INNOVATIONS in AGRICULTURAL STEWARDSHIP

Stories of Conservation and Drought Resilience in the Arid West

A compilation of case studies from

The **National Young Farmers Coalition (NYFC)** represents, mobilizes, and engages young farmers to ensure their success. We are a national network of farmers, ranchers, and consumers who support practices and policies that will sustain young, independent, and prosperous farmers now and in the future. Visit youngfarmers.org or contact kate@youngfarmers.org for more information.

The **Family Farm Alliance (FFA)** is a powerful advocate for family farmers, ranchers, irrigation districts, and allied industries in seventeen Western states. The Alliance is focused on one mission: to ensure the availability of reliable, affordable irrigation water supplies to Western farmers and ranchers. Visit familyfarmalliance.org or contact dankeppen@charter.net for more information.

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Photo courtesy Singing Frogs Farm

LETTER TO THE READER

In the arid West we are entering a new normal. Drought and climate variability are colliding with population growth, spiking the demand for food and fresh water. Across the Colorado River Basin, a geography that supplies water to over 35 million people in seven U.S. states from Wyoming to California, and two states in Mexico, new efforts are underway to close the gap between supply and demand. While everyone is feeling the sting, farmers and ranchers are all too often caught in the middle.

The last 14 years have seen prolonged drought in the western U.S., but 2015 has set new historical records. California offers a prime example. Like most western states, California relies primarily on snowmelt for its drinking water, irrigation, and water for the environment. On April 1st of this year, the state's snowpack was a mere 5% of normal.[1]

The southern portion of the state relies on melt from the Colorado River system, which is experiencing far below average snowpack, as well. In an urgent response, Governor Jerry Brown ordered mandatory water cutbacks in towns and cities statewide. Meanwhile, many farmers are already receiving little to no surface water allocation due to the miniscule supply and regulatory constraints, even after many regions have invested billions of dollars in efficiency improvements.

This sense of urgency has spurred renewed efforts to find solutions across western states. However, too often agriculture is viewed as the default "reservoir" that other sectors can access to satisfy growing demands for water. A report released by the Bureau of Reclamation in 2012 identifies a 3.2 million acre-foot gap between water supply and demand in the Colorado River Basin by 2060.[2]

Suggestions to meet this gap indicate taking 6-15% of existing irrigated agriculture out of production. Such efforts are already underway: Thirsty cities continue to buy water from farmers at tough-to-beat prices while the almond unfairly bears the brunt of the latest round of negative PR targeting water-demanding crops. If we continue down this path we risk serious implications for our farmers, ranchers, and food supply.

Without a doubt, agriculture has a significant role to play in water conservation. But all too often discussions of what to do about water scarcity take place off the farm, without input from those who have a direct connection to our food supply and far away from the landscapes that will be most affected. In order to develop **smart policy, it is critical to understand the solutions farmers and ranchers—young and seasoned alike—are utilizing to build drought resilience, steward water, and grow good food for all of us.**

The National Young Farmers Coalition and the Family Farm Alliance have teamed up to elevate the voices of farmers and ranchers doing just this. Following are five case studies profiling producers across the Colorado River Basin and beyond who—with curiosity, creativity, and seasons of trial and error—are conserving resources while enhancing productivity. Some are integrating efficient irrigation technology with soil health to increase both productivity and water savings. Others are navigating conservation within constraints outside of their control, such as the operations of the ditches which deliver water to farms.

To paint a deeper picture of the complexities and nuances of agricultural water conservation in the West, we worked with the engineering firm Applegate Group to create a water balance for three of the case studies. These water balances utilize a technical, objective approach to assess the producers' water rights, current conservation efforts, and barriers or opportunities for future conservation. They underscore the reality that conservation practices are different on every operation and unique from farm to farm.

Of all the producers whose stories are told here, what binds them together is their ability to manage for the economic, ecological, and social health of their operations, communities, and environments. They represent a growing movement of agriculturalists who are stepping up to the plate—and have been for years, despite the lack of attention—to farm with "whole systems" in mind. These farmers see that healthy soil is integral to healthy crops; that efficiency is an investment in future food and water security; that ecological services contribute to the bottom line; and that farmers sharing knowledge with one another is critical to innovation and adaptation.

As the pressures of climate variability and drought increase, farmers and ranchers are at the forefront of our national adaptation strategy. Producers are coming together to help one another, but they also need support from consumers, policy makers, scientists, and service providers. Our hope is these case studies will provide policy makers and other stakeholders with a more nuanced understanding of the diversity and complexity of western agricultural water conservation and an appreciation of what continuing to take agricultural lands out of production might mean.

Now is the time to engage farmers and ranchers as allies in finding innovative solutions that support the health of our land, water, and Western communities.

Sincerely,

Kate Greenberg
National Young Farmers Coalition

Dan Keppen
Family Farm Alliance

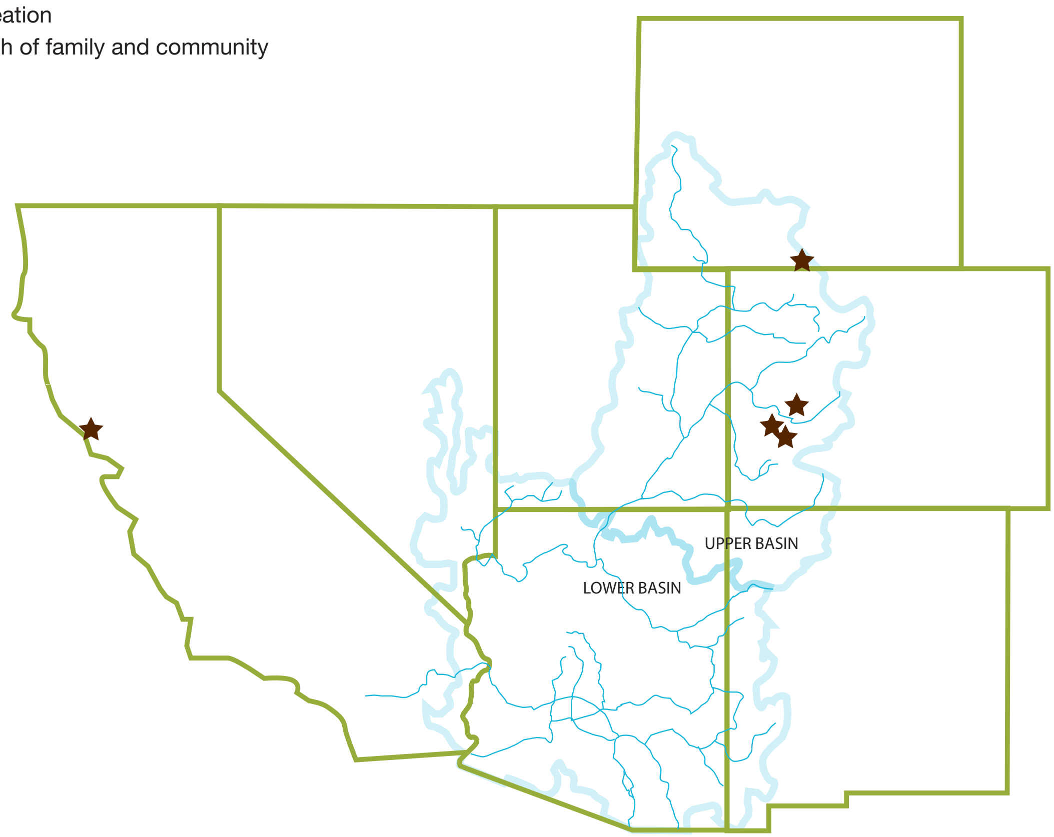
1 http://www.water.ca.gov/news/newsreleases/2015/040115snowsurvey.pdf

2 http://www.usbr.gov/lc/region/programs/crbstudy/FactSheet_June2013.pdf

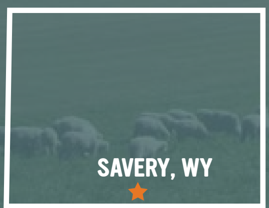
EXECUTIVE SUMMARY

Through the process of researching and compiling the following stories, a number of common themes emerged. These themes point toward more conservation-oriented, resilient agriculture evolving in the arid West. These ideas are not new but have not yet been implemented at a scale equivalent to their potential. The solutions illuminated here must be amplified across all sectors invested in western water.

- **Farmers are investing in irrigation efficiency and conservation**
- **Efficiency improvements may be cost-prohibitive for some producers**
- **Many farmers and ranchers manage their water for multiple values including:**
  - food production
  - ecosystem services
  - biodiversity and wildlife habitat
  - recreation
  - health of family and community
- **Soil health is critical to drought resilience, productivity, and water conservation. This includes such methods as:**
  - cover cropping
  - rotational grazing
  - no-till
  - mulching
- **Soil health is an investment with long-term benefits; it connects producers across operation types, regions, and philosophy; it enhances other forms of water-use efficiency**
- **Farmers and ranchers are our first line of innovation for climate change adaptation and drought resilience**



The Colorado River Basin is a seven-state geography governed by complex interstate and international water law. The river travels some 1,450 miles from the Rocky Mountains to the Gulf of California. It supports over 35 million people; 15% of U.S. produce; and recreation, industry, wildlife, and the environment.



