerable changes in order to become a more well-accepted and cost effective mechanism for making water typically used in irrigation available for fish recovery needs (O'Donnell and Colby, 2009; US Bureau of Reclamation). Such programs are likely to become more widespread, presenting farmers and irrigation districts with a new set of financial and farm management considerations to weigh.

Farmers considering enrolling in a DYO in their region will naturally want to consider what effect participation can have on the expected return and risk of their crop portfolio. There are no published studies on the effect of fallowing on crop portfolio risk although studies on the economic benefits of transferring water from agricultural to municipal uses and the value of water in agriculture abound. For example, Michelsen and Young (1993) describe DYOs from agricultural to urban uses and estimate the value of programs to municipalities. They find that dry-year options are cost effective under a variety of conditions. Michelsen and Booker (1999) estimate the cost of temporarily transferring water from agriculture to instream flows in the Yampa River Basin based on the water's value to farmers. Payments designed to keep farmers as well off as if they had used the water in production were estimated to be between $17 and $160 per acre-foot depending on the crop grown.

In this article, we complement existing research on temporary water transfers by examining how payment-supported fallowing programs affect farmers' portfolio of crop activities and risk. The approach we demonstrate here may help farmers decide whether or not to participate in such programs, and to what extent, while enabling policy makers to design fallowing programs. Programs that better consider farm portfolio and risk management strategies could prove more attractive to a broad range of farmers.

Conceptual Model

Farmers routinely encounter risks in producing crops related to: their decisions, the market, the possible return on water as an asset, and the investments they make in technology or efficiency improvements (Shaw, 2005). The USDA (1997) groups agricultural risks into five main categories: production, marketing, finance, legal, and human resources. Unpredictable weather, changing prices, the cost and availability of debt financing, tax planning, and hiring labor are among the risks that agriculture faces (USDA, 1997). See Figure 1 for a breakdown of losses reported to the Risk Management Agency of the USDA for Arizona in 2008 and 2009.

Risk preferences dictate how farmers, and all decision makers, deal with risk. People tend to apply different risk preferences to different aspects of life. For instance, a businessperson could be risk averse in managing their business assets while still enjoying hang gliding. In this article, we focus upon farmer preferences for higher-but-more-variable farm returns versus lower-but-more-stable farm returns. Risk-neutral farmers try to maximize expected or average farm returns, without taking

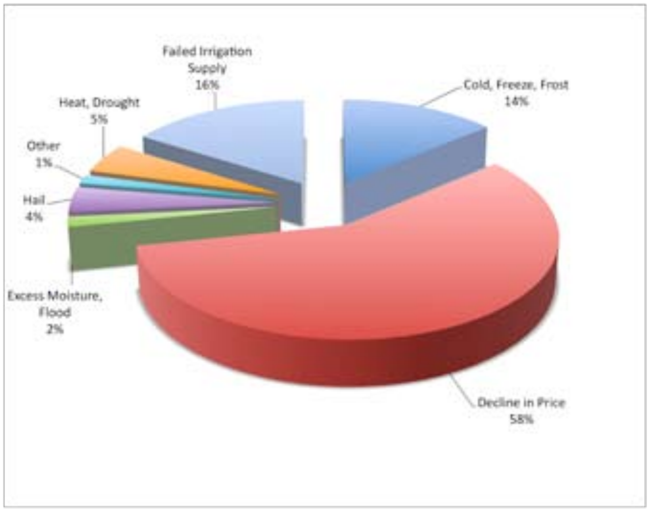


Figure 1. Breakdown of losses reported to the Risk Management Agency of the USDA for Arizona in 2008 and 2009.

the possible range, or variance, of those returns into account. Risk-averse farmers, on the other hand, would require a higher average farm return to engage in an activity that could yield a wider range of returns (Shaw, 2005). For example, a risk-neutral farmer who could produce cotton or wheat on the same field would be indifferent to the choice if they both yielded an average return of $50 per acre – even if cotton would likely yield from $0 to $100 per acre and wheat would likely yield from $25 to $75 per acre. A risk-averse farmer, on the other hand, would prefer wheat because although it has the same average return, the range of possible returns is smaller. Risk-averse farmers can reduce risk in one or more ways. They can hold on to their crops in the hope that prices will go up, for example, or diversify their operations (USDA, 1997).

Diversification of farm revenue-producing activities is a frequently suggested technique to reduce risk and income variability from year to year (Teegerstrom et al, 1997). Farmers diversify by planting different crops, combining crop and livestock production, or seeking alternate income sources. Participation in DYOs could also be viewed as a source of alternate income. DYOs may be more attractive than other forms of diversification (e.g., planting different crops), which can be prohibitively capital intensive and are subject to weather and pest risks. The diversification offered by option programs can be used as a farm risk-management tool. Since the payments are virtually risk-free once a farmer has enrolled in a program and has a contractual agreement, risk-averse farmers could benefit even if the per-acre payment were not as high as average - but uncertain - crop returns.

Diversification combines activities with varying degrees of correlation to reduce overall risk. Diversifying by growing wheat and cotton is less risky than growing cotton alone because cotton and wheat returns are not perfectly correlated. Combining positively, but not perfectly, correlated activities will reduce some risk but combining negatively correlated activities will provide the greatest risk reduction (Sonka and Patrick, 1984). The difference between positive and negative correlation is in how the two items change relative to one another. Gas prices, for example, are positively correlated with food prices – they tend to rise together in a relatively predictable pattern. Different crops may have highly correlated returns that move up and down together because of their shared reliance on weather (Markowitz, 1959). The payments from an option program, on the other hand, are fixed and so will have low correlation with crop returns. Dry-year options can offer farmers a fruitful way to reduce risk by diversification. A crop portfolio analysis is useful to examine how DYOs may benefit risk-averse farmers.

