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Colorado State University

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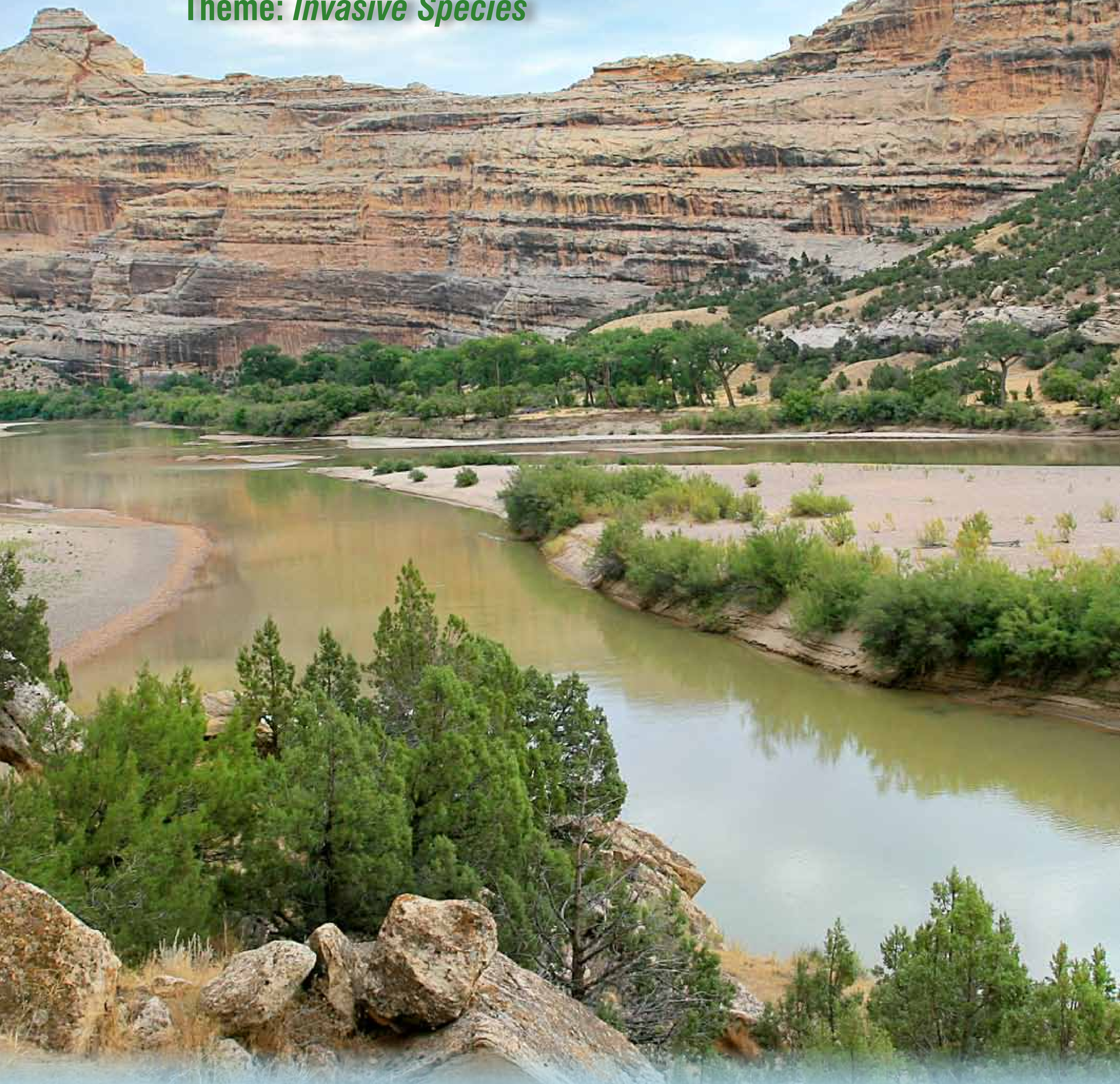
Theme: *Invasive Species*



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Highlights

In Every Issue

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Front Cover: Considered an invasive species, tamarisk grow along the shoreline at Dinosaur National Monument in western Colorado. (Photo by Andrew Norton.)

This Page: Russian olive trees, another invasive species, grow along the Cache la Poudre River. See Tina Booton's article on page 16 for more. (Photo by Terri McClellan.)

Editorial

by Reagan Waskom, Director, Colorado Water Institute

A recent idea gaining momentum among ecologists and geologists is that we are no longer in the geologic epoch of the Holocene, which includes the 10,000 years since the last major ice age. Evidence is gathering that we have entered what was coined by atmospheric chemist Paul Crutzen as the Anthropocene, a geologic epoch shaped by humans. Hypotheses indicate that the future fossil record for this period will primarily be distinguished by human impact on sediments, flora, fauna, atmosphere, oceans and the lithosphere. For example, the development of global agriculture has clearly reshaped the flora and soils of the planet's grasslands, forests and river valleys. One aspect of this is the widespread redistribution of so-called "invasive species" that have spread rapidly across the globe.

Invasive species are defined as plants, animals or other organisms that are non-native to a given ecosystem and whose introduction causes economic or environmental harm or harm to human health. Consistent with the Anthropocene concept, human actions are the primary means of invasive species introductions. Although it can take years for the impact of these invasions to become clear, it is estimated that nationwide, they cause environmental losses and damages of over $100 billion annually.

U.S. officials have been fighting invasive species for a number of years, but efforts have intensified recently as economic and environmental impacts have become clearer. Some of our most notable invasives, such as tamarisk and Russian olive, were introduced intentionally for ornamental purposes, erosion control and other well-meaning reasons, but with unintended consequences. Many others were unwittingly transported to the U.S. via ships, planes and other mechanisms. Zebra and quagga mussels, originally from Eastern Europe, were first found in the Great Lakes in the 1980s and have now moved west, obstructing water supply systems and damaging lake and reservoir ecosystems.

Colorado water managers have to worry about more than just water quantity and quality – they must also win the fight against invasives in their canal and ditch systems, along river banks and streams, and in pipes, reservoirs, dams and outlet works. This issue of *Colorado Water* newsletter focuses on recent work by Colorado State University researchers as well as colleagues from CU-Boulder and state and county agencies on nuisance species found in Colorado, including Eurasian watermilfoil, tamarisk, Russian olive, didymo, and quagga and zebra mussels. The total economic impact of these invaders is yet undetermined, but is estimated to represent millions of dollars in additional costs and lost revenue, not to mention lost ecosystem services and recreational values.

In the June 9, 2011 issue of *Nature*, Mark Davis and 18 ecologists co-authored a paper calling for a reexamination of our inherent prejudice against non-native species. Their argument was straightforward: in a world where global change, human population growth and globalization have scattered so many species, the distinction between native and non-native has become artificial. Their takeaway point is that conservationists should assess organisms on environmental impact rather than whether they are natives. The challenge, and counter to their argument, is that it is difficult to recognize the impact and sufficiently mobilize resources to restrict the human spread of non-native invasive species, such as New Zealand mudsnails, didymo or whirling disease, before they become widespread and too costly to control.

In most cases, preventing introduction is preferable to implementing control measures after invasives are established. However, it is not uniformly true that prevention is always the most economically feasible measure, particularly if cost-effective control methods can be established. These questions – the impact, the mechanisms of invasion and colonization, and appropriate control methods – require adequately funded and vigorous research programs. The partnerships between researchers, water managers and funding agencies reported in this issue of *Colorado Water* represent excellent examples of how university research programs can respond, partner and have direct economic impact for the benefit of Colorado.

Tamarisk Impacts on Colorado Watersheds

Scott Nissen and Andrew Norton, Bioagricultural Sciences and Pest Management, Colorado State University
Anna Sher, Department of Biological Sciences, University of Denver

The population of the western U.S. has been increasing over the past several decades, and this growth has placed more and more demands on a very limited resource – water. According to the 2010 Census, Colorado's population increased 16.9% over the past 10 years. As a result, water has been moving from agricultural uses to urban centers, and this has prompted many western states to look for ways to save and find more water. Tamarisk (Tamarix spp. aka Saltceder), an invasive shrubby tree native to Eurasia (Figure 1), has been targeted for control by county, state, and federal land managers with the idea that reducing its occurrence will have two important outcomes: improving riparian habitats and increasing water availability through water salvage. Water salvage is the concept of changing or clearing riparian vegetation to enhance downstream water supplies.

Figure 1. *A mature tamarisk in flower.*
Courtesy of Joseph Vassios

Tamarisk was intentionally introduced in the western U.S. in the late 1800s for a variety of good intentions. Different tamarisk species were introduced from Russia and China and promoted by nurseries and federal agencies to stabilize stream banks and provide windbreaks and shade; however, tamarisk's invasive nature raised concerns by the 1920s. Conservative estimates put the current tamarisk infestation at approximately 1.6 million acres of riparian habitat across 13 western states. The states with the most significant acreages include Arizona, California, Colorado, Nevada, New Mexico, Texas, and Utah. In Colorado, major stretches of the Colorado, Green, and Arkansas Rivers are occupied by dense tamarisk stands. The Arkansas River is the most severely infested, with 70% of all the infested acres occurring on the river between Pueblo and the Kansas border.

As can happen with many human interventions into natural processes, the ramifications of introducing tamarisk for stream bank stabilization had unintended consequences. In the west, rainfall was not sufficient to support row crop production, so large irrigation projects were initiated. Every major watershed in Colorado now has reservoirs to store snowmelt and irrigation systems to deliver that water for crop production. Tamarisk successfully reduced erosion along streams feeding western reservoirs, but it soon spread from its intended purpose to dominate riparian plant communities, replacing native cottonwood and willow. Surprisingly, tamarisk seedlings are not drought tolerant and are not strong competitors compared to native cottonwoods and willow; however, once established, tamarisk tolerates drought, inundation, and fire (Figure 2).

The extent to which tamarisk is a cause versus a consequence of ecological change is still somewhat controversial. Human activities have in many cases facilitated tamarisk's spread and persistence. Damming rivers has shifted the time of peak water flows from spring to summer and reduced overbank flooding necessary for cottonwood and willow establishment. Tamarisk-dominated stream channels tend to be deeper and narrower than those dominated by native cottonwood and willow. When the force of moving water is confined to a narrow channel,

Figure 2. *Tamarisk is adapted to fire and can significantly shorten the interval between fires. Frequent fires favor tamarisk over native vegetation. This photo demonstrates how quickly tamarisk can re-sprout after an intense fire.*
Courtesy of Scott Nissen

the stream channel is cut deeper, lowering the water table. Native riparian plants like cottonwoods and willows are obligate phreatophytes –,deep-rooted plants that require their roots to reach the zone of saturation (phreatic zone) that occurs just above the water table. Tamarisk is a facultative phreatophyte, meaning it can function as a phreatophye or can grow on upland sites without contact with the water table. Tamarisk's ecological adaptations have significant implications for water salvage, management, and riparian restoration.

The concept of water salvage has been a major driving force behind large-scale tamarisk removal. One commonly cited case study involved tamarisk removal from a dry lake bed near Artesia, New Mexico. The lake had been dry since the 1960s following tamarisk establishment around the lake. In 1989, an aerial herbicide application resulted in 95% tamarisk control, and over the next several years, the lake's water table rose 6-12 inches per month. Water has occurred continuously in the lake since 1996. More detailed studies on the relative water use of tamarisk and native vegetation have established that tamarisk and native riparian plant communities transpire similar amounts of water. The potential water salvage comes from the fact that native cottonwoods and willows (obligate phreatophytes) occupy a very narrow corridor in close proximity to the river, while tamarisk is adapted to occupy a much wider corridor, sometimes miles from the river. Replacing tamarisk with native shrubs and grasses on these upland sites has the potential reduce water use and return more water to the river system.

Tamarisk's impacts on recreation and wildlife habitat are as difficult to quantify as trying to estimate potential water salvage, but are certainly worth serious consideration. Thick tamarisk stands along Colorado's major rivers restrict or in some cases completely eliminate boating or fishing access. The diversity of tropical migratory birds, insects, and other animals are generally lower in tamarisk dominated plant communities. Unfortunately, some endangered species, including birds like the southwestern willow flycatcher, have been forced to use tamarisk thickets as nesting sites due to the lack of suitable native habitat.

This development has resulted in federal agencies with competing mandates, and has resulted in restrictions on the movement of the tamarisk biocontrol agent, *Diorhabda carinulata* (Figure 3), across state lines. *Diorhabda*, aka the tamarisk leaf beetle, has been very effective in defoliating tamarisk along Colorado's West Slope and in several areas around Canon City; however, it has not yet established in eastern Colorado. The tamarisk leaf beetle has had significant impacts on tamarisk around Grand Junction, Colorado; Moab, Utah; and Lovelock, Nevada. After multiple defoliations per year for several years, tamarisk plants tend to lose vigor and appear to be dead, but it is still too early to determine if repeated defoliations will result in significant tamarisk mortality. There are good indications that defoliation alone will provide more opportunities for native plant establishment by decreasing shading that previously allowed the tamarisk to grow in monotypic stands.

Figure 3. *Adult tamarisk leaf beetles (Diorhabda carinulata) mating. Most of the defoliation is a result of larval feeding.*
Courtesy of Andrew Norton

Biocontrol's overall goal is to reduce the competitive ability of the target weed so that it no longer dominates the plant community. Only in very rare cases are biocontrol agents able to provide control of target weeds above 80%, and we should feel fortunate if the tamarisk leaf beetle is able to reduced tamarisk to a minor component of the plant community. Biocontrol alone may not reduce tamarisk densities to a level that will meet all land management objectives under all conditions. Therefore, mechanical and chemical control strategies need to be part of any integrated management program.

The least selective, but most cost effective control methods are aerial herbicide applications by helicopter. This technique has been used effectively to control tamarisk all over the western U.S.   Helicopters equipped with GPS units and applying higher volumes per acre (higher for aerial applications) can make precise treatments and avoid desirable vegetation. Mulching trees on site or using a track hoe to removal individual plants can be effective management methods, but these strategies require follow-up treatments with herbicides to control re-sprouts. These combined mechanical and chemical strategies are expensive. In environmentally sensitive areas or sites with a limited number of plants per acre, cut stump treatments can be a viable control option. This is a very labor intensive treatment since trees must be cut level an inch or two above the soil surface, and a concentrated herbicide solution is applied to the cambium layer (the layer of living cells just inside the bark).

The overall objective of these treatment strategies is to reduce tamarisk densities and allow for passive or active restoration. Passive restoration simply means that enough native remnant species still occur at a location or are present as seed in the soil that controlling the tamarisk is sufficient to encourage native species establishment. This is the most cost effective re-vegetation method; unfortunately, many sites in Colorado have been dominated by tamarisk for extended periods so that active restoration is required. Active restoration means that desirable native species are planted as seeds, cuttings or even in pots. This process is extremely expensive. We have developed a guide called Tamarisk Best Management Practices for Colorado Watersheds that is available by contacting the senior author at snissen@lamar.colostate.edu (Figure 4).

Coloradoans are lucky that local, state, and federal agencies, non-profits, and regional weed management cooperatives are all actively involved in riparian improvement. Colorado State University, Colorado State Forest Service, NRCS, BLM, USGS, Bureau of Reclamation, Upper Arkansas Regional Weed Management Cooperative, Southeastern Colorado Water Conservancy District, Arkansas River Watershed Invasive Plant Project, Colorado Water Conservation Board, Tamarisk Coalition, The Nature Conservancy, etc., are all actively involved in cooperative efforts to map, restore, and monitor riparian health across all Colorado watersheds. Invasive species of all types threaten the health of Colorado's riparian corridors, and it is only through cooperative partnerships that we will be able find and implement sustainable solutions.

