Colorado Water

Colorado State University

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Highlights

In Every Issue

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Front Cover: Colorado State University professor of viticulture Horst Caspari inspects wine grape vines growing in the Western Colorado Research Center's Orchard Mesa site vineyard. Photo by Bill Cotton

This Page: Denver Botanic Garden. Photo by Jessica Feis

Editorial

by Reagan Waskom, Director, Colorado Water Institute

Thus far 2012 has been dry and warm, yet with the gardening season upon us it is time to start thinking about landscapes. Looking back on record 2011 snowpack in parts of Colorado reminds us of the difference a year can make in our semi-arid state. Hopefully, late spring precipitation will moderate conditions, but meanwhile, we need to start thinking about water conservation in our landscapes. This edition of Colorado Water includes updates on some of the work at CSU and around Colorado on landscape water use and conservation.

Water conservation as a drought response involves many of the same water efficiency tools contemplated for water supply planning, but there are important distinctions. In the 2002-2004 drought period, Colorado saw a 22 percent decrease in urban water use over a very short period of time. Although water use has rebounded by seven percent since 2004, it is clear that we will use even less water on a per capita basis in the future. Drought demand reduction is best achieved through short-term, mandatory restrictions and price signals, while urban water use efficiency is achieved gradually, and thus is more sustainable. Given that our population growth trends seem inevitable over the next few decades, we must get serious about increasing water efficiency. Urban water conservation also benefits society in some significant ancillary ways, including reduced energy consumption, preservation of irrigated agriculture, and enhanced natural ecosystems.

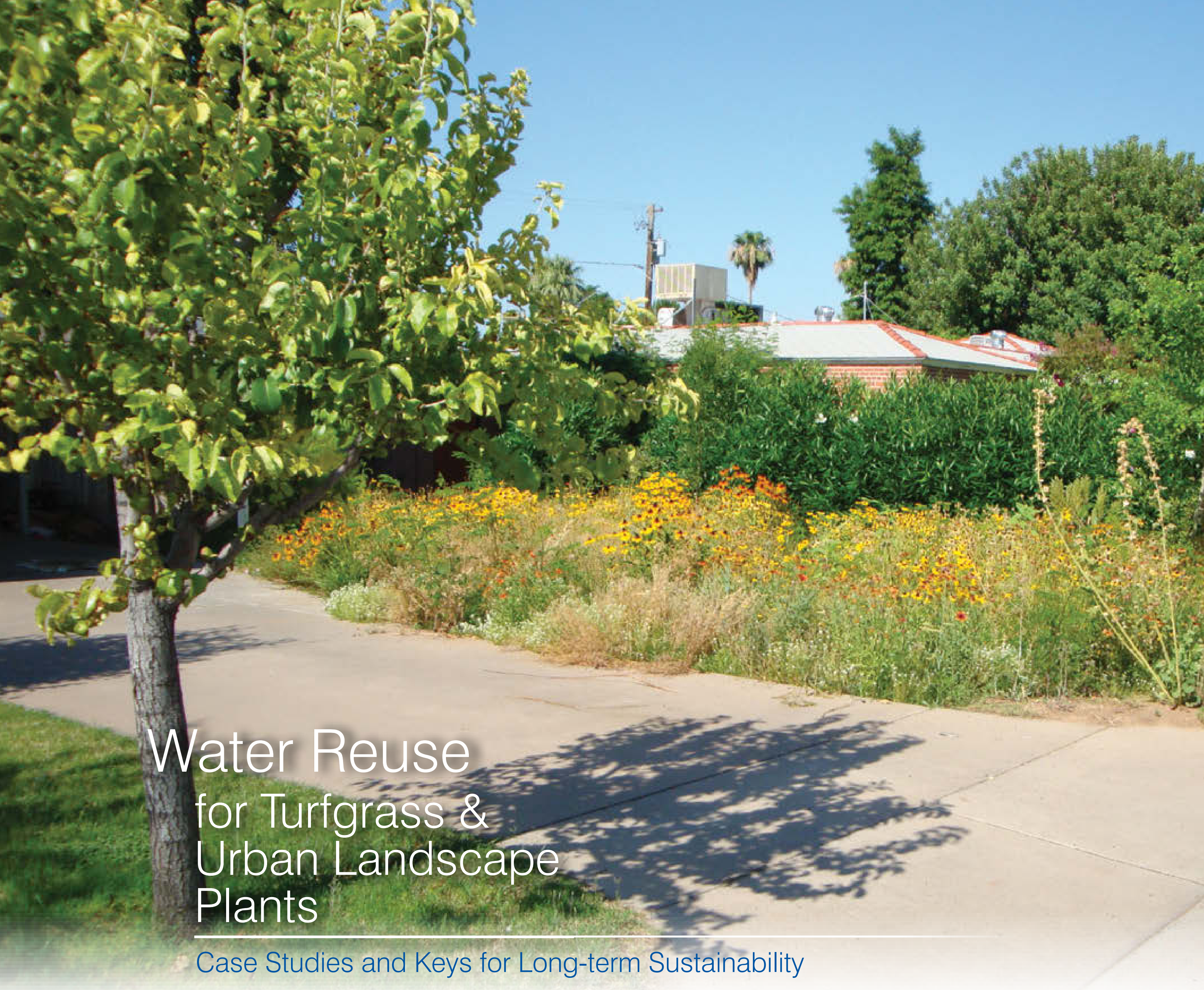
Currently, 1.1 million acre feet (MAF) of water are used annually in the municipal and industrial (M&I) sector in Colorado, out of a total of approximately 6 MAF of total consumptive use. Our population is projected to grow to 8.6 to 10.5 million people by 2050, two thirds of whom will be living in the S. Platte basin. That growth is expected to push urban and industrial water demand to over 1.5 MAF and perhaps double it to two MAF, depending upon the energy sector and oil shale development in particular. This trajectory does not have to be our future.

Over 40 percent of Colorado urban household water use is devoted to outdoor watering of landscapes. However, current water consumption in gallons per capita per day (gpcd) varies widely, from over 500 gpcd to less than 100 gpcd, depending upon a number of factors. West Slope communities that serve many second homes and tourists tend to have higher per capita use compared to more densely urbanized places, like Aurora or Colorado Springs. On a statewide basis, we are currently at 172 gpcd, but this

figure will decrease as tiered rates, education, landscape audits, rebates, and new water appliances are implemented as part of municipal water conservation programs.

Conservation professionals distinguish between passive and active water conservation. Passive measures include low flow fixtures and appliances that do not require homeowners to do anything special beyond installation. These measures are expected to deliver approximately 8 percent savings over time as they are implemented with new construction and remodels. Active water conservation was what paid off so well in the 2002 drought, mainly achieved through curtailing outdoor irrigation. Water supply managers view bluegrass lawns and lush gardens as a low cost reservoir that can be called upon when the occasional drought occurs. Active water conservation requires much more from homeowners, and for that reason, we need research-based information on new landscape plants and other methods to better manage our outdoor water.

California has become the first state to mandate a 20 percent reduction in urban water consumption by 2020. They will attain this through changing landscapes and utilizing stormwater, graywater, rainwater, and municipal effluents, among other things. Colorado has already achieved an 18 percent reduction in M&I in the last dozen years and may be able to squeeze out another 20 percent without a state mandate as we redevelop old urban infrastructure and build modern urban systems that are water and energy efficient. We know that xeriscapes, for example, can thrive on 40 percent less water than our bright green formal landscapes—we just have to learn accept different shades of green. We still have to plan for drought; let's just hope we do not have to deal with it this summer.



Water Reuse for Turfgrass & Urban Landscape Plants

Case Studies and Keys for Long-term Sustainability

Yaling Qian, Department of Horticulture and Landscape Architecture, Colorado State University

Introduction

Population growth in arid and semiarid regions of the U.S. continues to place an increasing demand on limited water supplies. Many cities and districts are struggling to balance water use among municipal, industrial, agricultural, and recreational users. Along with an increase in fresh water demand comes an increase in the volume of wastewater generated. Reuse of treated wastewater for turf and landscape irrigation is often viewed as one way to maximize the existing urban water resources. In addition to the growing concerns of the future water supply, the more stringent wastewater discharge standards make using recycled wastewater increasingly attractive. Urban green space (such as on golf courses, parks, school playgrounds, and sports fields) is the leading user of recycled water, because intensively managed turf can use nutrients in the wastewater efficiently, and large green spaces require a high volume of irrigation water.

There are two forms of reuse of residential wastewater for landscape irrigation: treated municipal sewage water (i.e., recycled water) and untreated household graywater. "Recycled water" refers to any water that after residential and sometimes industrial use undergoes significant treatment at a sewage treatment plant to meet standards set by federal or state water laws and regulations. This water is usually suitable for various reuse purposes, including irrigation. During treatment, suspended solids are removed,

Left: Household that uses graywater for irrigation,

Photo by Joe Cosenza

pathogens are disinfected, and partial to substantial reduction in nutrients occurs, depending on treatment stage. However, recycled wastewater may still contain different levels of dissolved solids, ions, nutrients (NO3 and P2O4), and other elements. "Graywater" refers to water that has gone through one cycle of use in laundry, shower, or bath; it does not include water from toilets and dishwashers. Graywater used in landscape irrigation typically goes without significant treatment. Several drought stricken states, including California, Arizona, New Mexico, Texas, and Florida have legalized the practice.

Research Projects

Studies have been conducted at CSU to evaluate the effects of recycled water and graywater irrigation on landscape plants and soils. In our first study, recycled water samples were collected to assess the variability of chemical properties of recycled water in the Front Range of Colorado. Results indicated that the chemical constituents of recycled wastewater were dominated by sulfate, bicarbonate, chloride, and sodium. The average sodium and chloride concentrations of the water samples collected were 99 mg/L and 95 mg/L, respectively. Adjusted sodium absorption ratio (SAR) of recycled water samples ranged from 1.6 to 8.3. We compared soil chemical properties on golf course fairways that have used recycled wastewater irrigation to those with non-saline surface water irrigation (surface water was stream and ditch water from melting snow of the Rocky Mountains). Seven

Table 1. *Mean soil chemical properties from landscapes with long-term recycled water irrigation vs. surface water irrigation.*

Soil Parameter	Recycled Water Irrigation	Surface Water Irrigation
Cation Exchange Capacity (meg/100g)	31.3	27.8
pH	7.7***	7.4
Ca (mg kg^{-1})	4524**	3605
Mg (mg kg^{-1})	518**	611
Na (mg kg^{-1})	419***	141
Fe (mg kg^{-1})	139*	172
Mn (mg kg^{-1})	58*	41
Cu (mg kg^{-1})	3.3*	5.7
Zn (mg kg^{-1})	12.0	11.1
SOM (%)	3.1	3.1
Extractable P (mg kg^{-1})	75.0***	58.0
Boron (mg kg^{-1})	1.54**	1.10
Al (mg kg^{-1})	219*	304
K (mg kg^{-1})	395	375
Ca (%)	71.8	70.4
Mg (%)	14.4*	18.8
K (%)	3.6	4.2
ESP	6.6*	2.0

*, **, *** Significantly different from surface water - irrigated sites at $P \le 0.05$, ≤ 0.005, and < 0.001, respectively.

to 33 years of irrigation of turfgrass on a fine textured soil with recycled water resulted in an increase of soil salinity [187 percent higher than sites irrigated with surface water (ECiw range = 0.15 to 0.30 dSm-1)]. Sites irrigated with recycled water for more than seven years had higher average soil exchangeable sodium percentages (ESP) than the surface water irrigated soil, although the ESP values on fairways are not high enough to classify that soil sodic (Table 1). Many turfgrass and landscape plants are tolerant of recycled water. Some species of trees and shrubs, however, are susceptible to certain attributes of recycled water, especially after several years of exposure. We used existing landscapes that were under long-term recycled water irrigation to determine the relative tolerance of different species of conifers to recycled wastewater. We tested more than 100 conifer trees, consisting of six confer species, on four large landscape facilities. It was found that Rocky Mountain juniper and pinion pine were more tolerant of recycled water irrigation than Austrian pine, which was in turn more tolerant than Scotch pine, ponderosa pine, and Colorado Blue Spruce. Rocky Mountain juniper and pinion pine grew well under recycled water irrigation for seven-20 years and accumulated lower levels of toxic ions (such as Na, Cl, and B) than other conifers. In contrast, the more sensitive species—scotch pine, ponderosa pine, and Colorado Blue Spruce—accumulated higher Na in the needles than juniper and pinion pine. The degree of needle burn was largely influenced by needle sodium concentration, i.e., the higher the sodium, the greater the needle burn.

In our second study, we collaborated with three CSU faculty members (Drs. Larry Roesner, Sybil Sharvelle, and Mary Stromberger) and the Water Environment Research Foundation. A field experiment has been conducted to evaluate the effects of application of graywater on landscape plant health. Data has been collected on plant health from four homes that have had graywater irrigation systems in place for five to 31 years. Homes included in the study are located in Arizona, California, Colorado, and Texas. For each site, sample areas were selected where graywater was applied for irrigation, and control areas were also sampled with similar vegetation that had been irrigated with fresh water. Plant growth was determined, and plant health was evaluated. For evergreen conifers, we also collected data on the number of years of needle retention and year-to-year growth increments.

Among landscape plants studied, St. Augustinegrass (Stenotaphrum secundatum), Bermudagrass (Cynodon dactylon L.), Four-Wing

Urban landscape using recycled water for irrigation.