Portfolio Analysis and Results

Portfolio analysis involves combining investments in various proportions and picking the best combination based on investment criteria. In basic portfolio analyses, the decision maker is assumed to have two basic objectives: high return and low variability in that return (Markowitz, 1959). For farmers, the potential portfolio consists of revenue-producing activities such as crop production, DYOs, off-farm employment and other choices. If a risk-averse farmer were given the choice of multiple portfolios that all had the same average or expected return, she would prefer the least risky portfolio. The least risky portfolio is the one with the smallest variance, or the smallest range of probable returns. The best portfolios are those that have the lowest risk for a given level of return. In situations where a high-risk, high-return portfolio is compared to a low-risk, low-return portfolio, the specific risk

Table 1. Crop Returns, Yuma County, Arizona.

Yuma County, Arizona	2000	2001	2002	2003	2004	2005	2006	2007	2008	AVG
Hay Alfalfa										
Acres Harvested	30000	31500	32000	31000	28000	28000	21500	25000	25000	28000
Yield/Acre (tons)	8.7	8.3	8.6	9.7	10.0	9.1	9.1	9.4	9.8	9.2
Price/Ton ($)	94.00	99.00	100.00	89.50	99.50	124.00	128.00	151.00	186.00	119.00
Gross Returns/ Acre ($)	814.98	816.75	862.00	866.36	995.00	1129.64	1160.96	1419.40	1822.80	1098.65
Cotton, Upland										
Acres Harvested	25300	25500	17900	24500	26700	27300	21900	16800	9800	21744
Yield/Acre (lbs)	1385	1129	1397	1254	1438	1213	1315	1457	1420	1334
Price/lb ($)	0.40	0.28	0.46	0.66	0.44	0.52	0.53	0.60	0.57	0.50
LDP/lb ($)*	0.04	0.30	0.14	0.04	0.13	0.15	0.09	0.00	0.00	0.10
Gross Returns/ Acre ($)	610.81	654.12	847.29	887.80	829.81	805.62	813.71	868.37	809.40	791.88
Wheat, Durum										
Acres Harvested	38600	36400	44300	46000	42500	36300	35000	36200	43100**	40050
Yield/Acre (bushels)	101.7	95.8	96.5	102.7	100.0	103.0	106.0	107.0	107.3**	102.5
Price/Bushel ($)	3.50	3.95	4.40	4.65	4.25	4.20	4.85	7.11	8.30	5.39
Gross Returns/ Acre ($)	355.94	378.64	424.70	477.40	425.10	432.60	514.21	760.77	890.70	560.78
Lettuce, Head										
Acres Harvested	50300	51800	50000	49600	46500	49600	47600	39900	32700	46444
Yield/Acre (cwt)	350.0	365.0	350.0	360.0	360.0	325.0	330.0	365.0	360.0	351.7
Price/cwt ($)	13.10	16.50	38.70	10.30	22.20	14.60	14.10	21.00	15.80	18.48
Gross Returns/ Acre ($)	4585.00	6022.50	13545.00	3708.00	7992.00	4745.00	4653.00	7665.00	5688.00	6511.50

*LDP: Loan Deficiency Payments are a form of US price support. Farmers may request and receive LDP when cotton price falls below an established minimum.
**2008 Acres Harvested & Yield/Acre unavailable for Wheat, Durum at county level. Average of 2007 and 2009 values used.

Table 2. Crop Returns, La Paz County, Arizona.

La Paz County, Arizona	2000	2001	2002	2003	2004	2005	2006	2007	2008	AVG
Hay Alfalfa										
Acres Harvested	59000	61100	63000	61000	65000	70000	55000	60000	57000	61233
Yield/Acre (tons)	8.5	8.4	7.9	8.0	6.9	8.1	8.0	7.6	8.6	8.0
Price/Ton ($)	94.00	99.00	100.00	89.50	99.50	124.00	128.00	151.00	186.00	119.00
Gross Returns/ Acre ($)	796.18	829.62	794.00	718.69	688.54	1000.68	1024.00	1143.07	1599.60	954.93
Cotton, Upland										
Acres Harvested	17900	17000	12000	16000	20400	17900	15400	11800	8200	15178
Yield/Acre (lbs)	1378	1200	1248	1350	1553	1421	1465	1546.0	1832.0	1443.7
Price/lb ($)	0.40	0.28	0.46	0.66	0.44	0.52	0.53	0.60	0.57	0.50
LDP/lb ($)*	0.03	0.27	0.00	0.00	0.18	0.12	0.00	0.00	0.00	0.07
Gross Returns/ Acre ($)	582.89	664.75	577.82	896.40	972.39	902.61	769.13	921.42	1044.24	814.63
Wheat, Durum										
Acres Harvested	6500	5100	5600	8000	10000	5000	4000	6800	7650**	6375
Yield/Acre (bushels)	94.7	96.2	92.7	101.3	88.0	92.0	87.5	97.3	100.7**	93.2
Price/Bushel ($)	3.50	3.95	4.40	4.65	4.25	4.20	4.85	7.11	8.30	4.26
Gross Returns/ Acre ($)	331.43	379.95	407.83	471.20	374.09	386.40	424.46	692.04	835.91	396.48

*LDP: Loan Deficiency Payments are a form of US price support. Farmers may request and receive LDP when cotton price falls below an established minimum.
**2008 Acres Harvested & Yield/Acre unavailable for Wheat, Durum at county level. Average of 2007 and 2009 values used.

preferences of the farmer dictate which portfolio is preferred.

Portfolios including major crops grown in the Yuma and La Paz Counties in Arizona are examined in this paper. Yuma and La Paz County are each located in western Arizona along the Colorado River, which is their primary source of irrigation water. The per-acre returns for the crops considered are summarized in Table 1 and Table 2. In Yuma County, head lettuce has the highest average per acre return and the largest average acreage harvested. However, as shown in Table 3 it also has a high standard deviation of return and coefficient of variation (a standardized measure of riskiness) compared to the other crops. It is highly profitable but also highly risky. The lowest returns are coupled with the lowest standard deviation of returns and coefficient of variation in both counties.

