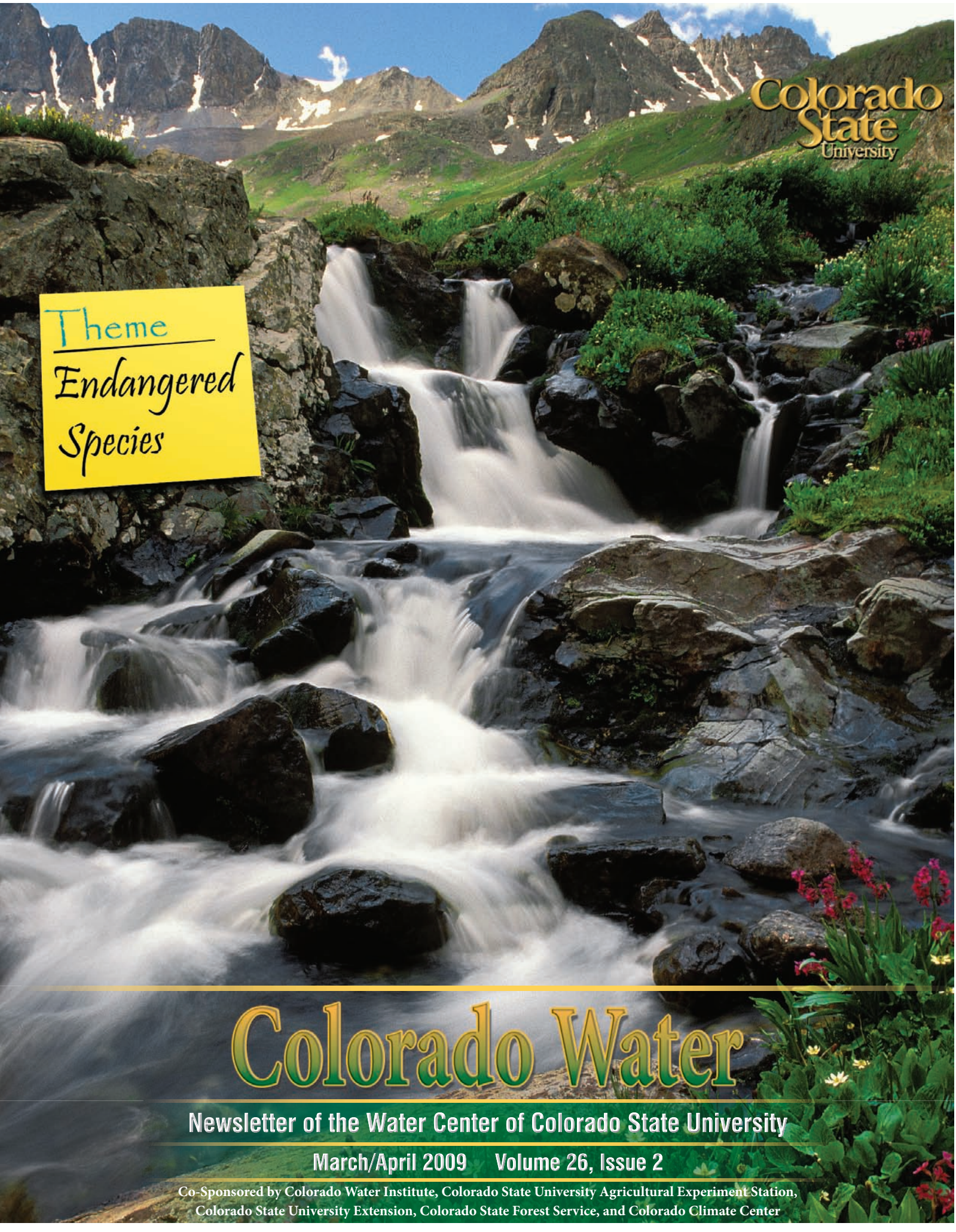

Colorado Water

Newsletter of the Water Center of Colorado State University

March/April 2009 Volume 26, Issue 2

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Cover Photo: A cascade plunges through American Basin high in Colorado's San Juan Mountains.
(Image courtesy of Andy Cook, Rocky Mountain Reflections Photography, Inc.; www.rockymountainreflections.com)

Editorial

by Reagan Waskom, Director, Colorado Water Institute

The impact of the Endangered Species Act on water management and development has been well documented in the media recently. Similar to the upheaval in the Klamath Basin earlier this decade, the current situation in the San Francisco Bay-Delta may result in unprecedented curtailments of water supplies in attempts to find water to preserve threatened fish. The combination of drought and the delta smelt decline has resulted in a zero percent allocation of agricultural water for the Central Valley Project this year.

In the context of current politics, it is interesting to note that Richard Nixon's administration produced three far-reaching pieces of national environmental legislation that forever altered the trajectory of water development in the West—the 1972 Clean Water Act, the National Environmental Policy Act of 1969, and the Endangered Species Act of 1973 (ESA). The ESA built on earlier legislation by applying a broad "take" prohibition to endangered species and prohibiting federal agencies from authorizing, funding, or carrying out any action that would jeopardize a listed species or destroy or modify its "critical habitat."

This issue of *Colorado Water* reports on some current work related to endangered species in Colorado and takes a look back at the impact of the ESA on past water projects. Notable Colorado success stories in recent years include the Platte River Recovery Program, the Upper Colorado River Endangered Fish Recovery Project, and the recent 10825 Water Supply Study. These projects have yet to result in delisting of any species, but they have demonstrated how disasters such as the Klamath and Bay-Delta can be averted through collaboration to protect aquatic habitat.

The success of ESA efforts may be incrementally measured by resolution of conflicts between environmental groups and water management interests, but the ultimate measure of success must be the recovery and delisting of endangered species such as the bald eagle or, most recently, the gray wolf. On March 6, 2009, Interior Secretary Ken Salazar upheld a decision by the U.S. Fish and Wildlife Service (USFWS) to remove gray wolves from the list of threatened and endangered species. "The recovery of the gray wolf throughout significant portions of its historic range is one of the great success stories of the Endangered Species Act," Salazar said. "When it was listed as endangered in 1974, the wolf had almost disappeared from the continental United States. Today, we have more than 5,500 wolves, including more than 1,600 in the Rockies."

Science plays a pivotal role in the listing of threatened or endangered species and management of critical habitat. The application of "best available science" is called for under the ESA but is not defined in the Act. Recently, the USFWS has been accused of "cherry picking" the science to justify the curtailment of the pumps for the Central Valley Project and State Water Project in the San Francisco Bay-Delta. This perception of advocacy by agency and university scientists should concern the research

community. Affected parties and policymakers desire definitive and actionable science on which to base policy decisions. Scientists, on the other hand, accept the fact that biological and physical systems are inherently uncertain. In the context of policy decisions, it is important to bear in mind that a scientist's opinion is not science. Science is a process that requires:

- a conceptual model or theory that provides a framework for testing a hypothesis
- a reproducible experimental design and method of observation
- statistical rigor in the analysis of data and interpretation of results
- clear documentation of methods, results, and conclusions
- peer review

Best available science is critical for objective evaluation of threatened and endangered species. It is also critical to understand that science can provide a basis for understanding how ecosystems operate; it cannot and should not provide the basis for establishing human goals and values with respect to the management of these systems. This is the role of policymaking. Our societal values and collective judgment must determine at what point we choose to limit human activities to prevent the loss of individual species. In his book *Collapse*, Jared Diamond wondered what the nameless Easter Islander was thinking as he cut down the last tree on the island. My guess is that he thought he needed that tree for his economic or physical survival and that if he did not cut it down, someone else would. In any event, it probably was not a science-based decision. Our new administration's guarantee of "scientific integrity" in federal policymaking is laudable, but it will not occur unless individual researchers are committed to scientific integrity and careful application of the scientific process. Our wildlife and our water users depend upon it.

Of Mice And Politics: A Long And Tangled Riparian Tale

by Kenneth Wilson, Professor and Head, Department of Fish, Wildlife, and Conservation Biology, Colorado State University
Tanya M. Shenk, Wildlife Researcher, Mammals Research Section, Colorado Division of Wildlife
Anne M. Trainor, PhD Candidate, University of North Carolina

The U.S. Fish and Wildlife Service (USFWS) listed the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) as a threatened subspecies under the Endangered Species Act (ESA) in 1998. Since then it has garnered much ecological and political attention. Its historical distribution is within riparian ecosystems below 2,300 meters (7,545 feet) along the foothills of the Front Range of Colorado and southeastern Wyoming—habitats that have undergone significant human-induced disturbance and loss.

For private landowners proposing activities that might affect the species' habitat, the focus has often been on development of Habitat Conservation Plans (HCPs) under the ESA that attempt to compensate for unavoidable habitat loss that results in "incidental take." Such plans require a better understanding of key resources that are biologically important to the mouse for foraging, resting, predator avoidance, and reproductive success. When listed, relatively little was known about the ecology and specific habitat requirements of the mouse. What was known was more qualitative in nature, with habitat requirements being described as encompassing well-developed riparian vegetation with an adjacent relatively undisturbed grassland community near open water. Initial research in Colorado after federal listing thus focused on increasing knowledge about resource requirements and population dynamics that could inform management and conservation efforts.

The Preble's meadow jumping mouse inhabits riparian ecosystems along the foothills of Colorado's Front Range. (Image courtesy of A. B. Franklin)

The mouse is named for Edward A. Preble, who identified the species in Colorado in 1899. It is a relatively small rodent distinguished by an extremely long tail, large hind feet, long hind legs, and a rather distinct dark, broad stripe on its back from head to tail. Jumping mice—there are twelve subspecies in North America—are true hibernators, an interesting and uncommon life history strategy compared to more common native mice such as the deer mouse (*Peromyscus maniculatus*) and voles (*Microtus sp.*) that are also encountered along the Front Range. The mouse emerges from hibernation in late May and is primarily nocturnal. It actively breeds from June through August with up to two breeding cycles, the first usually in late June. They do not store food underground for the winter, and a key to survival is storing fat reserves prior to beginning hibernation in late September to early October.