Photo by Yaling Qian

Saltbush (Atriplex canescens), Juniper (Juniperus spp), Euonymus (Euonymus spp.), Rose of Sharon (Hisbiscus syriacus), and Chrysanthemum (Chrysanthemum spp.) responded very well to graywater irrigation and were ranked as tolerant to graywater irrigation. The following plants exhibited moderate tolerance to graywater irrigation: California Valeriana (Valeriana californica) and plum tree (Prunus spp.). Landscape plants that are sensitive to graywater irrigation included the Scotch pine (Pinus sylvestris), Hass Avocado (Persea Americana Hass), and Lemon tree (Citrus limonium). We did not find consistent trends regarding the influence of irrigation water source and individual leaf mineral content. The nature of the plant sensitivity is likely complex. Nevertheless, one concern about the long-term use of graywater for landscape irrigation is the potential for salinity problems. The relationship between landscape plants' salinity tolerance and their graywater response was assessed by comparing individuals plants' salinity tolerance reported in the literature with the observations in this study. We found that although discrepancy existed, the correlation between graywater tolerance and salinity tolerance was significant. The regression coefficient value (R2 = 0.36) suggested that approximately 36 percent of the variance of landscape plants' response to graywater is associated with their response to salinity; in this case, salinity tolerance. SAR of recycled water irrigated soil has been found to be relatively high in our previous studies. As a comparison, this research indicates that graywater has less impact on soil SAR compared to recycled water irrigation. It is possible that sodium does not accumulate as much in soils irrigated with graywater compared to recycled wastewater due to the water chemistry, i.e., lower sodium and higher surfactants in graywater than recycled wastewater. The nutrient content in the graywater stimulated plant growth and showed beneficial effects on landscape plants in a two-year greenhouse study.

In our third study, we collected soil information from 10 landscape sites (parks and golf courses) at two time-points: 1) immediately after the site started to use recycled water for landscape irrigation, and 2) five years after the initiation of recycled water irrigation. We found that soil salinity did not increase significantly at most of the sample sites over the five-year period. However, the average soil exchangeable sodium percentage (ESP) increased from 2.65 percent to 5.35 percent over the five-year period. These results suggested sodicity (the amount of sodium present in irrigation water) is of greater concern than salinity at most of the testing sites, since soil ESP is the parameter that exhibited the most significant changes after the start of recycled water for irrigation. Increased soil ESP may reduce soil aggregates stability and reduce overall soil health. Soil and/or water amendment with calcium based products may help to displace Na and reduce ESP. To evaluate management practices for reducing soil ESP under recycled water irrigation, eight golf course fairways were subjected to different management treatments. Four fairways were subjected to gypsum application following aerification (aerify one to two times per year and apply gypsum at 50 lb/1000 sq ft/year). The other four fairways were control sites with no gypsum addition. For control sites, soil ESP at zero-40 cm depth tripled over a five year period. For gypsum treated fairways, the increase in ESP over the five-year period at zero-40 cm depths was not statistically significant. Our project demonstrated that gypsum application following aerification is effective in reducing soil ESP under recycled water irrigation, especially at the shallow soil depths (zero-40 cm).

Based on our experiments and literature review, the following are some of the steps that may be employed for long-term sustainability when recycled water is used for urban landscape irrigation:

- Regular monitoring of water and soil quality to develop appropriate management strategies
- Providing adequate leaching and sufficient drainage to remove excess Na and salts from the root zone. On sites where shallow water tables may rise to cause salt accumulation in the root zone, it may be helpful to investigate means of lowering the water table, possibly adding additional drainage lines with possible sump pumps to deposit the excess rising water into drainage canals.
- Adopting intensive cultivation programs (deep aeration and water injection) to maintain oxygen diffusion and water movement. Adding chemical amendments (such as gypsum or other soluble calcium products) to soil or injecting into irrigation water to reduce sodicity problems
- Reducing nitrogen and phosphorous fertilization, accounting for the fertilizer value present in recycled water

More research is needed to 1) develop low cost, pre-irrigation water treatment strategies to decrease sodicity, and 2) develop specific landscape management techniques that will help to achieve urban water reuse sustainability.

Horticulture Related Water Studies

James E. Klett, Department of Horticulture and Landscape Architecture, Colorado State University

Water is a precious and limited resource in Colorado. With an average annual precipitation of about 15.4 inches, water cannot be squandered. Drought conditions are common in Colorado and can occur in small areas or over the entire state. The recent drought of 2002 was listed as one of the most severe single drought years on record.

Water conservation is becoming essential in Colorado as a result of increased population in the state. One area where water use can be reduced is landscape irrigation for both residential and business landscapes. It is estimated that 7-10 percent of the total water supply for Colorado is used for landscape irrigation. Also, landscape water use in the summer could account for 50-75 percent of total treated water use in any community. Water efficiency in landscapes can have a large impact on the water supply for many Colorado communities.

Different plants require different watering amounts; therefore, choosing correct plant material for landscapes can be an effective way to reduce water use in landscapes.

General watering guidelines are easy to find for a particular area; however, knowing specific water requirements for each landscape so that all plants are sufficiently hydrated is more difficult. The Green Industries of Colorado have compiled results from a survey asking the estimated water use of some commonly grown ornamental landscape plants in Colorado (http://greenco.org/drought.html). Unfortunately, this compiled list is subjective data, as the compiled information came from a survey where respondents returned ratings that were based solely upon visual observations or opinions. Quantifiable scientific data does not exist to support the assumptions as to whether a plant is a "high," "medium," "low," or "very low" water user.

After the 2002 drought year, research was started at Colorado State University looking at water requirements of specific landscape plants. Several annual flower species were planted in the ground and trialed under progressively decreased amounts of irrigation based on percentages of reference evapotranspiration (ET). The irrigation amounts were 100 percent, 75 percent, 50 percent, 25 percent, and zero percent of ET. Numerous species were tested and it was found that *Petunia x hybrida* had good growth with minimal visual signs of stress in the zero percent treatment. However, *Impatiens walleriana* performed only acceptably with good visual ratings, growth, and low stress when irrigated with 100 percent of ET.

Colorado State University conducts numerous (over 1200 varieties) annual flower trial evaluations yearly at 1201 Remington Street near the university Center for the Arts (Figure 1). In these extensive trials, annual flowers are separated by their water requirements based on this earlier research conducted at CSU. These annual varieties are separated into planting beds with separate irrigation controls allowing for either one half inch, one inch, or one and one half inches of additional irrigation per week during the growing season once established. These recommendations have been distributed to members of the Green Industry and homeowners throughout the state and region. In addition to these studies with annuals, research has been done or continues to be conducted on herbaceous perennials and woody plants.

In 2005 and again in 2008 two separate woody plant experiments were conducted over several year periods to determine the growth response of several xeric and more mesic shrubs, commonly marketed throughout Colorado nurseries and garden centers, to various irrigation treatments. The shrubs were subjected to progressively decreased amounts of irrigation based on the evapotranspiration (ET) of a short reference crop, and the resulting responses were assessed. The 2005 study researched numerous xeric shrubs and at the end of the 2006 growing season, none of the shrub species showed any signs of stress. Both of the grass species in this trial, the tall fescue and Kentucky bluegrass, went completely dormant when no irrigation was applied. Because none of the shrub species were stressed, they avoided dormancy through deep rooting systems or tolerated the stress by closing their stomata (pores in the leaves and stem used for gas exchange). Two species, *Rhus trilobta* (three leaf sumac) and *Syringa vulgaris* (common lilac), were especially researched to investigate their drought survival strategy. Three leaf sumac is classified as a "very low" water user and common lilac a "low" water user. The lilac responded to more drought than three leaf sumac—it closed its stomata and built up larger water deficits. The sumac had deeper roots than the lilac, which helped it avoid drought better. Deeper rooted plants in general are able to avoid drought better than shallower rooted plants. Shrubs in this study avoided drought with no additional irrigation through their rooting depth better than both of the grass species. From this research, landscapers and homeowners can potentially offset peak water use by watering shrub species early in the spring and fall. However, it is important to note that all these woody plant species were established in the landscapes prior to starting the drought treatments.

The 2008 study tested four more mesic species, including *Cornus sericea* (Redosier dogwood), *Hydrangea arborescens* 'Annabelle' (Annabelle Hydrangea), *Physocarpus opulifolius* 'Monlo' (Diablo ninebark), and *Salix purpurea* (Artic blue willow); and one cold season grass was used as a control, *Poa pratensis* (Kentucky bluegrass). See the April/May 2011 issue of *Colorado Water* for an article by student researcher Jason Smith about the project.

In additional studies, it was shown that plants that received 100 percent ET came out of dormancy more quickly than those receiving less moisture. It appears when these woody plant species go into dormancy in a stressed state, the plants will come out of dormancy more slowly the next season with affected their growth habits.

Horticultural research continues on water requirements of landscape plants. Past research shows that many landscape plants are quite adaptable to normal Colorado conditions once established in a landscape. Research from these studies helps define and give credence to GreenCo's Best Management Practices.

Future water research is being planned to look more specifically at numerous herbaceous perennials and ornamental grasses.

Figure 1. *Left: The Annual Flower Trial Garden at CSU groups plants together in beds with similar irrigation requirements - 0.5 inches, 1.0 inch, and 1.5 inches per week.*

Photo courtesy of David Staats

Denver Parks and Recreation - A Rich Horticultural History Transitions to Meet Future Needs

Jill Wuertz, Water Conservation & Greenhouse Administrator, City and County of Denver Parks and Recreation Department

The City and County of Denver's Parks and Recreation Department (DPR) are the stewards of a vast array of horticultural resources. DPR maintains an enormous inventory of trees, native and naturalized landscapes, turf, shrubs, and flower beds in an urban environment for both beauty and utility. Additionally, DPR's City Park Greenhouse specializes in floriculture and nursery plant propagation for the Park system. In the past few years, DPR has also teamed with CSU Extension and local volunteer groups to utilize park land to showcase urban gardening.

With limited resources and ever increasing park acreage, DPR trains staff on plant/water/soil relationships and prioritizes long-lived plant material. In new parks, design includes a more Colorado-friendly plant palette. However in historic parks, some dating back over a hundred years, the landscape character of the park system references classic European design themes and palettes. The Game Plan, DPR's strategic master plan, recognizes Denver as a City in a Park and stresses an appreciation for both the traditional dark green of formal spaces with street trees and bluegrass lawns to the sage greens of the native Rocky Mountain landscape. The plan identifies the wide reaching benefits of a strong horticultural program, from the large scale importance of improving quality of life and defining neighborhood character to the small scale of providing a quiet place for retreat or the ability to support a richer variety of urban wildlife.

The horticultural assets of Denver Parks add value not just to the park system, but also to the Denver community. Numerous studies have consistently shown that parks and open space have a positive impact on nearby residential property values. In "The Economic Benefits of Denver's Park and Recreation System" report, property value near parks is quantified as an economic development tool. The report explains that park quality is one of two major factors that affect property value. Beautiful natural resource parks with great trees, trails, meadows, and gardens are markedly valuable to surrounding homes. Less attractive or poorly maintained parks, however, are only marginally valuable.

DPR has been adjusting its horticultural practices in recent years. In late

Production underway at the Parks and Recreation City Park Greenhouse. Plants are propagated at the Greenhouse for flower bed displays throughout the Park system.

Photo by Jill Wuertz

2009, the Department reorganized the Greenhouse under the Water Conservation program in an effort to better address plant/water/soil relationships. As part of that initiative, the Water Conservation and Greenhouse team, along with Park District field staff, have worked to update Horticultural Standards. The team has also drafted a Greenhouse Plan that sets a vision to maximize the 36,000 square feet of growing space and coordinate horticultural efforts within parks and parkways including visioning, design, installation, maintenance, and horticultural renovations.

The Water Conservation team continues to work with irrigation managers to better define water practices based on specific plant information. The team engages in planning, design, and construction processes to affect how planting plans are developed and implemented. They reinforce themes of water conserving plant palettes, the use of hydrozones, soil amendments, and establishment watering practices. The team also promotes landscape conversions from high water turf to lower water native landscapes.

DPR has been actively engaging with Denver Water to pilot three of these landscape conversions that are termed the Sustainable Landscape Initiative. Starting in 2007, DPR and Denver Water chose sites at Ruby Hill Park (16 acres), Milstein Park (5 acres) and the Montbello Islands along 45th Ave and 47th Ave (1.7 acres) as pilot projects. The sites were intended to show a representative mix of how conversions could take place: as partial conversions in large parks, as whole park conversions in areas along the South Platte River, and as median conversions. Denver Water provided funding for these twenty-two acres, and DPR managed the installation and a three-year maintenance contract. Through this project, valuable lessons were learned in converting existing turf landscapes to more drought tolerant grasses. In an effort to share this information, Denver Water recently hired a consultant team to document not only the practices used for the Sustainable Landscape Initiative, but also additional conversion styles and practices (http://bit.ly/xHRH2I).

The result of converting partial areas within parks is hard to quantify because water cannot be tracked to a specific tap. However, the islands along Montbello were converted in whole, and water consumption reports for these areas show a decrease of 73 percent from a typical irrigation target of 30 inches per acre and a 92 percent decrease in actual water use from 2006 (prior to the conversion) to 2011 (the final contracted maintenance year). Part of the reason the actual water use savings was greater is because these islands are located in a light industrial area of Denver and see heavy truck traffic that often negatively impacts the irrigation infrastructure, causing leaks and breaks. Based

Flower beds at Cheesman Park highlight the historic park and Cheesman Park Pavilion.