The correlations of crop returns (including fallowing) are in Table 4. The payment for fallowing used in the portfolio analysis comes from the average per acre payment in the PVID-MWD agreement (PVID-MWD, 2004). The payment started in 2005 and escalates by 2.5% each of the first five years. Since payments were not available for years prior to 2005, the payment was assumed to be 2.5% less for each preceding year, compounding annually. Most crops' returns are positively correlated, although some are lower than others. Cotton and wheat returns are highly correlated in both counties so portfolios containing a combination of those crops would only slightly reduce risk. A portfolio containing wheat and fallowing, on the other hand, would be expected to be very effective at reducing risk. The portfolios used in this analysis are summarized in Table 5. They are: 100% in each crop; a 50/50 cotton and wheat split (CW); a 50/50 wheat and lettuce split (WL); a 45/45/10 cotton, wheat, and fallowing split (CWF); and a 45/45/10 wheat, lettuce, and fallowing split (WLF).

The portfolio analysis indicates that in all cases adding fallowing reduces the expected return of the portfolio, and also

Table 3. Crop Return Variation.

Yuma County	Std Dev	CV
Hay Alfalfa	337.78	31%
Cotton, Upland	95.06	12%
Wheat, Durum	183.65	33%
Lettuce, Head	3001.15	46%
La Paz County		
Hay Alfalfa	285.36	30%
Cotton, Upland	172.39	21%
Wheat, Durum	170.31	43%

Std Dev: Standard deviation of crop return.
Example: Yuma, AZ Hay Alfalfa has an expected return of $1098.65. Most years the return on alfalfa in Yuma will fall between $337.78 above or below this expected value, or between $760.87 and $1436.43.
CV: Coefficient of Variation is a standardized measure of risk.
Example: The CV of Yuma lettuce is higher than the CV of alfalfa. Lettuce is a riskier crop.

Programs that better consider farm portfolio and risk management strategies could prove more attractive to a broad range of farmers.

Table 4. Crop Return Correlations.

	Yuma Crop Correlations					La Paz Crop Correlations			
	alfalfa	cotton	wheat	lettuce	fallow	alfalfa	cotton	wheat	fallow
alfalfa	1.00					1.00			
cotton	0.35	1.00				0.51	1.00		
wheat	0.95	0.43	1.00			0.87	0.63	1.00	
lettuce	-0.11	0.26	-0.04	1.00					
fallow	0.91	0.60	0.86	-0.12	1.00	0.80	0.79	0.79	1.00

Combining positively correlated crops will reduce risk less than combining negatively correlated crops. Diversifying a lettuce-only portfolio with cotton (correlation = .26) will reduce risk less than diversifying the same portfolio with alfalfa (correlation = -.11).

reduces risk. Combining fallowing with portfolios containing a mix of other crops reduces the coefficient of variation (risk) compared to the same portfolio without fallowing. Generally, the analysis reveals that higher returns are coupled with higher risk in single crop portfolios. The most preferred portfolio would depend on the risk aversion of the individual farmer.

Concluding Remarks

Portfolio analysis reveals that risk-averse farmers could benefit by enrolling in DYOs and adding fallowing to their crop portfolio. Expected returns would be slightly reduced but the variation of those returns would also be lower, leading to a lower variation per dollar of return. These results could be used by policy makers seeking to enter into DYOs with farmers to structure the price in such a way that it reduces income variability while still maintaining a base level of expected return. Farmers may also use a similar technique to determine the optimal amount of fallowing in their portfolio. While most programs impose a limit on the amount of fallowing any single farmer may do, the farmer must choose the optimal participation within that limit based on their risk preference.

For decision makers requiring a more sophisticated analysis, an extension of the approach presented here could specify varying levels of risk aversion and then solve for the expected value-variance efficiency frontier (Robison and Barry, 1987). Using this more detailed analysis, a farmer who knows their own level of risk aversion could rank the different portfolios and identify the optimal portfolio for their risk preference. In addition, scenario analyses could be combined with the portfolio analysis to determine if a farm's optimal portfolios change under different crop price and input cost conditions and with different payment levels for participating in temporary fallowing. However, in this brief article we wished to simply introduce the idea of DYO participation as a risk management strategy for farmers and to illustrate a basic approach to considering how participation can be considered in a farm's overall portfolio of revenue producing activities, each with their own variance. The type of analysis used here can be applied in any region where there is good information about crop production revenues and expenses, such as the farm production budgets commonly produced by agricultural economists at land grant universities in each state. ■

About the Authors

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Bonnie Colby is a professor in the Department of Agricultural and Resource Economics and the Department of Hydrology and Water Resources at the University of Arizona.

Additional Resources

These three recently completed guidebooks for stakeholders provide practical information for water supply climate change adaptation through using water banks, water auctions and dry-year contracts. The guidebooks provide a review of where and how these mechanisms have been used, implementation steps, and their strengths and weaknesses.

Michael O'Donnell and Bonnie Colby, Water Banks: A Tool for Enhancing Water Supply Reliability, January 2010, University of Arizona, Department of Agricultural and Resource Economics. http://ag.arizona.edu/arec/people/profiles/colby.html

Michael O'Donnell and Bonnie Colby, Dry-Year Water Supply Reliability Contracts: A Tool for Water Managers, October 2009; University of Arizona, Department of Agricultural and Resource Economics, http://ag.arizona.edu/arec/people/profiles/colby.html

Michael O'Donnell and Bonnie Colby, Water Auction Design for Supply Reliability: Design, Implementation, and Evaluation, May 2009. University of Arizona, Department of Agricultural and Resource Economics. http://ag.arizona.edu/arec/people/profiles/colby.html

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Table 5. Example Portfolios.