Much of the earlier understanding of the mouse's ecology, especially with respect to habitat associations, was based on trapping studies. Trapping studies can be biased, because animals can be attracted to bait in habitat areas that, in fact, do not have high fitness value (survival and reproduction). Our research focused on increasing understanding of the mouse's general ecology using radio telemetry methods. In particular, we wanted to increase our knowledge about specific habitat requirements, population dynamics, movement patterns, food habits, and hibernation of the mouse. Our studies involved the capture of individual mice using live traps; these individuals were then fitted with small radio telemetry collars with a battery life of approximately 21 days. The radio-collared individuals could then be relocated throughout the day or night to pinpoint more exact locations.

Soon after listing, the Colorado Division of Wildlife (CDOW) began several studies at Columbine Open Space and two additional sites in Douglas County that later involved collaborations with CSU. Mice were found to have strong site fidelity (an animal's tendency to return to or remain in areas where they previously occurred) to daytime nests and to specific communal nighttime feeding areas that were visited repeatedly by numerous individuals. Moreover, individuals visited several different feeding areas in a night. This led to studies in the early 2000s involving the CDOW and CSU to identify finer scale or microhabitat characteristics, in particular, within high-use areas or hotspots identified by site fidelity. The goal was to inform the

High-quality habitat for the Preble's meadow jumping mouse includes relatively undisturbed grassland areas near open water. (Image courtesy of A. M. Trainor)

process used to identify "good" habitat, which is essential in developing effective management and conservation strategies. The research indicated that mice were using high-use areas that were closer to the center of the creek bed and positively associated with shrub, grass, and woody debris cover compared to areas of no use. In particular, these high-use areas contained three times more grass cover than forb cover and, overall, had a greater proportion of wetland shrub and grass cover. Our suggestion was for continued management and conservation efforts that focus on establishing native wetland vegetation near streams and creeks, which, in our study areas, included shrubs and trees such as willow (*Salix* spp.), narrowleaf cottonwood (*Populus angustifolia*), alder (*Alnus incana*), and grasses such as fescue (*Fescue* spp.), sedges (*Carex* spp.), and rush (*Juncus* spp).

HCPs for the mouse often focus on mitigation through habitat restoration, e.g., replanting of willow in riparian areas where the mouse does not exist. Consequently, we were also interested in whether Preble's meadow jumping mice would detect restored habitats. Unfortunately, the time required for willow establishment was prohibitive for our two-year study. We thus asked a related question: would mice from a nearby, established population detect and use simulated restoration areas that were created by using supplemental food and cover? Our simulated areas were created in areas of poor habitat quality that showed no documented use by radio-collared individuals in the prior three years, and that were situated very near (in many cases, directly adjacent to) areas of strong site fidelity during the previous three years. In 2002, only 1 of 11 individuals used a simulated restoration area, whereas in 2003, 6 of 8 individuals used half of the simulated restoration areas. We believe that these results had to do with a combination of factors, including: (1) the strong site fidelity that the mouse exhibits, and (2) precipitation (2002 was much drier). Both factors probably affect exploratory movement behavior of the mouse. Site fidelity can directly limit exploratory behavior, and low precipitation, which results in decreased vegetation cover, can increase predation risk and thus decrease exploratory movement behavior. In fact, predation risk from snakes, bullfrogs, fox, long-tailed weasels, birds of prey, and house cats is particularly high during the summer months; one study in Boulder County reported only a 16% average summer survival rate for the mouse. Our results suggested that detection of restored habitat by the mouse, at least in the short-term, might not be certain and underscored the need for direct monitoring after restoration efforts to ensure that use occurs and that long-term persistence is attained.

Of course, no tale about a threatened and endangered species is without politics, especially when it involves riparian areas of the West. The listing caused disruption and consternation for landowners planning development activities in riparian habitats deemed suitable for the mouse in affected parts of Colorado and Wyoming. And in early 2004, Dr. R. Ramey, a curator with the Denver Museum of Natural History at the time, and others completed a report to the Governor of Wyoming and the USFWS that detailed why the mouse should not be considered a subspecies, and, thus, not listed as threatened. The report, which was based

This image illustrates poor-quality habitat for the Preble's meadow jumping mouse. (Image courtesy of A. M. Trainor)

partly on newer genetic techniques, quickly generated debate that included editorials on both sides of the debate and even a press release by a Colorado Congressman outlining the introduction of legislation to delist the mouse.

The State of Wyoming's Office of the Governor and Coloradans for Water Conservation and Development filed petitions with the USFWS for delisting, and in January 2005, the USFWS began the process to formally delist the mouse and expected a final determination in 2006. In 2005, a peer-reviewed publication of the Ramey et al. findings appeared in *Animal Conservation*. But by May 2006, the USFWS had issued a press release extending the evaluation of the delisting period until August 2006, due to the 2006 publication of a paper in *Molecular Ecology* by Dr. Timothy King et al. that was also based on genetic research and contradicted the Ramey et al. finding.

Interestingly, the USFWS had commissioned, at least in part, both the Ramey and King studies, and the conflicting conclusions of these papers prompted the USFWS to commission the Sustainable Ecosystems Institute (SEI) to "organize an independent scientific review panel" to assess the differing conclusions. On July 6 and 7, 2006, the SEI review panel convened in a public forum on the CSU campus with "The ultimate goal of the process [is] to provide a comprehensive and transparent evaluation of the science." On July 20, 2006, SEI issued its report to the USFWS, which concluded that the scientific review supported the evidence for *Z. h. preblei* as a distinct subspecies.

An interesting twist in the mouse's plight occurred when Julie MacDonald, then deputy assistant secretary for the U.S. Department of Interior, resigned in 2007 after an internal review determined that she violated federal rules on a number of endangered species cases, including our mouse. The infractions were serious enough to prompt H. Dale Hall, director of the USFWS, to review these cases.

On July 9, 2008, the USFWS issued a ruling that removed the mouse from protection under the ESA in Wyoming, but continued protection for the subspecies as threatened in Colorado.

2009 Arkansas River Basin Water Forum

The 2009 Arkansas River Basin Water Forum will be held March 31-April 1 at CSU-Pueblo in the Occhiato University Center.

Registration is $55 for both days, $25 for one day, and no charge for students.
Please visit the Forum web site at http://www.arbwf.org or contact Dr. Perry E. Cabot at (719) 549-2045 for more information.

Purpose

The Forum has been a focal point for highlighting current water issues in the Arkansas River Basin and in Colorado since its inception in 1995. Planners, presenters, and attendees represent a wide variety of organizations, agencies, and public citizenry working on water resources issues in the basin.

Description

As Colorado charts a course for a new energy economy, the Forum theme this year is "Water to Fuel Our Future." Topics discussed will include water use for energy production, invasive species, and other watershed management topics of interest to the basin. Our keynote speaker this year will be Jennifer Gimbel, director of the Colorado Water Conservation Board.

Scholarships

The Forum sponsors are pleased to offer a $4000 scholarship to an outstanding graduate student. Applicants must currently be enrolled as a second-year graduate student in a field relating to water resources management (e.g., water law, limnology, hydrology, water resources engineering) at a university or college in the state of Colorado. Applicants must have attended high school within the Arkansas River Basin.

Managing Stream Fish Movements in Colorado: Past and Present Research at the Fish Physiological Ecology Laboratory at Colorado State University

by Christopher A. Myrick, Associate Professor, Department of Fish, Wildlife, and Conservation Biology

Fisheries biologists and managers have long recognized that one of their roles is to study and manage the movement of fish within river and stream systems. The research interest is to determine when, where, why, and how the fish move. The management interest is in facilitating these movements, or, in some cases, restricting the movements. The Fish Physiological Ecology Laboratory (FPEL) at Colorado State University has specialized in studying the movements of Colorado fishes and, by applying physiological techniques to applied management questions, has begun to help natural resource managers devise strategies to better manage the movement of fishes, whether the ultimate goal is to improve the movements of the target species or, as is sometimes the case with non-native species like brook trout, restrict their movements. Before looking at two specific examples of the research conducted at the FPEL, let us first look at why fish move and why this is an important topic in Colorado.

Fish species that live in streams and rivers show a number of behavioral and physiological adaptations that enable them to cope with the dynamic nature of their environments. They are generally strong swimmers and most, if necessary, can undertake significant movements or migrations to seek out habitat suitable for spawning, rearing of juvenile fish, food supplies, or better environmental conditions. Because of this, stream- and river-dwelling fishes tend to thrive in areas where the rivers are longitudinally connected, at least some of the time, without the presence of permanent physical or environmental obstacles. When such obstacles do exist, then the ability of these fish species to migrate is compromised. In some cases, obstacles can restrict the distribution of the populations, lead to declines in their populations, or even lead to their local extinction. Although obstacles sometimes occur naturally, they have become much more prevalent following the development of Colorado's intensive water management and distribution system.

The state of Colorado is crisscrossed by a large number of streams and rivers, including the headwaters of the Rio Grande, Colorado, South Platte, and Arkansas River systems. These diverse waters hold a number of stream- and river-adapted fishes that have the potential, and in some cases a need, to make extensive up- and downstream movements. Examples of fish that make such movements include native cutthroat trout (*Oncorhynchus clarkii* subspp.), the endangered Colorado pikeminnow (*Ptychocheilus lucius*), and a variety of smaller fishes found in Front Range and eastern plains streams like the brassy minnow (*Hybognathus hankinsoni*), flathead chub (*Platygobio gracilis*), and common shiner (*Luxilus cornutus*).