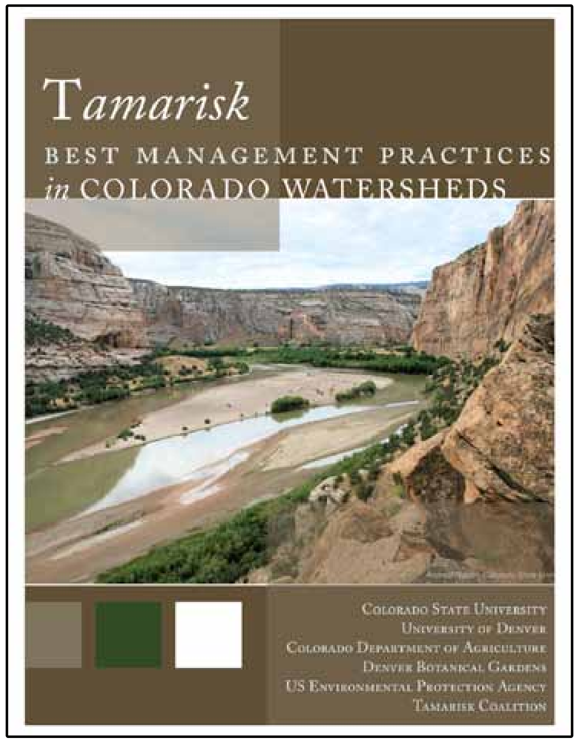

Figure 4. *The development of the Tamarisk BMP guide for Colorado watersheds was supported by a grant from U.S. EPA Region 8.*

Cover photo courtesy of Andrew Norton

CWC Summer Conference & Membership Meeting

The Summer Conference and Membership Meeting runs in the fourth week of August (23rd-25th) for two and a half days, where more than 200 attendees join annually to provide another important opportunity for education, legislative updates, networking and more.

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Please contact Meg Meyer at meg@cowatercongress.org with any questions.

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Colorado Water Congress

Eurasian Watermilfoil: Colorado's Most Prevalent Aquatic Invader

Joseph Vassios, PhD Candidate, and Scott Nissen, Professor, Bioagricultural Sciences and Pest Management, Colorado State University

There are several different organizations that coordinate aquatic nuisance species management in Colorado, including the Department of Agriculture and the Division of Wildlife. Both of these organizations have their own lists that categorize invasive aquatic plant species. Eurasian watermilfoil (*Myriophyllum spicatum*) is on the Colorado Division of Wildlife's Aquatic Nuisance Species Watch List and is designated a List B species on the Colorado Department of Agriculture's Noxious Weed List. The List B designation on the Noxious Weed List indicates that eradication or control may be required by the state noxious weed management plan. Of the three aquatic species listed on the Colorado Noxious Weed List, Eurasian watermilfoil is the only one that has been found in the state. It is a non-native invasive species that occurs in nearly every state, and is the most widespread, invasive aquatic plant in the Northern U.S.

Several introductions of Eurasian watermilfoil have occurred, and it was likely introduced into the U.S. through transport in ballast water of ships or through the aquarium trade. Since it was first indentified in natural systems in the U.S. in the 1940s, it has rapidly spread across the country. There are approximately 12 native *Myriophyllum* species and two non-native species (Eurasian watermilfoil and parrotfeather (*Myriophyllum aquaticum*)) that are invasive.

Many characteristics can be used distinguish Eurasian watermilfoil from native milfoil species. In general, Eurasian watermilfoil will have 12 or more pairs of leaflets per leaf (Figure 1), and native species, such as *Myriophyllum sibiricum*, will usually have fewer than 12 leaflet pairs. The presence of *spicatum*X*sibiricum* hybrids and variable-leaf milfoil can complicate identification. Genetic analysis is the only guaranteed method that can be used for species identification, but leaflet number can provide a sufficient in-field classification.

Figure 1. *Eurasian watermilfoil whorl showing greater than 12 leaflets per leaf.*

Courtesy of Joseph Vassios

Eurasian watermilfoil is a submersed perennial species that commonly grows in waters 1-10 feet deep, but it can grow in waters up to 30 feet deep if the water has sufficient clarity. The ability of Eurasian watermilfoil to thrive in these shallow waters allows it to easily colonize shallow areas of lakes, ponds, and reservoirs. In Colorado, Eurasian watermilfoil occurs primarily in reservoirs, reclaimed gravel pits, and irrigation canals along the Front Range. It has the ability to grow at lower water temperatures than many native species, allowing it to start growing in the spring and outcompete other species for light. Eurasian watermilfoil can reproduce through seed and underground rhizomes, but its main means of reproduction is through vegetative fragments like those shown in Figure 2. These vegetative fragments increase the opportunity for transport within a water body or between water bodies on recreational equipment.

Figure 2. *Eurasian watermilfoil fragments rooting on the bottom of an irrigation canal near Boulder, CO.*

Courtesy of Scott Nissen

Following establishment, Eurasian watermilfoil will rapidly colonize and spread. Infestations form dense mats, as shown in Figure 3, that can impact water quality, water delivery, sedimentation, water turbidity, and habitat.

Eurasian watermilfoil infestations impact water quality by shading out native species, altering water pH as a result of photosynthesis, depleting dissolved oxygen, and raising water temperatures. Dense infestations can impact water delivery by impeding water flow, interfering with diversion structures, or clogging water delivery equipment. If water flow is slowed, more sediment can fall out of the water column, increasing sedimentation and decreasing water turbidity (when particles hang in suspension). Decreased turbidity can in turn allow for Eurasian watermilfoil establishment in deeper water, increasing infestation size. While aquatic plants can provide forage for waterfowl, it may not be as desirable as native aquatic species. In addition to impacts on waterfowl, stagnant water resulting from impeded water flow can provide ideal breeding conditions for mosquitoes and other insects. Increases in these insect populations can promote the spread of diseases such as West Nile Virus, impacting human health. Although it may be obvious that a noxious species such as Eurasian watermilfoil can displace native vegetation, it can also have other far-reaching effects on water quality and the aquatic ecosystem.

Eurasian watermilfoil can be troublesome; however, there are many options available for its management. Chemical treatments are the most commonly used management strategy, but there are other biological, mechanical, and cultural options available. There are two primary biological control options available for Eurasian watermilfoil: triploid grass carp and a native milfoil weevil (*Eurychiopsis lecontei*). Grass carp are considered generalist feeders, but prefer many native aquatic plants to Eurasian watermilfoil. This feeding preference can impact the growth of desirable native plants, providing more opportunities for Eurasian watermilfoil establishment and spread. The milfoil weevil has been effective in small areas, but its performance is unpredictable. Large numbers of weevils are required to suppress Eurasian watermilfoil growth, and purchasing weevils can be very costly. Mechanical control, such as harvesting, can provide temporary control in some situations. Aquatic harvesters can be used to cut submersed vegetation several feet below the water surface. The plant material is then collected and moved off site. Mechanical harvesters may provide temporary control; however, they are not a viable long-term solution, and can actually contribute to the spread of Eurasian watermilfoil if all fragments are not collected. Cultural methods such as water drawdown and benthic barriers (screens that compress aquatic plants to the bottom and away from light) can also be used for Eurasian watermilfoil control.

Figure 3. *Dense Eurasian watermilfoil stand in a pond near Longmont, CO.*
Courtesy of Joseph Vassios

Since this species does not have underground reproductive structures, drying the plant crowns can lead to desiccation (extreme dryness), resulting in good control. Benthic barriers are similar to weed barrier fabric that may be used in home gardens. The barrier is placed on the infested area, shading any plants underneath it. Benthic barriers can be effective, but they are usually only practical for small infestations.

Chemical control methods are the most commonly used for Eurasian watermilfoil management, and there are several contact and systemic herbicides that can effectively control this plant. Contact herbicides usually require short exposure times (hours to days) and do not readily translocate to roots. These herbicides are ideal for spot treatment of small areas in a larger water body, flowing water, or other high water exchange areas. Contact herbicides that provide good Eurasian watermilfoil control include endothall (Cascade®, Aquathol®), diquat (Reward®), and flumioxazin (Clipper™). Systemic herbicides are generally slower acting, require longer exposure times (days to weeks), and are more readily translocated to roots. Due to longer exposure times, many systemic herbicides are better suited for whole-lake treatments or treatments in areas with less water exchange. Systemic herbicides that have provided good control include 2,4-D (Navigate®, Sculpin G™, DMA 4 IVM®), triclopyr (Renovate 3®, Navitrol®), and fluridone (Sonar™). It is important to choose a herbicide that is appropriate for the given conditions, and we also need to be aware of any irrigation or drinking water restrictions for the product chosen. If applied correctly, these herbicides can provide good control of Eurasian watermilfoil.

Eurasian watermilfoil is by far the most important aquatic weed in Colorado, and new infestations are being discovered as public awareness has increased. Boat inspections are being conducted at many state parks to reduce the potential for moving Eurasian watermilfoil to non-infested lake. The economic impacts caused by Eurasian watermilfoil are less then hydrilla (hydrilla infests more than 100,000 acres in Florida alone); however, its ecological range and geographic distribution exceeds any other aquatic weed in North America.

Didymo, a Threat to Mountain Streams in Colorado

James Cullis, PhD Candidate, and Diane McKnight, Professor, Institute for Arctic and Alpine Research, University of Colorado at Boulder

Didymosphenia geminata or didymo is a benthic diatom that has become a nuisance species in streams throughout the United States, Europe, and Asia. In North America, concerns about didymo blooms were first documented on Vancouver Island in the mid 1990s, and since then, there has been an apparent increase in the tendency for nuisance blooms to develop in many other watersheds in the United States and Canada. The preferred natural habitat for didymo is in the mountain streams of the Rocky Mountain region but is spreading to the north-eastern U.S. and has even been observed in Oklahoma. There are many streams in Colorado impacted by didymo, which poses a threat to the sustainability of these streams and the enjoyment potential of recreational users.

Didymo prefers stable substrate as shown by the massive extent of active (brown) and dried (white) mats at the Little Qualicum River on Vancouver Island

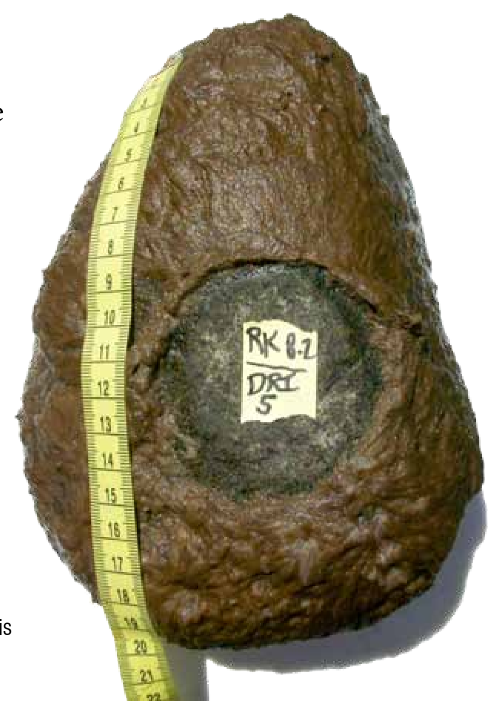
Photo by James Cullis

In 2004, didymo invaded a stream in New Zealand, and it spread quickly to most watersheds on the South Island. Due to favorable conditions for growth, the impact was startling, with mats up to 20 cm thick developing and covering 100% of the streambed. This significantly raised awareness of the potential impact of this nuisance species on the sustainability of stream ecosystems, prompting the classification of didymo as a threat to biodiversity in New Zealand. In January this year, didymo was observed in streams in Chile, and the impact was described in *Science*. Worldwide, didymo is now acknowledged as the most harmful invasive species in lotic systems.

Another name for didymo is "rock-snot," which refers to the thick mats that can blanket the streambed. Didymo mats have been compared to toilet paper or dead sheepskins. Such extensive mats greatly impact the aesthetic appearance of the stream and the enjoyment by recreational users such as fishermen, boaters, and swimmers. Didymo mats also significantly alter the habitat structure, thus potentially affecting the functioning of the stream ecosystem. With abundant didymo mats, there is a shift in macro-invertebrate species from large stoneflies and mayflies to smaller worms and other species that find refuge in the mats. These have a lower calorific value and hence, larger fish species, such as trout, have to invest more energy in foraging for reduced returns. The result is smaller fish. There are also concerns that thick mats can clog the intakes to water treatment plants or irrigation canals, resulting in reduced hydraulic efficiency and increased cleaning and maintenance costs.

Nuisance and harmful algal blooms are typically triggered by natural and/or manmade increases in nutrient concentrations in large rivers, lakes and oceans. In contrast, didymo prefers cold, clear, low-nutrient streams. Didymo therefore presents a paradox: how can such thick mats develop under these low nutrient conditions? The mechanism is still unknown, but is being actively investigated. There is some evidence that the stalk material may trap and concentrate the necessary nutrients during growth and in the chemical processes that convert particulate forms of phosphorus to more soluble reactive forms to be used by the cells. Alternatively, studies in New Zealand have concluded that the thicker mats did not help in securing vital nutrients for the cells, but were rather a consequence of the low nutrient conditions.

It is still not clear what has caused the apparent increase in didymo blooms. Some suggest that it is related to increasing ultraviolet light, increasing



A rock sampled from Boulder Creek showing a circular area where the approximately 5mm thick didymo mat has been removed for analysis.

Photo by James Cullis

nitrogen deposition, changes in the flow regime, or even the emergence of a new genetic variation. One clear thing is that humans have played a role in how it is spread to new areas.

Like other aquatic species, didymo is transported by numerous vectors. Individual cells can survive for extended periods of time outside the stream environment, allowing the diatom to re-establish colonies after droughts or when transported to new streams. The first documented nuisance didymo blooms in North America occurred at popular fishing sites along rivers on Vancouver Island. These blooms followed a significant increase in recreational fishing and the rise in popularity of felt soled wading boots. It is very likely that didymo was introduced to New Zealand and possibly Chile on the boots of a recreational fisherman from either Europe or North America.

Felt boots are an ideal means for transporting didymo, as they provide a continuous damp environment in which the cells can remain viable for weeks and even months. They are also difficult to clean and disinfect completely. Felt boots are also significant vectors for the transport of other nuisance species, such as whirling disease and New Zealand mudsnails. Felt boots have now been banned in New Zealand, and strict rules on cleaning and disinfecting wading boots were introduced at popular fishing sites. In September 2008, Trout Unlimited called for the elimination of felt boots in the US by 2011. As yet there have been no federal laws to this effect, but individual states such as Alaska, Vermont and Maryland have introduced legislation to this effect.

Didymo is a classic case study for studying stream ecology as it represents some of the key stream ecology concepts and highlights the role of humans in altering stream ecosystems. Here students from the University of Colorado partake in a class project to investigate the relative ability of felt and Vibram soled wading boots to transfer didymo cells from an impacted stream under the guidance of Prof. Diane McKnight.

Photo by James Cullis

There are few if any invertebrates or fish that consume didymo mats. In addition, traditional mitigation measures for algal blooms that include reducing nutrient inputs from the catchment have no impact, as didymo prefers low nutrient conditions. There is therefore little that can be done to remove didymo once it is established. Currently the only defence against didymo, as with zebra mussels, is to try to stop it getting into the watershed in the first place. This is hard to achieve, and once it's established, there is only the potential that didymo may be managed and the extent of nuisance blooms controlled.

As with most organisms adapted to living in mountain streams, the flow regime remains one of the most significant controls on growth. Studies in the U.S., New Zealand and Canada show higher didymo presence and persistence in stable bed rock channels and regulated flows downstream of lakes and reservoirs. The current hypothesis is that because didymo is adapted to living in high shear environments of mountain streams, flood events sufficiently high to mobilize the bed sediments are the only mechanism for getting rid of didymo by physically scouring it from the stream bed. This raises the potential to consider managed flood releases from dams as a possible mitigation measure. Flushing flows are already becoming part of the management of dams in the U.S., including for habitat maintenance along the Colorado River downstream of Glen Canyon Dam, and they are being used in New Zealand specifically to restore didymo-impacted streams.

Research has shown dams to be hot spots for didymo growth as they produce cold, clear, low-nutrient water ideal for didymo growth and reduce major flood events. There are, however, many aspects that need to be considered before flushing flows can be considered as a sustainable management option, particularly in Colorado and the West. First is a need to quantify the magnitude, duration, and timing of floods necessary to remove didymo. Secondly, it is important to determine the real impact of didymo and hence the benefits for managing its growth. Only then will it be possible to assess the likely tradeoff between making water available for flushing flows to get rid of "rock snot" and the many other competing demands for water.

Until that happens, the best approach in Colorado would be to raise awareness and attempt to limit its spread. Recognizing the potential threat from didymo is important, as the conditions that favor didymo growth mean that streams most at risk are also amongst the most picturesque and favored trout streams in a state where fishing and tourism is such a vital part of the local economy.