Yuma, AZ Portfolios									
Year	Alfalfa	Cotton	Wheat	Lettuce	Fallow	CW	LW	CWF	LWF
2000	814.98	610.81	355.94	4585.00	620.99	483.37	2470.47	497.13	2285.52
2001	816.75	654.12	378.64	6022.50	634.59	516.38	3200.57	528.20	2943.97
2002	862.00	847.29	424.70	13545.00	648.54	635.99	6984.85	637.25	6351.22
2003	866.36	887.80	477.40	3708.00	662.85	682.60	2092.70	680.63	1949.71
2004	995.00	829.81	425.10	7992.00	677.52	627.45	4208.55	632.46	3855.45
2005	1129.64	805.62	432.60	4745.00	692.57	619.11	2588.80	626.45	2399.18
2006	1160.96	813.71	514.21	4653.00	707.62	663.96	2583.60	668.32	2396.00
2007	1419.40	868.37	760.77	7665.00	723.05	814.57	4212.89	805.42	3863.90
2008	1822.80	809.40	890.70	5688.00	738.86	850.05	3289.35	838.93	3034.30
Exp. Return	1098.65	791.88	560.78	6511.50	678.51	654.83	3514.64	657.20	3231.03
Std. Dev.	337.78	95.06	183.65	3001.15	40.39	120.12	1499.88	111.09	1341.27
CV	30.7%	12.0%	32.7%	46.1%	6.0%	18.3%	42.7%	16.9%	41.5%
La Paz, AZ Portfolios									
Year	Alfalfa	Cotton	Wheat		Fallow	CW		CWF	
2000	796.18	582.89	331.43		620.99	457.16		473.54	
2001	829.62	664.75	379.95		634.59	522.35		533.57	
2002	794.00	577.82	407.83		648.54	492.83		508.40	
2003	718.69	896.40	471.20		662.85	683.80		681.70	
2004	688.54	972.39	374.09		677.52	673.24		673.67	
2005	1000.68	902.61	386.40		692.57	644.51		649.31	
2006	1024.00	769.13	424.46		707.62	596.79		607.88	
2007	1143.07	921.42	692.04		723.05	806.73		798.36	
2008	1599.60	1044.24	835.91		738.86	940.08		919.95	
Exp. Return	954.93	814.63	396.48		678.51	646.39		649.60	
Std. Dev.	285.36	172.39	170.31		40.39	154.64		141.89	
CV	29.9%	21.2%	43.0%		6.0%	23.9%		21.8%	

Water Policy *Innovations* and *Challenges* in ARIZONA

BY SHARON B. MEGDAL

The rapid growth in Arizona's population, coupled with prolonged drought, has strained its already scarce water resources. Accommodating population growth in a responsible manner has required Arizona to be a leader and innovator in water policy.

The rapid growth in Arizona's population, coupled with prolonged drought, has strained its already scarce water resources. Accommodating population growth in a responsible manner has required Arizona to be a leader and innovator in water policy. The Assured Water Supply Program requires 100 years of continuously, physically and legally available water for the areas where groundwater management is required. The Arizona Water Banking Authority, operating since 1997, has stored over three million acre-feet of Colorado River water in anticipation of future shortages. The Central Arizona Groundwater Replenishment District (CAGRD), authorized in 1993, enables affordable use of renewable water supplies by those without long-term contracts for Central Arizona Project (CAP) water and/or the ability to deliver CAP water to their service areas. Arizona's recharge and recovery statutes and regulations are central to all of these programs as well as the reuse of treated wastewater. Agriculture and municipal and industrial water users partner in a special recharge program, called the groundwater savings program. This program has conserved significant quantities of groundwater for future use.

Arizona's recharge and recovery program is carefully regulated and administered by the Arizona Department of Water Resources. ADWR was established in 1980 to implement and enforce the far-reaching groundwater regulations incorporated in the 1980 Groundwater Management Act. Permits are required for the recharge facilities, the actual storage of water, and for the recovery of stored water, respectively. Reports are filed and a careful accounting of stored quantities is made. The storage and recovery program has facilitated great progress in meeting the groundwater management goals of the Act. However, significant challenges still remain.

The Assured Water Supply program is designed to curtail groundwater overdraft in active management areas (AMAs), the geographic areas of the state subject to groundwater regulations (see Figure 1). However, water can be and often is recharged or replenished in areas that are hydrologically disconnected from the location of pumping. Therefore, the law allows for localized draw-down of aquifers to 1,000 feet below land surface. The CAGRD was created to help water users meet the renewable water use requirements of the Assured Water Supply Rules, but the CAGRD does not have the water supplies in hand to meet its long-term replenishment obligation. Legislation is pending that would allow for the sale of bonds to finance acquisition of supplies on behalf of CAGRD members. Moreover, the rules governing assured water supply only apply to AMAs. Several growth areas lie outside the AMAs, where in some cases development can occur even when water supplies are demonstrated to be inadequate. Examples of areas not subject to the AWS Rules include: the northwestern part of the state, soon to become a bedroom community of Las Vegas; the Sierra Vista area, home to an important Army base and a national riparian conservation area; and some areas near the Verde River, where conflicts exist over the implications of groundwater withdrawals and transportation.

Significant quantities of water have been stored for future use by the Arizona Water Banking Authority and the Central Arizona Project, but plans for the recovery of the stored water have lagged. In addition to storing for Arizona, the Banking Authority must fulfill storage and recovery obligations pursuant to an interstate agreement with Nevada. The Central Arizona Project, built to deliver 1.5 million acre-feet into Central Arizona, has the lowest priority of all Colorado River users.