Photo by Jill Wuertz

Flower beds at Harvard Gulch Park highlight the park entrance and enhance the view from building used by CSU Extension. In 2012, this display will feature an edible display highlighting the importance of growing food locally.

Photo by Jill Wuertz

on the results of this pilot project, the Parks Division will also be pursuing more median conversions to drought tolerant plant material.

Moving into the future, DPR is utilizing technology, such as GIS, to further inventory park horticultural assets such as flower beds, shrub beds, green infrastructure, and naturalized landscapes. In 2012, the department will look at re-visioning the direction of these assets in a Horticultural Strategic Plan. The future of the Horticultural Program at Denver Parks and Recreation is an ever-challenging task. The department will be working with our partners to be stewards of this amazing urban park system in Colorado.

For more information on the DPR Water Conservation & Greenhouse Team visit us at: http://www.denvergov.com/parksandrecreation/Parks/tabid/433973/Default.aspx or read about us in the July/August 2010 issue of Colorado Water (http://www.cwi.colostate.edu/newsletters/2010/ColoradoWater_27_4.pdf).

Photos of the Montbello Islands in 2007 and after conversion in 2011 showcase the success of the Sustainable Landscape Conversion project managed by Denver Parks and sponsored by Denver Water.

Photos by Jill Wuertz

Xeriscape: It's Easy, Cheap, Fun, and Saves Water

Jim Knopf, *Landscape Architect*

Generally, landscaping takes more than 50 percent of the treated drinking water supplied annually by Colorado cities, and these cities are growing fast. So "waterwise" landscaping can play an important role in managing the water resources of Colorado.

The good news: whether starting from scratch or "waterwising" an existing landscape, it's easy, cheap, and fun to save lots of water with xeriscapes.

It's gorgeous, too. Xeriscaping is not a style. For example, great xeriscapes are not gravel gardens. In fact, xeriscapes provide even more variety than heavily watered, lawn-dominated landscapes as in these photos. The lawn in Figure 1 (plan view in Figure 2) was made smaller with wider waterwise edges. The turf-type Tall Fescue lawn needs half the water of Bluegrass, and the surrounding plantings get enough water by being adjacent to the lawn.

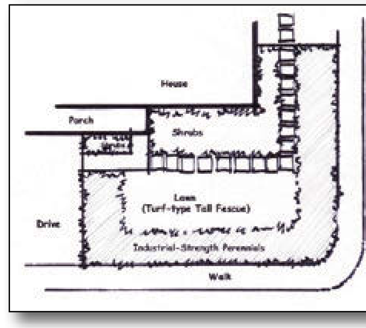


Figure 1. **(Top)** *Curb appeal with 1/4 the water of a Bluegrass lawn.*
Photo by Jim Knopf
Figure 2. **(Bottom)** *For best effects, plant in groups of three or more similar plants.*

Table 1. *Xeriscaping provides great new opportunities for artful landscaping, and horticulture provides the ability to quantify conservation savings.*

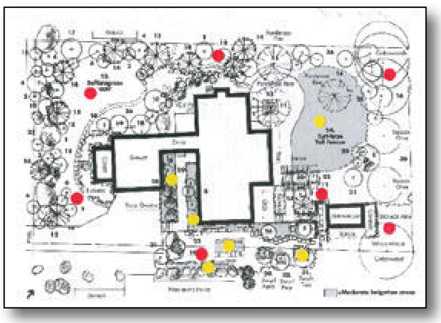
Table 1. QUANTIFYING CONSERVATION

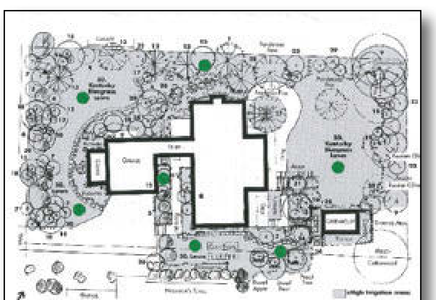
The following chart shows how to divide landscaping into different zones, based on the water needs of plants. Numbers illustrate typical Denver & Salt Lake City conditions.

HIGH WATER ZONES	MODERATE WATER ZONES	LOW WATER ZONES	VERY LOW ZONES
Bluegrass turf (always wet at surface)	**Half of Bluegrass turf**	**Buffalograss turf**	**Too dry for any turf** (drier than Denver)
18-20 gals./ S.F./season .5"-- 3 times per week	10± gals./S.F./ season .75" -- once per week	0-3 gals./S.F./season .5" per 2 weeks, optional	No irrigation No irrigation
Typical plants: Kentucky Bluegrass, Redtwig Dogwood, Pansies	**Typical plants:** Turf-type Tall Fescue, Potentilla, Purple Coneflower many shade trees	**Typical plants:** Buffalograss lawns, Rabbitbrush, Mexican Hat Coneflower	**Typical plants:** Piñon Pine, Yuccas, Apache Plume, Agaves, Penstemons

Figure 3. *The xeriscape cost far less than estimates for a lawnscape. The walk edge plantings are from the "Industrial-Strength" perennial list.*

Photo by Jim Knopf





Figures 4 (top) & 5 (bottom). *The actual plan for the xeriscape design in the cost study (Figure 8), and a "lawnscape" plan for the cost study. Red: no water; Yellow: moderate water; Green: high water.*

Xeriscape: It's Easy

Keep it simple. Waterwise plant selection is the most important thing. Select plants with similar water needs, and put them together. Don't mix plants of different water needs, and don't put high water plantings adjacent to dry plantings or pavement. Use moderate water plants between high and low water areas.

For water needs of hundreds of plants, see The Xeriscape Flower Gardener, and WaterWise Landscaping with Trees, Shrubs, & Vines. Both books are available from Amazon.com.

Plant Selection—Keep it Simple

Unlike some plant instructions, keep it simple. Just group plants by general water need, then don't over-water them. Use catch cans to learn how long to water for the amounts suggested for different watering zones.

Work can be done little by little or all at once. Try starting by making the lawn smaller with wider waterwise edges like "industrial-strength" perennials.

Xeriscape: It's Cheap

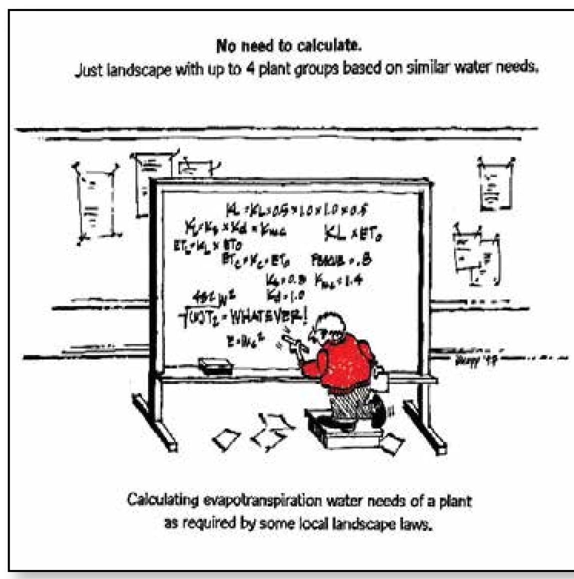
Yes...xeriscapes can cost far less than lawnscaping (Figures 3-5). Waterwise shrub, ground cover, and flower plantings require far less expensive soil preparation, making it easier and cheaper than traditional lawns. Also, irrigation can often be done with hose-end equipment for a few hundred dollars vs. several thousand for a fully automatic, underground system.

Xeriscape: It's Fun

Gardening is greatest when it's something to do and not to be done with. Think about what you like doing, and what you don't. Mowing must be done every week or everyone will know you didn't do it. Shrubs, ground covers and even flowers can be left for long periods without attention.

In flower plantings, minimize bare ground. Fill the areas with plants you want, and let them fight the weed war.

Get clever... there are endless ways to reduce regular maintenance chores, and endless ways to create a landscape that's fun to maintain. Even mowing can be fun if there is little of it, & if the mower eliminates the need for trimming edges. Experiment to find edges that work for your mower. Maintenance by puttering (little-by-little, and when you want to) is great. and Xeriscape makes it all possible.



Calculating evapotranspiration water needs of a plant as required by some local landscape laws.

	Contractor 1	Contractor 2
Traditional Design	**$18,834.00**	**$24,680.00**
Xeriscape Design	**$ 7,472.00**	**$14,089.00**
Savings	**$11,362.00**	**$10,591.00**

Xeriscape: Save Water Too!

Change plants and save water. In the study shown in Figure 6, only the plant selection changes among three designs. The location of all plants remains the same. Overall, visual appearance remains very similar, but the importance of grouping together plants of similar water needs, and using few high water plants, is dramatically illustrated.

Figure 6. *A house landscape design with a moderate water plan.*

Table 3. *Note how plant selection dramatically affects water use and therefore bills. Note also how water rates vary drastically among cities.*

	Design	Design	Design
	HIGH WATER	**MODERATE**	**LOW WATER**
Water use April-Oct	167,000 gals.	41,250 gals.	0-12,400 gals.
Santa Fe, NM	**$7,475.00**	**$1,626.00**	**$0-$456.00**
'96 emergency rates			
Pine Brook Hills, CO	**$3,674.00**	**$908.00**	**$0-$273.00**
'92 rates			
Lafayette, CO			
Inside City	**$679.00**	**$164.00**	**$0-$45.00**
Outside City	**$1,358.00**	**$328.00**	**$0-$90.00**
'97 rates			
Monument, CO	**$807.00**	**$179.00**	**$0-$62.00**
'95 rates			
Boulder, CO	**$454.00**	**$77.00**	**$0-$23.00**
'97 rates			
Denver, CO	**$260.00**	**$64.00**	**$0-$19.00**
'97 rates			
Albuquerque, NM	**$195.00**	**$45.00**	**$0-$11.00**
'97 rates			

Kurt Fausch Presenter at NDSU Distinguished Water Seminar

Dr. Kurt Fausch of the Colorado State University Department of Fish, Wildlife, and Conservation Biology was invited to present the 2nd Distinguished Water Seminar at North Dakota State University (NDSU) on Feb. 21, 2012, titled, "Linked for Life: The importance of sustaining hidden connections for conservation in streams." A main focus of his talk was how human impacts like nonnative fish invasions and riparian grazing alter key linkages between streams and riparian zones that sustain not only stream fish but also birds, bats, lizards, and spiders in the riparian zone. The invited seminar was sponsored by the North Dakota Water Resources Research Institute, the NDSU Environmental & Conservation Sciences Graduate Program, and the Department of Biological Sciences. For more information, visit http://www.ndsu.edu/wrri/Image/Flyerfinal.pdf

Urban Landscape and Horticulture

Paul W. Lander, Geography, Continuing Education & Sustainable Practices Program, University of Colorado

Colorado is a semi-arid state, averaging less than 15 inches of moisture in much of the urban Front Range. As we grow and mature as a state, that fact can help us achieve true resilience in managing our water resources while maintaining valuable landscape assets.

If we manage this site-based water, along with harvesting from other urban surfaces, there is a substantial amount of water available with which to grow things. Recent activities in the professional worlds of landscape architecture and water conservation all point to a future in which urban landscapes demand, and use, less water than is seen in current practice. Initiatives of every shape and form nationwide are focusing on more control and higher productivity of urban water and on more demonstrated knowledge and ability of landscape industry practitioners.

In San Diego early this winter, the American Society of Landscape Architects held its annual conference, which showcased many sessions on water, with most pushing integrated water management and sustainability. The discussions indicate that water management in the future is likely to include more management of all site water: stormwater, irrigation, condensate, etc. Cities like Philadelphia are leading the move toward full implementation of green infrastructure like rain gardens, urban forests, and green walls/roofs. Landscape professionals heard over and over that the future is sustainable water management; to greatly reduce the use of potable water in the landscape, and to handle all types of water generated on-site.

At the Water Smart Innovations conference in Las Vegas last fall, many sessions spoke to the trends of more guidelines and regulations concerning water management and the need for professionals to demonstrate knowledge and training. We simply need to wring more productivity out of our urban uses of water—especially in the landscape, where it's not uncommon for 50 percent of a city's treated drinking water to be used.

A design by Christy Ten Eyck celebrates the Arizona region, grouping plants by water needs, using water from the roof, creating a small scale oasis.

With a statewide mandate—the first in the nation—to reduce urban water use 20 percent by 2020, California is leading this strong trend in making urban landscapes more water-efficient. Professionals there are working to help cities meet the stipulations. And given the fact that California water is very energy-intensive (think of all that water pumped hundreds of miles), water providers are looking even more closely at landscape water as an opportunity to save both water and energy.

But what does it look like? From the boots-on-the-ground work of Tuscson's Brad Lancaster to the more formal work of Christy Ten Eyck, FASLA, and Bill Wenk, FASLA, practitioners in the southwest are showing that beautiful, water-sensitive landscapes are not only possible, but are setting the standard in many cities in the region. Through careful consideration of plant water needs and assessment of all water available to a site (stormwater, greywater, A/C condensate, ditch water, etc.), projects have been built that clearly demonstrate the future of urban landscapes in the southwest.

On a conceptual level, a group of professionals meeting at the

University of Colorado-Denver over the past 2 years has developed a system for clearly addressing the landscape-water issue, by providing an approach for addressing the question, What is reasonable urban water use in a drying west? Based on investigations of other projects, serious discussion, and professional experience, this group has forwarded a 'net-zero, water-budget-based' approach to planning, designing, and maintaining urban landscapes. This new-look-at-an-old-problem is just getting off the ground, but is receiving positive feedback at professional gatherings across the country.