Tamarisk Management in the Arkansas River Watershed

Cameron Douglass, PhD Candidate, and Scott Nissen, Professor, Bioagricultural Sciences and Pest Management Deptartment, Colorado State University

The research described in the following article was partially funded by a grant from the Colorado Water Conservation Board (CWCB) with the goal of understanding the potential outcomes of tamarisk management efforts in the Arkansas River watershed.

The Problem

The Upper Arkansas River watershed (Cañon City to Holly) contains many diverse ecosystems. Particularly important are the riparian areas, located between aquatic ecosystems and drier, upland habitats. In the western U.S., riparian areas like those in the Arkansas River watershed account for about 1% of the total land area, but 80% or more of the total biodiversity. Intact riparian areas perform many other critical functions, such as mitigating the negative impacts of floods and filtering pollutants from the water. Over the previous century, the health of riparian areas in Colorado and throughout the western U.S. have been substantially degraded by altered river flows (dams) and invasion by non-native plant species, among other factors. For example, the intentional introduction of non-native woody species such as tamarisk (saltcedar, *Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) in the early 1900s has negatively impacted riparian forests along the Arkansas River and its tributaries. Riparian forests that were historically dominated by native willow (*Salix* spp.) and cottonwood (*Populus* spp.) species are now mainly tamarisk, and to a lesser and more localized extent, Russian olive. This shift from native plants to invasive ones has caused numerous problems for both aquatic and riparian systems, including reducing the ability of affected riparian areas to absorb and minimize flood effects.

Tamarisk Management

The collective recognition that tamarisk has negatively impacted the Arkansas River watershed has led to aggressive, collaborative efforts aimed at removing tamarisk and Russian olive trees. There are a number of methods that can be used to control both species, including chemical, mechanical, and biological techniques. Successful tamarisk management is an intensive and lengthy process that requires integrated approaches, usually a combination of chemical treatments that kill living plants and mechanical methods of removing the standing dead trees. It is important to consider what the ultimate management objective is for the site that is to be treated; for example, whether the final goal is restoring the site to a native plant community or simply removing trees and restoring recreational access.

Environmental constraints (such as the arid climate), the large area invaded, and costs of tamarisk removal and habitat restoration mean that active site restoration activities (such as re-seeding desired species or planting native riparian trees) are not always feasible. While there are examples where desirable re-vegetation can occur naturally, there have also been cases where tamarisk removal created conditions that favored re-invasion by other noxious weeds. The goal of our project was to evaluate and compare the impact that commonly used tamarisk control strategies have on the plant communities, with a focus on impacts that effect natural re-vegetation.

Project Description

In 2009-2010 we established four experiment sites in the watershed: two locations along tributaries of the river above Pueblo (Four Mile Creek and Hardscrabble Creek), one adjacent to Lake Meredith near Ordway, and the fourth in the floodplain of the main Arkansas River channel at La Junta. At each experiment site, the following treatments were carried out in 1-2 acre adjacent plots (a portion of the site was also left untreated as a reference):

- Aerial helicopter application of Habitat® (active ingredient: imazapyr)
- Removal of entire, living trees using a track hoe equipped with a thumbed bucket (Figure 1)
- Shredding of aboveground biomass (tree trunk, stems and leaves) using a Hydro-Ax (Figure 2)

Figure 1. *Track hoe equipped with thumbed bucket being used to excavate entire, living tamarisk trees*

Figure 2. *Prentice Hydro-Ax equipped with a Fecon mulching head being used to shred the aboveground portion of tamarisk trees.*

Since completing these initial treatments we have sampled soils for herbicide residues and carried out surveys of the plants that are naturally re-establishing in treated plots, in addition to other monitoring. The two mechanical removal methods, and especially the Hydro-Ax shredding, resulted in tamarisk re-growth (Figure 3), and so the one-year-old regrowth was treated in one of the following ways in 2010-2011:

- Releases of tamarisk leaf beetles (*Diorhabda carinulata*)
- Individual tree (growing season) foliar applications of Habitat®
- Individual tree (winter dormant season) basal bark applications of Garlon 4 Ultra® (active ingredient: triclopyr)

Results

We found that the average tamarisk tree canopy retains 74% of helicopter-applied imazapyr herbicide (Habitat®), which means that only a relatively small amount of the herbicide ends up in soils underneath the trees. However, imazapyr is a non-selective herbicide (kills all plants) and we found that many desirable understory plant species were sensitive to even low concentrations of Habitat® that were found in soils underneath tree canopies after aerial herbicide applications. Overall, plant species abundance and diversity in aerially sprayed plots was 67% lower than in untreated plots (Figure 3). The only plant that was commonly found in plots after aerial Habitat® application was kochia (*Bassia scoparia*), which we suspect is resistant to imazapyr. Imazapyr breaks down relatively quickly, especially in wetter soils, and we expect that 18-24 months after application, soil concentrations will no longer be toxic to desirable plant species.

Plots in which tamarisk was mechanically removed had plant communities that were similar to untreated areas, indicating that these removal methods did not negatively impact natural re-vegetation the first year following treatments. A majority (67%) of all plant species found during 2010 surveys was native to Colorado; however, six of the ten most abundant species found would be considered weedy (Table 1). One of the common introduced species (Downy brome, *Bromus tectorum*) is classified by the Colorado Department of Agriculture as being "noxious." This result suggests that, despite the disturbance caused by heavy equipment and tree excavation, mechanical tamarisk removal does not necessarily lead to the establishment of other invasive plants. In a few cases, we did find isolated patches of other noxious plants (perennial pepperweed (*Lepidium latifolium*) and Russian knapweed (*Acroptilon repens*)), but these tended to be at sites where the species had already been part of the plant community, and

Figure 3. *One year after initial plot treatments at site adjacent to Lake Meredith, treatments included: Untreated (A); Aerial helicopter application of Habitat® herbicide (B); Aboveground portion of tamarisk trees shredded using a Hydro-Ax (C); and Entire tamarisk trees excavated using a track hoe (D).*

Table 1. *The ten most common species found post-treatment at four tamarisk removal experiment sites in Fremont, Crowley, and Otero Counties, CO. Origin and growth form designations were made according to the USDA PLANTS Database (plants.usda.gov). Desirability was based on a plant's presumed value, so that species with forage or ecological value would be rated "High" and weedy species with no value would be rated "Low."*

Species	Origin	Growth Form	Desirability
Kochia *(Bassia scoparia)*	Introduced	Forb	Low
Saltgrass *(Distichlis spicata)*	Native	Grass	High
Common sunflower *(Helianthus annuus)*	Native	Forb	Moderate
Sand dropseed *(Sporobolus crytandrus)*	Native	Grass	High
Mare's tail *(Conyza canadensis)*	Native	Forb	Low
Common lambsquarters *(Chenopodium album)*	Introduced	Forb	Moderate
Small tumblemustard *(Sisymbrium loeselii)*	Introduced	Forb	Low
Downy brome *(Bromus tectorum)*	Introduced	Grass	Low
Prickly lettuce *(Lactuca serriola)*	Introduced	Forb	Low
Russian thistle *(Salsola tragus)*	Introduced	Forb	Low

tamarisk removal did not immediately change the species' abundance.

Conclusions

Findings after a single year of our study indicated that while chemical tamarisk removal can strongly influence understory re-vegetation, mechanical tree removal might not always have a strong effect on re-vegetation patterns. Overall, there was more desirable natural re-vegetation than we had predicted at our project sites. Experiment sites will continue to be monitored and sampled for several years to provide a better understanding of the long-term plant community impacts that are caused by tamarisk tree removal. This monitoring will also allow us to evaluate the effects of re-treatment methods (biological control releases and individual plant herbicide treatments) in plots where aboveground tree biomass was first mechanically removed.

The final results from this study will provide data that can be used to predict the relative outcomes of commonly used methods for removing and controlling tamarisk trees. In addition to our research project sites, we are working alongside local and regional collaborators throughout the watershed to provide long-term monitoring for larger scale tamarisk removal projects. Data from the monitoring of these projects, in combination with our smaller scale experimental plots, will provide an important watershed-wide perspective to our research. These predictions could then be used by landowners and managers to plan long-term management efforts with a clearer understanding of the potential impacts that chosen tamarisk removal methods will have on invaded ecosystems.

Acknowledgements

This research was supported by grants from the Colorado Water Conservation Board (CWCB) and the Arkansas River Watershed Invasive Plants Program (ARKWIPP). We greatly appreciate the additional support and advice provided by the following individuals and groups: Leonard Felix (Olathe Spray Service Inc.); Bill Gray; Rich Green; North La Junta Conservancy District; Fran Pannebaker (National Park Service); Bill Phillips; JR Phillips (Fremont County Weed Control); Rick Romano (NRCS); Bill Schulze (Open Range Land LLC); Shelly Simmons (CSFS); Jean Van Pelt (Southeastern Colorado Water Conservancy District); and Jane Wustrow (Sangre de Cristo RC&D).

Combating Invasive Species: The Colorado Division of Wildlife's State Invasive Species Program

Elizabeth Brown, Invasive Species Coordinator, Colorado Division of Wildlife

Colorado's aquatic ecosystems are faced with a serious threat following the discovery of zebra and quagga mussels, a particularly destructive invasive species, in Colorado lakes and reservoirs. Aquatic Nuisance Species (ANS) such as zebra or quagga mussels are one of the most significant and rapidly growing threats to Colorado's waterways. In just about every direction, an array of exotic and nonnative invasive animals, plants, and pathogens exists that could devastate our fisheries and wreak havoc on aquatic ecosystems.

Initially found in Lake Pueblo in 2008, subsequent sampling confirmed the presence of zebra and/or quagga mussel larvae in six other Colorado reservoirs: Lake Granby, Shadow Mountain Reservoir, Willow Creek Reservoir, Grand Lake, Jumbo Reservoir (Logan County) and Tarryall Reservoir.

The Colorado General Assembly adopted the State ANS Act (Senate Bill 08-226) in May. The measure made it illegal to possess or transport an aquatic nuisance species, including the mussels. It also provided legal authority to wildlife officers, parks officials, and other qualified peace officers to stop, inspect, decontaminate, and if necessary, detain watercraft upon a "reasonable belief" that mussels or other ANS are present.

The mussels can live for 30 days on a boat between water bodies.
Courtesy of the Department of Wildlife

Because recreational boating and angling are the primary vectors for spreading ANS, the Colorado Division of Wildlife (CDOW) is taking proactive measures to contain existing invasive aquatic species and prevent the importation of others. As part of a statewide management plan to control ANS, the division has launched large-scale public-education and watercraft-inspection programs. The CDOW coordinates inspection statewide at over 100 locations. Inspections are conducted by CDOW, State Parks, the National Park Service, Larimer County, eight municipalities, private marinas, marine dealers, and private clubs. All combined, the partnership has conducted over 1,000,000 inspections since 2008. In total, 33 infested mussel boats have been intercepted at inspection stations coming into Colorado prior to launching in our waters.

The division also launched a multifaceted public education and outreach program, distributing thousands of informational brochures, signs, and billboards instructing boaters to get their inspections and keep their vessels clean, drained, and dry in between each and every use. Division staff continues to conduct numerous informational ANS meetings and seminars for boating and angling groups, marine dealers, and municipal water managers/providers.

This program will continue to be a top priority for the CDOW. Despite the recent discovery of zebra and quagga mussels, there are still hundreds of lakes in Colorado that remain free of invasive species, and the division plans to do everything we can to keep them that way.

While zebra mussels remain the CDOW's top priority, aquatic biologists search relentlessly for other uninvited and unwanted pests that may be lurking in our rivers, lakes, and reservoirs.

The division's ANS Program is monitoring over 230 locations statewide for both animal and plant invasive species. They are also looking for pathogens and diseases that could have negative impacts on our fisheries.

Due to their destructive nature and ability to reproduce at alarming rates, the following ANS pose the greatest threat to Colorado, earning them the moniker as Colorado's "least wanted" species.

Zebra and Quagga Mussels

Status

Native to Eastern Europe, zebra and quagga mussels were introduced to the Great Lakes Region in the late 1980s. Throughout the last two decades, the invasive thumbnail-size mussels have spread throughout the United States, wreaking havoc in countless rivers, lakes and reservoirs. Discovered in Lake Pueblo in 2008, zebra and/or quagga mussel larvae have since been detected at six other Colorado locations, as mentioned above. Blue Mesa Reservoir is considered "suspect" for presence of a mussel infestation, and the National Park Service has implemented containment measures.

Description/Identifying Marks

Zebra and quagga mussels are freshwater, bivalve (two-shelled) mollusks that typically exhibit an alternating light and dark pattern on their shells. Adults range in size from ½ inch to 2 inches in length. The mussels can attach to nearly any hard object with small fibers called byssal threads. They also attach to each other, forming large, dense colonies.

Impacts

When it comes to invasive species, few are as destructive and costly as zebra and quagga mussels. These menacing mollusks outcompete native species for food and habitat, foul boats and engines, and damage and clog water infrastructure of hydroelectric, agricultural, and municipal water facilities. Zebra and quagga mussels reproduce at alarming rates—one female mussel can produce up to one million eggs annually. As highly efficient filter feeders, zebra and quagga mussels attack the base of the food chain by removing large quantities of the planktonic food sources necessary to native fish and other aquatic organisms. In the Great Lakes, mussels have caused damages in the billions of dollars. If allowed to spread further in Colorado, zebra and quagga mussels could cause devastating social, environmental, and economic impacts.

Means of Spread

The primary vector for spreading zebra and quagga mussels is overland on recreational boats, trailers and other watercraft devices. Adult mussels attach to or "hitchhike" on boats and trailers, and can survive up to 30 days out of the water until deposited in a new location. Microscopic mussel larvae, called veligers, can be transported in water stored in live wells, bait buckets, engine cooling systems, and bilge/ballast tanks. Boaters and anglers must follow the Clean, Drain and Dry protocol before launching or leaving any reservoir to prevent spreading this dangerous species. Once introduced, there is no way to get rid of zebra and quagga mussels, and only expensive, regular maintenance mitigates damages.

New Zealand Mudsnail

Status

Native to New Zealand, the mudsnail was first detected in the United States in 1987 in Idaho's Snake River and has since spread throughout the West. Prior to last year, the mudsnail was only found in three Colorado locations: Boulder Creek, the South Platte River between Eleven Mile and Spinney Mountain reservoirs, and the Green River near the Colorado/Utah border. In 2010, they were also detected in South Delaney Buttes Reservoir in Jackson County and two Dry Creek locations within the city of Boulder.

Description/ Identifying Marks

The New Zealand mudsnail averages 1/8 of an inch in length and has a brown or black cone-shaped shell with five whorls. One way to identify this species is to hold the point of the shell upward. Unlike native snails, when the point of the shell is facing upward, the New Zealand mud snail's shell opening is on the right.

New Zealand mudsnails are only 1/8 of an inch long.
Photo by Elizabeth Brown

Impacts

The New Zealand mudsnail competes with native species and destroys forage important to trout and other native fishes. Mudsnails reproduce asexually (it takes just one to form a population) and spread rapidly, reaching densities of 100,000 to 700,000 per square meter. The New Zealand mudsnail has no natural predators in the United States and once introduced is extremely difficult to contain.

Means of Spread

Mudsnails typically hide in mud and spread by attaching to boats, waders and other recreational fishing gear. Anglers should clean their waders and equipment after every use. Fisherman also should avoid using felt-soled wading boats, as felt greatly increases the risk of spreading mudnails and other ANS.

Rusty Crayfish

Status

Native to the Ohio River Basin, the rusty crayfish has spread throughout the northeast United States. Although not yet confirmed in Colorado, rusty crayfish are used in the bait industry in other states, so the risk for introduction is extremely high. Rusty crayfish inhabit lakes, ponds, and both pool and fast-water areas of streams, making many areas in Colorado potentially suitable habitat. They were first found in Colorado in 2009 in Catamount Reservoir and the Yampa River south of Steamboat Springs, and were also detected in Sanchez Reservoir in Costilla County 2010. Due to the invasive crayfish, the Wildlife Commission passed regulation last November prohibiting the live transport of all crayfish on the West Slope and from Sanchez Reservoir.