What is Arizona doing to address these myriad issues? Water managers, public officials, and stakeholders are not sitting idly. Numerous collaborative efforts are underway. The Central Arizona Project has spearheaded a stakeholder-driven ADD (Acquire, Develop and Deliver) Water Process. Arizona worked with the six other Colorado River basin states to develop a shortage sharing agreement and is involved in collaborative efforts to augment water supplies. The Upper San Pedro River area is studying options for water augmentation and voters there will determine in November whether a water district is formed. The Verde River area is considering its options for regional management. Some counties have taken advantage of a relatively recent state law that allows counties to disallow development if water supplies are determined to be inadequate, but only if the county board of supervisors votes unanimously to do so. The Blue Ribbon Panel on Water Sustainability, co-chaired by the Directors of the Department of Environmental Quality and the Department of Water Resources as well as the Chairman of the Arizona Corporation Commission, is looking at many issues, especially increasing water reuse and reclamation. The Central Arizona Project is in the process, albeit a slow one, to develop a recovery plan for millions of acre-feet of water stored for future use. There is good collaboration with the university personnel at the University of Arizona, Arizona State University and Northern Arizona University, who are anxious to involve themselves in cutting-edge, real-world-relevant research, education and outreach.

The Water Resources Research Center's mission is to promote understanding of state and regional water issues, and the Center is an active participant in the state's water work. WRRC is home to Arizona Project WET, a vibrant water education program for K-12 teachers and their students, as well as outreach programs such as Arizona NEMO (non-point education for municipal officials) and the Master Watershed Steward Program. The Center is also involved in applied research projects. Two ongoing projects relate to what is an overlooked sector in Arizona statutes, namely the environment. Water use data are assembled by the state for the agricultural, industrial and municipal sectors only. State law does not provide for consideration of the implications on the environment of water development and use practices. With U.S. Bureau of Reclamation funding, the Center has developed the "Conserve to Enhance" mechanism, a voluntary conservation program designed to secure water for environmental restoration or enhancement purposes. In a state where there are no state-level legal protections for riparian areas, innovative and voluntary programs are required. The WRRC is working to pilot the program with a number of communities both inside and outside of Arizona and welcome inquiries regarding this innovative program. The Center is also working on assessing alternative approaches to quantifying environmental water needs.

Water management involves great complexities, especially when dealing with growth, water scarcity and recognition of environmental water needs. If the solutions were easy, we'd have identified them. Collectively, on multiple geographic scales and across water using sectors, we must work together to develop and implement solutions. ■

About the Author

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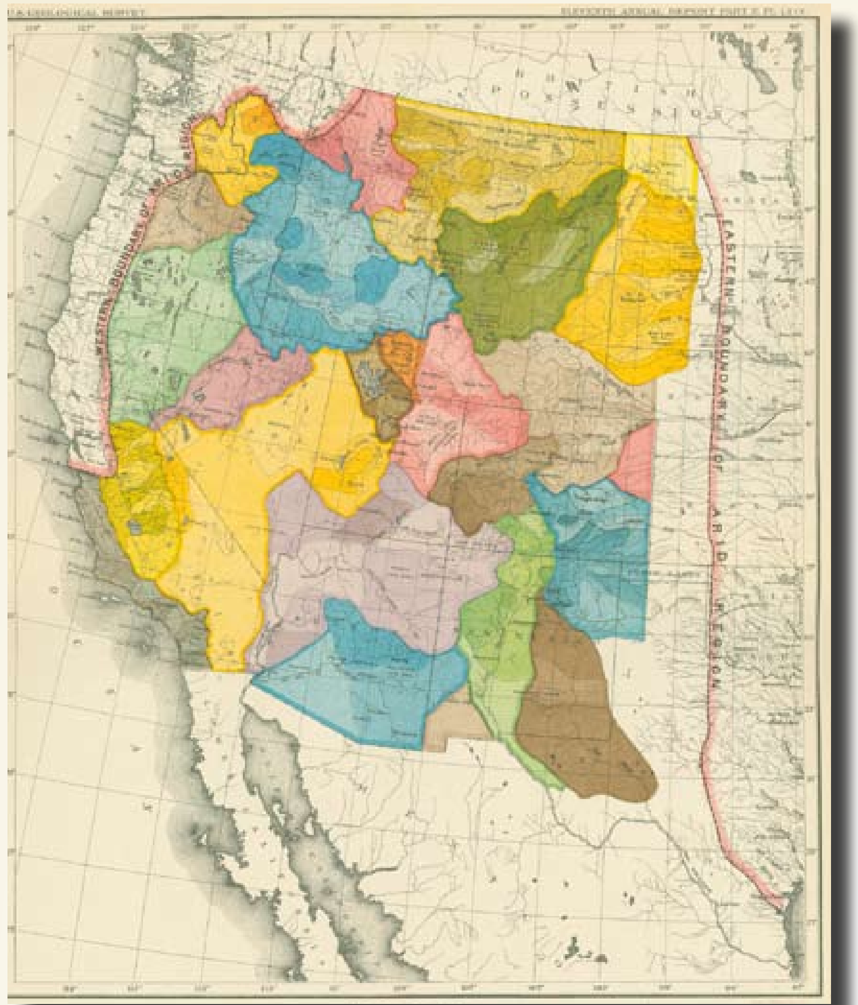
Additional Resources

University of Arizona Water Resources Research Center
www.cals.arizona.edu/azwater/
See particularly Layperson's Guide to Arizona Water, annual issues of Arroyos, and issues of the Arizona Water Resource newsletter.

Arizona Department of Water Resources web site, including its Water Atlas
www.azwater/gov

Central Arizona Project
www.cap-az.com

Arizona Water Banking Authority
www.azwaterbank.gov



Thinking AS A *Watershed*

BY JACK LOEFFLER

While thinking like a mountain implies a sense of inertia, thinking like a watershed evokes a sense of constant movement, fluidity, and change.