Pat & Sharon O'Toole

LADDER RANCH

A 135-year-old ranch built through holistic management

CONSERVATION AS FOUNDING PRINCIPLE

The Little Snake River Valley runs along the border between Colorado and Wyoming and helps form the headwaters of the Colorado River. This is a portion of the same water that eventually fills millions of taps in cities like Los Angeles and Phoenix. But first, it is stewarded on the Ladder Ranch, home to Pat and Sharon O'Toole, their children, and grandchildren.

The O'Tooles husband the same landscape that Sharon's great-grandparents settled on in 1881. Today, Ladder Ranch raises cattle, commercial sheep, horses, and working dogs. The O'Tooles have also created a ranch recreation business, which caters to fishermen, birders, hunters, and cyclers, as well as visitors interested in ranch life.

Sharon's family has long practiced what is known as holistic management—a way of integrating the whole farm or ranch, not just for economic health but for environmental and social benefits as well.[3] While Sharon grew up on the ranch, Pat is a first-generation rancher. From day one, he adopted the holistic management practices that for so long have been part of Sharon's family legacy. With their children taking on other elements of the business, the ethos of stewardship lives on.

To the O'Tooles, there is no inherent conflict between production and conservation. As Pat puts it, "We were always taught to keep one eye on the livestock and one eye on the landscape. One does not do well without the responsible management of the other. This is the resource ethic that we try to pass down through the generations."

WATER MANAGEMENT

Ladder Ranch, like many ranches in the interior West, relies on irrigation water derived from melting mountain snowpack. That water feeds a myriad of purposes. It grows hay and grass pasture, which supports the financial bottom line. It buffers soil against drought and fills creeks and streams. It supports trout fisheries and the anglers who seek them. It enhances biodiversity and provides water to wildlife that use Ladder Ranch as a migratory corridor. It draws in beneficial insects and pollinators and helps build a beautiful landscape. The O'Toole's holistic approach manages for all of these values simultaneously.

On 600 acres of irrigated land for hay and tens of thousands of additional acres of non-irrigated grazing land, the O'Tooles carefully monitor soil health. They plant

ABOVE: The O'Tooles have received many awards for conservation
TOP of PAGE: Ladder Ranch
Ladder Ranch photos courtesy Pat and Sharon O'Toole

Baling hay for the herd

cover crops on the farmland and utilize rotational grazing, which Sharon's father, George Salisbury, pioneered in the fifties. Rotational grazing imitates the movement of wild animals by rotating large herds of grazers—in this case sheep and cattle—on a carefully planned schedule. This allows the grasses ample time to regenerate while adding organic matter to the soil.

The irrigation practices the O'Tooles use vary depending on the nuances of the specific tract of land they are irrigating. Side-roll sprinklers irrigate about one-third of their pastures and flood irrigation waters the other two-thirds. While flood irrigation is considered less efficient, at the Ladder Ranch the "excess" water is essential to supporting waterfowl habitat. The water moves slowly across the land and eventually seeps back into rivers and streams to feed nine miles of trout fisheries and to provide irrigation for downstream users. In this specific case, increased irrigation efficiency could hinder other conservation values, a key example of the need for nuanced approaches to water management.

LEVERAGING PARTNERSHIPS

Another way the O'Tooles have conserved their lands' agricultural heritage is by partnering with land trusts to place a significant amount of acreage under conservation easement. Conservation easements are critical legal tools used to protect open space and working agricultural lands from development. The O'Toole's easement requires future owners to uphold the conservation values the family has agreed to, long into the future.

These decisions have made the O'Tooles leaders in collaborative conservation. Their partnerships include Trout Unlimited, Audubon Wyoming, and The Nature Conservancy—organizations some ranchers once viewed as adversaries. The O'Toole's recognize they share a common goal with many in the conservation community and have collaborated to protect threatened species, restore native habitat, and promote biodiversity.

A FAMILY ADAPTING TO A CHANGING CLIMATE

For the family, conservation is a pragmatic business choice that enhances their operation and ensures a productive landscape for future generations. With careful and specific management, the O'Tooles have watched their business and the landscape thrive together. In a changing climate—with a less reliable snowpack and thus a potentially less consistent water supply than in earlier years—they remain highly adaptable and responsive. Nothing is ever set in stone. As Pat puts it, "Our ranch is 135 years old, and we are still learning."

SNAPSHOT

Years owned by the same family: 135

Irrigated acres: 600

Commercial land use: cattle, sheep, working dogs, agritourism

Water management: Cover crops, rotational grazing, integrating ecosystem services

3 http://holisticmanagement.org/wp-content/uploads/2011/12/HolisticManagement-1-22.pdf

Cynthia and Ira Houseweart

★ HOTCHKISS, CO

PRINCESS BEEF

Raising grass-fed beef on the triple bottom line

RECORD OF RESILIENCE

Along the North Fork of the Gunnison River, a tributary of the Colorado River, orchards, ranches, and farm stands dot the landscape. This valley is home to rancher Cynthia Houseweart, who owns and operates Princess Beef, a grassfed beef operation she founded over 15 years ago with her husband, Ira. Like all farmers and ranchers in this arid region, Houseweart is constantly pushed to adapt her operation to an increasingly unpredictable water supply.

A historic drought in 2012 led many ranchers to cull their herds as they watched their pastures—and thus their winter feed—dry up. Yet Houseweart's pastures stayed alive, even after irrigation was turned off in August. Houseweart attributes this to how she manages her soil. As she recalls, "Down here on our place […] it stayed green. You couldn't really tell it was a drought. [The soil] holds the moisture so much better when the ground can soak it up." The unique way Houseweart manages her herd, her soil, and her water kept her afloat through one of the worst drought years on record. She is an example of how many innovative ranchers today think about their operations.

ROTATE RATHER THAN TILL

Houseweart's first tool for resilience is to keep the soil covered. She does this through rotational grazing and no-till pasture management. Traditional ranching involves moving cattle infrequently, leaving them out in open pastures to graze for extended periods of time. This often leads to over-grazing, which, in turn, compacts soil or makes it prone to erosion, heightens rates of evaporation, and prevents the soil from soaking up precious moisture.

Rotational grazing, on the other hand, is the practice of moving the herd frequently to allow previously grazed pastures to regenerate. Houseweart rotates her cattle every two to three days. This brings some short-term disturbance to the soil, but by resting each pasture for much longer than it was grazed, Houseweart builds up organic matter and naturally fertilizes her land through the cattle's urine and manure. This also helps restore the carbon and water cycles on her ranch.

In addition, Houseweart has not tilled her pastures in the nearly two decades she has managed them. Underneath the soil surface a complex ecosystem of life delivers water and nutrients to the plants. Tillage would disrupt and damage that ecosystem and the soil structure.

ABOVE: Cynthia Houseweart and her herding companion
TOP of PAGE: Cattle graze on healthy forage
Princess Beef photos courtesy Cynthia Houseweart

The Houseweart family on their centennial ranch

Houseweart has found that by not tilling her pastures, her forage grows more vigorously throughout the year and is supported by this subsurface ecosystem. She has also reduced fuel costs by not running a tractor over her pasture. These practices build soil structure and sequester carbon, which allows the soil to work as a sponge to hold water in place for when it's most needed. This means that even in extremely dry years, or when surface water is tenuous, Houseweart has a buffer against drought.

Houseweart's ranch is also unique in the efficiency of its irrigation technology. Instead of flood irrigating her pastures, as is common, Houseweart has invested in a center pivot sprinkler, which is typically around 80% efficient versus 65% efficiency for flood.
But Houseweart has taken her efficiency to the next level by integrating this technology with stewardship practices. She rotates her cattle behind the sprinkler, which both increases the fertility of her pasture and reduces the amount of cutting and baling hay she needs to do.

THE TRIPLE BOTTOM LINE

From the get-go, Houseweart has managed for the whole health of her ranch and family. The decisions she makes for economic reasons must also be ecologically viable while supporting the well-being of each individual on the ranch, her family, and the community. This way of managing is possible on any operation at any scale.

But it is not Houseweart alone who drives this. She collaborates with a broad host of partners, from her local Natural Resources Conservation Service (NRCS) agent to a strong local growers' network. The Housewearts rely not only on a supportive community but on their willingness to adapt and try new things to meet modern challenges. As snowpack and irrigation supplies become more variable, and aridity continues to be a growing pressure, producers like the Housewearts point to a viable way ahead.