Why all the fuss about urban landscape water, when agriculture uses the lion's share in the west? Because we have all the water on the planet we'll ever have; if we're using more in our urban areas, somewhere nearby is using less. The current target is to take it from the dominant water using class-agriculture. However, if we want to continue to support agriculture in the west, let alone natural systems, we've got to focus first on productivity, and secondly on "new supplies" (someone else's current water use).

Paul W. Lander, PhD, ASLA, LEED A.P. has worked in urban conservation for over 30 years. He currently teaches courses on western water, urban water systems, and sustainable landscape at CU-Boulder, and is active in professional affairs as Chair of the ASLA Water Conservation Professional Network, Chair of the Alliance for Water Efficiency Outreach & Education Committee, and as an AWWA Conservation Community Leader.

A design project by Christy Ten Eyck for the University of Arizona includes climate-appropriate design of adapted plants and use of all site water, including A/C condensate, to maintain plantings.

A Bill Wenk design for a public place features the manipulation of stormwater, showcasing the expression of water while improving water quality.

CSU Water Scientists Part of Key State Agency Trio

Answering Some of Colorado's Big Water Resource Questions

Denis Reich and Perry Cabot, Extension Water Resources Specialists, Colorado Water Institute
Allan Andales, Soil and Crop Sciences, Colorado State University
Timothy Gates, Civil and Environmental Engineering, Colorado State University

Extension

By the time this is printed, Colorado's 1177-Roundtable process will be digesting the second of its now annual state summits held in the Denver area on March 1. The summit convenes some of the best water minds in the state to collectively review the challenge of meeting Colorado's future water demand. Since the initial summit in 2011, the phrase "four-legged stool" has become somewhat of a catch phrase at Roundtable meetings in Colorado's various river basins. It's a term coined to describe the four strategies that most regional water leaders agree are needed to address the state's future municipal water deficit or "gap": New Supply, Conservation, Agricultural Transfers, and Identified Projects and Processes. The Roundtables' current philosophy subscribes to a balanced contribution from all four "legs" so all Coloradans can enjoy a safe and reliable water supply in perpetuity.

There's also a three-legged stool working on the objective of secure water resources for all Coloradans, now and into the future. It's perhaps not obvious to the water community, but its significance and contribution is real. It's the relationship between three of the state's institutions that are most directly focused on water-related investigations: the Colorado Water Conservation Board (CWCB), the Colorado Department of Public Health and Environment (CDPHE), and Colorado State University (CSU).[1] As questions continue to be asked of the state's water supply and quality, this relationship will continue to play a role in the major water concerns for Colorado.

A major metric for the strength of this relationship is the number and value of projects that CSU staff and faculty are seeing sponsored by CWCB and CDPHE. At the time of writing, CSU was under contract with CWCB for 11 current projects for a total value of $1,017,659, with at least three additional projects pending. With CDPHE's Water Quality Control Division (WQCD), CSU principal investigators (PIs) account for one project under contract for $501,735 with one project pending.[2] CDPHE also funds the state nonpoint source (NPS) pollution program coordinator through the Colorado Water Institute at CSU. Together this is about 16 percent of the combined annual budget of the Roundtable process ($7 million[3]) and the state's NPS allocation ($2 million[4]). None of these figures account for the many additional CWCB and CDPHE sponsored projects that CSU staff partner on as Co-Principal Investigators or the completed work that these three agencies have collaborated on in the past. The financial weight of such a healthy list of projects is strong evidence that this three-agency relationship is engaged and productive.

"The Colorado Water Conservation Board and Colorado State University enjoy a very positive relationship with each other," remarks Todd Doherty of the Colorado Water Conservation Board. Doherty manages two grant programs than have seeded partnerships with CSU personnel on numerous projects, such as the Roundtables' Water Supply Reserve Account and the Alternative Agricultural Water Transfer Methods program. "This relationship," he adds, "has helped bring the CWCB together with researchers and academics on water resource management issues that otherwise might not have occurred."

A good case study for some of this work is the Lower Arkansas River Valley where a number of programs have benefited from CWCB and CDPHE support. If there were a state scale for water scarcity and quality concerns (think the travelers alert we hear at airports), the Lower Arkansas probably would show up as dark orange. This is a region wrestling not only with the side-effects of irrigated land dry-up or "buy and dry" and river compact obligations with Kansas, but also with serious water quality concerns—especially

1. Projects funded by CWCB often involve cooperation with the Colorado Division of Water Resources (CDWR). The Division of Wildlife and State Parks also has a significant role in state water due its broad aquatic life and water-based recreational interests, but its scope is relatively narrow.
2. Source: Colorado State University Office of Sponsored Programs.
3. CWCB. Oct 2011. "Water Supply Reserve Account Annual Report." DNR Report to the respective House of Representatives and Senate committees for Colorado's consumptive and non-consumptive water needs.
4. 2011NPS Colorado 319 program funding announcement: http://npscolorado.com/2011%20Announcement.pdf

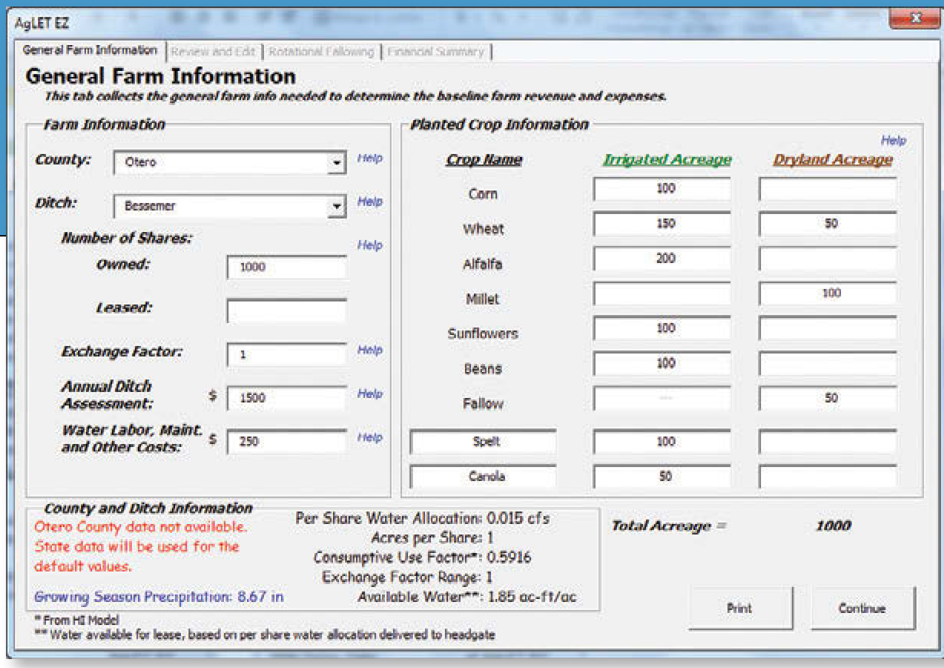


Figure 1. *The AgLet EZ software user interface for optimizing the use of irrigation water leasing.*

salinity and selenium. CSU, CWCB, and CDPHE have been cooperatively seeking to answer the challenging questions these problems present for a number of irrigation seasons, and they're starting to bear fruit.

In an attempt to alter the historic trends towards "buy-and-dry," and instead to support strategies to keep agriculture viable, several fallowing and leasing projects centered at the Rocky Ford Research Center have been commissioned. Since 2009, this CWCB-funded $92,000 three-year project has explored the profitability and stewardship potential of cropping systems that fallow proportions of land to incorporate potential water leasing arrangements. Such lease-fallow arrangements allow temporary water transfers to be controlled by the water rights holders in the Lower Arkansas Valley, thus helping satiate the growing thirst of front-range municipalities while preserving productive irrigated land. Mike Bartolo and Jim Valliant, research scientists at the Rocky Ford Agricultural Experiment Station, have been the primary partners working through CWCB's Alternative Agricultural Water Transfers Methods Program[5] to host this critical research. An important product of the study has been an Excel®-based lease-fallow simulator, developed in coordination with Harvey Economics and James Pritchett. This Agricultural Leasing Evaluation Tool, known as "AgLet," is an irrigator-focused software program that optimizes crop and fallow mixes based on market prices for leased water and commodities. Under the supervision of Perry Cabot and Caleb Erkman, the project team is developing an "EZ" version (Figure 1) that includes a user-friendly platform.

At the conclusion of the Colorado vs. Kansas litigation[6] on the Arkansas River compact, the Special Master accepted a new method for calculating potential evapotranspiration (ET) in the computer model that is used to determine compact compliance. This new method involves the use of the Penman-Monteith equation. The resulting Penman-Monteith reference (potential) ET number is then multiplied with a crop coefficient for the ET of a specific crop. To better understand more precisely the implications of using this new ET method for determining compact compliance, CWCB funded the installation and operation of two precision weighing lysimeters[7] at Rocky Ford.

Allan Andales of CSU's Soil and Crop Sciences has led the project partnering with other CSU personnel, the Arkansas Valley Research Center, and the Colorado Division of Water Resources. A four-year $375,000 project has been supporting the day-to-day operation and maintenance of one large and one small reference weighing lysimeter for determining local crop coefficients and for comparing physically-measured local ET to Penman-Monteith ET calculations (Figure 2). 2011 was the first year of simultaneous measurement of alfalfa ET on both lysimeters. This data will begin the process of formulating Lower Arkansas Basin crop coefficients that will improve consumptive use estimates that are used to ensure compact compliance. Better estimates of crop consumptive use can also help improve local irrigation water

5. http://cwcb.state.co.us/LoansGrants/alternative-agricultural-water-transfer-methods-grants/Pages/main.aspx
6. Montgomery, D. Oct 2003. "Lessons Learned from the Arkansas River Case." Keynote Presentation – South Platte River Forum. http://wsnet.colostate.edu/cwis31/ColoradoWater/Images/Newsletters/2003/CW_20_6.pdf
7. A lysimeter is a means of precisely quantifying crop water use by accounting for weight changes in a known mass of soil (a "monolith") growing a specific crop.

Figure 2. *A view at the Arkansas Valley Research Center of the large lysimeter and associated sensors.*

management, such as irrigation scheduling.

Timothy Gates of CSU's Civil and Environmental Engineering Department will this year conclude a $501-thousand dollar 3-year phase of research targeted on selenium and salt fate and transport in the Lower Arkansas River Valley, with 40 percent matching funds provided primarily by the Colorado Agricultural Experiment Station at CSU. The local Pierre shale soils are rich in selenium and salts that, upon contact with irrigation water, dissolve and concentrate in the groundwater aquifer and flow into the Arkansas River. Apart from the salinity challenge this presents for eastern plains and Kansan irrigators, there are aquatic life implications as well. Selenium is essential for most forms of life, even humans, but each species usually has an acceptable range of concentrations for healthy intake. Outside this range selenium can become particularly disruptive to physical development. Fish are highly sensitive to the slightest increases above background selenium levels. Scientists from the United States Department of the Interior are on record attributing population problems for a number of fish species in Colorado to above normal selenium concentrations in fish habitat reaches.[8]

The work of Gates and his team is aimed at reaching an understanding of the physical and chemical processes that influence salt and selenium mobilization. The resulting data are essential for designing agricultural best management practices (BMPs) that potentially reduce or eliminate contaminant loading. "We have enjoyed a long and productive relationship with Gates in the Lower Arkansas and a number of other CSU faculty," says Greg Naugle, Restoration and Protection Unit Manager at CDPHE's Water Quality Control Division. "Dr. Gates' work," Naugle continues, "will allow for large-scale and cost-effective remediation of selenium concerns."

Results of related work (some funded prior to this CDPHE project) suggest that groundwater salt movement and accumulation is inflicting damage on some agricultural ground, evidenced by water logging and high salt levels in otherwise productive soils. More recent determinations confirm the long held suspicion that nitrogen-based fertilizers have the potential to chemically accelerate selenium loading rates and slow compliance progress for the Arkansas river with the state selenium standard (4.7 ppb) – posing another challenge for the CSU and CDPHE partnership to address in their pursuit of preserving Arkansas Valley agriculture and mitigation for selenium pollution.

All of these projects provide a foundation for relevant work in other river basins around the state. For example, fallowing schemes are very much a part of the picture in the South Platte and Republican River Basins, and selenium is already a big piece of a Programmatic Biological Opinion for endangered fish species recovery in the Lower Gunnison River Basin. The less obvious component is the relationships that develop between staff members from these agencies as a result of these projects. This often results in informal problem solving outside of the scope of specific projects, adding value to the overall service that CWCB, CDPHE, and CSU are tasked with providing to the state's water-using community.

8. Lemley, DA. 1987. "Aquatic Cycling of Selenium: Implications for Fish and Wildlife." US-DOI Fish and wildlife Leaflet 12: http://www.cerc.usgs.gov/pubs/center/pdfDocs/90562.PDF. Also: Hamilton, SJ; et al. 2002. "Toxicity of selenium and other elements in food organisms to razorback sucker larvae." Aquat Toxicol. 2002 Sep 24;59(3-4):253-81.
9. Gates, T., Garcia, L., and Labadie, J. 2006. "Toward Optimal Water Management in Colorado's Lower Arkansas River Valley: Monitoring and Modeling to Enhance Agriculture and Environment." CWI Report: 205. CSU AES: TR06-10.Morway, E., and Gates, T. 2012. "Regional Assessment of Soil Water Salinity Across an Intensively Irrigated River Valley." Journal of Irrigation and Drainage Engineering, 138(5): In Press.
10. Gates, T. et al. 2009. "Assessing Selenium Contamination in the Irrigated Stream-Aquifer System of the Arkansas River, Colorado." Journal of Environmental Quality, 38:2344-2356. Bailey, R., Hunter, W., and Gates, T. 2012. "The Influence of Nitrate on Selenium in Irrigated Agricultural Groundwater Systems." Journal of Environmental Quality, 41:In Press.