In a semi-arid region like Colorado, streams and rivers and the water therein are understandably viewed as valuable resources for the delivery of water for agricultural, urban, and industrial uses. Unfortunately, some of the structures and practices used in water management can produce obstacles to the movement of Colorado fishes. Low-head diversion dams and weirs that are less than three feet high may not appear to be barriers to fish movement, but when

Figure 1. The Kondratieff-type artificial waterfall is used to measure the effects of waterfall height and plunge pool depth on the jumping ability of brook trout.

the majority of the fish species rarely reach one foot in length, as is the case for most of our eastern plains fish fauna, such an obstacle may indeed be insurmountable. In addition to instream structures associated with water development, there are also a number of structures associated with road crossings (e.g., culverts) or flood control that may also serve as barriers to the movements of Colorado fishes, particularly small species.

Instream structures, including culverts, low-head diversion dams, and weirs, have been in use for a long time—and for good reasons. Fisheries biologists typically acknowledge the need for such structures and have long recognized the necessity of developing tools for getting fish over or around these structures. Millions of dollars have been spent in the western United States and Canada on the development, testing, and installation of fish passage structures (also called fish ladders or fishways). This monumental effort has met with some success, and fisheries biologists now have a good understanding of what conditions or structures are necessary to allow the upstream movement of large-bodied species like rainbow trout (O. *mykiss*), sockeye salmon (O. *nerka*), and Chinook salmon (O. *tshawytscha*).

The problem with the majority of the research conducted on fish passages to date is that it has focused on these large-bodied, strong-swimming species and, thus, the resulting fishway designs (including the classic pool-and-weir fish ladders) are optimized for these species. *Most of the fish in Colorado's rivers and streams would not be considered large-bodied when compared to adult Pacific salmon*. Little information is available on the swimming and jumping performance of smaller fish species, and without such information, fisheries biologists and water resource managers cannot hope to succeed in the development of effective fishways. This was the challenge facing the FPEL when it came into being in early 2000—how could we collect data on the swimming and jumping performance of non-traditional fishes so that Colorado resource managers could use more applicable data in their efforts to enhance or restrict fish movements?

The first steps towards addressing this need were made in a project where a graduate student, Matthew Kondratieff, wanted to evaluate the jumping ability of brook trout *Salvelinus fontinalis*). The driving force for this project was the ongoing effort by the Colorado Division of Wildlife, National Park Service, and U.S. Forest Service to restore native cutthroat trout habitat, in part by using vertical barriers (often waterfalls) to prevent the non-native brook trout from invading prime cutthroat trout habitats. Data on brook trout swimming performance were available, but brook trout, like most other members of the salmon and trout family, were also known to negotiate instream obstacles by jumping over them, so we needed to find out how high they could jump. Kondratieff developed a novel pair of artificial waterfalls that had adjustable waterfall heights and plunge pool depths (Figure 1). The artificial waterfalls allowed the measurement of the jumping ability of brook trout of different sizes under different waterfall conditions.

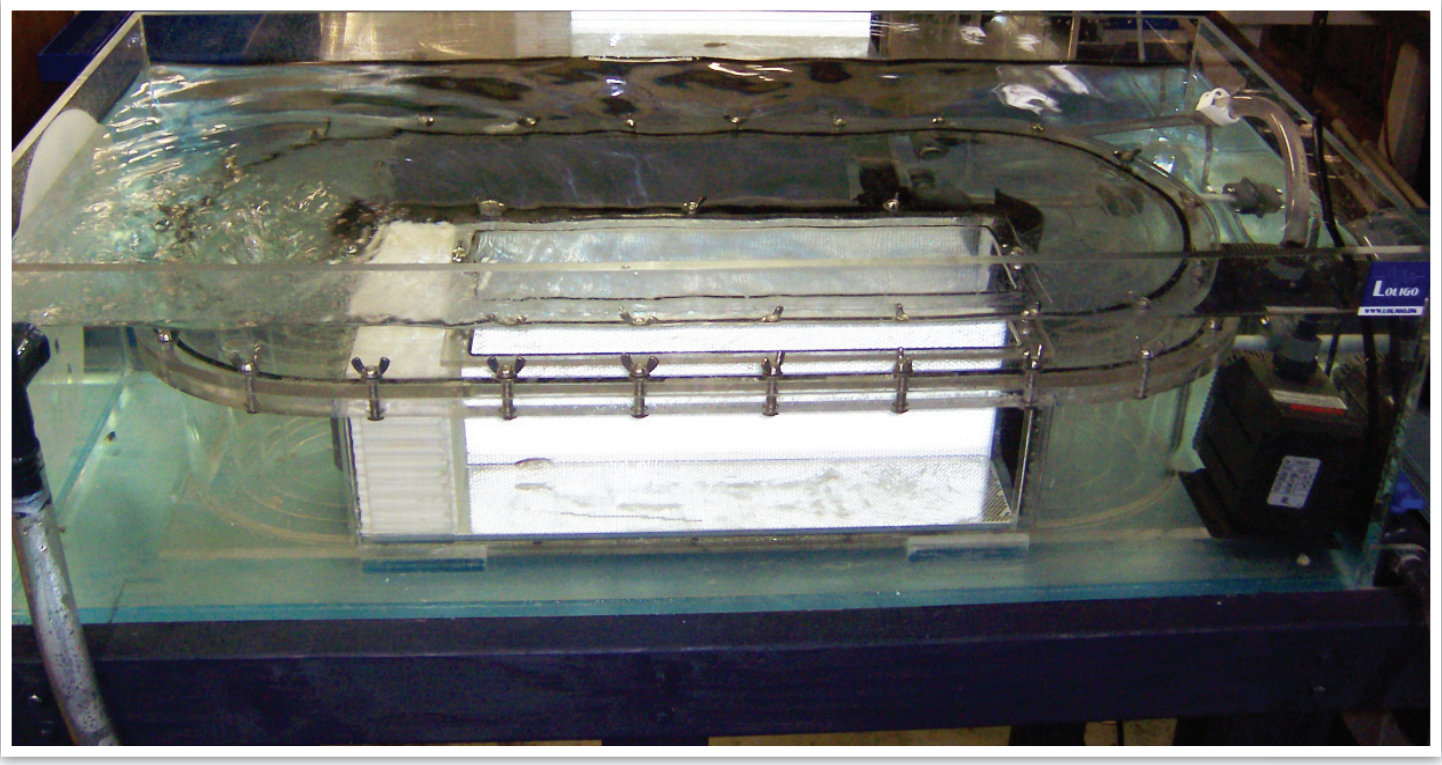


Figure 2. A Loligo™ Model 32 swimming flume (fish treadmill) is used to measure the swimming performance of fish species from Colorado's Front Range and eastern plains. A brassy minnow is just visible in the illuminated swimming chamber.

As expected, there was a maximum height that prevented the brook trout from moving upstream, and the experiments also identified combinations of low waterfall heights and shallow plunge pool depths that also deterred the upstream movement of brook trout. These results have been applied in the design of some of the new (artificial) barriers that are being used to protect native trout habitats.

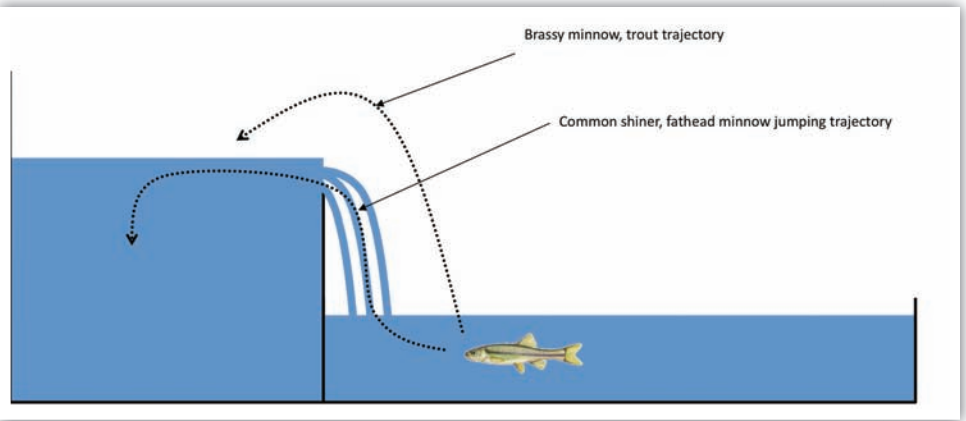


Figure 3. This diagram compares jumping trajectories used by trout and brassy minnows to the "vertical swimming" trajectories used by common shiners and fathead minnows when attempting to negotiate a vertical instream obstacle or drop structure.

Building upon this work, another graduate student, Ashley Ficke, took on a project designed to develop fish passage criteria for three of the fishes found on Colorado's eastern plains: the Arkansas darter (*Etheostoma cragini*), brassy minnow (*Hybognathus hankinsoni*), and common shiner (*Luxilus cornutus*). In the case of the previously studied brook trout, a lot of information was already available on swimming performance, so we only had to collect data on jumping ability. In the case of these three species, no information was available on either swimming performance or jumping ability, so the research had to start from scratch. Ficke used a modified (scaled-down) version of the Kondratieff-type artificial waterfalls developed earlier in the FPEL to measure the jumping ability of the three species, and then used two Loligo™ Model 32 swimming flumes to measure their swimming performance. The swimming flumes (Figure 2) are the fish equivalent of a treadmill, except instead of the subject animal running on a continuously moving belt, there is a continuous stream of water pumped past the fish at the desired speed.