Description/ Identifying Marks

The rusty crayfish has two rust-colored marks on its mid-back area. Adults can reach a maximum length of four inches.

Impacts

The rusty crayfish is an aggressive and opportunistic feeder with a voracious appetite for aquatic plants, native crayfish, juvenile fish, and fish eggs. Large crayfish populations can harm fish, resulting in reduced angling opportunities. In heavily infested areas, rusty crayfish also affect recreational swimming. The fear of stepping on and being pinched by the aggressive, large-clawed "rusties" is very real.

The Rusty Crayfish can grow four inches long and can be aggressive. Courtesy of Minnesota Sea Grant

Means of Spread

Rusty crayfish can be spread by anglers, aquarium hobbyists, and commercial harvesters. Teachers and students who use crayfish for classroom studies should not release them into local waters when their experiments/ projects are concluded.

IMPORTANT: It is illegal to use rusty crayfish as bait anywhere in the state of Colorado. Anglers should always dispose of any unused live bait into the trash to prevent introducing any unwanted species. In addition, state law prohibits releasing classroom pets or surplus laboratory specimens into the wild. Never "set free" any plants or animals into local waters!

Eurasian Watermilfoil

Status

Native of Europe, Asia, and Northern Africa, Eurasian Watermilfoil (EWM) was first documented in the eastern United States in the 1940s. First documented in Colorado the Rio Grande River in 1999, EWM has since been found up and down the Front Range but never on the West Slope.

Description/ Identifying Marks

EWM is a submersed, aquatic, perennial weed that roots to the bottom of water bodies. EWM leaves are finely divided with 12-20 leaflets and occur in whorls of 3 to 4 along the stem, giving milfoil a unique feather-like appearance. EWM stems are pink or olive in color, and they usually grow three to 10 feet in length, but can exceed 30 feet. New plants emerge from each stem joint, forming thick mats.

Impacts

EWM is one of the most problematic and destructive of all invasive aquatic weeds. With a rapid growth rate, averaging 1 foot per week, the highly aggressive species forms dense mats, which cover the surface of lakes and reservoirs. These dense mats impede all forms of water based recreation, such as swimming, fishing, and boating. The dense weed beds also have adverse effects on native aquatic vegetation important for waterfowl and other native species. EWM disrupts the forage mechanism of game fish by providing ample hiding spots for smaller prey fish causing a negative bottom-up effect on the food web. This nasty aquatic weed can colonize a variety of habitats including lakes, reservoirs, rivers, ditches, and canals. EWM is notorious for slowing or stopping the flow of water in natural and man-made systems.

Means of Spread

EWM is spread from lake to lake on recreational boats and trailers. Boaters and anglers should inspect and remove all plant materials before leaving any water body. A small plant fragment attached to boat, trailer, or waders can take root in a new location and form an entire colony. Once EWM becomes established in a waterway, it is nearly impossible to remove.

IMPORTANT: While prohibited for sale in Colorado, some Internet sites sell EWM and other aquatic weeds for ornamental or aquarium use. It is illegal to release any ornamental aquatic plants/weeds into Colorado waters!

Weld County Continues Eradication of Russian Olive and Tamarisk

Tina Booton, Weld County Weed Division Supervisor, Weld County Department of Public Works

Russian olive and tamarisk are both considered phreatophyte species, a classification for deep-rooted plants that reach down to or just above a ground water source. These plants can, therefore, readily consume as much water as they want or need, allowing them to be more drought tolerant than other species. Native phreatophyte species include willows and cottonwoods.

Russian olive trees were introduced from Eurasia for shelterbelts (windbreaks to protect farmsteads/livestock) in the early 1900s. These trees readily establish themselves and thrive in a variety of soil types. Not only is the Russian olive tree tolerant to inhospitable alkaline and saline soils, it is also able to fix nitrogen within the soil – convert nitrogen into ammonia for use – which aids in survivability. The younger trees also have very sharp spines for defense against predation. As the trees age, these spines continue to grow into additional branches. The spring flower blooms are very sweet-smelling, and the pollen from these trees may contribute to allergy problems.

Russian olive spines with alternating leaves.

Photo by Tina Booton

Russian olive trees are prolific seed producers. Current research is underway to determine the amount of Russian olive seed utilized by bird species as a food source. Preliminarily, it appears that birds will consume the Russian olive seed and digest the soft outer layer while spitting out the hard internal seed. Research is showing that Russian olive seeds that go through this process are more likely to germinate.

Russian olive seeds.

Photo by Tina Booton

Tamarisk, or saltcedar, was also an introduced Eurasian species for shoreline stabilization and as an ornamental shrub or tree for landscaping. Its tiny seeds are readily dispersed with the wind. With the extensive root system of the tamarisk tree, it is able to translocate (to move or transfer from one place to another) different types of salts. These salts are stored in the scale-like leaves of the plant. When these leaves fall to the soil surface, they deposit the salts on top of the soil, which limits the plant species that can grow in this alkaline and saline environment. This results in a monoculture (one species) over time.

Over the years, Russian olive trees were heavily planted as shelterbelt species, especially on the plains and along the Front Range in Colorado. The trees were readily available at nurseries and through mail order catalogs. While tamarisk had the same opportunity, they were not as recommended for shelterbelt establishment. However, they were planted along stream banks to reduce erosion.

Along the South Platte River, most of the shoreline stabilization that is visible is considered hard stabilization, such as concrete, cars, and tires; not soft stabilization such as tamarisk trees or grasses. However, winds blowing along the Front Range warrant the need for shelterbelts and the protection that they provide houses, fields, and livestock. As a result, the South Platte River watershed has a much larger problem with Russian olive trees than with tamarisk.

In 2008, the Platte Invasives Endeavor (PIE) plan was created. This plan looked at Russian olive and tamarisk within the South Platte Watershed and the trees that are growing within the floodplain of the South Platte River and its tributaries only. The PIE plan includes nine counties: Denver, Adams, Boulder, Larimer, Weld, Morgan, Logan, Washington, and Sedgewick.

In the PIE plan, the reported tamarisk infestation is estimated at 375 acres, while the estimated infestation size of Russian olive is around 1,900 acres. These estimated acres of infestation are for solid infestations (if all the plants were placed next to each other), not for actual number of acres partially infested. These estimates also do not include infestations that are not within the flood plain of the rivers.

Eradication of a tree species is labor-intensive. If the trees have a foliar (leaf) treatment or a "hack and squirt" treatment where the outer layer of bark is cut to expose the cambium (the layer of tree where growth occurs, just under the bark), the result is a standing dead tree. This may or may not be appropriate for the size of the tree and the use of the land. Unless the foliar treatment is applied aerially, every tree still has to be treated individually.

Therefore, the most commonly agreed-upon method for eradicating these tree species is called a cut stump treatment. With cut stumps, a saw of some kind (hand saw, lopper, or chain saw) is used to cut the trees down, and this material is moved out of the way in a short amount of time so that an herbicide can be applied to the fresh cut stump focusing on the cambium area. The cut material then needs to be disposed of. This can be done by creating piles of wood for wildlife habitat, chipping the cut trees into tiny pieces and either spreading them out on the ground in a thin layer or composting them, or drying the material for use as firewood.

Russian olive log piles after the small branches were chipped.
Photo by Teri McClellan

Some alternatives include using the wood chips in the process of making wood burning pellets. Wood turners maybe interested in the larger log pieces for making bowls, pots, plates and cups. Research is underway to determine if there are some bio-fuel opportunities.

Currently, tamarisk is labeled as an eradication species in all nine counties in the PIE plan. Most of the counties are focusing on tamarisk trees that are growing within the flood plain and the unexpected outlying small infestations. The individual ornamental trees in yards are on the bottom

Cache la Poudre River with Russian olive trees
Photo by Teri McClellan

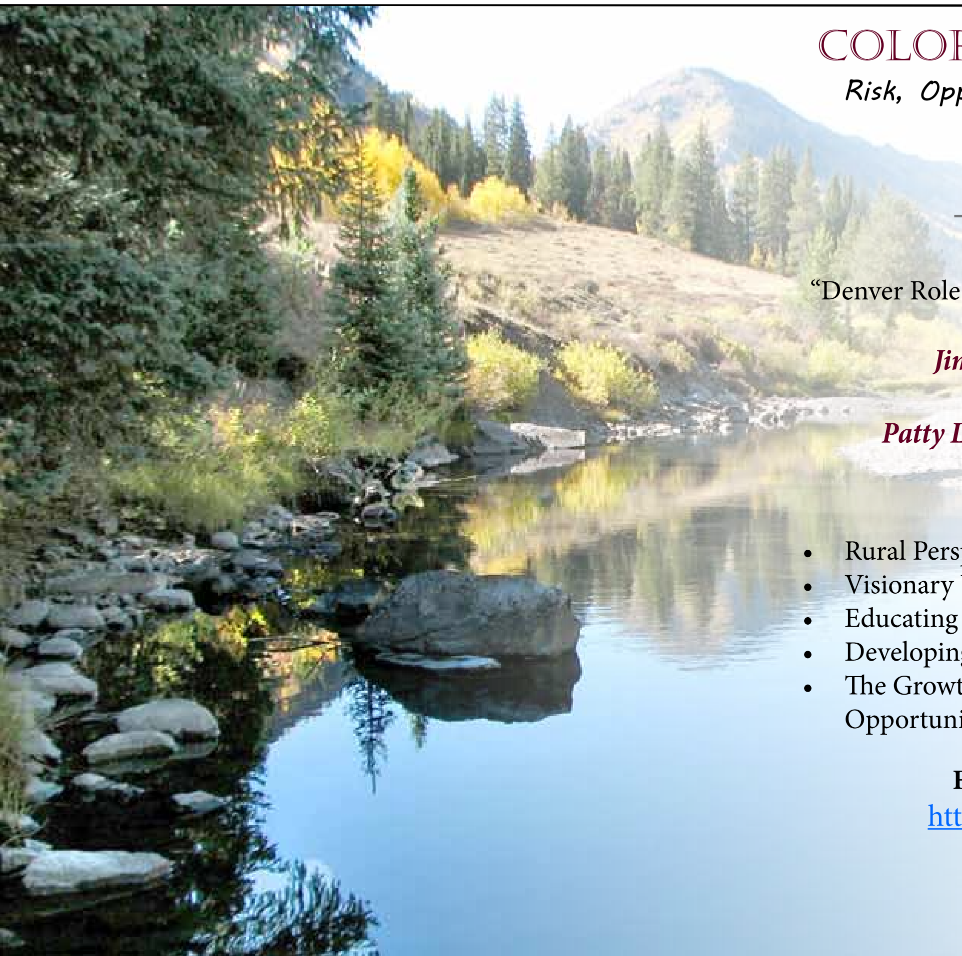
of the tamarisk priority list, unless you live within some of the major cities in the nine counties that have placed a higher focus on the eradication of the tamarisk.

Russian olive eradication is being actively pursued in Boulder and Weld Counties. To date, Boulder County has removed around 14,000 Russian olive trees from their open space lands. Weld County has removed the Russian olive trees that are growing along the Cache la Poudre River in Weld County from County Road 13 to 25th Avenue on the edge of Greeley. This grant funded project focused on lands that directly bordered the Cache La Poudre River, minus the lands within the city of Windsor. Another project to remove Russian olive is scheduled for the Big Thompson in Weld County to begin early summer of this year. The other counties have either not added Russian olive to their list of noxious weeds that require control or they do not currently have the manpower to address the numerous acres of infestations.

Ornamental tamarisk trees.
Photo by Tina Booton

Additional help is needed. This help could include removing your own Russian olive trees and speaking with your neighbors about doing the same, speaking to your local politicians about having the Russian olive tree listed as a noxious weed, helping organize parties to remove the Russian olive in parks and other open spaces (after permission is received), helping to find and/or write grants to fund Russian olive removal, and volunteering time to educate landowners about the impacts of Russian olive at local fairs and other events.

Find more information at www.weldweeds.org



Regional Water Program Creates Comprehensive Drinking Water Resource Webpage

Erik Wardle and Troy Bauder, Water Quality Program, Department of Soil and Crop Sciences, CSU
Julie Kallenberger, Assistant Regional Water Coordinator, Colorado Water Institute
Adam Sigler, Water Quality Associate Specialist, Montana State University

Sustainable supplies of quality drinking water are essential to the well-being of rural residents, small towns, and other users throughout the West. Protection and safe use of this valuable resource requires an understanding of potential contaminants and their sources. Drinking water quality standards for human consumption are enforced in public water supplies under the Safe Drinking Water Act; however, private wells are not regulated under this legislation. Consequently, private well water users are responsible for monitoring and understanding the suitability of water supplies for domestic, livestock, and irrigation use. Much of the water used by rural residents in the West is supplied by private wells pumped from groundwater aquifers. These aquifers can be susceptible to impacts from agriculture, mining, oil and gas development, and other surface land uses.

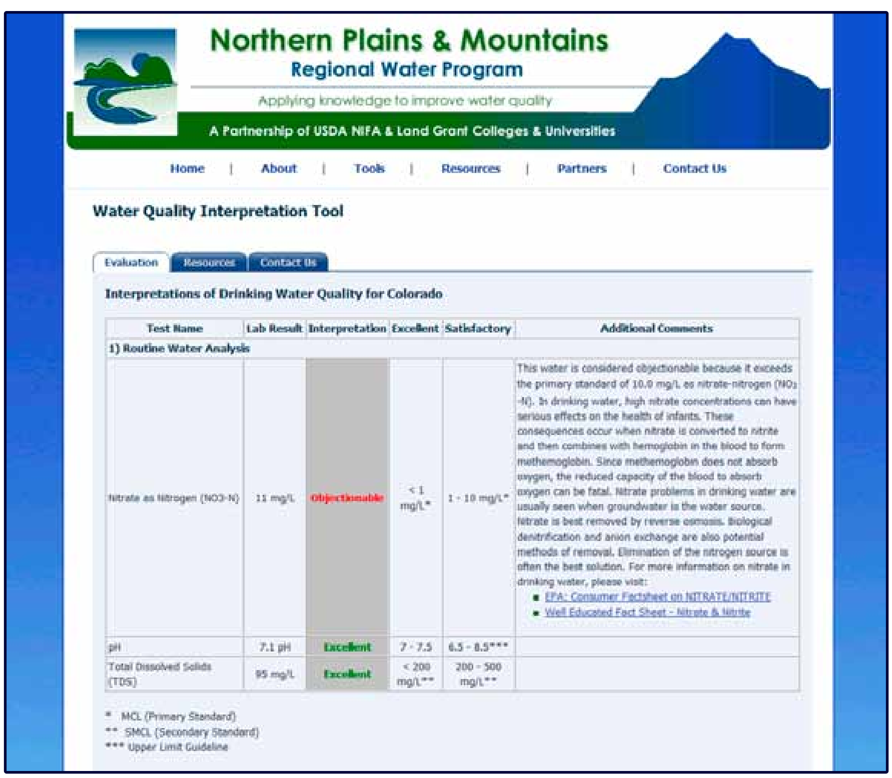
Potential groundwater quality impairments in Colorado and nearby states include salinity, nitrate, bacteria, sulfate, arsenic, hardness, excessive softness, metals, and an array of less common issues such as barium, radon, selenium, and organic compounds. The need for water testing, treatment, and protection is often not apparent to rural property owners until they discover a problem. Once this occurs, rapid access to high quality information from a source that can be trusted to be accurate and non-biased is critical. Correspondingly, easily accessible water quality information and educational curriculum for Extension professionals, technical service providers, landowners, and private well users is needed to address water quality questions and mitigate water problems in these environments.

State regulatory agencies and county environmental health offices in EPA Region 8 (Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming) have noted the need for private well and septic owner education to protect public health and water resources. In response, the Northern Plains and Mountains (NPM) Regional Water Program has developed a comprehensive website (region8water.colostate.edu/drinking_water) for well and septic educational information that includes newly developed resources and offers previously unavailable materials. Resources include an online Water Quality Interpretation Tool to help rural water users understand water quality analytical test results, a series of factsheets on drinking water quality and treatment, an educational DVD to provide homeowners information about their well and septic systems, well and septic record-keeping folders to encourage maintenance, and a guide on how to start a local well testing program. Let's look at these resources in a bit more detail.