Water 2012: Preserve Your Part in Colorado's Water Heritage

Patricia J. Rettig, Head Archivist, Water Resources Archive, Colorado State University Libraries

Big anniversaries, such as those being celebrated by several Colorado water agencies in 2012, often get organizations thinking about their histories. These thoughts might then turn to all those old files that have been around forever. Everyone knows they are important, but nobody ever looks at them. Maybe somebody then floats the thought that someone should go through all those files and see what is there and get it all organized. With sufficient time and resources, that thought might turn into action. More often than not, it is recognized as a good idea but remains low on the overflowing priority list.

Since every water organization in the state shares a part in the common water heritage, all can benefit from better file management. Sometimes, all people need is a starting point. Use the following twelve tips to get started in 2012, the "Year of Water," toward better preserving your organization's history.

12 Tips for 2012

1. Create a file structure, record it, and stick to it.

Determine the most sensible filing scheme for the organization and the types of records it creates. This may differ for various file types: chronological for financial records, alphabetical for correspondence files, by assigned number for project files. Use whatever works for adding to the files as well as finding files later. Write the system down so that anyone who needs to use it can get the details. Don't forget to note the exceptions that inevitably occur. Enforce the system consistently, including in both hard copy and electronic form.

Photo by Kyle Thompson

2. Keep all documents required for legal compliance.

This is self explanatory, though depending on the type of organization or work being done, local, state, or federal regulations may differ.

3. Consult with legal or financial advisors before doing anything drastic.

Before purging all financial files older than six years, or dumping that whole filing cabinet of "old" stuff, or digitizing paper files and shredding the originals, make sure that lawyers or accountants don't have a different opinion on the decision.

4. Eliminate redundancies.

The best example of redundant information is financial records, where you may have the original invoice or bill being paid, the check register, the cancelled check, the bank statement, and an itemized balance sheet. Figure out which one or two documents contain the essential information about the transaction, and toss the rest.

5. Discard duplicates.

Twenty copies of the report were made for distribution at the meeting in case people didn't bring their own copies, but only five were passed out. Instead of keeping the remaining fifteen in the file, keep just two or three.

6. Evaluate whether drafts are needed.

Determine if drafts are needed for any reason, and then purge unnecessary versions. Be careful, however, to save

and label any raw data that went into a final report.

7. Label folders, data, photographs, slides, videos, etc.

Labeling involves recording identification information, typically including a title and date. For some documents, especially visual ones such as photographs or videotapes, this might involve identifying people (full names, not just "John R."!) and places. What seems like common knowledge today may not be so obvious to the next generation. If particular materials are confidential due to attorney/client privilege, personnel information, or other reasons, make sure they are labeled accordingly.

8. Minimize use of materials that will deteriorate quickly.

Paper is a fairly stable medium if stored in the right conditions, so avoid introducing materials that degrade quickly, including rubber bands and plastic binders. If these are needed, opt for string or cloth-covered binders instead. For photographs, avoid adhesive albums and plastic sleeves; opt instead for polyester sleeves with an "archival quality" rating. Metal fasteners are okay to use, though they are in danger of rusting should materials be stored in too humid a location.

9. Eliminate adhesive labels or secure in another fashion.

Nicely typed labels stuck on to folders help create an organized and efficient filing system, but those labels have the tendency to fall off over time. Eliminate this problem by either typing or writing directly on the folder, or by stapling on the labels.

10. Maintain a clean, dry, temperature-controlled storage area.

While the supply shed out back may have space in it for boxes of old documents, using it for such storage is essentially a death sentence for those documents. Any space that is subject to pests, flooding, excessive dirt or dust, or extreme temperature changes should be avoided for document storage.

11. Keep media and electronic files in accessible formats.

Have any of those old 5.25 inch floppy disks still tucked away? Have

The Water Resources Archive Head Archivist, Patricia Rettig, works in the archive room in CSU's library.

Photo by Lindsey Knebel

any hardware that can read them? That should be good enough reason to keep such files not only stored on currently accessible media but also in software formats that can still be read. While digital file technology is a rapidly moving target, other media formats such as videotapes and audiotapes are dying breeds as well. If you have important files that can't be migrated, be sure to keep the relevant equipment for playback.

12. Document the documents.

If there are multiple storage locations, record where they are and what sets of files are in them. Additionally, if you clean out files, document what was tossed, when, and why. That makes clear to whoever comes along in later years what does or doesn't exist.

Or, Consider Professional Help

Many people know the importance of their files but do not have time to keep them as maintained and accessible as they would like. In this case, if the files are of historic importance, consider contacting the Water Resources Archive to donate them. The archivist can not only help determine what files are important to preserve, but after donation she will see that they are organized, inventoried, and potentially digitized.

Donation to an archive, while a big decision, is a fairly simple process. Archivists are always glad to visit with and talk to potential donors to hear their reminiscences, find out about the materials, and discuss making a donation. If privacy of records is a concern, the organization can discuss those issues with the archivist so appropriate restrictions can be put in place. Once agreement about a donation has been reached, the archivist can help pack up and transport the materials.

At the Water Resources Archive, every day is spent thinking about Colorado's water heritage and preserving the documents essential for maintaining such a legacy. The Archive serves as Colorado's only repository dedicated solely to documenting western water history. The unique historical documents held by the Archive range from ditch company minute books to letters of water lawyers, from century-old hand-drawn maps to modern digital photographs. By collecting and preserving these materials, the Archive enables research and discovery. Lawyers, historians, engineers, and educators, as well as students and community members, use the Archive to explore stories about the region's most valuable resource. Preserve your role in this heritage by using the twelve tips above, or contact the Water Resources Archive. For more information, see the website [http://lib.colostate.edu/archives/water/] or contact the author (970-491-1939; Patricia.Rettig@ColoState.edu) at any time.

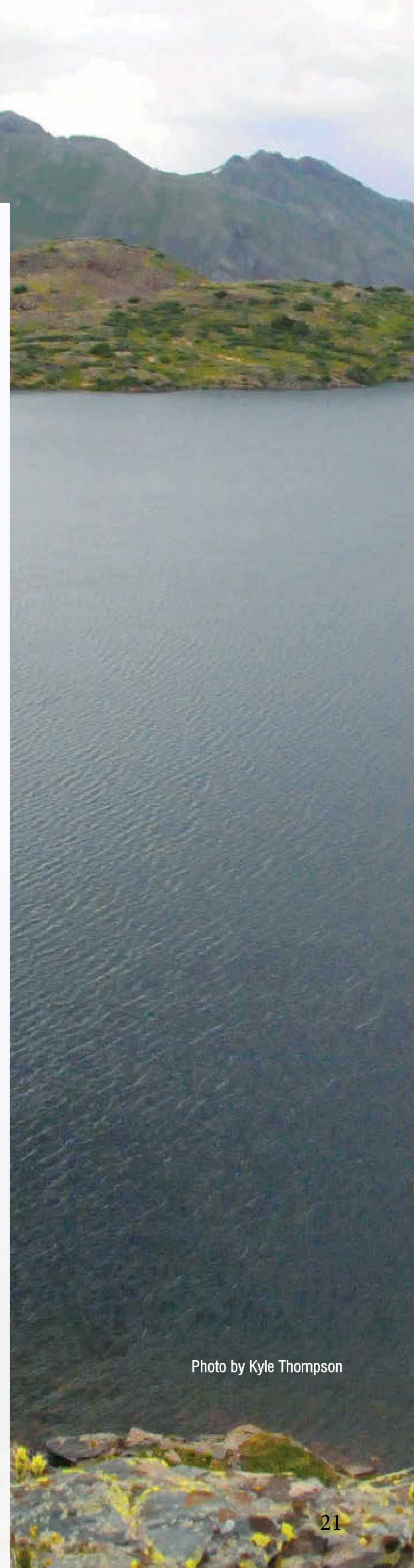


Photo by Kyle Thompson

Lady of the Law Left a Lasting Legacy:
Vena Pointer Remembered as Colorado's First Woman Water Lawyer

Chris Woodka, News Reporter – Water, The Pueblo Chieftan
Clarissa Trapp, MA Candidate, History, Colorado State University

Colorado is famous for its mountains, forests, rivers and…

Water lawyers.

In the annals of water, one woman water lawyer often is overlooked for an unusual career working on the most important as well as mundane projects in the Arkansas River Basin. She was a driving force behind construction of John Martin Dam, which she and others in the valley saw as an answer to disputes with Kansas over the Arkansas River.

Vena Pointer was the state's first female water lawyer, an original member of the Colorado Water Conservation Board, and Pueblo's only woman lawyer when she retired in 1960. She died at a Pueblo nursing home on Dec. 6, 1971, at the age of 91.

Her accomplishments were recently recalled by Tom Cech, who directs of the water center at Metro State College of Denver and who has co-authored a history of the CWCB with former CWCB director Bill McDonald. They spoke at the Colorado Water Congress convention in January 2011.

Alvena Pointer was born in Republic County, Kansas, in 1880, to Joseph and Rena Pointer, and after graduating from high school, she attended Kansas Wesleyan College business school. She became a stenographer and moved to La Junta in 1911, working for lawyer George Wallis.

Lawyer in her own right

Pointer passed the Colorado Bar examination in 1926, and was the last person in Colorado admitted to the bar under "clerkship"—reading the law under a lawyer's supervision, rather than attending law school. She read the law for seven years in preparation.

She was a law partner with Fred Sabin, and they moved their law offices to Pueblo in 1927. When Sabin died in 1931, she became affiliated with A.W. McHendrie, a Pueblo lawyer who also was an authority on water law.

While studying for the bar, Pointer worked as the secretary of the Arkansas Valley Ditch Association 1919-1959, and in the early 1920s she served as Secretary-Treasurer of the nascent Colorado State Water Users' Protective Association and vigorously recruited local water users' associations from all over the state into the organization. In both positions she proved to be an enthusiastic booster for irrigation interests in the Arkansas Valley and Colorado as a whole.

To this end, Pointer corresponded with Delph Carpenter, a Greeley water lawyer and Colorado's compact commissioner who was instrumental in Colorado interstate compact negotiations, including the 1922 Colorado River Compact. In letters collected by the Water Resources Archive at Colorado State University-Fort Collins, Carpenter and Pointer discussed the strategies for coming to an agreement with Kansas.

Kansas and Colorado had been at loggerheads over the allocation of water in the Arkansas River since 1902, and Pointer's letters to Carpenter indicated her tenacity in trying to reach a resolution.

On Aug. 18, 1923, she wrote:

"The folks down here ask me every now and then when you are going to work on Kansas. We continue to receive our daily rain in the Arkansas Valley, and there could never be a better time to point with pride to the Picketwire (Purgatoire River), than exists right now."

In her own hand, at the end of the letter, she added: "She is drowning everything in sight."

The Arkansas Valley Protective Association looked to Delph Carpenter for advice during legal battles with Kansas.

From the Delph Carpenter papers, Water Resources Archive, CSU Libraries

RAY McGRATH, President
Lamar, Colo.

J. H. COWDEN, Vice-Pres.
Olney Springs, Colo.

MISS VENA POINTER, Secretary
La Junta, Colo.

RAY STRAIN, Treasurer
Lamar, Colo.

Members

The Colorado Fuel & Iron Co.
The Bessemer Irrigating Ditch Co.
The Excelsior Irrigating Ditch Co.
The Twin Lakes Reservoir & Canal Co.
The Rocky Ford High Line Canal Co.
The Oxford Farmers' Ditch Co.
The Reorganized Catlin Con. Canal Co.
The Holbrook Irrigation District
The Rocky Ford Ditch Co.
The Fort Lyon Canal Co.
The Fort Bent Ditch Co.
The A. V. S. B. & Irrigated Land Co.
The Lamar Canal & Irrigation Co.
The Hyde Ditch Co.
The X Y Canal Co.
The Graham Ditch Co.

The Arkansas Valley Ditch Association

OFFICE: 404 CENTRAL BLOCK

Executive Committee

RAY McGRATH Lamar, Colo.
J. H. COWDEN Olney Spgs., Colo.
LEWIS SICKENBERGER Manzanola, Colo.
W. S. PARTRIDGE Holly, Colo.
C. K. McHARG Pueblo, Colo.
FRANK NOBLE Rocky Ford, Colo.
DAVID HAMM, R. R. No. 3, La Junta, Colo.

La Junta,
~~PUEBLO~~, COLORADO, June 5, 1923.

Hon. D. E. Carpenter,
Capitol Bldg.,
Denver, Colorado.

Dear Mr. Carpenter:

If for any reason you cannot be present at the meeting of the Executive Committee of the newly organized Arkansas Valley Protective Association, to be held in Pueblo on Friday, the 8th inst., I want to suggest that it might be a good thing for you to in some manner inform the meeting as to what the Valley may expect from the defense fund, provided, of course, any such arrangement has been worked out. I understand that you have not been able to push this matter because of the Governor's preoccupation with other matters, but if he has not already given it attention, and could do so in time for that meeting to be advised, as well as the Executive Committee of our own old Association, which meets Monday, it would be greatly appreciated, I am sure.