SNAPSHOT

Years owned by the same family: 100

Irrigated acres: 100

Commercial land use: Grass-fed beef

Water management: Rotational grazing, no-till, center pivot irrigation

4 http://www.cprl.ars.usda.gov/pdfs/Howell-Irrig%20Efficiency-Ency%20Water%20Sci.pdf P. 468

HOTCHKISS, CO

Steve Ela

ELA FAMILY FARM

A highly efficient, 80-acre, organic orchard building soil for the future

WATER ONLY WHERE IT'S NEEDED

High up on a south-facing hillside overlooking the North Fork Valley in north-central Colorado, orchardist Steve Ela grows 80 acres of organic tree fruits. In the peak of summer, Ela Family Farm is a locus of bounty: apples, peaches, pears, plums, and cherries hang heavy from the trees, tempting passersby with their undeniable sweetness. But the bounty doesn't grow itself: In as hot and dry a region as this, averaging less than 15 inches of precipitation a year, water is a top limiting factor to success. In his decades of farming, Ela has learned a thing or two about water.

When Ela's family bought the orchard in 1987 it was furrow irrigated. This form of irrigation, which remains a standard practice for many orchards to this day, lets water flow by gravity from a ditch or stream through furrows running through the crop. Based on the specific needs of his orchard, Ela felt he could improve the growing environment for his trees—and thus his productivity—by becoming more efficient.

Upgrading the orchards' irrigation system was Ela's first priority. He worked with his local Natural Resource Conservation Service (NRCS) agent to design and install a permanent drip irrigation system, an array of flexible plastic tubing with small emitters that release water directly where and when it's needed. The cost of this upgrade was significant, running nearly $2,500 per acre. The upgrade required care during installation to avoid damaging the tree roots as well as additional maintenance. But the increased efficiency has allowed for more effective watering, so the trees are irrigated consistently and with only the amount of water they need.

MANY SOURCES OF IRRIGATION

One of the primary challenges when it comes to irrigation water for farmers in the valley is late-season irrigation water. Surface water there is stored in a series of reservoirs and released into a network of ditches throughout the growing season. When the reservoirs are empty, the ditches are shut off. The amount of water in the reservoirs is primarily determined by that years' snowpack and subsequent spring melt.

Snowpack in recent years has been well below average. To mitigate this, Ela uses a few techniques. First, the farm owns and utilizes a broad array of water rights from multiple sources. These include Leroux Creek, the Highline Ditch, and numerous small reservoirs. Not only does this offer Ela options throughout the growing season, many of these rights are senior rights. That means that in the event of a "call," or when water supplies are too low for every user to get their full share, senior rights take priority. These rules are based on western water law that is over a century old. When Ela is unable to pull from the ditches, he can then tap the reservoir supply.

ABOVE: Ela admires his orchard
TOP of PAGE: Spring blossoms mark the start of the growing season
Ela Family Farm photos courtesy Steve Ela

A view of the North Fork Valley from Ela Family Farm

But relying on this system of water allocation isn't Ela's only approach. Nor is being as efficient as possible with his irrigation technology. Ela takes it yet a step further: into the soil.

HEALTHY SOIL GROWS HEALTHY FRUIT

Step into Ela's office and you will find binders full of farm records tracking the soil fertility of his orchard. Before becoming a full-time farmer, Ela received his Masters degree in soil science from the University of Minnesota. With the desire to someday return to his family's land, he knew that growing healthy soil would be essential to fostering a thriving business.

On his orchard, Ela curates what he calls a "soil smorgasbord," meaning he manages for overall soil health so the ecology of his orchard can provide the crops with what they need at a given time. A key part of this "smorgasbord" is a permanent cover crop mix, which holds water in the soil, provides nutrients, and produces a healthier fruit crop. The mix, which includes species such as alfalfa and white clover, provides the orchard with 50% of its nitrogen needs and the majority of its mineral needs. This greatly reduces the need to apply organic fertilizers and also reduces the associated cost. Ela mows the cover crop three to four times a year, which has built his soil organic matter (SOM) to 3-4%, an impressive percentage for a region where average SOM is 2% or less. These healthier soils wick up moisture and maintain cooler temperatures in the orchard throughout the hot summer months. The less water the trees expend under heat stress, the less water needs to be applied to keep them thriving. And the more water they can keep in the soil to grow larger, sweeter fruit.

DOLLARS AND "SENSE" OF CONSERVATION

Economics may best explain the value for these improvements. When the orchard was purchased in 1988, gross revenue was about $200,000. Now, 27 years later, the orchard's gross revenue is $1.1 million, a 450% increase using the same amount of water and acreage. By integrating modern irrigation technology, soil health practices and a tenacious marketing sense, Ela has watched his productivity climb and his operation withstand the tests of time. Water efficiency and conservation have proven smart business risks that turned into real returns. For Ela, managing his orchard for long-term ecological health and economic viability just makes sense.

SNAPSHOT

Years owned by the same family: 27

Irrigated acres: 80

Commercial land use: Organic apples, peaches, pears, plums, and cherries

Water management: Drip irrigation, microsprinklers, cover crops

Harrison Topp

PAONIA, CO

TOPP FRUIT

Beginning farmer brings an octogenarian orchard back to life

LEARNING TO FARM

In the fertile North Fork Valley outside of Paonia, Colorado, Harrison Topp prepares for his second season growing organic cherries and plums. The orchard, which Topp's parents purchased in 2007, has been in production for over eighty years. His family previously leased the orchard to a larger farm in the valley, but due to the age and condition of the trees, the operators decided to end the lease. In 2014, the responsibility of bringing the orchard back into working order fell to Topp.

At a spry 28 years old, Topp first began farming six years ago on small-scale vegetable operations, first as an apprentice and then as manager. It wasn't until last year that Topp took the leap from annual vegetable production to perennial fruit and became the primary operator of his new business, Topp Fruit. When asked what drew him to farming, Topp notes a desire for the lifestyle and a good dose of stubbornness. Now he is figuring out the day-to-day work of growing food in a region with just 15 inches of average annual precipitation.

WATER MANAGEMENT

As Topp experiments with the arts of pruning, cover cropping, harvesting, and caring for the daily needs of his orchard, he is also learning the intricacies of irrigation. Topp has a single source of irrigation water: surface water from the Fire Mountain Canal. The canal runs just upslope of the orchard and carries water to many producers throughout the valley. In Colorado, as in many western states, this is the original irrigation structure: Canals, also known as "ditches," supply users water that has often been captured and stored in reservoirs. Many ditches in Colorado are earthen—the same canals hand-carved through the landscape by homesteaders or, in some places, by native farmers millennia ago. The Fire Mountain canal is concrete lined, while others in the area have been piped to save water.

The way the Fire Mountain Canal is operated determines to a great extent the choices Topp can make with his irrigation practices. Some ditch systems deliver water to users throughout the season according to their rights and needs. The Fire Mountain Canal, however, runs on what is called a constant flow: when water flows through the canal, Topp and the other water users must use it before it flows downstream. However, neither Topp nor any individual producer alone can determine canal or ditch operations as the ditch is operated by the Fire Mountain Canal and Reservoir Company whose members include shareholders along the ditch. When water is released from Fire Mountain Canal, Topp receives the entire amount diverted at this point for four-and-a-half days straight on an ongoing cycle until the water is turned off. There

ABOVE: Topp takes a break for a photo shoot
TOP of PAGE: Gated pipe irrigates Topp's orchard
Topp Fruit photos by Kate Greenberg

Topp and fellow farmer Elizabeth Woods Darby mark irrigation furrows

is no benefit to him as a producer—and in fact some disincentives—to use less than his full allocation.

RESILIENCE IN HEALTHY SOIL

Topp uses furrow irrigation, or shallow channels that run alongside the trees. This type of flood irrigation is often considered less efficient than such technologies as sprinklers or drip irrigation. But for Topp, installing more efficient irrigation comes with a steep price tag, one he might be willing to consider if it did not also pose a risk to the health of his orchard.

Some years, particularly in drought years, the Fire Mountain Canal can be turned off as early as July. This is often due to scant snowpack producing below-average runoff. Summer rains can help but are not reliable. This means Topp risks losing late-season irrigation, which is critical to fruit ripening. Topp relies on furrow irrigation to store water in the soil. As water flows through the furrows, some of it is used by the trees, some returns to the river, and some is stored in the soil. Topp is essentially using his irrigation technology to do what the larger irrigation infrastructure prohibits him from doing: storing water on-farm for late-season irrigation. His management also supports multiple values, including building healthy soil, enhancing river flows, and growing delicious fruit. While water conservation and efficiency are critical to the future of the West, Topp offers an example of why their nuances must be sufficiently understood.

The limits on Topp's irrigation infrastructure have urged him to build the health of his soil. This year he is planting multiple mixes of cover crops—an amalgamation of crop types that bring nutrients and organic matter to the orchard. The healthier the soil, the more water it can store. And the more water Topp can store in his soil, the less he risks losing his crop in a drought year due to lack of surface water. (See the Appendix for an in-depth discussion on options for supplementing irrigation supplies).