The results from this study were interesting. The brassy minnows, like the brook trout tested earlier, would jump out of the water and over the lip of the waterfall when moving upstream, but the common shiners would attempt to swim vertically through the falling water to negotiate the waterfall. The same behavior was also seen in a common Colorado species, the fathead minnow (*Pimephales promelas*), which was tested during a CSU course taught by Dr. Myrick (FW405, Fish Physiology) (Figure 3). Arkansas darters did not try to jump, which was not surprising given that they are a small bottom-oriented species. For their size, brassy minnows and common shiners were very good swimmers; Arkansas darters did not achieve similar levels of performance. Using these results, we recommended that the use of traditional pool-and-weir fishways not be considered for plains fishes, primarily because their small size and variable jumping ability rendered effective designs impractical from an engineering standpoint (picture a stair-step arrangement of pools, with 1- or 2-inch-high steps). However, based on the swimming performance of these fishes, we recommended that water velocities in fishways not exceed two feet per second for the minnows and one foot per second for the darters, with refuge areas (fish "rest stops") every 8–12 inches to accommodate the slower-moving species.

Research into the passage requirements of plains and Front Range fish species continues at the FPEL. Ficke has returned to CSU to earn her Ph.D. in fish, wildlife, and conservation biology. Her project, funded by the Colorado Division of Wildlife, builds upon her Masters work on plains fish passage. The project has two goals: (1) to expand the knowledge base of plains fish swimming performance with further laboratory studies of fish species like flathead chub (*Platygobio gracilis*), red shiner (*Cyprinella lutrensis*), and longnose dace (*Rhinichthys cataractae*); and (2) to conduct an extensive field study on the success of existing fishways in Front Range streams by using PIT (Passive Integrated Transponder) tags (similar to the radio frequency identification [RFID] microchips used to identify pets and livestock) and remote antenna arrays to measure the passage rates of resident stream fishes.

Research on the movement of fishes has been, and will continue to be, a core mission of the FPEL. While not all of the research is conducted on fish species that have popular acceptance because of their status as game fish, the information produced is no less important. Resource managers in Colorado, regardless of their area of specialization, have a responsibility to strike a balance between the careful use of natural resources for beneficial purposes and the preservation of those same resources for future generations. Projects such as those conducted at the FPEL have contributed to the knowledge used to make informed management decisions; our goal is to continue to do so in future years.

The Upper Colorado River Endangered Fish Recovery Program: A Success Story

by Tom Pitts, Water Consult, Engineering and Planning Consultants

> *"For its history of successful stakeholder collaboration resolving seemingly intractable water use conflicts, the Upper Colorado River Endangered Fish Recovery Program is granted the Cooperative Conservation Award of the Department of the Interior."*
> -Dirk Kempthorne, Secretary of the Interior, April 21, 2008

Born of controversy, the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) has become a model of collaboration and cooperation in attaining the goals of the Endangered Species Act (ESA), while remaining fully consistent with state water law and interstate water compacts. Unprecedented in scope, scale, and diversity, the Recovery Program includes the Colorado, Wyoming, and Utah drainages of the Colorado River, encompassing more than 800 river miles of federally designated critical habitat for four endangered fish species. The success of the multifaceted Recovery Program over two decades is the result of long-term commitments and efforts by the states of Colorado, Utah, and Wyoming, water users, environmentalists, power customers, and federal agencies.

Origins

Four warm-water endangered fish species (Colorado pikeminnow, razorback sucker, humpback chub, and bonytail) inhabit the Colorado River and Green River subbasins of the Upper Colorado River basin. In mid-1983, the U.S. Fish and Wildlife Service (Service) proposed that any depletion of water in the Upper Colorado River Basin would have to be matched by release of water in the same amount to avoid further jeopardy to the species. If implemented, this proposal would have curtailed the development of water under interstate compacts governing water allocation in the seven Colorado River Basin states.

In response to this proposal, the Colorado Water Congress organized a special project on endangered species on December 1, 1983, and hired a project coordinator. The objective was to develop an administrative solution that would satisfy the Endangered Species Act, yet still meet the needs of the states and private parties to manage and develop water resources. A federal/state coordinating committee on the matter was established in March 1984.

In 1985, the Colorado Water Congress proposed that the four fish species be recovered and delisted under a programmatic approach. CWC recognized that the fundamental problem was that the fish are endangered and that the fundamental solution was to make them not endangered. Recovery of the species achieves the goal of the Endangered Species Act and provides the greatest regulatory certainty for federal and non-federal water development and management activities. Following a period of intense negotiation to develop the details of the Recovery Program, the Secretary of the Interior; the governors of Colorado, Wyoming, and Utah; and the Administrator of the Western Area Power Administration signed a Memorandum of Agreement to implement the Recovery Program on January 21, 1988.

Water for Endangered Fish

One of the most fundamental problems is how to provide water for endangered fish within state water law and interstate water compacts. Water from existing projects was fully allocated to human uses. Construction of new, stand-alone projects to provide water for endangered fish was considered cost prohibitive. Despite the obvious obstacles, the states, water users, and U.S. Bureau of Reclamation (Reclamation) agreed to cooperate in providing water for endangered fish consistent with state law, federal project purposes, and interstate compacts. Under the Recovery Program, water for endangered fish is provided from the following primary sources: (1) modified operation of Bureau of Reclamation projects to benefit endangered species, (2) construction of water conservation projects on existing irrigation projects and enlargement of an existing reservoir, and (3) voluntary cooperation by federal and

Recovery Program Participants

- States of Colorado, Utah, and Wyoming
- Colorado River Energy Distributors Association
- Colorado Water Congress
- Utah Water Users Association
- Wyoming Water Association
- The Nature Conservancy
- Western Resource Advocates
- Bureau of Reclamation
- U.S. Fish and Wildlife Service
- National Park Service
- Western Area Power Administration

non-federal reservoir operators to enhance flows without impacting reservoir yield.

From the onset of the Recovery Program, it was anticipated that operations of Flaming Gorge Dam on the Green River and the Aspinall Unit on the Gunnison River would be modified to benefit endangered fish. Operational modifications include more stable base flow release patterns, changes in timing of releases, and releases to increase peak flows. It was anticipated that (1) reoperation of these federal projects would result in substantial benefits to endangered species, (2) the projects had sufficient capacity to be reoperated while maintaining authorized purposes, and (3) the benefits of reoperation, along with the implementation of other program actions, would provide the means of ESA compliance for other Upper Colorado River Basin Reclamation and non-federal projects that had supplies fully allocated to existing uses, thus precluding the need for reducing deliveries for human uses from those projects. Flaming Gorge Dam on the Green River is being reoperated pursuant to a Reclamation administrative decision issued in 2006. Reclamation is engaged in an environmental impact statement (EIS) process on modified operation of the Aspinall Unit to benefit the species while meeting other authorized purposes. The final EIS and administrative decision regarding Aspinall reoperation are anticipated in 2009.

The fish passage at the Roller Dam constructed by the Recovery Program helps provide endangered fish access to 340 miles of critical habitat on the Gunnison and Colorado Rivers. (Image courtesy of Upper Colorado River Endangered Fish Recovery Program)

Grand Valley Project Water Control/Conservation Structures

The Grand Valley Project is a Reclamation project constructed in 1908, with accompanying senior water rights. The facility can divert up to 1,640 cubic feet per second from the 15-Mile Reach of the Colorado River near Grand Junction. This reach of designated critical habitat historically experienced dry or near dry conditions during the irrigation season. The Project includes a 30-mile-long canal that had to be kept full in order to deliver water to numerous laterals. The Recovery Program invested $7 million to construct control structures in the canal, with the saved water stored in Green Mountain Reservoir and released in late summer for the benefit of endangered fish. It appears that average annual yields will be approximately 30,000 to 40,000 acre-feet per year. During the 2002 drought, the check structures substantially benefited water deliveries to Project irrigators.

Elkhead Reservoir

The Recovery Program partnered with the Colorado River Water Conservation District and other reservoir owners to enlarge Elkhead Reservoir on Elkhead Creek, a tributary to the lower Yampa River. The lower Yampa includes spawning habitat for the three of the four endangered fish species and has a significant need for augmentation of critical late summer low flows. The Recovery Program invested $13 million in the $31 million expansion project for ownership of 5,000 acre-feet of storage in the reconstructed reservoir. The Program also leased an additional 2,000 acre-feet of water per year under favorable terms from the Colorado River Water Conservation District for 20 years to augment low flows.

Spring Flow Enhancements

Coordinated reservoir operations enhance spring peak flows in the critical 15-Mile Reach of the Colorado River, upstream of the Gunnison River confluence. This is accomplished by coordinating bypasses of reservoir inflows during spring runoff in a manner that does not impair yields of participating reservoirs. Extensive and complex coordination occurs among Reclamation, Denver Water, the Colorado River Water Conservation District, Northern Colorado Water Conservancy District, and the Colorado River Water Conservation Board. From 1997 to 2008, approximately 106,500 acre-feet of water was released to enhance spring peak flows.

The Recovery Program constructed state-of-the-art fish hatcheries to restore populations of endangered razorback sucker and bonytail. (Image courtesy of Upper Colorado River Endangered Fish Recovery Program)

Base Flow Enhancements

Between 2000 and 2008, 500,000 acre-feet of water was delivered to the critical 15-Mile Reach of the Colorado River to enhance late summer low flows. These deliveries result from the cooperative efforts of Reclamation, the Colorado River Water Conservation District, and Denver Water and include water saved by the Grand Valley Project water control/conservation structures and stored in Green Mountain Reservoir. Via contracts and other delivery mechanisms, state water law protects water that is released for endangered fish species.

ESA Compliance for Water Projects

One of the goals of the Recovery Program is to provide ESA compliance for water development and management activities in the Upper Colorado River Basin. In conducting consultations required by the ESA on water development and management activities, the Service has agreed to first consider actions taken by the Recovery Program as the means of providing ESA compliance for those activities. In reviewing water project impacts, whether existing or new, the Service reviews Recovery Program actions and determines whether those actions sufficiently benefit the species so as to provide the "mitigation" (reasonable prudent alternatives and reasonable prudent measures) to offset impacts of the project. Since the inception of the Recovery Program, the Service has found that ESA compliance is provided for approximately 1,700 water projects in the Upper Colorado River Basin, depleting 2.4 million acre-feet per year, including both existing and new depletions.