I hope, however, to see you at Pueblo Friday.

Yours truly,

Vena Pointer

Secretary.

VP:P

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MISS VENA POINTER, SECRETARY-TREASURER
LA JUNTA, COLO.

THE COLORADO STATE WATER USERS PROTECTIVE ASSOCIATION

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DENVER, COLO.

La Junta, Colo., August 18, 1923.

Hon. D. E. Carpenter,
Greeley, Colorado.

Dear Mr. Carpenter:

I think I ought to have your bill before tackling the San Luis Valley.

By the way, I asked Mr. Colwell if he approved of my trying to work the proposition out with the San Luis people, and he said to go ahead.

The folks down here ask me every now and then when you are going to work on Kansas. We continue to receive our daily rain in the Arkansas Valley, and there could never be a better time to point with pride to the Picketwire, than exists right now. She is drowning everything in sight.

Yours truly,

Vena Pointer

Left: Beginning in the early 1920s, Pointer advocated the construction of a reservoir on the Purgatoire River as a way to resolve disagreements between Colorado and Kansas over the Arkansas River.

From the Delph Carpenter papers, Water Resources Archive, CSU Libraries

Pointer shared Carpenter's opinion that to make compact negotiations go more smoothly, water associations in the Arkansas Basin needed to present a united defense to Kansas's challenges at the regional and state level rather than becoming bogged down in local conflicts. Even with the pooling of regional resources, the costs of fighting Kansas's suits was burdensome for Arkansas water users, and Pointer wrote to Carpenter on multiple occasions to ask for financial support or reimbursement from the state's Water Defense Fund.

Dam at Caddoa

In 1933, Gov. Edwin C. Johnson appointed Pointer to the Caddoa Commission, where she served for more than 20 years on the board of directors. The commission lobbied for and oversaw the construction of what is now John Martin Reservoir.

In early letters to Carpenter, Pointer advised that building the dam at Caddoa would be the ultimate solution to Colorado's problems with Kansas. Colorado could build a reservoir on the Purgatoire to fulfill Kansas's needs and then demand that Kansas give up other claims to Arkansas River water. Indeed, when John Martin Reservoir began filling in 1948, the two states were able to reach agreement on the Arkansas River Compact—a truce that would last until Kansas sued Colorado in the U.S. Supreme Court in 1985.

Pointer's role in the construction of John Martin Dam is recounted in James Earl Sherow's history of Arkansas water development, "Watering the Valley."

"Two tireless Colorado promoters of Caddoa had made a significant move toward realizing the project near the close of 1933. John Martin, a congressman from the district that includes the Arkansas Valley, took a special interest in securing congressional support, while Vena Pointer organized the local boosters of the dam and reservoir."

She also was credited by the late Frank Milenski, in his 1990 book, Water: The Answer to a Desert's Prayer.

"Miss Pointer was a wonderful, older lady when I knew her.... She was very influential in the early attempts to promote the building of the Caddoa Dam."

Arkansas Valley Representative

Pointer acted as a political and legal representative of the Arkansas Valley throughout her career. Besides her role in the Caddoa project, she served on the Colorado Planning Commission from 1935-1938. She also served as Pueblo County public administrator from 1944-46.

In 1937, Pointer was named to represent the Arkansas Valley on the CWCB. She was the only woman member of the board at the time and served until 1948. After Pointer, no woman served on the CWCB until Susan Sanfilippo Keck joined in 1984 as a representative from the San Juan Basin.

While Pointer tackled the biggest issues in the Arkansas Valley, she also was involved with the everyday cases, some of which were humorous.

In a Sept. 20, 1953 article in The Pueblo Chieftain, she recounted the unusual case of the hermit of Arbor-Villa.

The hermit, F.E. Gimlett of Salida, made national news in 1939 when he informed Colorado Gov. Ralph Carr that if moisture stored in snowbanks belonged to an Arkansas Valley irrigation company, he intended to collect fees.

"If the snow belongs to the company in spring, it belongs to them in the winter, and I do not choose to let them use my land for storage purposes," Gimlett's letter stated. He included a bill for $3,640 for 55 years of storage and $890.62 in accumulated interest.

The hermit said he would sell the property to the highest bidder if the bill was not paid, or "I'm going to demand that the ditch company shovel the snow off my property as fast as it falls."

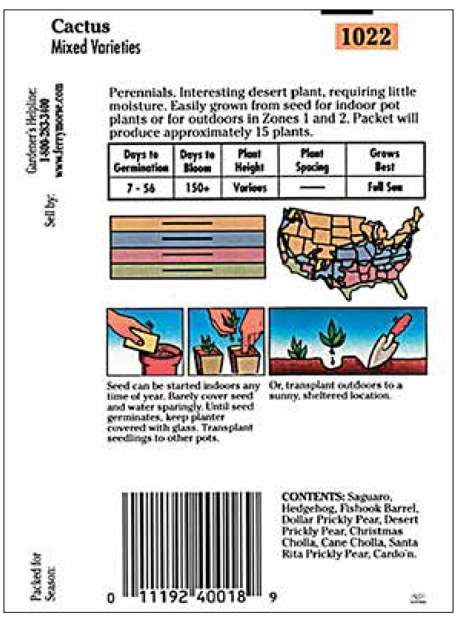
The Chieftain reported: "This incident had Colorado's irrigation experts performing mental gymnastics until Pointer pointed out a state statute prohibiting any mining claim holder from interfering with the flow of streams and ditches."

The new USDA Plant Hardiness Zone Map

Nolan Doesken and Wendy Ryan, Colorado Climate Center

The U.S. Department of Agriculture (USDA) Plant Hardiness Zone Map may be the most widely distributed climate map of all time. It shows up in practically every seed catalog—winter, spring summer, and fall. It can even be found on some individual seed packages sold in tens of thousands of stores across the country, and it's in practically every horticultural text book and many horticultural magazines (Figure 1). You'll find it mounted on the wall in garden shops and nurseries all across the country. Without even realizing it, you probably already have several copies of this map tucked away somewhere in your home, garage, or garden shed.

Figure 1. *Some seed packets have planting zone maps displayed on them.*
Courtesy of Wendy Ryan



Why is this one little map so popular and so widely distributed? That little map is the single easiest indicator or index to predict what perennial plants will survive and grow in any particular part of the country and to determine where various annual plants are most likely to thrive. These days you can purchase and have any cultivar shipped to any location in the U.S. But for that plant to live and live well, it must be compatible with the local climate. This one map tries to make that connection.

When people see this map, they most likely believe it is based on specific knowledge— perhaps experiential—of what plants actually do live in each part of the country. But in reality, plant hardiness zones are derived directly from climate data and are not plant specific. In particular, this map is based on just one temperature statistic, and an obscure one at that. That statistic is the average annual extreme minimum temperature. The single coldest temperature observed each year is identified from the daily temperature readings at each available weather station. These annual values are then summed and averaged over a fixed and consistent period of years to give the average coldest temperature. Horticulturalists have found that this easy to compute temperature index reasonably defines and distinguishes the various climate zones of the country. For example, many varieties of lilacs thrive in cold climates. Drive up to Gunnison in June and you'll likely see the town in bloom with lovely purple lilacs. But you'll never find black sweet cherries growing there. In fact, there are just a few small areas in western Colorado where sweet cherries grow and reliably produce fruit.

We were delighted to hear that the Colorado Water Institute was dedicating an issue of their magazine to horticulture this year, since a fantastic new USDA Plant Hardiness Zone map is hot off the press (actually hot off the computer). It was just released to the public in late January 2012 (Figure 2). This is the latest in a series of similar maps. The first was printed back in 1938 (published by the Arnold Arboretum—the first USDA version was printed in 1960) and there have been at least six updates since then. The latest map is based on climate data from a few thousand weather stations across the U.S. covering the period 1976-2005. This supersedes the previous map that has been in use since 1990 that was based on only a 13-year period of 1974-1986. The period for this latest maps already seems a bit out of date, but it literally took six years to complete the analysis, publish the results, complete a comprehensive peer review process both within and outside the USDA, and finally share the information publically. It has taken nearly two years just to develop the website and Web services to accommodate the millions of users. (http://planthardiness.ars.usda.gov/PHZMWeb/)

Most of the early versions of these maps were hand drawn, smoothly interpolated, and based on only a subset of the available historical climate data from NOAA. However, the significance of this map (both horticulturally and economically) has become so great in recent decades that the USDA selected the Parameter-elevation Regressions on Independent Slopes Model (PRISM) Climate Group at Oregon State University to lead this latest mapping effort. The Colorado Climate Center has worked with Chris Daly and his PRISM group on various projects for nearly 20 years, and they are the premier climate mappers, especially for mountainous areas. The PRISM Climate Group went all out on this new horticultural application, using literally thousands of weather stations with many years of daily

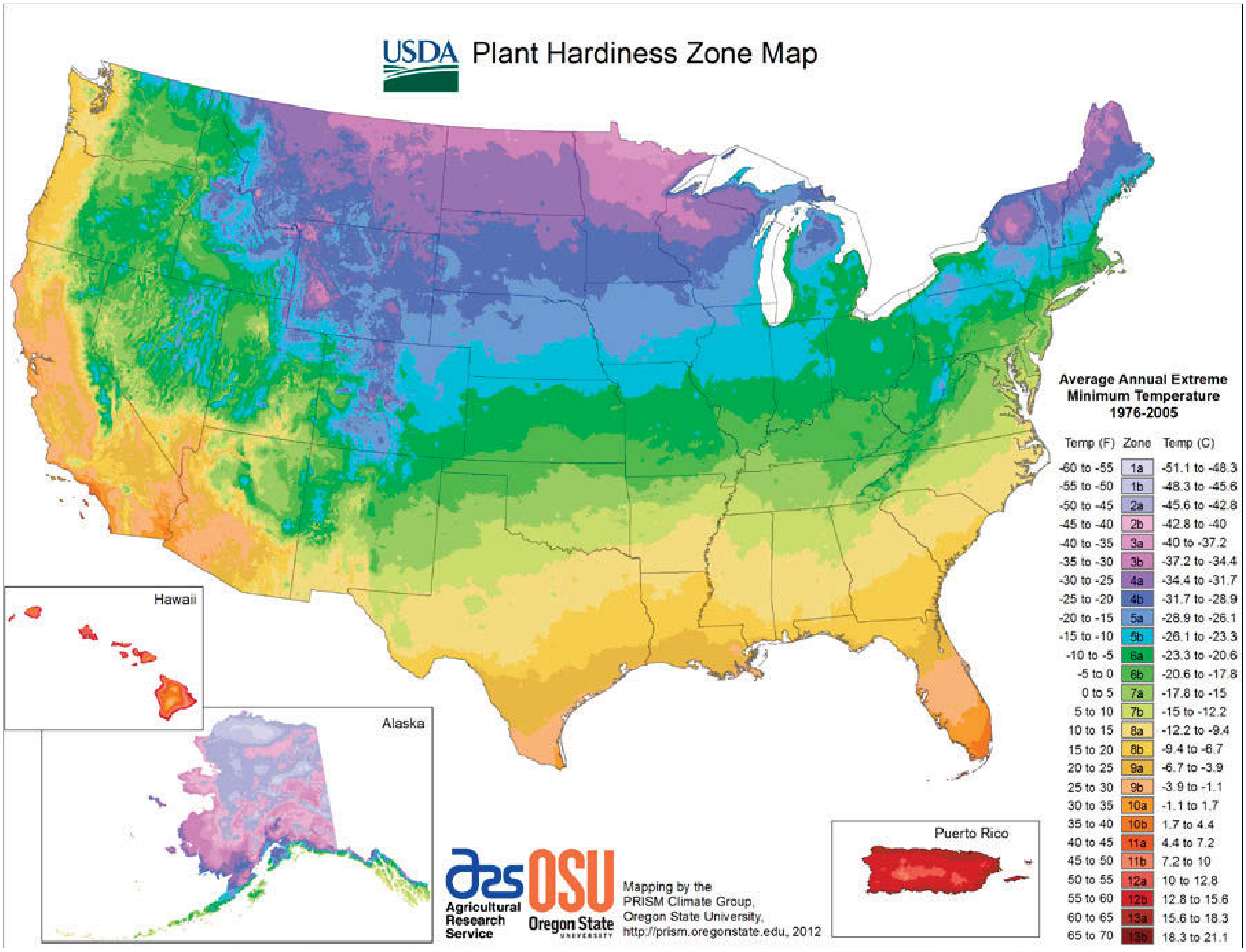


Figure 2. *Newly released USDA Plant Hardiness Zone Map, 1976-2005.*

temperature data. PRISM climate analysis and mapping techniques developed over the past 20 years were applied that deal particularly well with climate variations in mountainous areas and other regions with complex topography (Daly, et al., 2012). By using more data and more advanced mapping capabilities, a finer resolution map was possible. Instead of the traditional eight hardiness zones often shown in seed catalogues, the new map has a total of 13 zones, and each of these are split in half (a and b) to give a total of 26 plant hardiness zones. This allows full delineation all the way from the coldest parts of Alaska to the warmest portions of Hawaii and south Florida.

What is particularly exciting about this latest Plant Hardiness Zone Map is that for the first time it is not just a static map image, but an interactive website where anyone can select their specific part of the country and zoom right into their own neighborhood (http://planthardiness.ars.usda.gov/PHZMWeb/InteractiveMap.aspx). We are especially pleased with this new map product since the Colorado Climate Center at CSU had ample opportunity to review the input climate data, the methodologies, and the subsequent map analysis well in advance of this public release. We are impressed with this work and it is already serving many needs.