Water Quality Interpretation Tool

This online assessment tool allows users to enter the results of their water quality analytical test and receive immediate feedback about suitability of the water for drinking, livestock consumption, or irrigation use. Increased understanding of test results is key to helping well owners

A sample interpretation from the tool shows high nitrate (as nitrogen) water.



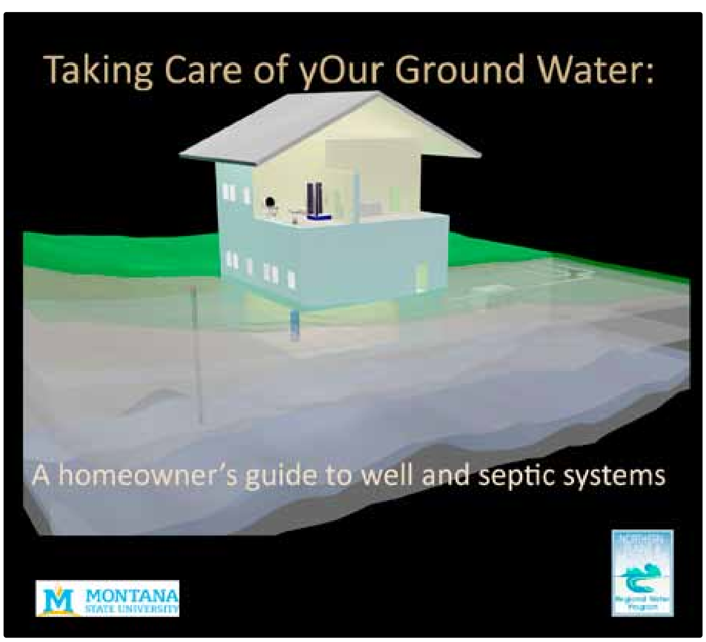
take possible actions to protect and/or treat their water for its intended uses. The tool delivers state-specific interpretations and directs users to additional resources related to the quality of their water supply. These resources include information on proper testing procedures, private and public resources available for testing water, treatment options, contaminant specific details, and well and septic system management. The tool is free, easy to use, and it requires no registration or personal information.

Well Educated Fact Sheets

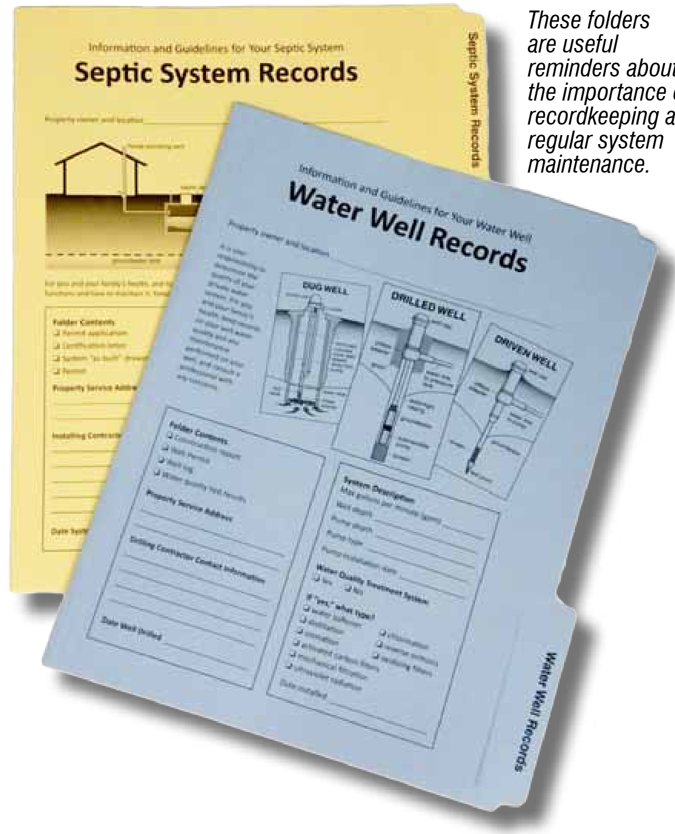
This series of fact sheets addresses issues related to drinking water quality. They provide detailed information on common water contaminants, drinking water standards, and further assistance with interpreting test results.

Well & Septic Educational Videos

Also included is an educational DVD called "Taking Care of yOur Ground Water." This DVD was designed to educate homeowners about caring for their well and septic systems to protect their drinking water resources. The title film provides basic information on well and septic systems and offers guidance on what users can do to ensure their systems function properly. There are additional chapters covering specific topics in more detail. These videos include, "Sampling for Well Water Quality," "Water Treatment Options," and "Protecting the Wellhead," among others. All videos include detailed three-dimensional graphics to aid the viewer in understanding the inter-workings of well and septic systems. Postcard surveys included in the DVD jacket have shown that most viewers are finding the material useful for understanding their well and septic systems, and some have identified and corrected potential problems that could impact their families' health.



In addition to hard copies of the DVD, these videos are available for online viewing.



These folders are useful reminders about the importance of recordkeeping and regular system maintenance.

Well & Septic File Folders

Maintaining accurate and complete records is essential to helping households protect the health of their family and the environment. The well and septic file folders are a tool to encourage users to save their water quality test results, keep detailed installation and maintenance records, and provide critical information to users. The folders contain a description of typical systems, suggestions for maintenance, tables for critical dates, and other essential information to help private well and septic owners keep their systems operating efficiently. As was done with the DVDs, postcard surveys were distributed with the folders, and they have shown that people have found folders useful to keep well and septic records.

Guide to Offering a Well Testing Program

In order to support those that have interest in offering a well water testing program in their communities, the NPM team has created a comprehensive document titled "Private Well Testing Program Guidance." The document is intended to provide complete information for an organization or individual that wishes to start a well testing and educational program in their area. A well testing program is a public education program that guides private well owners through the process of testing their water, helps them to interpret their water quality results, and reminds them about the importance of testing. Testing is the most accurate way for well owners to learn about the quality of their well water. Sampling is not complicated or expensive, but many homeowners do not know where to begin. Providing a well testing program offers well owners guidance on how to collect samples and which parameters to select for analysis. This process may help homeowners find issues with their well and learn how to remediate the problem. Using this document is a great way to organize an effective program that can have lasting benefits for private well water users who may otherwise not know the quality of their water.

Until recently, these resources were only available through scattered web sources and local providers. The comprehensive website that the NPM team put together allows access to all of these resources in one convenient location. These materials have already reached thousands of homeowners through Land Grant University faculty, state Extension networks, county environmental health offices, and water quality districts in the six cooperating states. By organizing these resources in one location, the NPM team expects to increase access to and use of these tools, thereby increasing knowledge and understanding of well and septic systems, groundwater protection, and water quality testing. Although most of these resources are available free of charge, some materials may have a small fee in order to recuperate costs of production. However, at the state level, resources may be available to help reduce these costs. Whether a private well user, Extension specialist, health department agent, citizens group, small community, or other interested group, the NPM team encourages you to visit the drinking water resources webpage and put these tools to work for you.

For More Information Please Visit:

Region 8 drinking water resources page:
www.region8water.colostate.edu/drinking_water

Colorado State University Extension Water Quality Programs:
www.csuwater.info

Or Contact

Erik Wardle - CSU Water Quality Program
erik.wardle@colostate.edu

Julie Kallenberger – Colorado Water Institute
julie.kallenberger@colostate.edu

National Geographic Freshwater Fellow Sandra Postel Visits CSU

Lindsey A. Knebel, Editor, Colorado Water Institute

Sandra Postel, who founded and directs the Global Water Policy Project out of New Mexico, is National Geographic Society's first Freshwater Fellow. She is the author of several books on global water issues and lectures to broad audiences across the globe on finding innovative solutions to questions about water scarcity.

Postel presented a lecture at Colorado State University (CSU) in April and communicated her desire to share her experiences in water with the CSU community and collaborate with CSU water researchers.

During her presentation, Postel pointed to important trends, themes, and new technologies in water resources. Her central question: "Can we meet the water demands of eight billion people by 2025 while protecting the ecosystems that support life on the planet?" The simple answer, she said, is yes – but not without some fundamental changes.

After her presentation, Sandra Postel signed copies of her recent books and spoke with members of the CSU water community.

Photo by Lindsey A. Knebel

Postel emphasized during her speech that water is central to life, and that human needs consume the most of it. Among her examples: about 40% of the world's food supply comes from irrigated cropland; the number of dams worldwide has increased from 5,000 to 50,000 from 1950 to now; and it takes large amounts of water to produce common goods – 2,900 gallons go into producing a pair of jeans.

Postel also pointed out that in the U.S., we consume about 2,000 gallons of water per day in diet, transport, and other uses – twice the global average. She encouraged listeners to visit the online "Water Footprint Calculator" on National Geographic's website, where users can see how their average water consumption compared to the national average. After running the calculator, users can make a pledge to reduce their water use in specific areas. See http://environment.nationalgeographic.com/environment/freshwater/water-footprint-calculator/ or search for "Water Footprint Calculator – National Geographic" to try this feature.

In addition to human dependence on water resources, Postel noted that we must consider the other forms of life that depend upon water. A resounding idea she presented was, "Provide all people and all living things with enough water before some get more than enough."

On that note, Postel gave examples of times humans have damaged water ecosystems as demand outpaced natural supplies. Included in her examples was the Colorado River, whose flow to the Delta has declined since the Hoover and Glen Canyon Dams were completed in 1935 and 1963, respectively. Postel also referred to the Aral Sea in Central Asia. Formerly one of the four largest lakes in the world, when water was diverted for crops, the Aral Sea dropped to 10% of its original size by 2007. Fishing, commerce, and public health were severely damaged. Such changes have led to extinction rates in freshwater species that are four to six times higher than for terrestrial or marine species. "The web of life is fraying in freshwater," said Postel. She also noted that both human health and the health of our economies depend directly on the health of the ecosystem.

These examples were soon followed by a few of what Postel considers to be positive steps toward more sustainable ecosystem management. Recognizing the importance of protecting the upper watershed, New York City made the decision in the early 1990s to allocate money to preserve its wetlands rather than construct a treatment plant. According to Postel, they spent around $1 billion in watershed protection rather than the $8 billion a plant would have cost to serve the same functions.

Boston was an example Postel gave of conservation efforts. In the 1980s, Boston was reaching a city water demand that was about to outgrow its supply. Due to aggressive conservation programs, the city dropped its usage by more than 40% by 2009 and didn't have to disturb nearby water systems to find more water.

In addition to these and other cities' vast improvements, several organizations have taken action, according to Postel, such as Unilever, a company that owns 400 brands of foods and other goods. Unilever, she said, worked on installing drip irrigation, greatly increasing the efficiency of their water usage while dropping their factory water usage by 63% since 1995.

Such successful water management must spread and continue, Postel said, for future populations to have access to enough water. "We need to start the conversation," she argued. "We need to ask questions in a way that guides research."

Postel gave some examples of positive directions, including giving incentives to farmers to make decisions that protect water. Wetlands provide valuable services that would cost us billions to replace with man-made systems, including water storage, salinity balance, water purification, flood and drought mitigation, nutrient cycling, groundwater recharge, sediment transport, and biodiversity, among others. The roughly estimated monetary value of replacing wetlands with man-made filters and other services is somewhere between $200-$940 billion/year. She proposed we should acknowledge this value, and recognize the cost of replacing wetland services, rather than taking it for granted.

Another positive change might be restoring the natural flow regime of rivers, which have been altered by human interferences like dams. Postel argued that we might be able to give something back to the rivers, like spring flooding, while still using the dams.

Postel is a proponent of rain fed or dryland agriculture and solutions that consider best management practices for both range and grasslands systems. She also advocated for increased irrigation efficiency and urban farming.

"You can't solve a problem within the same mindset that created that problem," said Postel of implementing such change. She believes we need to start valuing and using water in a different way if we want to plan for the future. We should consider, the idea that "stationarity is dead" – we can no longer look to history to predict the future as far as natural events. Climate change has increased the boundaries, so we don't know what extremes will come.

Something else to consider is sustainability. The old mindset, said Postel, was that we can take from the ecosystem as human demands grow, but we've learned that we must operate within a "sustainability boundary."

Some areas to expand research, said Postel, are in the connection between humans and ecosystems, ecosystem functions and health, irrigation efficiency, dryland agriculture, grasslands/range education – food scarcity for people and animals, role of technology, environmental flows in policy, and flood mitigation. She encouraged students and young researchers by saying that water is a big challenge, and everyone needs to be part of the solution – "find your niche," she advised.

Sandra Postel presented to the CSU community some of her experience with and ideas about global water resources.
Photo by Lindsey A. Knebel

Monitoring the Climate of Colorado – Where do the Data Come From?

Nolan Doesken, State Climatologist, Colorado State University

Weather data is one of those things that we all take for granted. It seems like there has always been the "National Weather Service" and, before that, the "U.S. Weather Bureau." Somehow, without even thinking, we all expect there should be perfect and complete historical weather data back to the 1800s for every city, town, and county in Colorado and across the country.

Ever since 1870, even before Colorado was a state, our country has had federal organizations in place to help track of and predict weather conditions. From 1870-1890 it was a military responsibility, and some of Colorado's original forts were set up with weather stations. Then from 1890 to 1940, the U.S. Department of Agriculture took over. Beginning around 1940, the responsibility for weather data collection and weather forecasts was shifted to the Dept. of Commerce as more and more critical needs for weather information shifted to business and transportation.

Since the late 1930s, with the rapid advance of civilian aviation, most major airports were staffed with weather observers. For Colorado, this was between 10 and 20 locations in the state – our "First Order" stations at Denver, Colorado Springs, Pueblo, Alamosa and Grand Junction, and then smaller weather stations at other airports such as Trinidad, La Junta, Akron, Broomfield, Eagle, Durango, Gunnison, Montrose, Hayden, and a few others. Since the mid 1990s, these airport weather stations were automated so that human observers were no longer required. These automated stations don't measure snowfall, and their precipitation measurements aren't all perfect, but they do measure around the clock and provide instantaneous updates – a great improvement for aircraft operations and flight safety. Now, almost every airport in the country has an advanced set of electronic sensors measuring temperature, humidity, wind, pressure, clouds, and even visibility (how far a pilot can see in the vicinity of the runway).

Airport weather stations are useful for obvious reasons, but airport locations are often unique and not representative of most areas. That leaves out a huge part of the landscape, including most of the mountains and most of Colorado's eastern plains. If all we had were airport weather stations, we would do a lousy job anticipating runoff and water supplies or tracking agriculture weather conditions. Fortunately, since the late 1800s, there has been a secondary network of simpler weather stations that has become the foundation for nationwide climate monitoring.

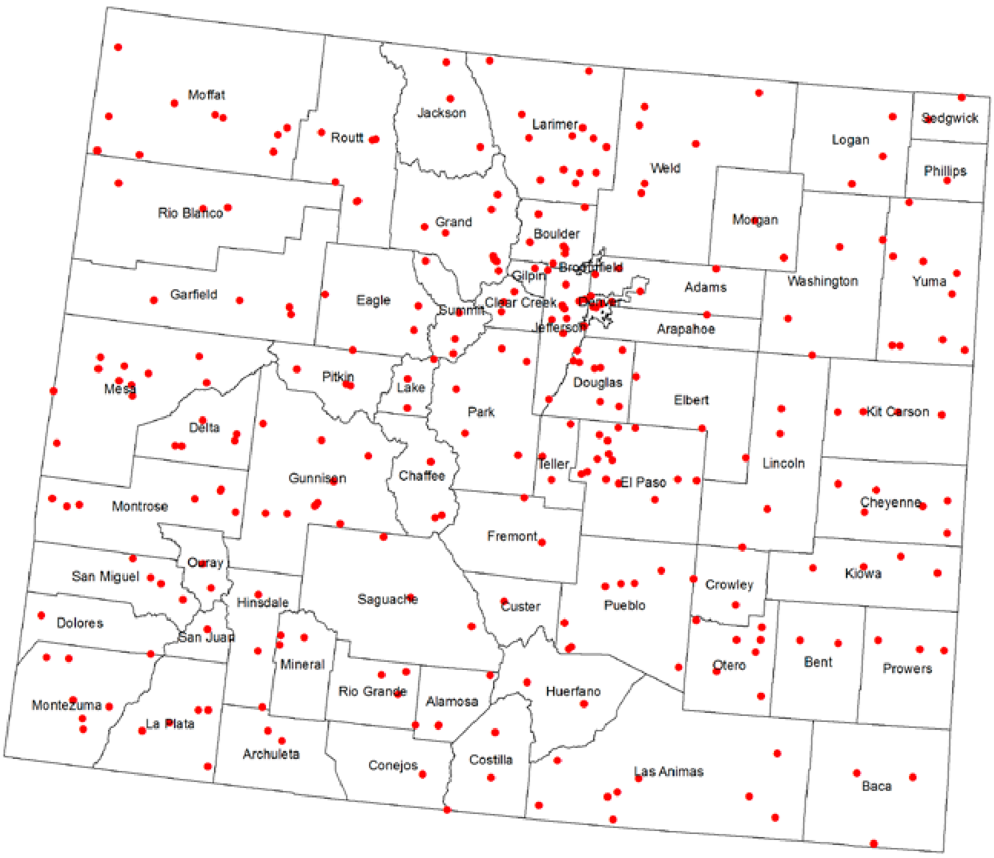
This network, named the "Cooperative Program" by the National Weather Service, is made up primarily of volunteers in almost every county of the U.S. They are equipped and trained by the National Weather Service, and their data are archived and distributed by NOAA's (Dept. of Commerce, National Oceanic and Atmospheric Administration) National Climatic Data Center. The Colorado Climate Center has relied on this data source for much of our climate monitoring and research.