Working with Congress

In the mid-1990s, it became apparent to all participants in the Recovery Program that (1) Program participants had underestimated the level of funding needed to achieve Program objectives, (2) cost sharing by Program participants with the federal government would be needed, and (3) a dependable source of annual operations funds would be needed to operate and maintain Program facilities. As a result, federal authorizing legislation was developed to address these needs. The authorizing legislation recognized cost sharing agreed to by the states, water users, and power customers. The legislation (P.L. 106-392) was passed and signed into law in 2000 and has been subsequently amended to meet current needs.

Each year Congress has appropriated funds to the Program. Strong bipartisan support exists in Congress and among congressional committees for the Program. This bipartisan support is based on the Program's track record of accomplishments, resolution of conflicts, and strong grass roots support among states, water users, power customers, and environmentalists.

Recovery of the Species

The originators of the Program recognized that factors other than water affected both the endangerment and the recovery of the endangered fish species. The multifaceted Recovery Program includes the following elements:

- provision of water for fish habitat
- habitat development (fish screens, fish passages, flooded bottomlands)
- research and monitoring
- stocking of endangered fish
- controlling interactions among native and non-native fish species

The Program also includes information/education and program management components.

Some 340 miles of critical habitat in the Colorado River and Gunnison River are now accessible to the endangered fish and other native species due to fish passages. Hatcheries are producing genetically diverse razorback suckers and bonytail to restore these species. Non-native

Mike Montagne of the U.S. Fish and Wildlife Service introduces a young visitor to a razorback sucker fish at the Ouray National Fish Hatchery, located on the Green River in Utah. (Image courtesy of Upper Colorado River Endangered Fish Recovery Program)

fish control, while controversial, is reducing populations of competing introduced species. Research and monitoring continue to evaluate the populations and impacts of recovery actions on those populations, and to identify the need for adaptive management.

The status of the four endangered fish has improved substantially since initiation of the Recovery Program. The population of Colorado pikeminnow in the Colorado River has quadrupled since 1991 and is approaching or exceeding the numeric population recovery goals. The Colorado pikeminnow in the Green River Basin suffered during the 2002 drought. Razorback sucker, with a declining population of a few hundred adults when the Recovery Program was initiated, have been stocked extensively due to their low numbers. The stocked fish are reproducing, and the next generation is recruiting into the population. Humpback chub populations have fluctuated with the drought and are currently under assessment with respect to the need for additional recovery actions. Bonytail, considered extinct in the Upper Colorado River Basin, are being stocked and monitored to determine habitat and other critical needs.

Future of the Program

The capital construction program is essentially complete. Additional stocking of razorback sucker and bonytail will likely be needed to achieve population goals. Stocking of other endangered species is also an option, if needed. Water augmentation via reoperation of the federal projects and through cooperation by water users will continue. All four species are projected to be recovered and delisted by 2023. Until that time, it is likely that the Recovery Program, as an institution, will continue. As a condition of recovery and delisting, agreements will have to be implemented to maintain those conditions (flows, passages, screens, habitats, etc.) that led to recovery and delisting of the species.

A Success Story

The Recovery Program is moving towards recovery of endangered species—the ultimate, and rarely achieved, goal of the ESA. One of the Recovery Program's greatest accomplishments has been to bring people together in a collaborative effort that serves many diverse interests. Enormous conflicts with uncertain outcomes have been avoided. Potential adversaries have become allies and partners.

Since December 1, 1983, Tom Pitts has represented Upper Colorado River Basin water users in the negotiation and implementation of the Upper Colorado River Endangered Fish Recovery Program.

The Recovery Program helped fund the expansion of Elkhead Reservoir on the lower Yampa River to provide late summer flows for endangered fish. (Image courtesy of Colorado River Water Conservation District)

Endangered Species – Where Does "Climate" Fit In?

by Nolan Doesken, State Climatologist, Colorado State University

First of all, let me make it very clear that I am not an expert on endangered species or the efforts that can or should be taken to protect endangered and threatened plant, animal, and aquatic life. But that being said, in over 30 years here at CSU's Colorado Climate Center, I have fielded hundreds of requests for climate information from research scientists, environmental consultants, media, students, and the general public pertaining to this subject. Here are a few of the many climate information requests we've received and tried to answer:

- The relationship between air temperature and water temperature affecting native cutthroat trout populations
- Wind patterns over mountain passes affecting butterfly migrations
- Precipitation variations and drought patterns affecting water supplies for the Central Platte Recovery Project downstream from Colorado in central Nebraska
- Localized summer rain patterns and their relationship to mosquito larvae hatches—a potentially critical food source for certain endangered plains minnows
- Trends in high-elevation cold and warm temperature extremes and their relationship to declining pika populations (and other species)
- Climatic conditions favoring invasive plant species that are now outcompeting native plants in foothill and mountain environments
- The flood history of some of Colorado's rivers and streams and the relationship of floods to the formation of sand bars and other critical habitat for certain endangered species

These are challenging questions that cannot always be answered with the basic temperature and precipitation data resources that have been the 'bread and butter' of climatology in Colorado since the late 1880s. Furthermore, climate is just one of multiple factors that may jointly contribute to the demise of fish, insect, plant, and animal populations. Rarely is climate the only factor, but climate is certainly a contributing factor to the health, competitiveness, and reproduction of species.

Changing climatic conditions often enable invasive plant species like the plumeless thistle, which is rapidly increasing in northwestern Colorado, to outcompete native plants. (Image courtesy of U.S. Forest Service)

Data Challenges and Limitations

Our state and national weather observing networks were never set up with endangered species applications in mind. Weather stations are more likely to be found at airports and in towns and cities than along rivers or in the highest mountains. Only a subset of our historic weather stations include measurements of soil temperature, soil moisture, wind, and sunshine—all very important to plant and animal life. And only recently have some monitoring stations begun routine and continuous measurement of water temperature in our rivers and streams.

I have always been acutely aware of the weaknesses of our weather and climate observing systems. Over time we keep changing and moving weather stations (case in point—Denver, which was originally downtown, then at old Stapleton airport, and is now at Denver International Airport many miles away and in a much different climate setting). Even when we leave our stations alone, their surrounding environments can change (example, Fort Collins where our once rural campus is now surrounded by city and an "urban heat island"). Inevitably, we change weather instrumentation and observing techniques. As a result, continuous and homogeneous long-term climate records for any location in our state are hard to find. Long-term data on wind, humidity, and solar radiation are practically impossible to find.

Then, a few years ago I began attending some ecology conferences. When I realized what poor data exist on the population, habitats, and reproduction variability of many plant and animal species, I realized our climate data weren't so bad after all. While imperfect, we can track and approximate climatic conditions with instrumental records for a solid 120 years and can infer conditions even farther back in time using tree rings and other paleoclimatic indicators.

Changing Climate?

As climate change has become the "hot topic" in recent years, ecologists have been almost too quick to draw conclusions between climate and population declines in some fish, insect, plant, and animal species. Our climate data here in Colorado do give some indication of warming in the past two decades compared to earlier periods, but that warming is not yet dramatic. Precipitation variations in recent years have been huge, but that is, and always has been, the norm for semiarid regions. Our recent dry and wet spells are no more extreme than others in the recent and historic past. So to blame today's climate on all the observed changes in our ecosystem is going way too far.

However, to ignore climate and climate change would also be naïve. While models of future climate show some dramatic changes ahead for our area (warmer, that is), they are models, not fact. But they are based on sound physics and should not be ignored, and if there is a systematic shift to warmer temperatures in our region, it will have an impact on our environment. Humans have many adaptive strategies and capabilities at our disposal that plants and animals don't have. We will do our best to track the climate statewide in these years ahead to document confidently what changes may be occurring. Compared to protecting what could be a growing list of threatened and endangered species, our job will be the easier one.

You Can Be Involved

The most variable element of our climate system here in Colorado is precipitation. From a very dry year to a very wet one, annual precipitation can vary by up to 400%. The Community Collaborative Rain, Hail and Snow network (CoCoRaHS) was initiated here in Colorado in 1998 and offers citizens anywhere in Colorado or across the country the opportunity to help monitor precipitation by taking measurements from their own back yard. Volunteers report their data online, and within minutes we can map and display results by county, state, or nationwide.

The CoCoRaHS Network originated at the Colorado Climate Center at Colorado State University in 1998, thanks in part to the flash flood that occurred in Fort Collins in July 1997. Since then, the Network has expanded rapidly to more than 12,000 observers in 39 states.

Citizens of all ages can participate in CoCoRaHS. By providing your daily observations, you can help fill in a piece of the weather puzzle, which affects many people in your area. If you are interested in becoming a volunteer, or know others who might be, please visit http://www.cocorahs.org and click "Join CoCoRaHS" to sign up and help.

Water Providers Make Progress On 10825 Water Supply Study

by Caroline Bradford, Project Coordinator, Grand River Consulting, 10825 Water Supply Study, Phase 1 & 2

Four warmwater fish species that inhabit the lower reaches of the Colorado River watershed in western Colorado have been listed as endangered under the federal Endangered Species Act. The four fish are the Colorado pikeminnow razorback sucker, humpback chub, and the bonytail. A critical reach of the Colorado River for these fish is known as the 15-Mile Reach, located in Grand Junction, Colorado. During late summer, the stream flow within the 15-Mile Reach is substantially impacted by upstream water diversions.

The U.S. Fish and Wildlife Service (USFWS) has developed minimum flow recommendations for this reach as one of several important tools to help the Recovery Program meet its goals to recover these fish species. Strategies include constructing fish ladders and screens, building an extensive hatchery program, enhancing peak spring flows, and supplementing base summer flows with releases of stored water in the Colorado River. The Recovery Program has a variety of agreements in place to use reservoir releases to supplement late summer flows in the 15-Mile Reach. Combined amounts available from storage vary from about 20,000 acre-feet in dry years to over 66,000 acre-feet in wet years.