Zones present in Colorado include 3a to 7a (Figure 3). The average annual extreme minimum temperatures associated with these zones are shown in Table 1.

Never before have we seen such detail. For example, the map shows warm spots in the Denver-Boulder area (a combination of prevailing wintertime downslope warming winds at the base of the Flatirons and the urban heat island that has developed near central Denver in recent decades). The milder areas of the Arkansas Valley in southeastern Colorado are also clearly delineated including what the locals have always called "the banana belt," which refers to areas that are warmer than their surroundings, in the upper Arkansas from Salida to Buena Vista.

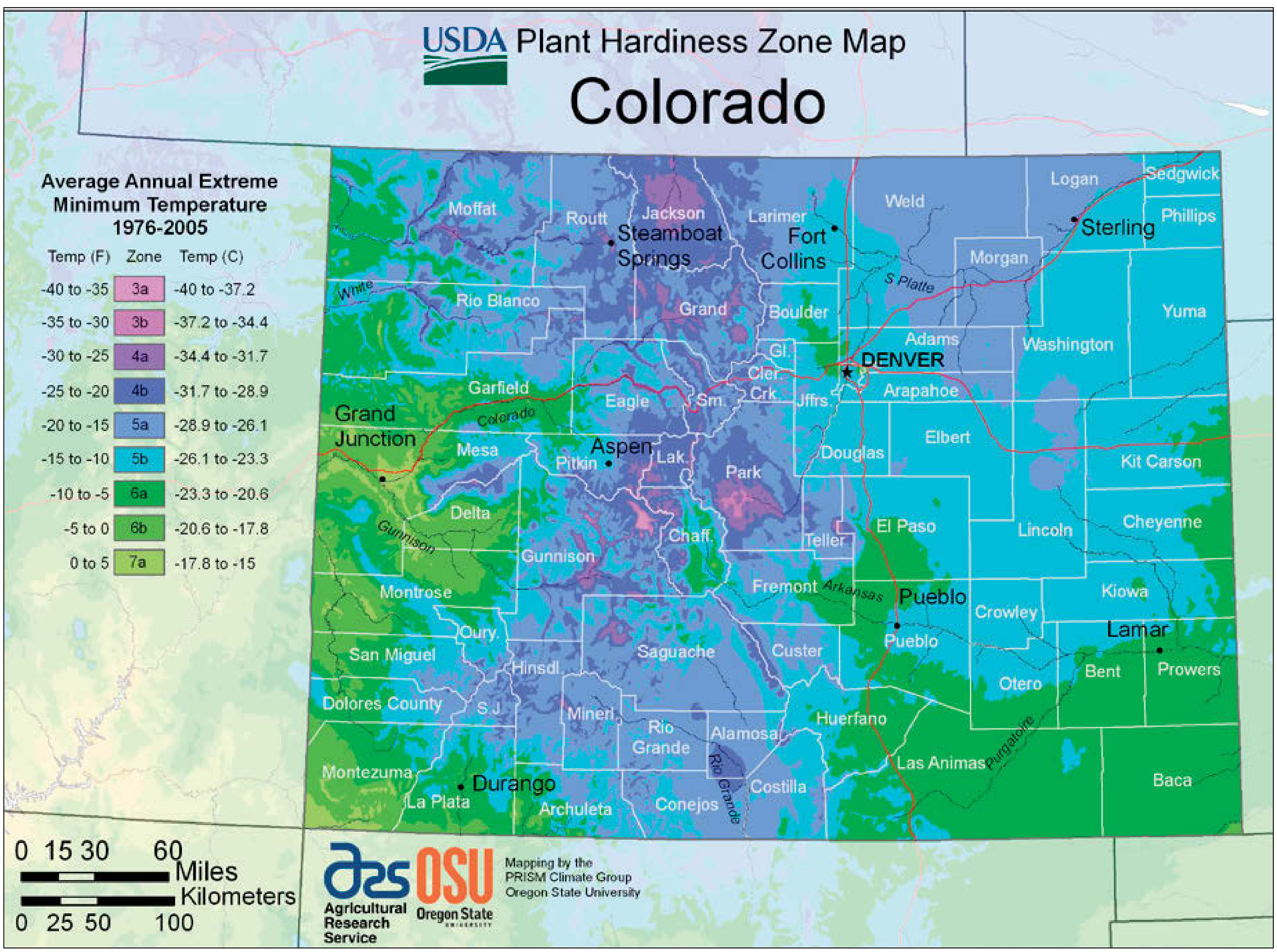
Of particular interest is our traditional fruit growing region of west central Colorado. Not surprisingly, it shows up nicely on these new maps. As expected, the mildest area (Plant Hardiness zone 7a) encompasses the Palisade area, where the bulk of Colorado's peaches and wine grapes are grown, and it wraps part way around the base of the amazing Grand Mesa that towers over the valley. But what is interesting is the band of milder temperatures found south of the Colorado River and west of the Gunnison River at the base of the northern edge of the Uncompahgre Plateau, including portions of the Colorado National Monument. This is an area where climate data (and population) are very sparse. Climatically, that area may have also had high potential for fruit production but with one notable exception--mild temperatures are not the only thing needed. A reliable water supply and appropriate soils are also essential, and this combination was limited in those areas.

Please take time to study these maps, as they contain a great deal of interesting climate information. Also remember that this temperature indicator is NOT the same as average temperature. We know, for example, that the coldest average temperatures are found as you increase in elevation. However, the coldest individual low temperature extremes normally occur in high mountain valleys where the heavier, denser cold air gathers in the low spots on clear and snow covered winter nights. This can clearly be seen

Table 1. *Average Extreme Minimum Temperatures associated with plant hardiness zones.*

Zone	Average Extreme Minimum Temperature (F)
3a	-40 to -35
3b	-35 to -30
4a	-30 to -25
4b	-25 to -20
5a	-20 to -15
5b	-15 to -10
6a	-10 to -5
6b	-5 to 0
7a	0 to +5

Figure 3. *USDA Plant Hardiness Zone Map for Colorado, 1976-2005.*



in the San Luis Valley in south central Colorado surrounding Alamosa.

Are plant hardiness zones changing?

The release of the new plant hardiness maps in late January stirred quite a debate in the national media. The new maps showed that for much of the country zones had shifted about a half category (2.5 degrees) towards the next milder zone. Figure 4 shows the change in average extreme minimum temperature for three locations across Colorado for the base periods of the two most recent plant hardiness zone map releases. The changes in these extreme minimum means range from 2.0 degrees warmer at Stapleton to 3.5 degrees warmer at the Dillon station. Is this an indication of climate change in action that may already be affecting plants? Well, let's take a look at some Colorado data to see for ourselves.

Figure 5 below shows time series of annual extreme minimum temperatures from 1961 to 2011 for three sites traversing our state from east to west: Denver-Stapleton, Lake Dillon, and Montrose. This includes the 1976-2005 data used to produce the new map as well as several years of data before and after. This graphic illustrates that over the past 50 years, our annual extreme minimum temperatures just aren't what they used to be. The trend lines show the mountains and western slope increasing by about +0.2 degrees per year and +0.1 degree per year at the Stapleton station. It is interesting however, that in 2011 all three stations set the lowest annual minimum since 1990 in an early February cold snap. The moral of the story is that even though we see a trend toward warmer extreme minimums over this 50 year period, that doesn't mean we won't see those temperatures ever again, just as 2011 proved true. In fact, due to the use of a longer base period, the map is more likely to depict the local surroundings better than the previous release, which used only 13 years of data.

References:

Daly, Christopher, Mark P. Widrlechner, Michael D. Halbleib, Joseph I. Smith, Wayne P. Gibson, 2012: Development of a new usda plant hardiness zone map for the united states. J. Appl. Meteor. Climatol., 51, 242–264. doi: http://dx.doi.org/10.1175/2010JAMC2536.1

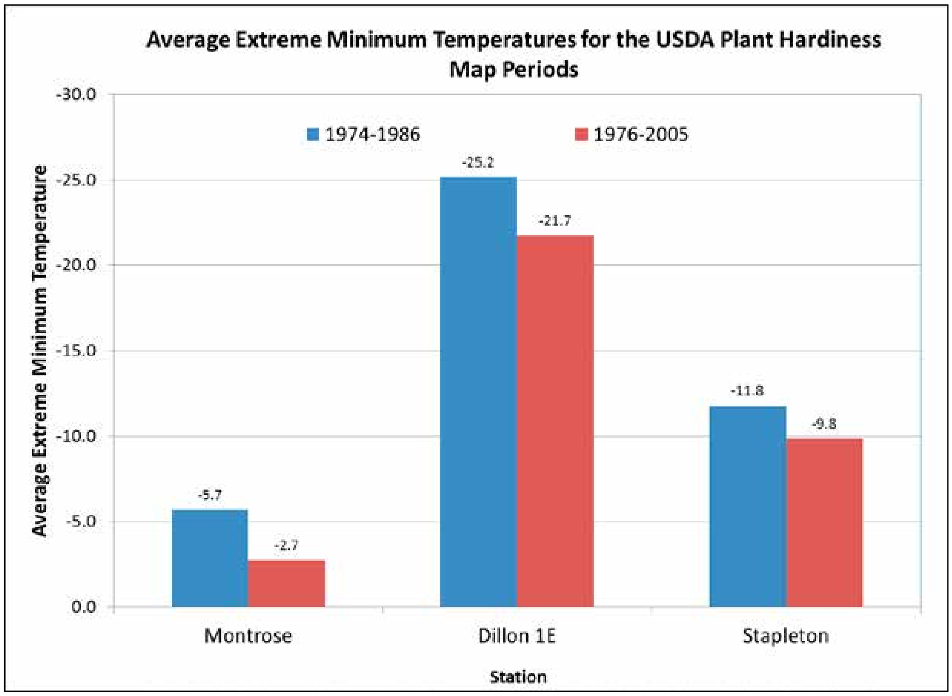


Figure 4. *Change in Average Annual Extreme Minimum for the two most recent USDA Plant Hardiness Analyses.*

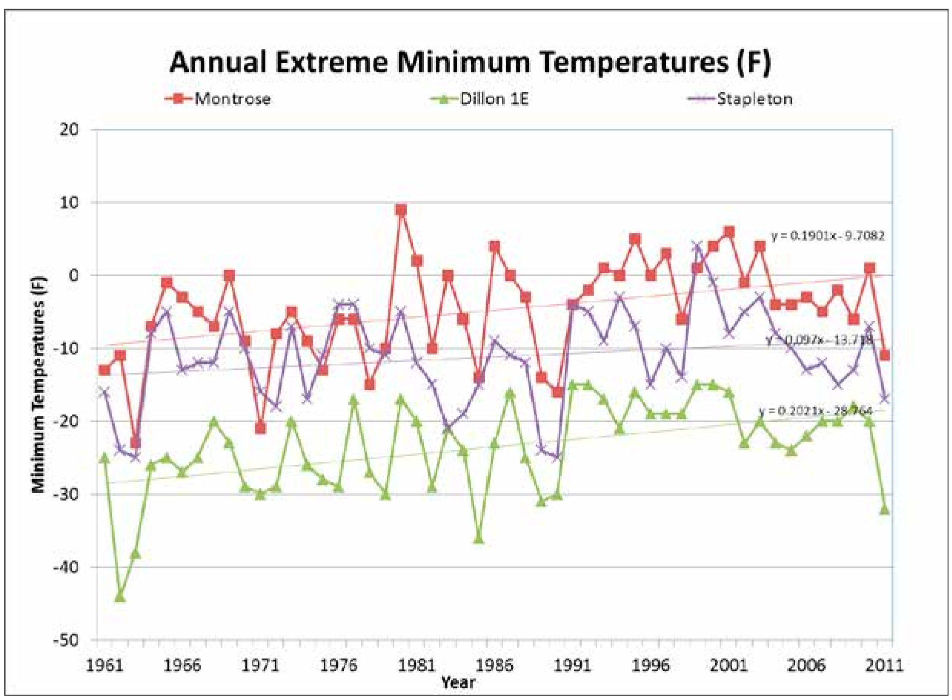


Figure 5. *Annual Extreme Minimum Temperature Time Series for Montrose, Dillon, and Stapleton.*

CJ Mucklow

Lindsey A. Knebel, Editor, Colorado Water Institute

CJ Mucklow, Colorado State University's Western Regional Extension Director since the fall of 2011, oversees extension programs in Colorado counties west of the Continental Divide, plus Jackson County.

Mucklow says his position mostly entails "making Extension valued and valuable to the citizens of Western Colorado." He says by linking CSU faculty to local Extension offices and local issues, his job helps contribute to making CSU "the best land grant university."

Prior to his regional directing position, Mucklow worked as an agent at the Routt County Extension Office for 22 years. Mucklow says he enjoyed working with people and helping them solve problems. "Related to agriculture, the most important thing I have done is help people with small scale acreage management," says Mucklow, citing his book, "A Guide to Rural Living and Small Scale Agriculture."

Mucklow's background in agriculture has also guided his involvement in projects on the Western Slope. He explains a study conducted by Andy Seidl that enumerates the amenities that bring people to Steamboat—its natural environment and "pastoral landscapes." Mucklow says that although it's a growing urban culture, Steamboat maintains the look and feel of a western agricultural landscape, and that draws people. "The value of the view is more important than the production of hay and cattle," Mucklow says.