Here in Colorado at any given time, there are between 220 and 270 of these "Cooperative weather stations." Most of these measure and report the following elements: daily maximum and minimum temperatures, daily precipitation (rain and the water content from snow), snowfall, and the total depth of snow on the ground. About ¼ of these stations are equipped with recording rain gauges that measure every 15 minutes, but most of the stations measure only once a day. A very small number of the stations across the state are also equipped to measure evaporation using the "Class A" evaporation pan – a standard for nearly 40 years.

Standard NWS Cooperative station on the Eastern Plains of Colorado showing Cotton Region Shelter and 8 inch Standard Rain Gage.

In some ways, this network seems old fashioned today, since most of the stations require the presence of a volunteer observer to check the instruments and record the data. But this trait now makes the climate data of incredibly

Colorado NWS Cooperative Stations



high value to scientists and data users, since the data have been collected consistently for so many years from so many places. The Cooperative Network is the only source of nationwide snowfall and snow depth data.

Our historic weather station here on the Colorado State University Campus in Fort Collins contributes data to the NWS Cooperative Network (for more information, see the article entitled "The Fort Collins Weather Station-120 years" from January/February 2009 at www.cwi.colostate.edu/newsletters.asp). Several of CSU's research centers across the state are also Cooperative weather stations as well as hosts to specialized agricultural weather stations (for information about CoAgMet, see the article "Progress Report: Toward Sustaining the Colorado Agricultural Meteorological Network" in January/February 2011).

Where are all the other stations? Some are at dams, reservoirs, water treatment plants, and sewage treatment plants – locations with a key interest in local climate. Some are on farms and ranches, and a few are at schools and radio stations. Some are at state and federal offices. Several are at National Parks and Monuments, and others are simply in the back yards of individuals who love keeping track of the weather. Colorado's highest elevation Cooperative station at the current time is at the Climax Molybdenum mine at an elevation of 11,294 feet between Leadville and Copper Mountain.

Together, these stations span nearly every county. A few have been in the same place for 100 years or more (Akron 4E, Cheyenne Wells, Rocky Ford 2ESE, Montrose, Cheesman Dam). Many more have been in the same place for 50 years or longer (Dillon, Grand Lake, Cochetopa Creek, and many others). Collectively, these weather stations provide the basic data we need to describe the basic elements of the climate of Colorado and how it varies.

How to access these data?

Data from the National Weather Service's Cooperative Network are used daily in many applications such as monitoring drought, predicting water supplies, assessing crop conditions, architectural and engineering design, research, and much more. Anyone with Internet access can obtain recent and historic data. The Colorado Climate Center is one source, but data can be accessed through the Western or High Plains Regional Climate Center or from the National Climatic Data Center. If you have questions or need help acquiring these data please contact us (ccc.atmos.colostate.edu).

New Climate "Normals"

Using data from all these weather stations, climatologists are currently rushing to update the "Climate Normals" for the country. These normals are the climate averages for the past 30 years covering the period from 1981-2010. Thirty-year averages, updated at the end of each decade, are the standard way for describing and comparing data from region to region. Based on preliminary data (results will be released in summer 2011), temperatures for this new "normal" period will be a little warmer than the previous 1971-2000 values for most of Colorado. Precipitation, however, is showing very little change.

Daniel Tyler Completes Biographical Book, WD Farr: Cowboy in the Boardroom

Daniel Tyler, Professor Emeritus, History, Colorado State University

The last time I interviewed William Daven (WD) Farr in the spring of 2007, I asked him if he knew I was writing his biography. He was sleepy, not very alert, and I knew the usual Q and A routine we had enjoyed earlier would not be possible that day. But my question caused him to open his eyes. He looked at me directly, raised up from his bed ever so slightly and said, "Tell them I knew water." Then he closed his eyes and sank back into the bed. That was it for the day. I correctly assumed we had had our final conversation. WD died a few months later.

Over the years that I worked on his story, I confirmed WD's self-assessment. I always knew that water issues were of special interest to him. He had read and commented on chapters I sent him when writing The Last Water Hole in the West and The Silver Fox of the Rockies. I was also aware that his long service to the Northern Colorado Water Conservancy District (NCWCD) and the Greeley Water and Sewer Board were a measure of the esteem in which he was held and the high priority he gave to assuring Northern Colorado an ample water supply for the future.

What I hadn't realized was how instrumental he was in forging water policies and developing an approach to conflict resolution that made possible his many successes. His quiet, determined, behind-the-scenes style of negotiation, inspired by unrelenting memories of devastating water shortages in the 1930s and 1950s, made him a crusading advocate for water storage and waste prevention. The appearance of environmental laws after 1970, along with rapid population growth on the Front Range, presented obstacles to WD's visionary plans. But his dedication to Weld County, and his commitment to the betterment of all who tried to make a living in the semi-arid West, caused him to multiply his efforts to accomplish what he believed was required for economic growth. During one interview he said to me, "Life is just circumstances; you deal with them. I don't think I have ever wasted a day in my life."

Again, I think he was on the mark. His mind was always working, always trying to imagine a better way to do things, whether he was feeding cattle, leveling crop land, bringing water through the Continental Divide, cleaning up pollution on the South Platte River, or finding a better way for banks to loan money to entrepreneurs. But it was the development and management of water of which he was most proud. "Of all that I've done," WD told a Rocky Mountain News reporter, "I'm still proudest of the water. It's here in perpetuity. In 500 years people will still benefit from it."

WD's interest in securing a reliable supply of water for Northern Colorado emerged from the devastation he witnessed during the Dust Bowl. First recognized in 1931, the drought intensified in 1932 and continued through the decade. Summers were mostly hot and dry, and when the few rains came, they were gully washers, eroding the brittle land and flooding low lying areas. Dust storms that shut out the sun and terrified children in southeastern Colorado were also a fact of life in Greeley. "The dust was terrible," WD recalled, "and I've seen many a day here when you couldn't cross the street in the middle of the day because of the dust." Grasshoppers returned to eat the few crops that survived, and so much topsoil lifted in the wind that it rained mud in Denver in 1935.

With good reason, farmers were discouraged. The ditch and reservoir system in northern Colorado had been built before World War I. Since then, population had grown, but the supply of irrigation water remained constant. When drought conditions developed, the mountain snow melt ended early, ditch companies incurred water shortages, and row crops needing late summer water to mature dried up. "No point in planting potato seed," WD noted, "because water was too short. You couldn't raise enough hay to feed the lambs. It was disheartening, and that's what made us go after the C-BT (Colorado Big-Thompson Project). We didn't know about conservation or weather patterns or anything else at that time."

He was twenty-three years old in the summer of 1933 when New Deal representatives called from Washington to ask if the communities of Northern Colorado could use $200 million to build a trans-mountain water diversion project from the Colorado River. Over the next four years, East Slope and West Slope representatives worked on a compromise agreement that would provide water from the Colorado River to seven Front Range counties along with a compensatory reservoir for the West Slope. By 1937, when the Colorado legislature passed the Conservancy District Act, WD and his father, Harry, were prepared to do whatever it took to convince farmers to subscribe to C-BT water. Harry had a six-passenger Buick; WD knew how to drive. With other advocates of the project as passengers, they took a dog and pony show all over the seven counties, overcoming resistance from water monopolists and debt-ridden land owners. WD was the chauffeur, but the farmers listened to him. Most young people had been driven out of the area by drought and economic depression. They knew WD represented the future, and he was persuasive in support of the C-BT. When the seven-county vote was tallied, those in favor had a majority of 20:1. And when the first water came through the Adams Tunnel ten years later, WD was a witness – June 23, 1947.

"We had been there about an hour waiting," WD remembered. "Here is just the tunnel, and it is blank. Nothing! Very quiet! This group of men . . . we were up there to see what was going to happen. We had no idea. We stood around, fidgeted and talked. All of a sudden we heard a roaring noise, not like water or anything. It sounded like a train coming. We couldn't figure that out. Then the biggest cloud of dust I ever saw came out of that tunnel ahead of the water. You can imagine that. Thirteen miles long. It just covered us with dust. We were just filthy, our hats, our clothes. That dust hit us and we couldn't see anything. As that dust dropped down, then [came] the lighter dust behind it. Here was the water rushing out, and we knew it was going to work. We knew the water was there. I have never seen men as happy in my life. Never expect to [again]. Finally you had the water, and you knew it was going to change northern Colorado. You had no idea how, but that was the answer."

The thrill of seeing the first Colorado River water was tempered by the slow pace of construction by the United States Bureau of Reclamation (USBR). The bureau became disgruntled over the NCWCD's refusal to pay more than its contracted cost of the project, and whether delays were intentional or not, construction appeared to focus more on revenue-generating hydro-power facilities than on the structures required for water delivery. Post-war inflation had caused original estimates of C-BT construction to increase 400%. Ten years passed after the first water came through the Adams Tunnel before the C-BT was entirely built out, and during that period, drought returned to Colorado. Many who had subscribed to C-BT shares with mortgages on their property and an obligation to pay a percentage of the agreed upon one-mill levy were wondering if they would ever see the water they had been promised.

WD responded to these concerns by introducing Irving Krick to Northern Colorado. Krick was an unorthodox meteorologist who disdained the chaos theory of weather patterns. His advice had been solicited in June 1944 when the Allies invaded Normandy. He believed that weather patterns were orderly and could be predicted. He also believed that moisture could be coaxed from the clouds by propelling silver iodide into the atmosphere from ground level generators located in the mountains. The objective was to increase snow pack. WD liked Krick's maverick approach to the region's recurring droughts. He organized a committee, paid for Krick's initial experiments, and responded to individuals who worried about the potential for unwanted snow storms and floods. In the long run, Krick's efforts had little impact on the drought, but WD's willingness to try anything reasonable to improve the region's water supply revealed his ongoing commitment to problem solving on a large scale.

WD Farr and others witness first water through the Adams Tunnel, June 23, 1947.
Courtesy of Northern Colorado Water Conservancy District

By 1970 WD was convinced that even with C-BT construction complete, Northern Colorado was going to need additional water. Growth data along the Front Range demonstrated the fast pace of urban development. The balanced integration of farming lands, prairie, and towns was threatened by growing contention for limited water supplies and the application of federal and state environmental laws that threatened the viability of new water projects. As head of the American National Cattlemen's Association, and known in Washington as a frequent spokesman of the National Livestock and Meat Board, WD received an invitation from Richard Nixon to join the President's Water Pollution Advisory Board. A national pollution crisis was in the making as a result of unregulated industrial and municipal wastes. The Advisory Board was instructed to tour the nation's most polluted areas and make recommendations to William Ruckelshaus, head of the newly created Environmental Protection Agency (EPA).

By inclination, the Farrs traditionally opposed government intervention at any level. The work of the USBR in building the C-BT was, perhaps, an exception that proved the rule. But as a result of monthly flights with the Advisory Board to Lake Michigan, Chesapeake Bay, Pearl Harbor, California's Central Valley, Lake Tahoe, and the South Platte River, WD came to realize that building a secure water supply for Northern Colorado would have to include environmental protection. He never became, or thought of himself as, an environmentalist, but from seeing first-hand the degradation caused by such polluters as the Great Western Sugar Company, which dumped refuse into one of the principal rivers in his own back yard, he learned to accept the role of environmental proponents and regulators in regard to water projects. He also learned that he would need immeasurable creativity and staying power when, as newly appointed chairman of a Municipal Subdistrict of the NCWCD, he accepted the challenge of persuading all stakeholders that it was appropriate to build a corollary project within the C-BT system. Labeled Windy Gap, this project would enable the C-BT to deliver the amount of water for which it was designed.

The C-BT had functioned well, but annually it averaged 80,000 acre-feet less than the original plan. Anticipating additional urban growth along the Front Range corridor, six cities[1] came together to fund an off-channel reservoir on the Colorado River from which 30,000 to 50,000 acre-feet a year would be pumped into existing C-BT facilities. WD, as NCWCD board member, and chairman of the Municipal Subdistrict, was the principal advocate and decision maker for this project.

The task would have killed a lesser man. Between the West Slope digging in its heals at the thought of additional water leaving their region, and environmental agencies and advocacy groups throwing up seemingly endless obstacles, WD had to contend with a loose alliance of cities that faced a water cost forty times what farmers paid for the first C-BT shares. Windy Gap negotiations continued for ten years, frustrating everyone as estimated construction figures escalated with every passing month. Finally, when all sides appeared exhausted and beaten down by obduracy, deliberate delays, and law suits, WD traveled to Kremmling to meet with Chris Jouflas, chairman of the Colorado Water Conservation District (River District) board. Lawyers were excluded from the meeting.

"For a lot of years," Jouflas recalled, "the lawyers had been making money off of us. WD decided we could work out our differences face to face, so we decided how much money we needed to abandon the lawsuit [and construct a storage reservoir], but in the final analysis, it came down to WD who wanted to get something done. We were sick and tired of the lawyers making their living on us, so we ended up with an agreement, settled the lawsuit for $10.2 million, and we eventually built the Wolford Mountain Reservoir with the help of Denver. It was a far reaching decision, really; one of the best things that the River District and Northern had ever done, because they got what they wanted and we got what we wanted, and it was strictly Mr. Farr, I think, whose influence made that happen. . . . I had known about him for some time. His reputation preceded him. You knew he was straight-forward, wasn't trying to catch you on anything, and just wanted to get something done. We all did!"

It took until 1985 to complete Windy Gap construction, but WD never doubted the value of the struggle. He had the kind of vision that disdained ideology while embracing a western version of utilitarianism. He could see how Windy Gap would benefit all the people involved in the negotiations for many years to come, and he believed that the benefits would far outweigh the negative aspects of so much conflict. The vision he maintained bolstered him through endless arguments and won him the respect of those on the other side of the table. Although the battles were bitterer than he anticipated, in his later years WD viewed Windy Gap as "the single thing I'm most proud of. . . . Fifty years from now," he predicted in 1997, "Windy Gap will be used – every bit of it, every year, and that will be the best water the city [of Greeley] will own."

1 Greeley, Longmont, Loveland, Boulder, Fort Collins, and Estes Park. Fort Collins transferred its allotment to the Platte River Power Authority.

WD's ability to look ahead, to anticipate the needs of people and their communities in a changing world, was in itself extraordinary. Everyone I interviewed for Cowboy in the Boardroom remarked on this talent as one of the reasons he was considered such a strong leader. As Eric Wilkinson explained to me, there are many people who attempt to articulate a better future, but their views are based on a dream. WD constantly thought about practical solutions to future problems. He was always ruminating, compiling, and assimilating data, but he wasn't just interested in facts. His thought process was dynamic, responsive to unexpected changes. "It was the cause and effect," Wilkinson mused, "and the human relationships. . . To me his whole target, long distance, far down the road was to ask, 'Where are we going as a community, a ditch company, a city, a region, a water district, whatever? Where are we going and what's best for the constituents of that group?'"