East Slope and West Slope water providers in the Upper Colorado Basin have committed to permanently supply 10,825 acre-feet of water per year (10825 Water) to assist with the recovery of the endangered fish. This water is supplied to the 15-Mile Reach of the Colorado River upstream from the confluence with the Gunnison River in Grand Junction during the late summer months.

The commitment to provide 10825 Water is divided equally between East Slope and West Slope water providers, with each responsible for supplying 5,412.5 acre-feet per year on a permanent basis. Currently, the 10825 Water is provided on a temporary and interim basis by Denver Water (from Williams Fork Reservoir) and by the Colorado River Water Conservation District (from Wolford Mountain Reservoir). The water providers must have permanent agreements in place that identify the permanent source of the 10825 Water by December of 2009. Unlike the existing temporary 10825 agreements, the permanent agreements will require delivery of the 10825 water in all years, including drought years.

After two years of study and deliberation, the water providers recently identified a preferred alternative for

The 15-Mile Reach of the Colorado River near Palisade, Colorado. (Image courtesy of Jerry Nolan, Photographer)

supplying the 10825 Water on a permanent basis. Under this alternative, about half of the water would come from Granby Reservoir, and the other half would come from Ruedi Reservoir. The concept appears to have the support of all the myriad stakeholders necessary for the program to work.

East and West Come Together

In early 2007, a broad coalition of East and West Slope water providers initiated a collaborative study process to cooperatively analyze and compare a wide range of alternatives to meet their obligations to provide additional water in the 15-Mile Reach. Representatives from all the major Colorado River diverters on the East Slope and West Slope met in a facilitated process supported by hydrologists, engineers, biologists, and NEPA (National Environmental Policy Act) specialists. The group included federal and state agencies and local stakeholders that helped identify issues and concerns, as well as alternatives that should be considered.

All the members of the group agreed that one of the primary objectives in fulfilling this obligation was not to impair or reduce the water supply available to any East or West Slope water provider. Just as important to the group was respecting the local concern that alternatives would benefit or have only minor negative impacts on the headwater streams in the Colorado River Basin. There was a concerted effort to maintain and respect the delicate balancing act on the heavily altered flow regimes of the Upper Colorado River in Grand County, as well as in the Fryingpan River below Ruedi Reservoir. Concerns of the Grand Valley water providers included ensuring that good water quality would continue to be supplied to the orchards, vineyards, and farms of the West Slope.

During the course of the study, over 25 different creative alternatives have been explored, ranging from new reservoir construction and expansion of existing reservoirs, to major pipelines and pump backs and releases from a variety of existing facilities. Many of the alternatives were screened from further consideration for technical feasibility reasons. One of the study's evaluation criteria was reaching consensus by all the stakeholders on the solution. It was important to the group not to pursue an alternative that would likely end up being consumed in a long, drawn-out water fight where nobody wins.

The Granby-Ruedi solution is the one option considered in the 10825 Water Supply Study that has the full and unanimous support of all the East Slope and West Slope stakeholders. This solution will efficiently and effectively provide 10,825 acre-feet of water to the Recovery Program to supplement stream flow from July through October in the 15-Mile Reach.

How Will it Work?

Half from Granby Reservoir

Approximately 5,400 acre-feet of water would be released from Granby Reservoir each and every year. The Granby releases would occur in late summer at rates determined to be most beneficial to aquatic habitat of the Colorado River below Granby Reservoir and to simultaneously benefit the 15-Mile Reach. It is anticipated that the Granby Reservoir releases would occur on pre-determined schedules that complement existing discharges from the reservoir, with one schedule adopted for dry years and another schedule for average and wetter-than-average years.

The Redtop Valley Ditch would provide the 5,400 acre-feet of water that is delivered from Granby Reservoir. The Northern Colorado Water Conservancy District (Northern) is the majority shareholder in the Red Top Valley Ditch by virtue of its purchase of the Miller-Hereford Ranch back in the late 1970s. The ranch was intended to be the site of Jasper Reservoir, although it also turned out to be the site of fens—important wetlands that precluded the construction of the reservoir. The intention is to curtail the irrigation on Northern's ranch and on an adjacent ranch, the C Lazy U Ranch.

The Redtop Valley Ditch water that was previously used to irrigate these two ranches would accrue to, and be stored in, the regulatory space of Granby Reservoir. Northern would subsequently release this water to benefit both the upper Colorado River and the Recovery Program flows in the 15-Mile Reach.

It is estimated that proposed steady, stair-stepped releases of 20 to 25 cfs from Granby Reservoir would be enough to double late summer flows in the Colorado River between Granby Reservoir and Hot Sulphur Springs. This is expected to significantly benefit the aquatic habitat in this reach that is so important to Grand County interests.

Half from Ruedi Reservoir

Approximately 5,425 acre-feet of water would be released annually from Ruedi Reservoir for 10825 purposes. The releases would be coordinated with supplemental releases from other Recovery Program sources of water (i.e., Green Mountain Reservoir, Wolford Mountain Reservoir, Granby Reservoir, and another "pot" of water from Ruedi) to provide maximum benefit to the Recovery Program, while also providing an acceptable flow regime in the Fryingpan River.

Currently, 10,825 acre-feet of water is released from Ruedi Reservoir each year, pursuant to an arrangement known as the "2012 Agreement." Under this alternative, the total amount of water released from Ruedi Reservoir

The 15-Mile Reach section of the Colorado River runs roughly from Grand Junction to Palisade, Colorado.

for Recovery Program purposes would decline by 5,425 acre-feet from the amount that is currently released.

Managing flows for fishermen is important to the local community, which values the tourism dollars provided by fly fishing enthusiasts who flock to the Fryingpan River's renowned tail water fishery below Ruedi Reservoir. The USFWS and the Bureau of Reclamation work together to keep releases from the Reservoir at a level where fishermen can comfortably wade fish in the Fryingpan River.

Safely Delivered down the River

The 10825 Water released would be delivered to the 15-Mile Reach using a new Municipal-Recreation Contract with an appropriate Grand Valley municipality. This contract would provide a mechanism to ensure that the releases are not diverted by other water users located upstream of the 15-Mile Reach. This is similar to the way other Recovery Program releases in the headwaters are delivered to the Grand Junction area.

On the Home Stretch

The 10825 Stakeholders are currently working through the remaining details with the Bureau of Reclamation and the USFWS to ensure they stay on track to meet their December 2009 deadline for an agreement to provide 10,825 acre-feet of water to supplement summer and fall base flows in the 15-Mile Reach. While the game isn't over yet, when East and West Slope water providers come together to support the Upper Colorado River Recovery Program, the real winners will ultimately be the endangered fish.

The 10825 Water Supply Study was funded in part by a CWCB Water Supply Reserve Account grant from the statewide account with support from the Colorado, Arkansas, Metro, and South Platte Roundtables.

For more information, visit www.grandriver.us/10825 or contact Caroline Bradford at carolinebradford@wildblue.net or 970-827-4203.

Two Forks Dam and Endangered Species

by Daniel F. Luecke, Water Resources and Environmental Consultant

To paraphrase Wallace Stegner, it is aridity that gives the western landscape its character. An important consequence of this shortage of water is the relative deficit of aquatic and riparian areas in the West—a scarcity that magnifies their significance to a wide range of native species. Another consequence of aridity is our attempt to compensate for what nature does not provide by remaking whole sections of the western landscape. This process of transformation has reduced an already scarce but essential habitat, forcing to the brink many of the species that depend on aquatic and riparian areas for their very existence.

A 'near miss' in this transformational march occurred two decades ago in the controversy over the construction of Two Forks Dam on the South Platte River. Were the dam to have been built, the adverse effects on aquatic habitat and native species would have been profound and pervasive, extending more than 100 miles both east and west.

The South Platte Valley, the Colorado River, and Two Forks Dam

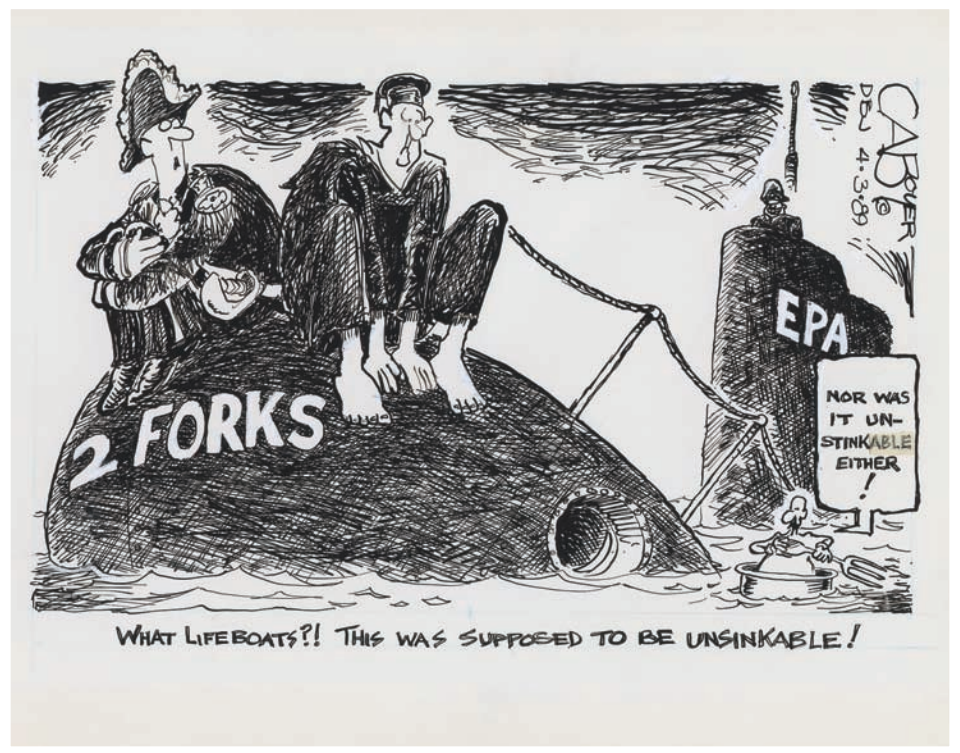
The South Platte River Valley, immediately downstream of its confluence with the North Fork, is an ideal place to build a dam. The valley is narrow, its walls are steep, and upstream the valley widens, allowing a dam in the narrows to store massive amounts of water. The Denver Water Board had planned to build at this site for more than 80 years; its water rights for the location dated back to 1902, and its original dam construction right-of-way on what is now U.S. Forest Service land was first granted in 1931.