Several years ago, my friend author William deBuys was writing his fine book, Seeing Things Whole: The Essential John Wesley Powell. He had selected several illustrations for the book including a map of the drainage areas of the arid West rendered by John Wesley Powell. This map appears in the Eleventh Annual Report of the United States Geographical Survey, 1889-90. Powell had wandered throughout the American West during the late 19th century, and recognizing that aridity was the West's primary characteristic, had organized this map of the West watershed by watershed. When Bill showed me this map, a wave of clarity re-arranged my mental coordinates, and it became obvious to me that watershed thinking is key to human survival in the 21st century. The map is a work of art in its deepest sense. I commandeered Powell's map for the cover of my own book, Survival Along the Continental Divide: An Anthology of Interviews. Thanks to another friend, Craig Newbill, Director of the New Mexico Humanities Council, that map is now a beautiful poster published by the Council.

Powell's map is part of my daily consciousness. Powell had an evolved mind and is regarded by Bill deBuys - as well as writer, tree farmer, and environmental thinker Gary Snyder along with myself - to have been the original bioregional thinker. In 1985, I recorded Snyder as he articulated what remains to me the best definition of bioregionalism: "Bioregionalism goes beyond simple geography or biology by its cultural concern, its human concern. It is to know not only the plants and animals of a place, but also the cultural information of how people live there—the ones who know how to do it. Knowing the deeper, mythic, spiritual, archetypal implications of a fir, or a coyote, or a bluejay might be to know from both inside and outside what the total implications of a place are. So it becomes a study not only of place, but a study of psyche in place. That's what makes it so interesting."

If we look at Powell's map, bearing in mind Gary Snyder's definition of bioregionalism, it becomes abundantly clear that there is no better way for society to organize itself than within the context of home watershed. Powell recognized that watershed boundaries make a lot more sense than our current ephemeral geo-political boundaries. Watershed boundaries are natural boundaries that cradle bio-geographical drainage systems that are inhabited by many species of biota including the human species.

Human consciousness finds deep meaning in homeland, be that meaning scientific, mythic, or eminently practical—or all of the above. It's as though a single span of human consciousness, or lifetime, is part of a whole, a whole that includes the mosaic of watersheds and seas that surround our planet, that indeed we are part of the consciousness of the planet. Every morning at sunrise, I face east, and while watching the grasses sway in the breeze, speak four words: Sun, Earth, Life, Consciousness. My four-word mantra carries me through each day. I frequently gaze west out over that portion of the Río Grande watershed, my home watershed, to a distant peak, Mount Taylor, that is the sacred mountain to the south for the Navajo Indians. Or I look to the northwest, to the peak of the Jemez Mountain, an enormous volcano whose eastern aspect is sacred to the Tewa Indians, who live in pueblos that line the banks of the Río Grande. To the North, I look into the looming reaches of the Sangre de Cristos, those Southern Rockies that form the northeastern rim of the Río Grande Watershed, and the eastern horizon of the Tewa World. All of this is visible from where I live, from where I look out over ten thousand square miles of arid, beautiful landscape that is both named and nameless, whose presence is sculpted by the passage of great epochs. I am reminded that rumblings from deep within the Earth resulted in this mighty rift of a plateau, the second largest in the world. Some may regard this as a hostile environment, but to me, it is my greatest friend and has taught me about life.

This northern Río Grande Watershed was rendered in green by Powell, its shape vaguely resembling the profile of a seahorse as seen from the left—a seahorse dancing westward about to hop over the Continental Divide to join its sibling, the Colorado River Watershed. These two great watersheds are modest in their yields of water. However, they contain the American Southwest, and are themselves comprised of myriad smaller watersheds, each unique with its own story, history, and character. The landscape of the American Southwest and northwestern Mexico is the most arid patch of North America. This is desert country broken by mountain ranges. The sense of space is vast. Biota exist relative to the amount of water. Biodiversity abounds. As does cultural diversity. Aridity defines the way we biota comport ourselves. We do not belong to the verdant east. We belong to the arid West.

Some of us are exotic, even within our respective species, having blown in from without and somehow affixed ourselves to this land, and have selected to re-establish our sense of indigeneity. Others of us boast ancestors whose footprints were trod into this soil, then erased by the winds of antiquity.

While thinking like a mountain implies a sense of inertia, thinking like a watershed evokes a sense of constant movement, fluidity, and change. The mountain contains the headwaters of the watershed and cradles biotic communities including those "sky islands" perched precariously at the top defying the possibility of extinction. Below the piedmont, the watershed fans out, expands, the water joining the main stem, thence to flow into the seas that interact with the atmosphere and begin the cyclic process anew. The interactive factors seem infinite, the metaphor too complex to be understood by a single mind. Still, to dance about within the metaphor is comforting. Human consciousness has yet to evolve sufficiently to perceive the raw truth.

Speaking of metaphors, how about "sky islands?" The Madrean Archipelago of the American Southwest is comprised of a series of mountain ranges in Arizona and New Mexico whose peaks contain biotic communities that are separated by seas of desert. These biotic communities have migrated up mountains over a period of millennia that separates our present point in the Holocene epoch from the Pleistocene that ended over 10,000 years ago. Selected species have evolved within these communities, with characteristics distinct from their cousins in other sky island environments. Over geological time, some species sought genetic expression unique to their tiny mountaintop habitats. Their foothold is precarious. If warming trends continue, their respective biotic communities will falter by virtue of inability to migrate up into thin air.

Metaphorically, the human species is poised atop the pinnacle of a dilemma of our own making. We may not go extinct, but the environment that we've "cooked up" is burning away myriad species at a rate that parallels spasms of extinction of species that have occurred only five times throughout the previous 540 million years.