YOUNG FARMERS OF THE FUTURE

Conservation means many things to farmers and ranchers. Soil conservation is critical to Topp's ability to conserve water, while his operation is also driven by the constraints of his irrigation infrastructure, the cost of efficiency improvements, and the particular operations of his ditch. Yet Topp is perpetually questioning how to do things better. He looks to his neighbors who, as one-time beginning farmers, have navigated decades of their own challenges. Topp says there have been few things more valuable than the mentorship of fellow farmers.

When asked where he sees himself in forty years, Topp replies, "I'd like to say I'm still farming [….] If I do continue, I'd like to expand to a scale that gives me more flexibility so I can grow fruit for a greater portion of the population." It will take a reliable water supply for Topp to realize that future. There is no easy answer. But one thing is clear: We need more young farmers like Topp on the land, learning from their predecessors, forging innovative routes to conservation, and adapting to the variables of a changing climate.

SNAPSHOT

Years owned by the same family: 8

Years operated by Topp: 2

Irrigated acres: 4.4

Commercial land use: Organic cherries and plums

Water management: Cover cropping, soil moisture management, furrow irrigation

Paul and Elizabeth Kaiser

SINGING FROGS FARM

A small-scale, organic, no-till vegetable operation

GROWTH IN DROUGHT

Take a tour of Singing Frogs Farm and you will see crop rows packed with purple kale, butterhead lettuce, and heirloom tomatoes—over one hundred vegetable varieties in total. In this cool, low valley just outside of Sebastopol, California, farmers Paul and Elizabeth Kaiser are surprising their neighbors. In the midst of California's driest year on record, the Kaisers are increasing revenue on their two-and-a-half acres of cultivated bottomland while drastically reducing water consumption, an unlikely combination when the drought is driving farms elsewhere out of business.

Even in a historically unprecedented dry year, and in a region with an average of 30 inches of annual precipitation, the Kaisers are not daunted by the drought. Instead, they take it as a challenge to build drought resilience on their farm, where the precious groundwater they use to irrigate is just as tenuous as surface flows elsewhere. Whether through no-till, composting, or an intensive greenhouse schedule, the Kaiser's resilience always comes back to the health of their soil.

THE PATH TO NO-TILL

Like many young farmers today, the Kaisers did not grow up on a farm. In 2004, ready to raise a family and try out the ideas they experimented with while working on land restoration in The Gambia, West Africa, they purchased eight acres in Sonoma County. This land was not exceptional. The light, tan soil had only 2.4% soil organic matter (SOM) when the Kaisers bought the property, relatively low for the area. Only a couple of the acres were arable. Cold air funnels in from the surrounding vineyards, driving temperatures below freezing in the winter and bringing frost dates as early as September and as late as May.

The Kaisers started out tilling the soil, as is still the norm on most operations big and small. Soon they realized tillage, the process of breaking up the soil for cultivation, was disturbing critical life processes taking place underground. Now with no-till, Paul and Elizabeth are building their soil structure. This means they are able to capture more water—not to mention beneficial carbon and nitrogen—and store it in the soil where it supports the soil biome and the next crop.

The Kaisers also use an intensive greenhouse schedule to rotate crop successions and keep the soil covered at all times. The beds are not bare for more than a few

ABOVE: Farm employee Marty harvests a head of lettuce
TOP of PAGE: Singing Frogs Farm produces over 100 varieties of vegetables
Singing Frogs Farm photos courtesy Paul Kaiser

Most of the Singing Frogs Farm Crew: L to R (back row) Miguel, Elizabeth, Paul, John, Marty & Kim. L to R (front row) Anna, Lucas, Nina and Bryanna

hours at a time, which greatly reduces water loss to evaporation. Paul and Elizabeth are able to achieve this with transplants grown in their greenhouse and ready to plant-out immediately following harvest. They also apply a massive amount of compost, which they top-dress to the beds rather than tilling in. They plant directly into the compost, which retains moisture, builds organic matter, and delivers nutrients to the crop.

MORE ORGANIC MATTER, LESS IRRIGATION

Now, after eight years of no-till production, composting, and keeping the ground covered, the Kaisers have measured their soil organic matter at a twelve-inch depth at 6.5% and at a six-inch depth an astounding 9.5%. That's an increase of over four-fold from when the couple turned over their first row on this land. With every percent increase in SOM, the soil can hold upwards of twenty thousand gallons of water per acre, with some sources citing that number up to twenty seven thousand gallons. So when the rains come, as they have been and are predicted to continue in more intense events, Kaiser's soil not only captures and retains that moisture, but also evades damaging erosion. After a recent eleven-inch downpour, the Kaiser's fields remained intact.

The Kaisers's soil water savings is showing up as savings in their irrigation, too. The Kaisers use precision drip irrigation across the farm. Two slender tubes run the length of each thirty-inch wide bed, dripping water precisely where it's needed. This system irrigates at around 90% efficiency, meaning that 90% of the water diverted to the farm is used by the crop, rather than lost to evaporation, runoff, or deep percolation, an extremely high level of efficiency for any farm.

The Kaiser's attribute the efficiency of their farm to a combination of healthy soil, efficient irrigation technology, and refined management practices. Paul explains, "When we started farming here […] I was typically running the irrigation system two to three hours every-other day. And that was pretty standard. Now I am down to 45 minutes to an hour every five to seven days." The Kaisers grow the same crops now as they did then.

Not only are the Kaisers saving water, they're making more money doing it. Their high-intensity production pumps out over seven times the average volume of similar farms in California, pulling in around $100,000 an acre in sales and supporting four full-time staff.

A COMMITMENT TO INNOVATION

The improvements at Singing Frogs Farm didn't happen overnight. The Kaisers have put in seasons of trial and error integrating biology, ecology, and human stewardship to realize a profitable, productive, and conservation-oriented operation. They have invested in efficient irrigation and continue to refine their water management. Rather than finding productivity and drought resilience at the expense of healthy soil and an intact ecosystem, the farm is thriving precisely because they foster both.

SNAPSHOT

Years owned by the same family: 11

Acres owned/managed: 8

Irrigated acres: 2.5

Commercial land use: Diversified vegetable operation

Water management: No-till, composting, constant soil cover, drip irrigation

5 http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1082147.pdf

6 https://scripps.ucsd.edu/news/8155

GLOSSARY

WATER MANAGEMENT

Acre-foot: Amount of water that will cover an acre of land at a depth of one foot, or 325,851 gallons of water[1]
Center pivot: A type of automated sprinkler irrigation that rotates around a fixed point
Ditch: A channel constructed to deliver water for irrigation (see also “canal”)[2]
Efficiency: Quantity of water consumed by crops versus the amount of water delivered[3]
Flood irrigation: Water diverted from ditches and spread across the field or pasture[4]
Furrow irrigation: A type of flood irrigation that applies water into shallow, evenly spaced channels that convey water through a field to the crops[5]
Irrigation canal: A channel constructed to deliver water for irrigation (see also “ditch”)[6]
Micro sprinklers: Small sprinklers that deliver water just above the soil surface[7]
Reservoir: An artificial lake built to store water
Side roll: A type of automated sprinkler irrigation that moves in a line across a field
Sprinkler Irrigation: A form of irrigation typically higher in efficiency than flood; includes such technology as side rolls and center pivots[8]
Surface drip irrigation: Pipes or hoses that deliver water directly to the soil surface through small emitters[9]
Subsurface drip irrigation: Pipes or hoses that deliver water below the soil surface through small emitters[10]

SOIL HEALTH

Conservation tillage: Any tillage system in which at least 30% of the previous crops’ residue is left in the field to protect the soil
Cover crops: Non-cash crops that can provide multiple benefits including erosion prevention, nutrient availability, weed suppression, and water availability[11]
Holistic management: A whole farm planning system that helps farmers, ranchers and other land stewards better manage resources for environmental, economic, and social benefits[12]
No-till: Process of crop production that does not disturb the soil through tillage
Rotational grazing: Rotating livestock frequently throughout many small pastures to allow for pastures to regenerate[13]
Soil food web: Diverse soil community that includes bacteria, fungi, protozoa, nematodes, worms, insects, and more that work in tandem to create healthy soil
Soil health: The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals and humans[14]
Soil organic matter (SOM): The part of the soil that contains anything that once lived. It aids in crop growth, reduces erosion, retains nutrients, stores water, and sequesters carbon, among other benefits[15]
SOM: Short for “soil organic matter”
Tillage: Preparation of the soil for cultivation