Mucklow is involved in several initiatives to sustain agriculture on the Western Slope. With its abundance of natural forage and warm summers, "Routt County is one of the greatest places to raise cattle," he says. He also notes a project with three farmers trying to grow crops that make farming sustainable—peas, for instance, use less fertilizer and would contribute to less nitrogen pollution, and oil seeds might be more sustainable as far as farmer income than the wheat crops that have dominated Western Slope agriculture in the past.

"Routt County is a real leader in agricultural conservation," he says, mainly through conservation easements (CEs). "The Cattlemen's Land Trust alone protects over 300,000 acres from future development. The total land protected by CEs is nearing one million acres," he says. Though this has not been researched in the state, Mucklow says it will be interesting to see the impact of CEs on water availability, because they often legally tie water to the easements.

"We're at the tip of challenges with water supply and increasing demands," says Mucklow of issues affecting the West Slope. He adds that water quality and urbanization of water are among the most prominent issues that Extension faculty address.

Oil and gas is a booming industry on the Western Slope, and Mucklow says that issues there include meeting needs and addressing fears. "People are afraid of things like hydraulic fracturing because they don't understand it well," he says.

Mucklow also notes invasive species like the New Zealand Mudsnail as an issue facing water supplies on the Western Slope.

Mucklow foresees Extension programs moving more (as they have been) into addressing and uncovering local issues. Even though Extension has been around for almost 100 years, Mucklow believes it still holds value, and says his goal is to "make the system work better."

Mucklow notes a part of his past that helps contribute to his perspective on the job—he grew up in the travel business. "To be able to travel growing up, and realize how rich Americans are, and how inventive Americans are, was really a lucky experience for me."

"Now," he says, "I'm in charge of Western Colorado—can you think of a better place to be?"

CJ Mucklow
Western Region Director

Colorado State University Extension

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Recent Publications

LandsatLook images; 2011; FS; 2011-3153; Jonescheit, Linda

Geology and ore deposits of the Front Range, Colorado; 1950; PP; 223; Lovering, T. S.; Goddard, E. N.

Baseline and projected future carbon storage and greenhouse-gas fluxes in the Great Plains region of the United States; 2011; PP; 1787; Bouchard, Michelle ; Butman, David ; Hawbaker, Todd ; Li, Zhengpeng ; Liu, Jinxun ; Liu, Shuguang ; McDonald, Cory ; Reker, Ryan ; Sayler, Kristi ; Sleeter, Benjamin ; Sohl, Terry ; Stackpoole, Sarah ; Wein, Anne ; Zhu, Zhiliang

Assessing the vulnerability of public-supply wells to contamination—Edwards aquifer near San Antonio, Texas; 2011; FS; 2011-3142; Jagucki, Martha L.; Musgrove, MaryLynn ; Lindgren, Richard J.; Fahlquist, Lynne; Eberts, Sandra M.

Sources and preparation of data for assessing trends in concentrations of pesticides in streams of the United States, 1992–2010; 2011; DS; 655; Martin, Jeffrey D.; Eberle, Michael; Nakagaki, Naomi

Earth as art three; 2010; GIP; 111; U.S. Geological Survey

The story of the Hawaiian Volcano Observatory -- A remarkable first 100 years of tracking eruptions and earthquakes; 2011; GIP; 135; Babb, Janet L.; Kauahikaua, James P.; Tilling, Robert I.

LandsatLook images; 2011; FS; 2011-3153; Jonescheit, Linda

Groundwater availability of the Denver Basin aquifer system, Colorado; 2011; PP; 1770; Edited by Paschke, Suzanne S.

Geographic information system (GIS) representation of coal-bearing areas in India and Bangladesh; 2011; OFR; 2011-1296; Compiled by: Trippi, Michael H.; Tewalt, Susan J.

Watershed modeling applications in south Texas; 2012; FS; 2012-3005; Pedraza, Diana E.; Ockerman, Darwin J.

Changing Arctic ecosystems-Research to understand and project changes in marine and terrestrial ecosystems of the Arctic; 2012; FS; 2011-3136; Geiselman, Joy; DeGange, Tony; Oakley, Karen; Derksen, Dirk; Whalen, Mary

Assessment of potential shale gas resources of the Bombay, Cauvery, and Krishna-Godavari Provinces, India, 2011; 2011; FS; 2011-3131; U.S. Geological Survey

Generalized potentiometric surface, estimated depth to water, and estimated saturated thickness of the High Plains aquifer system, March–June 2009, Laramie County, Wyoming; 2011; SIM; 3180; Bartos, Timothy T.; Hallberg, Laura L.

User's guide for mapIMG 3--Map image re-projection software package; 2012; OFR; 2011-1306; Finn, Michael P.; Mattli, David M.

Decision-support systems for natural-hazards and land-management issues; 2012; FS; 2012-3001; Dinitz, Laura ; Forney, William ; Byrd, Kristin

Potential water-quality effects of coal-bed methane production water discharged along the upper Tongue River, Wyoming and Montana; 2011; SIR; 2011-5196; Kinsey, Stacy M.; Nimick, David A.

Conceptual model of the Great Basin carbonate and alluvial aquifer system; 2011; SIR; 2010-5193; Editors: Heilweil, Victor M.; Brooks, Lynette E.

Water Research Awards

Colorado State University (January 16, 2012 to March 15, 2012)

Arabi, Mazdak, Colorado Water Innovation Cluster, Optimizing Nutrient Removal at WWTPs through Real-time Monitoring of the Watershed, $80,853.00

Berrada, Abdelfettah, National Sunflower Association, Response of Two Sunflower Hybrids to Limited Irrigation and N rate, $8,754.00

Bestgen, Kevin R, Colorado Division of Wildlife, Anthropogenic Changes to Colorado's Eastern Plains Streams & Their Impact on Connectivity for Native Fishes, $60,324.00

Bestgen, Kevin R, DOI-Bureau of Reclamation, Abundance Estimates for Colorado Pikeminnow in the Green River Basin, Utah & Colorado, $77,839.00

Bestgen, Kevin R, DOI-Bureau of Reclamation, Evaluating Effects of Non-Native Predator Fish Removal on Native Fishes in the Yampa River (Project No. 140), $85,976.00

Caldwell, Elizabeth D, DOD-ARMY-Corps of Engineers, Low Impact Development Non-Point Sources Assessment of Snow Storage Areas for Fort Richardson, Alaska, $60,912.00

Carlson, Kenneth H, DOE-NREL-JISEA-Joint Institute for Strat, JISEA NG Study -Water-related Data and Analysis, $35,000.00

Chen, Suren, Colorado Department of Transportation, Investigation of Optimal Seismic Design of Bridges in Colorado, $80,000.00

Cheng, Antony S, DOI-USGS-Geological Survey, Assessing the Benefits & Drawbacks of Different Institutional Arrangements to Enhancing Forest & Water Ecosystem Se?, $5,000.00

Cooper, David Jonathan, DOI-USGS-Geological Survey, Structural & Functional Controls of Tree Transpiration in Front Range Urban Forests, $5,000.00

Cooper, David Jonathan, DOD-ARMY-Corps of Engineers, Watershed to Local Scale Characterization & Functioning of Intermittent and Ephemeral Streams on Military Lands, $362,322.00

Doesken, Nolan J, Colorado Water Conservation Board, Communications Upgrade for CoAgMet (Colorado Agricultural Meteorological Network) to Ensure Data Accessibility ..., $49,500.00

Doesken, Nolan J, DOI-USGS-Geological Survey, Winter Precipitation Variability in the Colorado Rocky Mountains, $5,000.00

Egenhoff, Sven Olaf, Marathon Oil Company, Reservoir Potential of the Lower Bakken Shale Member - Facies & Sequence Stratigraphy as the Key to Successful ..., $42,460.00

Fassnacht, Steven, DOI-USGS-Geological Survey, Reconstructing a Water Balance for the San Luis Valley: Streamflow Variability, Change, & Extremes in a Snowmelt Do?, $4,945.00

Goemans, Christopher G, DOI-USGS-Geological Survey, The Short & Long-Term Impacts of Drought on the Structure of Regional Economics: Investigating the Farm Supply Chain, $5,000.00

Goemans, Christopher G, DOI-USGS-Geological Survey, Quantifying Risks Producers Face When Entering Agricultural Water Lease Contracts, $5,000.00

Myrick, Christopher A, DOI-USGS-Geological Survey, Thermal Preference of Age-0 Stonecats (Noturus Flavus): Are Thermal Water Quality Standards Protective for This Sp?, $4,858.00

Norton, Andrew P, Three Rivers Alliance, Environmental Impacts of Russian Olive on the South Fork of the Republican River in Eastern Colorado, $14,949.00

Omur-Ozbek, Pinar,DOI-USGS-Geological Survey, Biowin Simulation to Assess Alternative Treatment Units for a Local Wastewater Treatment Plant to Meet the New Efflue?, $5,000.00

Pritchett, James G, Brown and Caldwell, Economics of Innovative Water Sharing within the LSP Water Cooperative, $40,000.00

Rathburn, Sara L, DOI-USGS-Geological Survey, Analyze & Map Cottonwood Forest Area-Age Distribution for the Flood-Plain Forest of the Little Missouri Rive..., $15,750.00

Rondeau, Renee, The Nature Conservancy, Assistance in Completion of Freshwater Measures Report, $9,890.00

Rondeau, Renee, The Nature Conservancy, Enhancing Resilience of Riparian and Wetland Habitats for the Gunnison Sage-grouse in Gunnison Basin, $22,595.00

Sale, Thomas C, Chevron Corporation, 2010-2011 Studies Addressing Processes and Solutions for Hydrocarbon Sheens, $190,000.00

Sale, Thomas C, Chevron Corporation, 2011-2012 Natural Attenuation of LNAPL Sources, $79,600.00

Stednick, John D, DOI-USGS-Geological Survey, Using Water Chemistry to Characterize the Connection Between Alluvial Groundwater & Streamflow Water Under Au?, $5,000.00

Stephens, Graeme L, Calif. Inst. of Tech/Jet Propulsion Lab, CloudSat Science, $32,383.00

Twitchell, John, USDA-USFS-Rocky Mtn. Rsrch Station – CO, Effects of Mountain Pine Beetle & Forest Management on Water Quantity, Quality & Forest Recovery, $40,899.00

Venayagamoorthy, Subhas K, DOD-NAVY-ONR-Office of Naval Research, Early Student Support: Improved Turbulence Parameterizations for Oceanic Flows, $55,322.00

Venayagamoorthy, Subhas K, DOD-NAVY-ONR-Office of Naval Research, Flow Dynamics and Turbulent Mixing around Obstacles in Oceanic Flows, $71,626.00

Waskom, Reagan M, DOI-USGS-Geological Survey, Program Administration Project, $10,000.00

Waskom, Reagan M, DOI-USGS-Geological Survey, Technology Transfer & Information Dissemination, $37,532.00

Waskom¸ Reagan M, Colorado Water Conservation Board, CWCB/CWI Cooperative Intern Program, $5,765.00

Wu, Mingzhong, Western Digital, High-Frequency Measurements and Analysis on Western Digital Materials and Devices, $12,000.00

Calendar

April

19 **Rivers of Conflict: Water as the Source of Inter and Intra-state Conflict; Denver, CO**
The Center on Rights Development presents its annual symposium, *Dying of Thirst: The Right to Water in a Globalized World.* www.centeronrightsdevelopment.org/symposia/

20 **Colorado Foundation for Water Education's 10th Anniversary Celebration; Denver, CO**
Celebrate 10 years of Water Education. www.cfwe.org

25-26 **Arkansas River Basin Water Forum; Leadville, CO**
The Arkansas River Basin Water Forum serves as a conduit for information about the Arkansas River Basin in Colorado, and for issues related to water allocation and management. The 18th Annual Forum will be held at Colorado Mountain College - Timberline Campus. www.arbwf.org/

27 **American Water Resource Association Annual Symposium; Golden, CO**
Beyond Our Borders: Water Lessons from Outside Colorado. awracolorado.havoclite.com/

27 **Colorado Volunteer Lake Monitoring Association Spring Conference; Grand Junction, CO**
CLRMA is organizing another great spring luncheon that will include great speakers and food. This year's topic will be Lake Management Plans. www.clrma.org

May

1-2 **Metro State Water Festival; Denver, CO**
An event to raise awareness about Metro State's new OWOW, One World One Water, Center for Urban Water Education and Stewardship, located at Metropolitan State College in Denver. water2012.org

3 **Water 2012/AWRA Metro Networking Event; Denver, CO**
AWRA Colorado and Metro State will be hosting a student networking event with a panel of professionals at Auraria Campus at Metro State - Tivoli Student Union. Students from universities across Colorado are invited to ask questions of the panel and network with other professionals present. awracolorado.havoclite.com/events/

June

12 **Ruedi Dam Hydroelectric Tour; Basalt, CO**
Join City officials to tour and learn about Ruedi Hydroelectric facility. www.www.roaringfork.org/events

25-27 **Contaminants of Emerging Concern in Water Resources II: Research, Engineering & Community Action Conference; Denver, CO**
www.awra.org/meetings/

July

17-19 **2012 UCOWR/NIWR Conference; Santa Fe, NM**
Managing Water, Energy, & Food in an Uncertain World. www.ucowr.org

18-20 **37th Annual Colorado Water Workshop; Gunnison, CO**
Water Taboos: Addressing our most challenging issues. www.western.edu/academics/water

August

15-17 **Colorado Water Congress Summer Conference; Steamboat Springs, CO**
Summer Conference and Membership Meeting. www.cowatercongress.org

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