Earth's wondrous mosaic of watersheds is constantly shifting, endlessly changing. Our species, the human species has come to predominate, even if temporarily. Our longevity within this mosaic will be determined by our degree of wisdom and our future practices. Our wisdom must meld many components including lessons that may be learned only by swimming heartily within the flow of Nature. Much wisdom comes from observation and practice, from aesthetics, from trial and error, from lingering along the edges of existence rather than from a centrist position. One must encompass and digest a mighty array of factors, realize that oneself is but a single tiny factor within that mighty array, then plan and react accordingly. An appropriate metaphor for that state of mind is to think as a watershed. ■

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Jack Loeffler is a writer, radio producer, and aural historian. He is affiliated with the Lore of the Land, a non-profit, which nurtures bioregional documentation within indigenous communities.

Additional Resources

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Lore of the Land
www.loreoftheland.org

Agricultural Water Conservation Clearinghouse

Addressing Agricultural Water Security in a Changing Climate

BY FAITH STERNLIEB, JULIE KALLENBERGER, REAGAN WASKOM, TROY BAUDER, AND JIM BAUDER

Agricultural water conservation is a highly complex issue that is often mistakenly simplified at the public discussion and policy-making level.

Introduction

Conservation of agricultural water is complex and today, more than ever, the forces applying pressure and attention to water conservation are many, including: increasing competition for water resources due to a changing climate and population shifts and growth, an array of widely dispersed and contradictory information about agricultural water use and conservation, and mounting pressure to improve agricultural water use efficiency while at the same time increasing agricultural output. Additionally, needs for water for wildlife support and habitat improvement, recreational and leisure-time activities, expansion of domestic energy production as biofuel, and other industrial uses continue to grow and become more vocalized. Today, competition for limited water supplies is evident in the semi-arid and arid West, as well as throughout the United States.

A myriad of factors can influence how the agricultural sector manages its water supplies including availability, timing, quantity, quality of water, water rights, crops, timing of water application, precipitation patterns, pests that can influence crop performance, irrigation equipment availability and performance, labor, farming costs and available finances. Agricultural water conservation is a highly complex issue that is often mistakenly simplified at the public discussion and policy-making level. The complexity of understanding and practicing agricultural water conservation is mainly due to:

- state water laws (or lack of laws and regulations) which limit or provide incentives for agricultural water conservation;
- the variability and inconsistency of policies from state to state, despite water resources transcending geographic and political boundaries;
- research that has far surpassed applicability to practitioners;
- financial barriers and lack of recognizable incentive to practitioners for conservation;
- cumulative basin-scale impacts and the downstream dependency on return flows;
- producer economics and risk management strategies;
- limitations imposed by out-dated irrigation equipment and water delivery infrastructure;
- current approaches to ditch and reservoir system management.

In recognition of the possibility of a drastic change in availability of water and demands of re-allocation and use of water resources in the western U.S., the USDA and the Interior Department recently signed a Memorandum of Understanding to promote improved water management in the seventeen western states, where up to 90% of available freshwater resources are used for food production. Additionally, politicians recognize that water for agriculture holds the key to the future of food security in this region. The arid/semi-arid west is only one region in the U.S. undergoing such changes. There is also increasing competition between agriculture and urban populations for fresh water in the southeast, particularly in Georgia, South Carolina, and Florida. The World Economic Forum predicts that percentage change in demand for water between 2000 and 2030 for industrial and domestic use will crowd out any growth in agricultural water use (WEF 2009). Water demands from urban growth, increases in reservoir evaporation, and increases in crop consumptive use must be accommodated by timely improvements in agricultural water delivery, management practices, and technology (Strzepek et al. 1999).

Because agriculture accounts for over 70 % of the total water used consumptively in the U.S., the public, some natural resource regulatory agencies, and policy makers have started to place an increasing focus on the notion of agricultural water conservation as a partial solution to existing water shortages or those being forecast as a consequence of climate change predictions, over-appropriate and use of existing water resources, and growing and shifting populations throughout the U.S. Yet, in light of growing emphasis on water conservation, it is estimated that present agricultural water shortages have cost the U.S. agricultural sector $4 billion a year for the past two years (WEF 2009).

There is no shortage of information about agricultural water management available to the public. However, published information and research results are scattered throughout an array of sources that are hard to reconcile. Moreover, the technical language in which most of the research articles and bulletins are published may be a limitation for some audiences seeking information about agricultural water conservation. Hence, there is a great need to compile and make accessible the array of technical information, tools, and water expertise for these audiences.

Agricultural Water Technology

Sustainable agricultural water conservation technologies and practices are not always the cheapest or the least technically complex. In addition, the impact of agricultural water conservation at the river basin scale can be either beneficial or detrimental to the environment, particularly if acreage in response to water made available because of conservation is expanded and consumptive use of water by agriculture is increased. Despite these complexities, the future of U.S. food security and agricultural water security are tightly linked to and dependent to some degree on our ability to use water more efficiently to produce food, fiber, and bioenergy. The impact of a changing climate on agriculture has become tantamount to understanding water and food security. The extent to which the changing climate will impact water availability in the future is uncertain, despite predictions in reports of the Intergovernmental Panel on Climate Change. What is certain is that precipitation variability and increased evapotranspiration (ET) will influence short and long term irrigation water supply and crop water demand, respectively.

Even though there is much effort to accelerate the development of cellulosic biofuels in order to minimize both water and energy consumption, overall water use for energy production is expected to grow by as much as 165% in the U.S. alone (WEF 2009). Recent efforts to use genetic technologies to improve crop water use efficiency may help produce bioenergy and feed crops with less water, but it is not likely that these improvements alone can bridge the coming water gap. These emerging genetic technologies are most likely to become part of new water efficient cropping systems that have improved tolerance to drought and short-term water interruptions.