WATER LAW

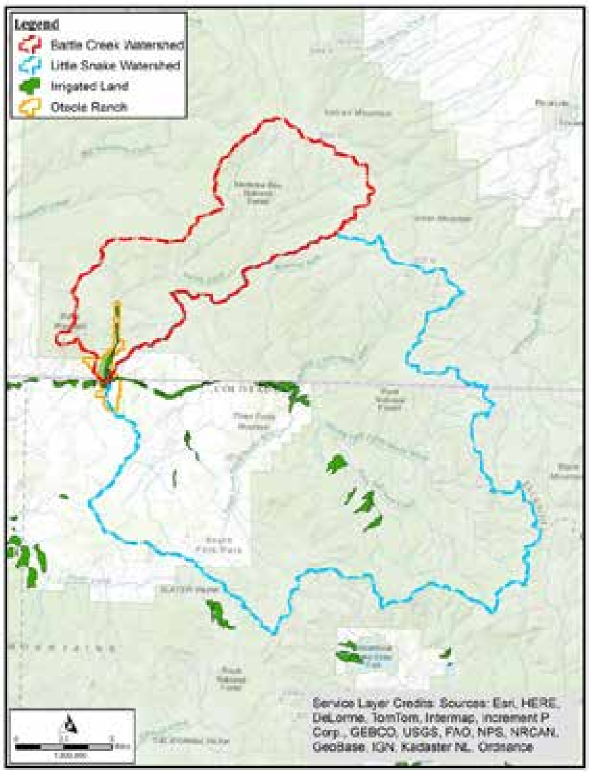
Beneficial use: The lawful use of water for a beneficial purpose which includes agricultural, industrial, and household use and may include environmental use
Call: In times of shortage senior water rights holders may “call” for water, thus curtailing deliveries to undecreed or junior water users in order to fulfill the beneficial use need of the decreed senior use right[16]
Consumptive use: Water use that permanently withdraws water from its source; water that is no longer available because it has evaporated, been transpired by plants, incorporated into products or crops, consumed by people or livestock, or otherwise removed from the immediate water environment[17]
Diversion: Removing water from its natural course or location, or controlling water in its natural course or location, by means of a water structure such as a ditch, pipeline, pump, reservoir, or well[18]
Return flow: Water that returns to streams, rivers or aquifers after it has been applied to a beneficial use[19]
Water right: Considered a property right; the right to use a portion of the public’s surface or groundwater resource under applicable legal procedures[20]

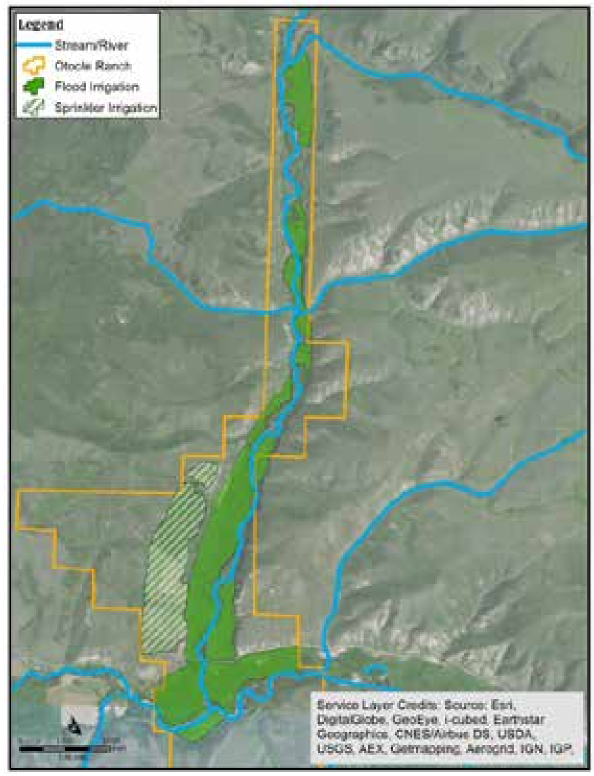
Definitions #1, 3, 4, 7-10, 16-20 courtesy of Colorado Foundation for Water Education (CFWE) from their publications *Citizen’s Guide to Colorado Water Conservation* and *Citizen’s Guide to Colorado Water Law*. Visit yourwatercolorado.org
Definitions #5, 11, 13-15 courtesy of the Natural Resources Conservation Service (NRCS), visit nrcs.usda.gov; #2 and #6 courtesy of the Bureau of Reclamation (BOR), visit usbr.gov; #12 courtesy of Holistic Management International, visit holisticmanagement.org

APPENDIX I: LADDER RANCH WATER BALANCE

Background

Ladder Ranch is located at the confluence of Battle Creek and the Little Snake River and straddles the Colorado-Wyoming border. The ranch draws water from Battle Creek and the Little Snake at multiple points for the irrigation of over 600 acres of hay pasture. Approximately 400 acres of flood irrigated pastures lie within a quarter mile of the two streams. Pressurized side roll sprinklers are used to irrigate approximately 175 acres on higher ground on the west side of Battle Creek.



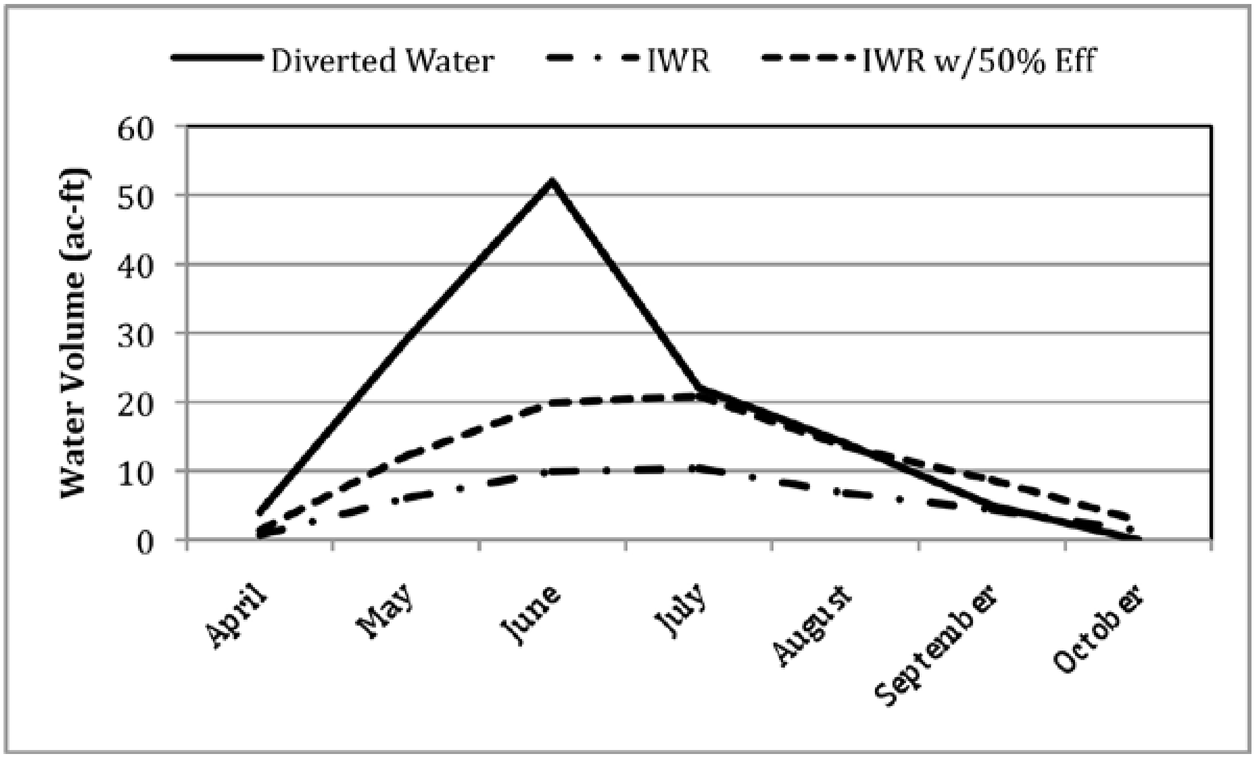


Water Rights

There is no irrigation and very little water use located above the ranch on Battle Creek, while there are approximately 2,200 acres of irrigated land above the ranch on the Little Snake. There is very little reservoir storage in the basin, which results in high peak flows that quickly taper off once the snowmelt is over. The ranch holds very senior water rights in Wyoming and Colorado, and these rights have never been called out or subject to administration during historical calls on the Little Snake in 2002 and 2004. Pat O'Toole stated that the ranch does reduce their irrigation diversions during low flow periods in order to leave sufficient water in both streams to maintain the fisheries there.

According to a recent study by CDM entitled "Agricultural Water Needs Study," hay pasture in this area requires approximately 2.28 acre-feet of supplemental irrigation water per acre to adequately meet the annual crop water demand. This means that crops on the ranch consume approximately 1,350 acre-feet of water annually (one acre-foot can cover a football field with one foot of water). Supplying a maximum crop demand of approximately 0.30 inches per day would require a total peak diversion flowrate of 15 cubic feet per second (cfs) assuming a system efficiency of 50 percent. Some diversion records are available from the Colorado Water Conservation Board for water rights filed with the state. One water right with fairly complete records is the Porter Salisbury Pump 1 & 2. The diversion records are compared to the irrigation water requirement (IWR) for this right in the figure on the next page.