In many ways, Windy Gap was his biggest test as a leader. As Steven B. Sample[2] has noted, vision is great, but if you can't articulate it to others, and if you aren't willing to hear, consider, and appropriate fresh ideas, you can't be effective. WD was a listener. As Linda Mitchell Davis, a successful cattlewoman, said to me, "WD remembered everything, and he was able to connect the dots in a way that listeners would understand him." He sought out the most experienced individuals in fields that interested him and he was able to synthesize and verbalize the opinions he heard. By validating everyone's viewpoint and maintaining a steadfast focus on outcomes, he was able to overcome the territoriality and jealousies that prevented participants from working together.

Hank Brown viewed this quality of WD's leadership as a product of his years in the cattle business. In 1985, the Colorado Water Resources and Power Development Authority (CWRPDA) authorized a study of the Cache la Poudre River for the purpose of determining how a "Wild and Scenic" designation might fit with NCWCD aspirations to build a dam and reservoir on that same river. Farmers were furious that their "right" to build water storage might be denied by environmentalist groups, which saw dams and reservoirs as sacrilege to free flowing streams. Senator Brown convened both sides to see if a compromise could be worked out, but the animosities were too intense for agreement. He called in WD. "Within a few weeks," Brown recalled, "WD had everybody on board. It was just a miracle. When the farmers knew that a 'Wild and Scenic' designation was okay with WD, everybody fell in line and we got it passed. People had so much confidence in him, that if he would sign off on something, it would make the difference." The result was a "Wild and Scenic" label for seventy-file miles of the Poudre River and eight miles of the lower river reserved for future development. Brown concluded that the compromise resulted from trust. WD had earned the respect of his peers, but he had also learned from his many years in the cattle business.

WD Farr signs the Windy Gap contract, January 1970.
Courtesy of Northern Colorado Water Conservancy District

That same sense of trust enabled WD to succeed in other water related challenges. He persuaded Kodak to build its plant in Windsor after personally escorting officials to Grand Lake, where they saw for themselves the quality of water they would be getting through the C-BT for their plant. On another occasion, he convinced the Greeley Water Board to recommend abandonment of five mountain lakes, deeding them to the City of Thornton in exchange for cash and the right to additional shares of water from the Greeley-Loveland Ditch Company. Although a group of citizens persuaded the city council to reject WD's plan, within a year the vote was overturned, and WD's vision of how best to stimulate Greeley's growth with a secure water supply was embraced.

2 Steven B. Sample, The Contrarian's Guide to Leadership. Sample was the tenth president of the University of Southern California (1991-2010).

WD didn't win every battle, but his passion for progress and his willingness to accept and deal with change inspired those around him. He was optimistic about the future, willing to endure temporary setbacks if necessary, unstintingly committed to the best interests of his community – local, regional, national – and vehement about the importance of acknowledging the kindness of others. In his later years, WD shared an office and a secretary with the Colorado Sugar Beet Association. Susi Seawald became his amanuensis, confidante, and therapist, especially when WD's wife, Judy was diagnosed with Alzheimer 's disease. WD loved writing letters, thanking people for every little favor bestowed on him, even the Christmas cards he received. On one occasion, Susi recalled, she brought some baked good to the office. WD wanted to write a thank you letter to her husband. "But he didn't do the baking," she told him, "so I never had to write a thank you note to myself for my own baking. But I had to fight him on it."

In his final years, WD continued to pursue the fullest life his tired body would allow. He frequently expressed a desire to live another fifty years to see how things turned out. When he was finally confined to bed in the Greeley home he and Judy built in 1937, one of the things he missed most was strolling in his beloved garden. Neighbors produced a video, so he could see the flowers and shrubs blooming. Because his legs had weakened, he was unable to go outside, and he was also prevented from traveling to Oklahoma City to receive the "Wrangler" award, symbolizing his induction into the Hall of Great Westerners at the National Cowboy and Western Heritage Museum. There had been many other awards for WD, but this one placed him in the company of Kit Carson, Abe Lincoln, Lewis and Clark, Charlie Russell, Frederic Remington, Teddy Roosevelt, John Muir, Levi Strauss, Will Rogers, Dwight Eisenhower, and many others. It was the highest praise bestowed on any westerner. To compensate for his disappointment, WD's care givers dressed him in western attire, put his "Citizen of the West" hat on his head, and read out loud from *Persimmon Hill* magazine, the Museum's flagship publication. It was a celebratory moment, an exclamation point on a full and productive life. WD died four months later.

Although the end of a fulfilling life is always sad to those who survive, WD probably had few regrets when he reflected on his ninety-seven years. He had done just about everything he had wanted to do, and he had been chosen to lead others in the boardroom, on the farm, in the feedlot, and at the bank. Of all the indications that reveal his satisfaction with life, one statement on a 3x5 card in his handwriting stands out. It can be viewed in the Farr Papers at the Colorado State University Water Archives. What he wrote was most likely heard by WD at a cattle convention in Lubbock, Texas. Its author is anonymous, but its meaning is clear. The card reads: "If I had her to do over, I'd let her go just like she went."

A fine epitaph for a full life!

WD in his garden on his 90th birthday.
From the Papers of W.D. Farr. Courtesy of the CSU Water Resources Archive

A Decade Later: The Water Resources Archive Celebrates

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

Travel down memory lane back to 2001... It was a time when Dick MacRavey was still head of the Colorado Water Congress, and Chips Barry was in charge at Denver Water. It was a time before Colorado's worst drought in modern history, before the letters IBCC stood for anything, and before the Water Resources Archive (WRA) existed. How much has changed since 2001!

In July 2011, the WRA celebrates its 10th anniversary. Though long on the minds of the people who made it happen—most especially Robert Ward, at the time director of what was then called the Colorado Water Resources Research Institute (CWRRI)—the Water Resources Archive was established in 2001, primarily through funding allocated to the Colorado State University (CSU) Libraries after the insurance payment resulting from the 1997 Fort Collins flood.

In the decade of its existence, the WRA has reached not only across the state but also across the world with its collections and its activities. With the core mission of preserving and providing access to the historical documents related to Colorado water organizations and individuals, and the additional mission of promoting those materials and Colorado water history, the WRA has begun accomplishing these goals and much more.

The WRA began with a running start, bringing in collections that had been accumulating around the CSU campus for years. These included materials the CWRRI had accepted from various individuals, water-related collections housed by the Colorado Agriculture Archive (at the time, part of the History Department, now part of the Libraries), and materials which had been neglected at the Engineering Research Center on CSU's Foothills Campus. These initial collections included materials from Ival Goslin, James Ogilvie, Whitney Borland, Robert Glover, and Daryl Simons, coincidentally all engineers at various agencies.

That first year was spent organizing and inventorying these collections and building a website to put information about them online. With a growing mass of information to offer to the public, the WRA began generating publicity in 2002, getting some coverage in newsletters and a Fort Collins *Coloradoan* article. In 2003 staff made the first of many presentations about the Archive at water-related conferences, one being the first annual conference of DARCA (Ditch and Reservoir Company Alliance), itself a new organization.

Additional collections have been arriving since the beginning, especially following the initial and ongoing outreach. The WRA has now preserved just over seventy collections, which go far beyond engineering. Among the most prominent are the Papers of Delph E. Carpenter and Family, the Ralph L. Parshall Collection, and the Records of GASP (Groundwater Appropriators of the South Platte). Until 2004, the significant collection of interstate compact drafts and correspondence of Delph Carpenter had been housed for over a decade at the Northern Colorado Water Conservancy District, as the University had not had sufficient facilities or staff to accept it in 1993 when it was moved out of the family's flooded basement. The materials making up the Parshall Collection were squirreled away in the College of Engineering, by people who knew their importance but did not know what else to do with them. The Records of GASP might have been kept by the former management—or disposed entirely—once the organization ceased operations in 2007 if it were not for the existence of the Water Resources Archive.

The Carpenter family was recognized in 2004 for donating the Delph Carpenter Papers. From left: Doris Carpenter, Ward Carpenter, Brian Werner, Robert Ward.

All of these materials and more are now preserved and protected. They are available to any researcher who wants to examine them, for whatever purpose. They have been used by history classes, lawyers, genealogists, water managers, and historians. They have been used in on-site and online exhibits which educate the public about Colorado's water heritage. They are being scanned

John Keyes and Roger Patterson were table hosts at the first Water Tables in 2006.

for online accessibility so the world can use them without traveling to Fort Collins.

It is gratifying to know, however, that people do travel to Fort Collins, that people do use these documents, and that people from around the world support the work of the WRA. This is most evident during the archive's annual fundraiser, Water Tables, which has been held six times, getting bigger and better every year. What started out as an event drawing about 100 guests from across the state has expanded to include over 200 people, with international table hosts featured at the last two events.

This event, other funding support, and the many collaborations formed with numerous water agencies are testimony to the benefits the WRA provides to the state of Colorado and beyond. The formation of the archive a decade ago has filled an important hole in the Colorado water community. In the coming decades, the work of the archive will continue to fill that hole and to grow larger, more comprehensive, and more important.

On July 1, in celebration of the past decade and the coming ones, raise a glass of water and toast the existence of the Water Resources Archive.

The Water Resources Archive will be celebrating its anniversary in various ways during the next year. For more information about the Water Resources Archive and its plans, visit the website (http://lib.colostate.edu/archives/water/) or contact the author (970-491-1939; Patricia.Rettig@ColoState.edu).

Remembering Shirley Miller

Shirley Miller, dedicated office manager at the Colorado Water Institute (CWI) for 30 years, passed away on May 24, 2011 at her home in Fort Collins. Before retiring, she took on many roles in the office, including secretary, editor, accountant, and administrator. Shirley gave her best to the CSU Water Center, the Colorado Water Resources Research Institute, and the *Colorado Water* Newsletter.

Robert Ward, CWRRI Director, 1991-2005:

"Shirley Miller was a one-person office! During my time as director of the Colorado Water Resources Research Institute (CWRRI), I was half time director and half time faculty member. Shirley was the only full-time employee of CWRRI. Shirley was the rock that held the organization together over many years. She was the newsletter editor, the accountant, the office manager, the receptionist, and the personnel officer for an organization that established water research priorities in Colorado, conducted an annual research competition, and funded (staffed) projects at a number of different institutions of higher education in Colorado. CWRRI received funding from local water organizations, the state of Colorado, the federal government, and Colorado State University, and was accountable to all for satisfying their regulations, rules, and reporting requirements, including periodic formal reviews (this was a huge task that she more than satisfactorily accomplished each year).

She guided faculty in the successful, administrative, completion of CWRRI sponsored research projects. She hired and managed students over the years who assisted CWRRI in meeting its water research goals. Many of these former CWRRI-supported students are today's water leaders in Colorado and across the U.S. and world. She was able to keep up with the latest desktop publishing developments to publish the CWRRI newsletter at minimal cost. She epitomized the employee who makes a university organization work, at nationally recognized levels of success, at minimum cost. She will be remembered, not only for her effectiveness, but also the special grace with which she accomplished her many tasks at CWRRI."

Neil Grigg, CWRRI Director, 1988-1991:

"We will miss Shirley a lot. She really was a shining light in CWRRI and at CSU. I knew her from the time she started working there, and we shared a short time when I was the director. Unless you work in an institute, it can be hard to understand the special skills it takes to juggle faculty, students, uncertain funding, water politicians, and the public. Shirley handled all of that with integrity and grace, and she added her own creativity and management skills to make CWRRI one of the nation's best and an institute that will transcend the fickle nature of federal funding and continue to serve Colorado well. In addition to being so capable at CWRRI, she was also a good Colorado State University citizen, and she and Wes were often seen at events and keeping in touch with our community. To her family and friends, you can be happy about Shirley's life and many contributions. You can be sure that we will continue to appreciate and miss her."

Norm Evans, CWRRI Director, 1967-1988:

"Shirley Miller joined the staff of the Colorado Water Resources Research Institute in the early 1970s during a period of establishment and growth of the Institute. She served as the face and voice of CWRRI for 30 years until her retirement. Shirley was skillful in establishing effective relationships with key people in the many water management organizations, research universities of Colorado and Federal agencies. Not only was she competent and dependable in doing her work, but she did it joyfully, enthusiastically and with great creativity.

I consider it a privilege to have worked with Shirley for 21 years."

Hydrology Days 2011

Lindsey A. Knebel, Editor, Colorado Water Institute

Hydrology Days has been an annual event at Colorado State University (CSU) since 1981. Each year, both student and professional researchers come from Colorado and across the U.S. – in recent years, international participation has included scientists from Colombia, Peru, Chile, Spain, Italy, Switzerland, South Korea, and Canada.

"It's an intimate setting where students can meet and talk to the world's top hydrologists," says Jorge Ramirez, Department of Civil and Environmental Engineering, who has organized the event since 2000.

Hydrology Days consists of three days of poster sessions (where researchers display recent work), oral presentations, a Hydrology Days Award Lecture, and two Borland lectures.

This year, the Hydrology Days Award went to Professor W. James Shuttleworth of the University of Arizona Department of Hydrology and Water Resources. Shuttleworth lectured on a new technology to measure soil moisture with cosmic rays, a non-invasive technique that could be used for studying plant/soil/atmosphere interactions as well as for weather and short-term climate forecasting. The award is given based on worldwide nominations, which are reviewed by an awards committee of previous winners.

Another part of the annual event, the Borland Lectures, are based on the Whiteney Borland fund, which is used in general for promoting faculty, students, and research and education in hydrology and hydraulics. Borland lecturers this year were Tissa H. Illangasekare, Colorado School of Mines Center for Experimental Study of Subsurface Environmental Processes, and Stephen G. Monismith, Stanford University Department of Civil and Environmental Engineering.

Illangasekare lectured on how critical it is to understand and accurately measure the shallow subsurface soil layer moisture content, and he discussed various techniques for doing so, including a proposed "low velocity boundary layer climate wind tunnel" and other techniques. Monismith discussed the Sacramento/San Joaquin Delta, located in the upper region of San Francisco Bay. He said that understanding the physics of the region would be important to understanding the San Francisco Bay Estuary, but that several of the processes within the delta are difficult to model.

Overall, Ramirez says the event this year was a success. He emphasized that most of the presentations during Hydrology Days are made by students, which helps encourage their research, teaching abilities, and presentation skills. "Students devote a lot of time to preparing their papers," he says.

In the future, Ramirez hopes to continue Hydrology Days' legacy of communicating about all aspects of hydrology with presenters from many water related disciplines. In order to make the event broader and allow for more interdisciplinary communication, he says he's also considering the idea of making the even coincide with the annual symposium of the newly funded I-WATER program at CSU, of which he is the director. I-WATER (Integrated Water Atmosphere Ecosystem Education and Research program) is part of the Integrative Graduate Education and Research Traineeship program of the National Science Foundation.

Jason Messamer, a graduate research assistant with CSU's Department of Civil and Environmental Engineering, discusses his research during the Hydrology Days poster viewing.

Photo by Lindsey A. Knebel

CFWE 2011 President's Award Goes to CSU's Nolan Doesken

Lindsey A. Knebel, Editor, Colorado Water Institute

Nolan Doesken, State Climatologist at Colorado State University (CSU), was recently awarded with the Colorado Foundation for Water Education's (CFWE) President's Award, which goes to "those who demonstrate steadfast commitment to water resources education," according to CFWE, which is a non-profit, non-advocacy organization that promotes the better understanding of Colorado's water resources via education and access to accurate information.

"As an outstanding water educator, Nolan travels throughout Colorado, showing how its climate shapes our great land, wildlife and people," says the CFWE website.

Doesken recalls the list of previous winners of the President's Award, saying he felt honored to be included alongside such well-known individuals.

Doesken was pleased with the image selected for his award – he says it's reminiscent of his Midwest upbringing, where he grew up watching the thunderstorms move across the prairie.

Courtesy of CFWE

Doesken has worked with the Colorado Climate Center since 1977, serving as Assistant State Climatologist until 2006, when he received his current title as State Climatologist. His three primary goals there, he says, are as follows:

1. Monitor climate by recording measurements and tracking trends and variations
2. Conduct applied research of benefit to the citizens of Colorado, especially drought research, and mostly water-related
3. Share research with citizens of Colorado via service and outreach

His work in education, as a CFWE award indicates, have been significant – one primary example is a project called CoCoRAHS, the Community Collaborative Rain, Hail, and Snow Network. The goal is to engage the public in helping scientists better understand where water comes from in Colorado.