Named for its location, the Two Forks Dam would have risen 615 feet (Glen Canyon Dam is 710 feet high) above the river bed, stored more than 1.1 million acre-feet of water, and flooded 31 miles of the valley. Though east of the Continental Divide, the dam would have reserved most of its storage capacity for Colorado River water delivered through a tunnel under the Rocky Mountains. The dam's size would also permit Denver to change operations in the rest of its system and bring additional water from the Colorado River through another of its tunnels under the Divide.

Based on a U.S. Bureau of Reclamation proposal of the 1950s, Two Forks was designed to serve a two-fold purpose. First, it would deliver 98,000 acre-feet of water per year of firm yield (sometimes called drought yield) to the Denver metropolitan area to meet future demands. Second, it would provide storage capacity for additional diversions from other Colorado River tributaries on which Denver held water rights.

Though the site is a tempting place to build a dam, hydrologically the dam itself would not have been very efficient. For all the water Two Forks would have stored, its firm yield was less than one-tenth of its storage capacity, making it one of the least efficient large storage projects in the West. This inefficiency, coupled with the fact that so much of its yield involved an interbasin transfer of water from the Colorado, meant that the dam would create large and widespread environmental losses.

These environmental losses would have included impacts to several threatened or endangered species. Inundation of a river valley, most of which the U.S. Fish and Wildlife



This cartoon, which appeared in the Denver Business Journal in April 1989, illustrates the political controversy surrounding the proposed construction of Two Forks Dam. (cartoon by Christopher A. Boyer; courtesy of Denver Business Journal)

This cartoon, which appeared in the Denver Business Journal in April 1990, illustrates the political controversy surrounding the proposed construction of Two Forks Dam. (cartoon by Christopher A. Boyer; courtesy of Denver Business Journal)

Service had found to be unique and irreplaceable, would flood the habitat of the threatened pawnee montane skipper (an upland species of butterfly). Reduction of Colorado River flows would alter habitat for the endangered Colorado pikeminnow, the humpback chub, the bonytail, and the razorback sucker (not listed at the time of the dam controversy). Modification of flows in the Big Bend reach of the Platte River in Nebraska would alter critical habitat for the whooping crane, the interior least tern, and the piping plover—all endangered birds. The skipper and the Colorado River fish are endemic, and the whooping crane occurs only in North America.

The Controversy Surrounding the Dam and the 1980s Permitting Process

More than 60 years ago, the Colorado Water Conservation Board rejected the Bureau plan mentioned above. Again in 1974, then-governor John Vanderhoof opposed another version of the same concept—the Bureau's Upper South Platte Storage Unit project. Both were earlier incarnations of Two Forks.

The 1980s version of the project, strongly opposed by the Colorado environmental community, was under the control of the Denver Water Board, but it needed several federal authorizations and permissions, the most important being the Clean Water Act 404 permit. In 1982, Denver went to the U.S. Army Corps of Engineers (Corps) to request a review of the full range of water supply options, as a precondition to filing a specific permit application. The Corps agreed to initiate a "systemwide" NEPA (National Environmental Policy Act) process that same year. However, in 1984 Denver requested that a site-specific Two Forks NEPA process be started before the comprehensive review could be completed. The Corps consented.

Two Forks Politics and the Final Decision

Just before completing the Final Environmental Impact Statement required by NEPA, the Corps wrote to governor Roy Romer asking his opinion on the issuance of a 404 permit. It appeared the Corps was looking to the governor for political cover. Romer took the Corps' invitation seriously and initiated a staff review. By his own admission, Romer was neither an environmental sympathizer nor an aficionado of Colorado's water "range wars," but he and his staff did an exhaustive assessment under constant pressure from both the water and environmental community. Denver and allies argued that their agreement to cooperate on Two Forks constituted a unique and otherwise unachievable metropolitan accord that deserved the governor's support. The opponents of the dam contended that the governor was more than the chief executive of the Denver region and that he had to look at the whole state, particularly western Colorado from which most of the water would come. They also claimed that there were a host of technically and economically feasible alternatives to the dam.

In June 1988, Romer announced his decision with a carefully prepared statement labeling Two Forks "a last resort," but at the same time endorsing the issuance of a permit as an insurance policy that would give Denver time to find a satisfactory alternative. Neither side was very pleased, but the very fact that a western governor referred to a dam as the "last resort" gave the environmental community some comfort.

Romer's stance appeared to give the Corps comfort too. Seven months later, in January 1989, it announced that, in its opinion, the environmental damage Two Forks would cause could be mitigated. Thus, it intended to issue a 404 permit for the dam. The Denver regional office of the U.S. Environmental Protection Agency (EPA), referencing its shared 404 permitting authority with the Corps, expressed

concern over the announcement and initiated discussions with the Corps and Denver. After six weeks of negotiations, the EPA's regional administrator appeared to be prepared to endorse the permit. However, on March 24, 1989, before he could act, the newly appointed EPA administrator William Reilly intervened, directing the regional administrator to inform the Corps that EPA intended to initiate a permit review.

The political dimensions of Reilly's actions were clear to both proponents and opponents of the dam, assuming that his decision was not unassociated with George Bush's campaign pledge to be the "environmental president." Based on this view, the water suppliers and the environmental community sought political leverage and access where they could. The dam proponents chose Lee Atwater, Republican National Committee chairman and Bush's campaign manager, to act on their behalf, and the environmentalists solicited former President Gerald Ford's help, based to a large extent on an alliance that dated back to Colorado wilderness designations when he was a congressman. At a Denver meeting in late spring of 1989, Atwater promised the water suppliers that he would convince the President to support the dam and reverse the review process. After a briefing by environmental representatives the following February, Ford wrote Bush urging him to let the proceeding continue and to endorse a veto of the dam.

Atwater's efforts were not successful, though it is hard to tell if his failure was in any way the result of Ford's intervention. In November 1990, the EPA made its final determination prohibiting the issuance of the 404 permit. On November 23, (the Friday evening of Thanksgiving weekend) it "vetoed" the permit, concluding that the environmental losses caused by the dam were both unacceptable and avoidable.

In 1991, suburban water interests that had contracted with Denver for Two Forks water filed suit in federal district court challenging the EPA action. Interestingly, Denver chose not to join the plaintiffs, and its absence ultimately led the court to conclude, in 1996, that the suburbs did not have standing to bring the suit. The court went on to offer the plaintiffs an "advisory" that even with standing they would have lost, for they had not "…proved that EPA [had] acted in excess of its authority or made an arbitrary and capricious decision." The advisory was clearly intended to discourage an appeal. It did. After almost 12 years and $40 million dollars, the Two Forks controversy was put to rest, but the debate over what public policy lessons are to be drawn from it continues.

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Summary of Fluvial Sediment Collected at Selected Sites on the Gunnison River in Colorado and the Green and Duchesne Rivers in Utah, Water Years 2005-2008 by C.A. Williams, S.J. Gerner, and J.G. Elliott; http://pubs.usgs.gov/ds/409/

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Colorado Water Congress 51st Annual Convention

by Laurie Schmidt, Colorado Water Institute

The 51st Annual Convention of the Colorado Water Congress was held on January 28-30, 2009, at the Hyatt Regency Denver Tech Center. With the theme "Water Buffaloes in the Mist: On Solid Ground in an Uncertain Time," the meeting kicked off with a legislative breakfast, during which Senator Jim Isgar and Representative Kathleen Curry reviewed water legislation for 2009.

Tim Storey, National Conference of State Legislatures, opened the general session by discussing national election trends, priorities, and budgets for state legislatures. He listed the top nine legislative issues for 2009 as state budget gaps, transportation and infrastructure, access to higher education, health costs and reform, energy alternatives, sentencing and corrections, home ownership, working families, and unemployment. State budget gaps on a national level are expected to reach $84 billion in 2010, he said. Pam Inmann followed Storey with a discussion of the strategic agenda for the Western Governors Association.

Thursday's luncheon keynote speaker was the Honorable Terrance Carroll, Speaker of the Colorado House of Representatives, who discussed "beginning with a vision" and entertained attendees with humorous anecdotes about his knowledge of water (or lack thereof) and his observations on water bills and the legislature. The afternoon general session included a presentation by Colorado pollster Floyd Ciruli, who presented the results of a survey titled "What Coloradans Think about Water."

Don Ament (left) presents Tillie Bishop with the 2009 Wayne Aspinall Water Leader of the Year Award at the Colorado Water Congress 51st Annual Convention on January 30, 2009.

The general session on Friday morning featured talks by Rick Cables, Regional Forester with the U.S. Forest Service; Sally Wisely, Colorado State Director for the BLM; and Larry Walkoviak, Upper Colorado Regional Director for the Bureau of Reclamation. Cables focused on the importance of Colorado's forests to the future of the state's water. "The reach of the watersheds in our state is huge—143 counties in 10 states use a piece of Colorado's water," he said. Referring to Colorado's high country and forests as the "water towers of the West," Cables discussed the impacts of forested lands on water quality and quantity. Addressing the current mountain pine beetle outbreak, he highlighted the indirect impacts of dead trees, including blocked access to 3,500 miles of roads and power lines when the trees fall, and increased wildfire threat. "Denver Water can tell you—post-Hayman Fire—that the cost of dredging reservoirs after the fact (post-fire) is hugely expensive," he said. (Cables' talk can be read in its entirety in this issue of *Colorado Water*.)