LADDER RANCH WATER BALANCE, CONTINUED



This figure confirms comments by Pat O'Toole that when excess water is available, it is diverted, but once runoff tapers off, diversions are reduced to better match needs.

Irrigation Practices

The potential conversion of additional lands to sprinkler irrigation has helped many farmers and ranchers better manage their limited water supply. The impacts, however, of making such a change has both pros and cons that must be evaluated on a case by case basis. As mentioned previously, most of the irrigated lands on this ranch are located close to the creek. When excess water is applied in the spring, some of it would quickly return to the stream via surface return flows and be available by the next diverter downstream. In many cases, on this ranch the water is diverted from the stream and return flows accrue to the stream all within the ranch property, which implies that the only potential beneficiary of reduced diversions would be the stream in between. Some water would also penetrate below the root zone of the crops and travel through the soil back to the creek. This practice would tend to build up the amount of water stored in the soil and delay its release back to the stream system, thereby acting as an uncontrolled reservoir.

Future Water Conservation Measures

The "Agricultural Water Needs Study" mentioned earlier estimated that 72 percent of return flows in this area return to the stream within the same month that they are diverted, while most of the remainder returns over the following 4 months. This implies that most of the excess water diverted in May and June would return during those months; however, stream flows would continue to benefit from this return water through October. Based on our analysis of available data it appears that the current practices on the ranch are reasonable. While converting more areas to sprinklers would reduce the amount of flow diverted during the runoff season, it could negatively impact stream flows during the late summer and fall periods. Additional data would need to be collected to better predict the potential impacts of any large scale irrigation changes on the ranch.

Water balance researched and written by Applegate Group

APPENDIX II: ELA FAMILY FARM WATER BALANCE

Background

The Ela Family Farm is located on the upper portion of Rogers Mesa at an elevation of 5,850 feet near Hotchkiss, Colorado. The farm primarily grows a variety of fruits including apples, pears, cherries, peaches, and plums. The growing season extends from a blooming of the trees in mid-April to mid-May and concludes with harvest primarily in late August and September. The climate in this area is semi-arid with rainfall only contributing a small percentage of the annual crop water requirements. Crop production is heavily reliant on irrigation water. The soils consist of up to 20-24 inches of stony clay loam with an organic content of 3-4 percent.

Water Rights

The farm owns a wide variety of water rights that are used on the property, all of which are delivered through a combined ditch system off of Leroux Creek. Direct flow decrees include shares in the Allen Mesa, Highline, and Ellington Ditches, which have been physically combined into one ditch system. Their most senior decree includes 0.5 cubic feet per second out of Leroux Creek, which is typically in priority until August. After all the direct flow decrees are out of priority, the farm utilizes 250 shares it owns in the Leroux Creek Water Users Association, which operates numerous small reservoirs in the Leroux Creek Drainage.

The amount of water available from these shares varies depending on the snowpack. On average years, these shares will net about 190 acre-feet of water, but the volume can range from 100 acre-feet in dry years up to 225 acre-feet in wet years (one acre-foot can cover a football field in one foot of water). In order to have a firm water supply during dry years, Ela leases an adjoining parcel of land to the south and fallows the majority of that land in order to focus the water supply on the orchards. Ela also owns 200 shares in the Fire Mountain Canal, which equates to approximately 0.13 cubic feet per second (cfs). However, that water is leased to other users and is not used on Ela's property.

Irrigation Practices

Information regarding the property and associated irrigation practices were obtained from a meeting with Steve Ela on January 8, 2015. The property was originally purchased by the Ela family in 1987. At that time the entire orchard was irrigated with flood irrigation in furrows between the rows of trees. The family immediately started installing the backbone of infrastructure that would be required to convert over to micro-sprinklers in 1989. This included an NRCS Yak screen, main pipeline, and filtration system. Water would pass through the yak screen at the pipeline entrance and pressurize using the gravity fall from that point to the filter location. Pressures in the northeast corner of the property were not sufficient, so a 2 horsepower pump was added to increase the pressure there. Overflow from the Yak screen is conveyed to the alfalfa pastures for irrigation there. No flow measurement device is in place to determine the amount of overflow water, but according to Ela, during dry years there is very little overflow once spring runoff is over.

The first micro sprinklers were installed in 1990 and all orchards on the property were converted by 2000. Around 2002, the Ela family started to install buried drip lines in some orchards. After experimenting with multiple arrangements they determined that three drip lines per tree row is most effective. The drip lines contain pressure compensating drippers spaced 2 feet apart with flowrates of 0.25 gallons per hour. Once buried, the drip lines have assisted with controlling the ground cover near the tree trunks since that area is drier than between the rows where the cover crop can be managed easier. The drip system currently covers approximately 30 acres of the farm in 1-acre zones with the rest remaining on micro sprinklers. One distinct advantage to the drip system is that it is set up so that the user can adjust the application rate by simply entering the percentage of a full irrigation that is required. This makes seasonal adjustments much simpler than the micro sprinklers.

Installing the drip system necessitated increased water filtration in order to avoid plugging the drippers. After experimenting with numerous filtration options, the farm determined that sand media filters were the most effective. There are currently six of these filters in the system, and they are automatically backwashed as necessary. The frequency of backwash cycles depends greatly on the time of year.

Irrigation Demand vs. Supply

Aerial photography obtained from the National Aerial Imagery Program (NAIP) was used to determine the number of irrigated acres. The farm has 83.3 acres of orchards on the sprinkler and drip system and 6.4 acres of alfalfa/hay that are currently irrigated. Another 5.4 acres of potential orchard exists between older remaining rows of some crops. Evapotranspiration (ET) data was obtained from Colorado Agricultural Meteorological Network

ELA FAMILY FARM WATER BALANCE, CONTINUED

(CoAgMet) from their nearby station on Rogers Mesa. The station is located about 1 mile to the south and about 200 feet lower in elevation. The ET data is for a reference crop of alfalfa, which can be converted to other crops such as orchards by applying a crop coefficient to the data.

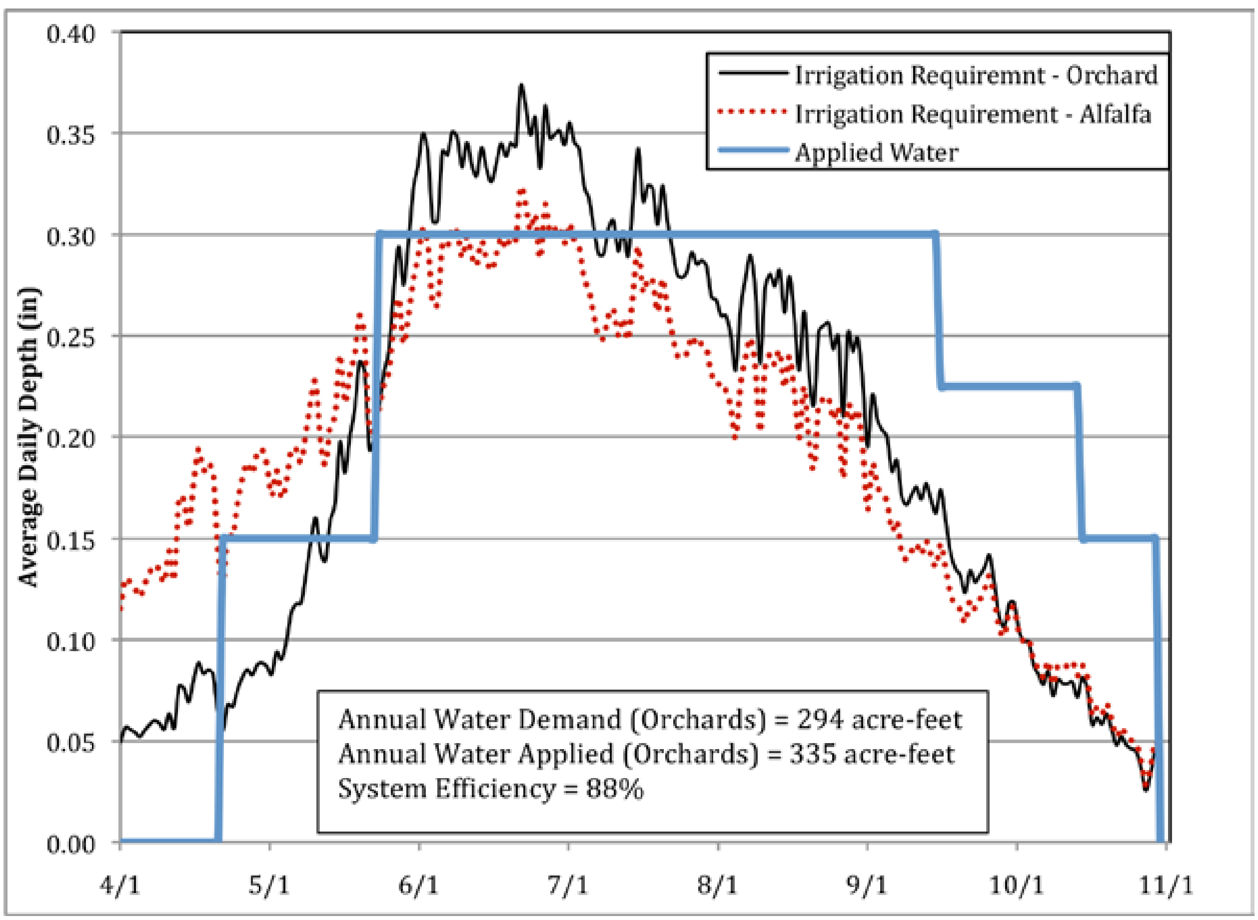
The Food and Agricultural Organization (FAO) published crop coefficients for a wide range of crops including orchards. These values were used to estimate the ET demand for the crops. Average precipitation data was also obtained from CoAgMet and to the ET demand at an 80% efficiency rate in order to calculate the Irrigation Requirement (IR) for the orchards. The amount of irrigation water supplied to the orchards was calculated by applying the dripper/micro sprinkler spacing and flowrate to the average irrigation schedule described by Ela. The figure below depicts a comparison between the irrigation supply and demand for an average year.