The Agricultural Water Conservation Project

To help address these various needs, the Northern Plains and Mountain Regional Water Program of the USDA National Institute for Food and Agriculture (USDA-NIFA) National Water Program developed the Agricultural Water Conservation Clearinghouse (www.agwaterconservation.colostate.edu–Figure 1). The Clearinghouse has been instrumental in building partnerships within the academic community. Colorado State University (CSU) Libraries has provided support for the library feature, while the Agricultural Network Information Center (AgNIC) has increased the visibility necessary to build a resource information network for irrigators, agricultural producers, and water resource managers.

The Clearinghouse is a comprehensive repository of information and resources with a central focus on agricultural water management and conservation. Our vision is to develop a globally recognized information source and community of practice consisting of technical experts and researchers who will collaboratively address the complex issues of agricultural water conservation and water security. The Clearinghouse's mission is to create a comprehensive, one-stop-shop information resource system on agricultural water conservation by accomplishing two goals: 1) building linkages between water agency partners and experts to share information, research, and outreach activities; and 2) providing the agricultural water community tools and resources to assist them in coping with water management in a changing climate.

Currently, policies applied to saved, conserved, produced, or developed water vary greatly from state to state. Collective and coordinated watershed-scale approaches to managing any conserved water can only enhance national water security. The Clearinghouse has created an online meeting place, where individuals can express ideas, facts, and opinions and where discourse about solutions to agricultural water conservation challenges will open a dialogue between experts, decision makers, and stakeholders. The Clearinghouse supports the development of teams of experts who will be instrumental in discovering information gaps in both technical literature and educational curriculum.

Building partnerships between researchers, educators, practitioners, and industry experts can be instrumental in helping agricultural water users learn about new technologies and how to implement them. These partnerships foster a community of practice that enables communication between different interest groups to share common concerns about agricultural water management and conservation. Connecting water users to the manufacturers of water technologies enhances the possibility of adopting and implementing agricultural water conservation practices in the field, thereby improving farmers' abilities to remain financially solvent and profitable, while at the same time dealing with short- and long-term water scarce circumstances. Such exchange and dialogue furthers the formulation of well-thought-out standards for best management practices in agricultural water conservation. This leads to improved data sharing and a better understanding of agricultural water policy implications on basin scale hydrology.

The Clearinghouse website provides

Figure 1. Agricultural Water Conservation Clearinghouse homepage (www.agwaterconservation.colostate.edu).

current links and contact information to federal and state Agricultural Experiment Stations and Land-Grant Universities, as well as up-to-date information on agricultural water related research centers, irrigation management curricula, workshops, conferences, irrigation tools, software, manuals, guides, calculators, and irrigation schedulers. It features upcoming events and news related to agricultural water conservation at a regional and national scale.

The Clearinghouse is in the form of an interactive website, featuring a searchable library database, an agricultural water expert directory, Frequently Asked Questions (FAQs), and fact sheets. The Clearinghouse library is a comprehensive database which identifies current research and educational outreach publications regarding agricultural water policy, agricultural water recovery and recycling, resource economics, crop water use, cropping systems, drought tolerance, irrigation management and systems, irrigation water conveyance and delivery, phreatophyte management, utilization of marginal water, and water supply, sources and storage. The searchable library database hosts refereed journal articles, books, reports, theses/dissertations, conference proceedings, and easy-to-read fact sheets and bulletins.

The library is populated by contributions from Extension specialists, research scientists, and educators and provides a refined bibliographic review of agriculture water conservation grey literature. Grey literature refers to materials that cannot be found easily through conventional channels such as publishers, however is frequently original and usually recent. Examples of grey literature include technical reports from government agencies or scientific research groups, working papers from research groups or committees, white papers, or preprints. The term grey literature is often, but not exclusively, used for scientific reports. To date, the project has impacted over 7,100 users who have been able to access over 700 entries in the Clearinghouse library. Request for feedback from users helps strengthen the resource system and expand the network of water resource practitioners from local, state, regional, and national organizations instrumental in providing solutions for water management challenges now and in the future.

The Clearinghouse expands outreach and education efforts by initiating virtual online wiki forums for four initial communities of interest: 1) policy makers and administrators, 2) agricultural producers, 3) water educators and practitioners, and 4) research scientists. Wiki forums allow the easy creation and editing of multiple text entries and interlinked web pages via a web browser using a simplified markup language. Online forums enable ongoing dialogue about alternatives and the effects of agricultural water policy, and the impacts of basin scale agricultural water conservation. Additionally, online forums foster and promote interaction between the community of practice and communities of interest.

Conclusion

The outcomes of this project have provided benefits to agricultural water users, natural resource management agencies, policy makers, the general public, and the industries supporting agricultural water users attempting to address the increasing complexity of agricultural water conservation. For example, the Clearinghouse currently performs the following functions:

- Creates a venue for sharing of information regarding agricultural water conservation; advances awareness about and increasing access to new technologies and best management practices; offers a platform which unites researchers, administrators and policy-makers, practitioners, and educator communities with a commonality of focus of addressing the complexities of agricultural water conservation in the future.
- Provides targeted audiences current information about pressing and complex agricultural water conservation and security challenges, helping them to make more informed decisions and to accurately communicate information about agricultural water use and conservation.
- Identifies gaps in current research, education, and outreach related to agricultural water conservation, thereby helping U.S. federal, state, and local natural resource management and policy-making agencies to better target programs to improve water and food security.
- Informs technical experts, support industries, and educators of the latest agricultural water research and technology, allowing them to better inform their clientele.
- Links industry with the research and education communities.
- Links educators to scientists and technical experts to resource materials.
- Helps agricultural water users make better-informed decisions about their cropping systems.
- Enhances resources and information available through eXtension by expanding virtual and live networks to provide extended outreach.
- Provides support and assistance to policy makers by linking them to experts and current research, as well as to the USDA-NIFA National and Regional water programs.■

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The future of U.S. food security and agricultural water security are tightly linked to and dependent to some degree on our ability to use water more efficiently to produce food, fiber, and bioenergy.