By the end of 2012, Doesken plans to have every K-12 school in the state reporting precipitation information with the program. "If you see how much precipitation falls from the sky and how it is distributed across the state," says Doesken, "you become more impressed with how we thrive and how we manage our water in Colorado."

CoAgMet (Colorado Agricultural Meteorological Network) is another example of Doesken's projects that extend his research to the state – its importance, he says, is the ability to track evapotranspiration – how water is used by crops, and how this varies over time.

One aspect of Doesken's job that he enjoys is overseeing the Fort Collins Historic Weather Station. Since some of the earliest days of climate recording, CSU has maintained daily recordings of temperature, humidity, wind, soil temperature, evaporation, barometric pressure, and other data. Some of the processes have been automated, but much of the process is checked by hand as it was in the late 1800s. Doesken has given presentations, overseen field trips, and trained student employees at the station since the 1980s.

Evan Vlachos Receives Honorary Doctorate

Lindsey A. Knebel, Editor, Colorado Water Institute

In March, Evan Vlachos, who has been a lawyer, professor, researcher, and consultant in urban planning, water resource planning and management, forecasting and futurism, technology assessment and demography, and other areas for over 40 years, was presented with an honorary doctorate in Civil Engineering from the Aristotle University of Thessaloniki (AUTH) in Greece. Following the award, Vlachos and CSU President Tony Frank attended and signed an international memorandum of understanding (IMOU) that called for a partnership between the universities on certain water-related projects. Vlachos emphasized that the event signifies an emphasis on integrated, interdisciplinary, and transnational research and communication between the universities.

Vlachos was born in Greece, and he earned a law degree there before coming to the U.S. and earning a Master's and Ph.D. in Sociology as well as a Certificate of Russian Studies. In his career, Vlachos' work included directing the Environmental Resources Center, acting as Associate Director of the International School for Water Resources, and serving as member and chairman of the Environmental Advisory Board, the U.S. Army Corps of Engineers, and the Advisory Panel on Environmental and Earth S&T in NATO, Brussels, to name a few, and he has authored many books and articles. Vlachos' interests when he first came to the U.S. were sociology and the environment, which quickly grew into studying and learning about water and other related issues. He explains that receiving an honorary doctorate in Civil Engineering is a tremendous honor for someone who studied as a lawyer and sociologist.

The IMOU signing took place during a Water Day meeting, during which President Frank made a speech, and the two universities discussed water issues. The IMOU included the following as tentative joint projects between CSU and AUTH:

- Transboundary hydrodiplomacy (with focus on the Balkans and Circum-Mediterranean areas) and special attention to transboundary aquifers;
- Water Resources Planning and Management, with emphasis on new techniques, as well as, methodological advances and models;
- The increasing number of extreme hydrological events and their consequences for water-scarce and water-stressed hydrological regimes;
- The use of scenarios for outlining options in comprehensive planning and management;
- Exchanges of students and faculty for improving ties with the Unesco ICIWaRM program at CSU and AUTH; and
- Comparative drought and desertification studies affecting the agricultural economies of Colorado and Greece.

Vlachos explains that CSU has experience in agriculture and a reputation in the water field, and AUTH has a central location in Europe with many similar agreements with around 200 European universities. The agreement would also bring more international students to each university, strengthening international ties and increasing knowledge.

Vlachos discusses growing up in Greece, saying that especially in the islands, fresh water was scarce. "Water is a sacred thing," he says, and it's important for historians and anthropologists, who understand older, traditional ways of dealing with water scarcity, to be involved. Such an integrated approach is necessary for water resources.

ICIWaRM, the International Center for Integrated Water Resources Management, where CSU participates as a founding member, is an example of an integrated and international approach to water. ICIWaRM was established in 2007 by organizations "sharing an interest in the advancement of the science and practice of integrated water resources management around the globe," according to its website.

Vlachos expresses his hope that this international approach to water issues will continue with CSU, which has been known for its involvement in water. "We're engineering the planet," he says.

Evan Vlachos, center, is pictured with CSU President Tony Frank, AUTH President Ioannis Mylopoulos, and surrounded by members of the Department of Civil Engineering of AUTH.

Faculty Profile: Bill Nobles

Lindsey A. Knebel, Editor, Colorado Water Institute

Until recently, Bill Nobles directed the Archuleta County Extension office, where he implemented and supervised Extension programs in a rapidly-growing county. Nobles was recently selected as Extension's Southern Regional Director, a job that encompasses around 15-18 counties in southeast Colorado, depending on redistricting.

"I understand the system," Nobles says – "I know the challenges agents face in the field." Helping those Extension Agents in the field is among his primary duties, including dealing with advisory boards and groups, and basically providing a connection between Colorado State University (CSU) and county staff, personnel, and commissioners.

"My job is to provide that link so the university can benefit, and the community can benefit," he says.

Nobles' vision as a Regional Director includes enhancing communications, providing guidance and support, and increasing motivation "through autonomy, mastery and purpose," he says. He plans to accomplish this via the following:

- Working with the Extension Director and Regional Directors to provide vision, direction, and priorities for CSU Extension
- Working with county directors on county related issues and assist them with county government and decision maker contacts
- Facilitating problem solving and negotiate workable solutions to county related issues and campus/county connections
- Working with Extension leadership to assure that Extension resources are appropriately applied to meet high priority needs
- Coordinating program planning and accountability (PLT's)
- Supervising, guiding, and supporting county Extension directors

Before entering into this position, Nobles was Archuleta County's director for more than 20 years, and before that, he worked at Sam Houston State University in Texas as a lecturer and coach for intercollegiate livestock judging teams.

As a County Extension Director, Nobles maintained a weekly radio broadcast and column in a local paper, and was involved with setting up many programs, including the San Juan Basin Beef and Weed Symposium, the Colorado State Tree Seedling Program, and several 4-H/Youth programs, among many others. His awards include an NAE4-HA Distinguished Service Award and Who's Who Among Academic Professionals, as well as the Teaching Award of Merit from the National Association of Colleges and Teachers of Agriculture.

Nobles says he enjoys inspiring and motivating others through his leadership – of his work with Archuleta County, he says he enjoyed building relationships and motivating and retaining community leaders, such as the local 4-H leaders, to help local youth succeed.

Nobles says he will bring these skills to his new position, and that for now, he's learning the system, getting to know his new surroundings, and working forward to fulfill his goals.

Colorado State University

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Water Research Awards

Colorado State University (March 16 to May 15, 2011)

Abt, Steven R, Civil & Environmental Engineering, USDA-USFS-Rocky Mtn. Rsrch Station - CO, Bedload Transport in Gravel-Bed Rivers and Channel Change, $85,667

Aloise-Young, Patricia A, Psychology, R. W. Beck, Customer Messaging to Support Smart Meter Fort Collins, $17,337

Berrada, Abdelfettah, Southwestern Colorado Res Ctr, National Sunflower Association, Boosting Sunflower Production in SW Colorado with Supplemental Irrigation, $8,000

Bestgen, Kevin R, Fish, Wildlife & Conservation Biology, DOI-Bureau of Reclamation, Abundance Estimates for Colorado Pikeminnow in the Green River Basin, Utah & Colorado, $85,189

Bestgen, Kevin R, Fish, Wildlife & Conservation Biology, DOI-Bureau of Reclamation, Identification & Curation of Larval & Juvenile Fish (Project No. 15), $116,679

Clements, William H, Cooperative Fish & Wildlife Research, Colorado Division of Wildlife, Mesocosm Experiment to Investigate Effects of Iron on Benthic Communities, $11,928

Cooper, David Jonathan, Forest Rangeland Watershed Stwrd, DOD-ARMY-Corps of Engineers, Watershed to Local Scale Characterization & Functioning of Intermittent and Ephemeral Streams on Military Lands, $193,106

Cox, Amanda L, Civil & Environmental Engineering, North American Tube Products, Evaluation of Hydraulic Capabilities of the E-tube Sediment Retention Device, $26,560

Hawkins, John A, Fish, Wildlife & Conservation Biology, DOI-Bureau of Reclamation, Middle Yampa Smallmouth Bass & Northern Pike, $22,640

Johnson, Frank P, Agric Experiment Station, Colorado Division of Water Resources, Determine Consumptive Water Use by Alfalfa in the Arkansas Valley in KS v CO Litigation, $25,000

Kummerow, Christian D, Atmospheric Science, NASA - Natl Aeronautics & Space Admin., AMSR-E Precipitation and its Relationship to Aqua Products, $169,687

Lemly, Joanna, Fish, Wildlife & Conservation Biology, EPA-Environmental Protection Agency, CSU 2010 WPDG: Lower South Platte River Basinwide Wetland Profile, $140,000

Lemly, Joanna, Fish, Wildlife & Conservation Biology, Tetra Tech, Inc., National Wetland Condition Assessment Sampling in Colorado and Wyoming, $138,825

Moore, Chester G, Micro, Immuno & Path, City of Fort Collins, West Nile Virus Testing, City of Fort Collins, 2011, $25,469

Oad, Ramchand, Civil & Environmental Engineering, Water Resources University (Vietnam), Capacity Building of Vietnam Water Resources University, $60,529

Pott, Richard M, HDS Operations Management, State of Colorado-Governors Energy Offic, ARRA: GEO Energy and Water Efficiency Grant - Residence Hall Showerhead Replacement, $46,870

Reardon, Kenneth F, Chemical & Biological Engineering, CSURF-CSU Research Foundation, Multichannel Optical Biosensor for Detection of Contaminants in Water and Food, $75,000

Sale, Thomas C, Civil & Environmental Engineering, General Electric Corporation, CSU - GE Environmental Research Collaboration Proposal for 2010, $130,000

Twitchell, John, Colorado State Forest Service, USDA-USFS-Rocky Mtn. Rsrch Station - CO, Effects of Mountain Pine Beetle and Forest Management on Water Quantity, State Forest, $110,468

Wilson, Kenneth R, Fish, Wildlife & Conservation Biology, Colorado Division of Wildlife, Statewide Aquatic Sonar Research Technician Training, $6,670

Calendar

June

6/1-9/30

Colorado Lake and Reservoir Management Association's Volunteer Lake Monitoring Program; Colorado lakes
The purpose of the Colorado Volunteer Lake Monitoring (CVLM) program is to seek to improve the understanding of lake and reservoir conditions in Colorado and to help protect and improve lake and reservoir water quality conditions.
www.clrma.org

July

10-17 **CAMP ROCKY Outdoor Environmental Adventure for Youth; Divide, CO**
Camp Rocky is an outdoor educational opportunity for youth ages 14 through 19 who are looking for an outdoors adventure. The camp provides a great opportunity for teens who enjoy the outdoors and are interested in learning more about Colorado's natural resources.
www.coloradoacd.org/camprocky

11-14 **2011 UCOWR/NIWR Conference; Boulder, CO**
Planning for tomorrow's water: Snowpack, aquifers, and reservoirs
www.ucowr.org

20-23 **Colorado Water Workshop: "Opportunity, and Leadership in Changing Climates"; Gunnison, CO**
This workshop will focus on recent trends, developments, and hot topics in Colorado water law, but a brief overview of some fundamental background principles will also be provided.
www.western.edu/academics/water

21 **Irrigation Association's Annual Water Conference; Broomfield, CO**
The Irrigation Association's Annual Water Conference will bring together experts and leaders from business, government and academia to debate water and environmnetal issues. Join industry experts and policy makers for discussions on sustainability practices and the future of irrigation.
www.irrigation.org/Events/Water_Conference.aspx

August

14 **Friends of the Lower Blue River Annual Meeting: "Vision for 2022: Blue River Valley in Balance"; Silverthorne, CO**
The 2011 Annual Meeting, "Vision for 2022: Blue River Valley in Balance" will be at Blue Tree Ranch. Featured speaker will be Scott Fitzwilliams, USFS Director of the White River National Forest.
Email Marty@folbr.org for more information.

23-25 **Colorado Water Congress Summer Conference; Steamboat Springs, CO**
Summer Conference and Membership Meeting
Water professionals go to stay well-informed on the most important issues, current legislation, and latest developments that impact water users in Colorado and other western states.
www.cowatercongress.org

25 **Water 2012: Vail, CO**
CFWE has amassed over 125 volunteers across Colorado who are ready to celebrate water in 2012. Committees are working on K-12 activities, university collaboration, library displays, Web-based tools, watershed groups and a speakers bureau. There are many opportunities to get involved, including leading events in your community. Recently, a new Water 2012 Coordinator was hired to help move the effort forward.
www.cfwe.org/2012

December

1 **Colorado Ag Water Alliance: "Ag Water Summit"; Loveland, CO**
One day meeting to explore agricultural water issues and solutions for keeping water in agriculture.

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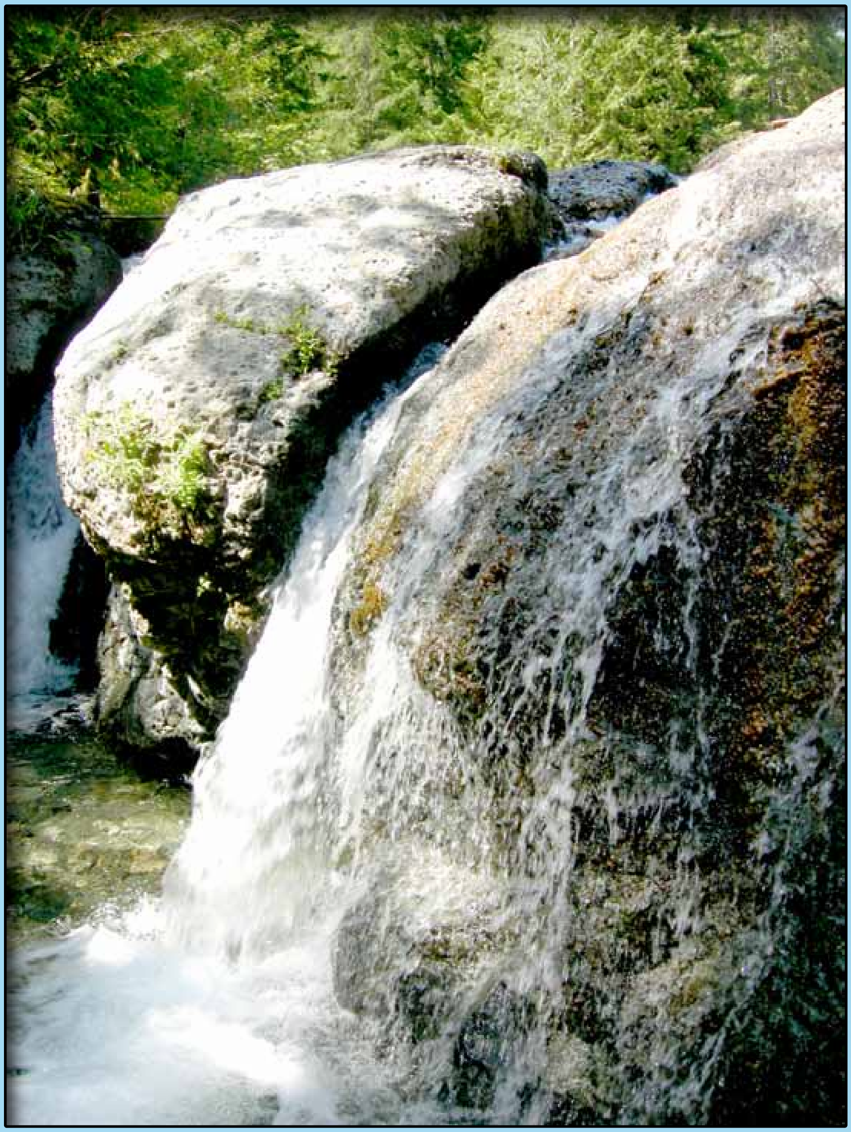

Before it moved to Colorado, Didymo, an invasive species, was first found in Canada like in this example, on Vancouver Island. It can grow in high shear environments, like this waterfall, which is why research in Colorado rivers is important.

Photo by James Cullis