This analysis shows that the orchard irrigation system is achieving an efficiency of approximately 88%, which is very close to accepted values of 90% for drip systems and 80-90% for micro sprinklers.

Future Water Conservation Measures

There does not appear to be a significant amount of additional water that could be saved by increasing water conservation practices on the orchard portion of the farm. Converting more land to drip would allow the system to be managed so that the supply can even more closely follow the demand, but this will not likely result in a significant amount of conserved water. Rather it would allow the user to easily adjust the system to better match daily demand and maintain more consistent soil moisture. Backwash water could be used if a larger settling pond was provided to store backwash sediment and water, but another pump would be required to inject this water back into the system. This would also increase the complexity of operations while not resulting in a significant amount of water savings. Ela's willingness to experiment with various technologies and his efforts to continuously improve the system have resulted in a very efficient system overall.

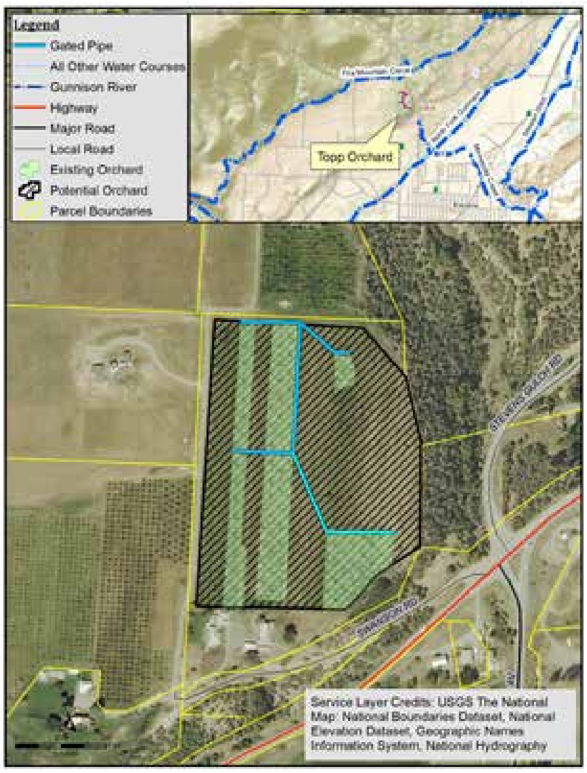
Water balance researched and written by Applegate Group



APPENDIX III: TOPP FRUIT WATER BALANCE

Background

The orchard owned by Harrison Topp is located on the upper portion of Rogers Mesa at an elevation of 5,850 feet near Paonia Colorado. The orchard has not been intensively managed in the past and only 14 acres of the site remains planted. The growing season extends from a blooming of the trees in mid-April to mid-May and concludes with harvest, primarily in late August and September. The climate in this area is semi-arid with rainfall only contributing a small percentage of the annual crop water requirements. Thus crop production is heavily reliant on irrigation water. The soils consist of up to 20-24 inches of stony clay loam.



Water Rights

The orchard owns 480 shares of water in the Fire Mountain canal, which is the only irrigation water supply on the property. These shares equate to 0.33 cubic feet per second (cfs) of water according to the Fire Mountain Ditch Company. Water is diverted from the Fire Mountain Canal in conjunction with the neighbors' shares on the north side of the property. The entire amount diverted at this point is routed to the Topp Orchard 4.5 days per week, while the northern neighbor takes the water the remaining 2.5 days a week.

The Fire Mountain Canal has a relatively junior water right on the North Fork of the Gunnison River, and it is called out every summer. When direct flows are not available, water is released from Paonia Reservoir in order to achieve a full decreed flow of approximately 175 cubic feet per second (cfs). The canal typically turns on around mid to late April and runs at a full canal flow until the reservoir is drained. After the reservoir is drained the canal typically has to shut down for the season. The average shutdown date is September 24th; however it varies greatly from late July to late October. The figure on the next page shows the frequency of start and stop dates for the canal.

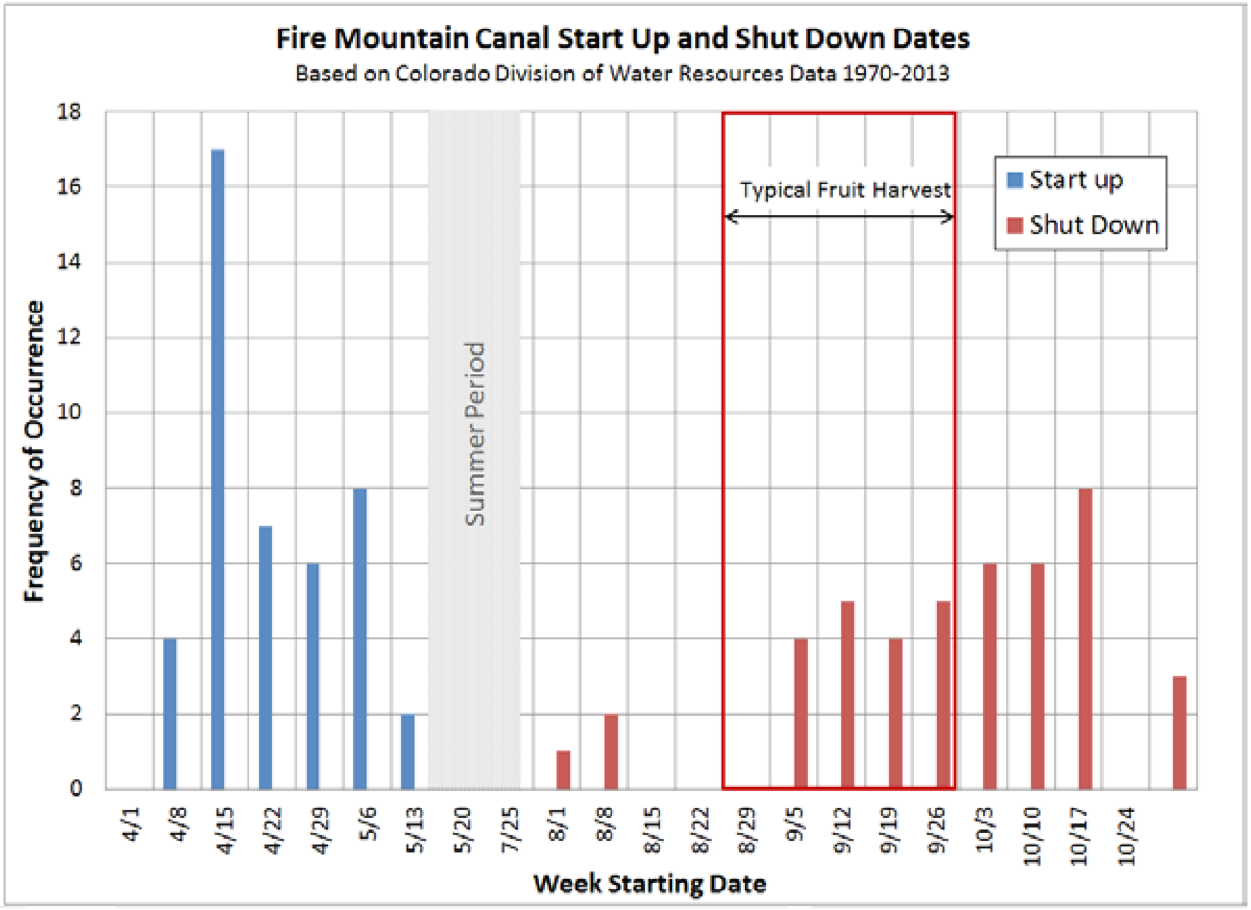
Irrigation Practices

Information regarding the property and associated irrigation practices were obtained from a meeting with Harrison Topp on January 8, 2015. The property was originally irrigated with flood irrigation in furrows between the rows of trees. The farm has 14.4 acres of potential orchard; however, many of the trees were recently removed and there is currently only 4.4 acres of orchard under irrigation. Gated pipe has been installed along the top and middle of the remaining orchard blocks as shown in the attached map. The remaining land is irrigated on a very limited basis.

Irrigation Demand vs Supply

Aerial photography obtained from the National Aerial Imagery Program (NAIP) was used to determine the number of irrigated acres. Evapotranspiration (ET) data was obtained from Colorado Agricultural Meteorological Network (CoAgMet) for their nearby station on Rogers Mesa. The station is located about 12 miles to the southwest and about 200 feet lower than the orchard. The ET data is for a reference crop of alfalfa, which can be converted to other crops such as orchards by applying a crop coefficient to the data. The Food and Agricultural Organization (FAO) published crop coefficients for a wide range of crops including orchards and these values were used to estimate the ET demand for the crops. Average precipitation data was also obtained from CoAgMet and to the ET demand at an 80% efficiency rate in order to calculate the Irrigation Requirement (IR) for the orchards. The amount of irrigation water available for the orchards was assumed to be constant since flows in the Fire Mountain Canal are typically constant when the canal is in operation. The figure on the next page depicts a comparison between the average demand, the average supply, and the supply in 1977.

TOPP FRUIT WATER BALANCE, CONTINUED



This analysis shows that on an average year the orchard irrigation system has surplus water when water is available. The largest potential hindrance to a productive orchard at this location is the uncertainty of late season water, which is critical as the fruit is ripening. Data from the Colorado Division of Water Resources shows that the canal is typically turned on in mid to late April but turns off as early as late July in extreme drought years. The driest year on record was 1977. During that season, approximately 47.7 acre-feet of water was available, which is nearly enough to meet the annual demand of the orchard. The timing of the water, however, would not have been sufficient to produce a crop and may have even resulted in tree mortality.

Harrison Topp indicated that he estimates he applied 18 acre-feet to the remaining orchards in 2014. Based on the irrigation requirement estimated from CoAgMet, the 4.4 acres would have required 15.5 acre-feet. This results in an estimated efficiency of 86 percent. This would be very high for gated pipe, which is typically around 60-70 percent efficient.

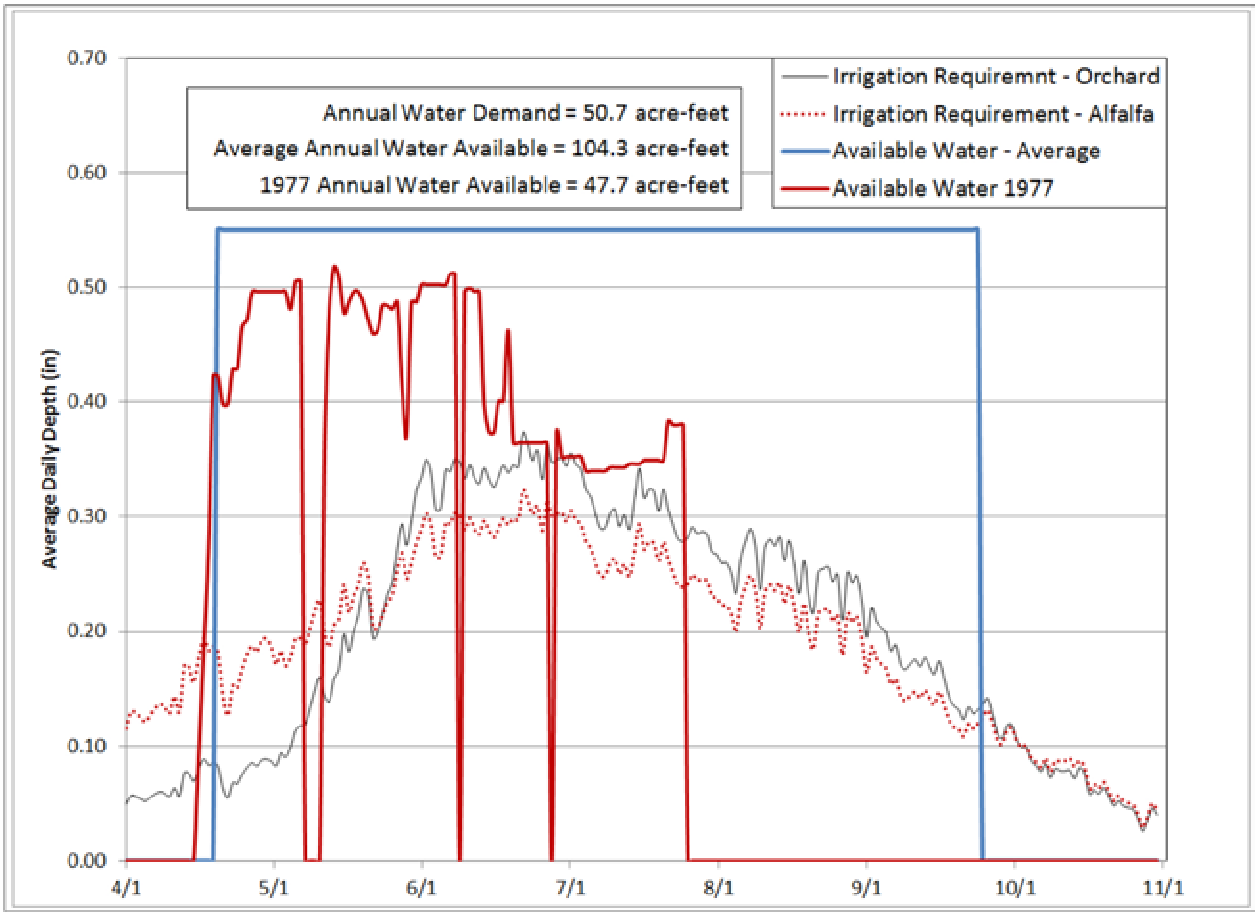
Future Water Conservation Measures

In order for this property to reach its full potential as an orchard, late season water would be required. In extreme drought years it would take approximately 18 acre-feet of storage to bank extra water in the spring for use in the fall. Constructing a reservoir of this size on the property would significantly reduce the amount of orchard acreage. Another option would be to seek out a supplemental water supply.

If a new supply was obtained through a well such diversions would require augmentation water to offset stream depletions when it was used. It is our understanding that augmentation water is difficult to find in the North Fork of the Gunnison due to the lack of storage available. A final option to address this shortage would involve operating the Fire Mountain canal at lower flowrates in late summer and fall when the canal is relying on storage water. This would require a major organizational change for the Ditch Company but the benefits to the users could be substantial.

Under the current method of canal operation, converting to micro sprinklers or a drip system would not help solve

TOPP FRUIT WATER BALANCE, CONTINUED



the potential water shortage late in the season and it could, in fact, negatively impact the orchard. Under flood irrigation, while the canal is on the entire soil profile could be irrigated to the field capacity. Then when the canal is shut down, there will be a sufficient amount of water stored in the soil column for use by the trees. If micro sprinkler or drip irrigation was installed it could limit the amount of soil moisture that could be built up and stored in the soil for later use. These systems would conserve water while the canal is on, but without the benefit of a local storage vessel the water supply for the property would remain unchanged.

If the orchard was completely replanted and irrigated with all 480 shares of water, on an average year about 53.6 acre-feet of water would return to the stream system through seepage or surface runoff. Some of this water might be intercepted by the North Fork Farmers Ditch and incorporated into their system for use by downstream users. The remaining water would enter the North Fork of the Gunnison upstream of a couple of very senior ditch diversions. This water would help fulfill their water decrees and be diverted into their system.

Another option would involve buying additional land that does not have a sufficient water supply and using some of the excess shares from this property to bolster irrigation there. Assuming the Fire Mountain Canal continues to operate the canal at a constant flow, we estimate that the 480 shares would be sufficient to irrigate approximately 6 additional acres. This estimate also assumes that drip or micro sprinkler irrigation systems were installed and managed to achieve 90% efficiency, similar to other local orchards. This option would actually increase the consumption of water since only 10% of diverted flows would then be returning to the stream system.

In summary, the best alternative for this property would involve changing the diversion patterns of the Fire Mountain Canal. However, that is beyond the control of a single shareholder. The lack of late season water likely explains why there are not as many orchards on in the North Fork Valley that rely strictly on Fire Mountain Canal water.

Water balance researched and written by Applegate Group

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