Wisely discussed the value of partnerships and working together to create a sustainable future, saying "The bottom line of our (BLM) multi-use mission must be sustainability." Walkoviak reviewed priorities for the Upper Colorado region, including project maintenance, such as for the Animas La-Plata, and project completion. He also discussed the ongoing challenge of equalization efforts to keep a balance between Lake Powell and Lake Mead.

The conference wrapped up during Friday's luncheon with a keynote address by the Honorable Hank Brown, after which Tilman "Tillie" Bishop, former Mesa County commissioner and state lawmaker, was presented with the 2009 Wayne Aspinall Water Leader of the Year Award.

No Forests, No Rivers: Why Forests Matter

by Rick D. Cables, Regional Forester, Rocky Mountain Region, U.S. Forest Service

Presented at the 51st Annual Convention of the Colorado Water Congress

Our most famous Chief of the United States Forest Service said long ago that "the connection between forests and rivers is like that between father and son: no forests, no rivers."

Gifford Pinchot, who invented American forestry, knew something most of us never think about. Without forests to capture snow and hold water, and then to filter and slowly release clean water to the rivers and streams, we would have both less water and lower water quality.

You have only to look around Colorado's famous Rockies to see that our forests are in trouble. What is less visible is that our water supplies and water quality are in trouble as a result. I'll address these issues in a moment.

First, let me say that it is an honor to have been asked to address all of you about water. I tell Forest Service people—tongue in cheek—that there are only three land management issues that really matter in the coming years: water, water, water.

You might ask, "What about climate change—doesn't it matter?" Of course it does, but I will not spend much time today addressing climate change, but not because it's not critically important. Climate always affects people and the environment. It is part of the context of today and certainly affects water supply and demand. There are things we can do about climate change and things we probably can't. We don't have all the answers, but we know forests play a critical role in sequestering carbon and storing water.

What we do know is that we can change how we think about and work with each other where our common need for water is concerned. I am reminded that Denver Mayor Hickenlooper reached out to neighboring communities in the Denver area at the height of our drought in 2002 by assuring them that if they ran out of water, Denver Water would help them through that tough time. They could work out how to pay it back later. It is that wonderful and honorable spirit of give and take for the common good that will mark the success of our efforts to provide water to each other in Colorado, and to all the other people who depend on this state and our public forests for their water as well.

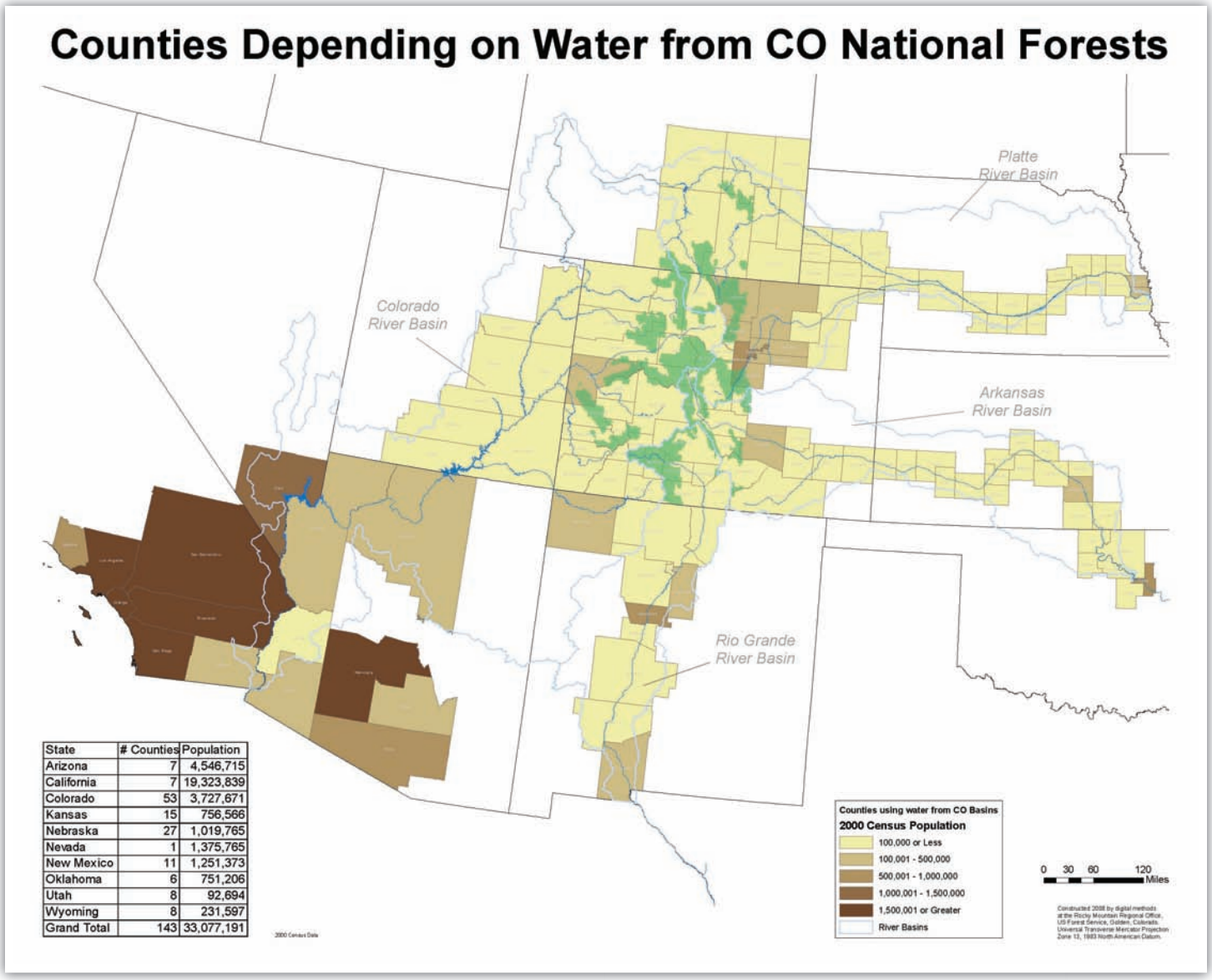
It is my intention, and our intention in the U.S. Forest Service, to partner with you on water issues more than ever before. Many of you have been engaged in water projects, both large and small, over the years, and I want you to think of a very large brand new water project called "protecting the headwaters." Without the headwaters, many of the other water projects may not be relevant.

Working Together

I sometimes think that water issues are so intractable that we can never solve them. Standing on the banks of the Colorado River, it's hard to think that water from our mountains in Colorado is filling up a bathtub in Las Vegas, Nevada, or washing a car in southern California. People in 143 counties in 10 states use water that falls in the Rocky Mountain region.

I am committed to the idea of working together that Mayor Hickenlooper so perfectly illustrated for all of us. Water law is complex, and the issues are life and death for people, businesses, healthy communities, and healthy ecosystems. We can and must work together to do all that human beings can do to see that the water we have in common is shared for the greatest good for all, including for the living forests that provide the water in the first place.

We can do it. We have made great progress in working together to make sure our air is clean. Denver's



State	# Counties	Population
Arizona	7	4,546,715
California	7	19,323,839
Colorado	53	3,727,671
Kansas	15	756,566
Nebraska	27	1,019,765
Nevada	1	1,375,765
New Mexico	11	1,251,373
Oklahoma	6	751,206
Utah	8	92,694
Wyoming	8	231,597
Grand Total	143	33,077,191

commitment to cleaning up air on the Front Range and its success is now the stuff of textbooks. We can think of water the same way. Clean air and clean water are life. Forests of living healthy trees produce lots of both. Working together is the only way I see forward on water issues.

In the end, having enough clean water is your focus as a Water Congress and our focus as caretakers of your forests. It is also the focus of government at every level, especially in the West where unprecedented growth, drought, and other factors such as insects and fire have affected water supplies.

We are seeing the effects of trees dying on a massive scale in Colorado and in other western forests. Over two million acres of our trees are dead from tiny insects. Soon, those trees will fall to the forest floor like pick-up sticks and then, at some point, probably catch on fire. Imagine a slow, hot fire burning for days, baking the soil, killing or destroying every living and organic thing in the soil, and even removing the top inch or so of mineral soil because the fire is so severe and so intense. It's not hard to imagine. We've all seen it before.

And then imagine the winter snow pack with no trees to shade it or hold it in place. Come spring thaw and spring rain and the water on the mountain tops will roar down the denuded slopes, filling our rivers and reservoirs with sand and gravel and ash, leaving big gullies, and—heaven forbid—taking out small communities. None of this is hypothetical. Any one of you could describe, and have even lived through and personally seen, exactly what I am talking about.

There is change coming to both water supply and demand in Colorado and elsewhere. Some of it we can do something about if we work together. Some of it, like the weather, we can't change. What is certain is that we must try.

Water Towers of the West

I said that water is life. Your national forests are the highest water towers of the West, and they provide the largest and most reliable source of clean water for our people, coming to us directly from the ecosystems we sustain and protect. Why do we protect ecosystems? Because ecosystems protect people. Just thinking about Colorado, we have millions of acres of wonderful, productive, forested ecosystems in our combined public and private forests. All forested lands affect water quantity and quality. Because our national forests are the highest elevations in our watersheds, they play a particularly significant role. Here are some things that may surprise you about our national forests across the country:

- In the lower 48 states, national forests account for 9% of the area and yield 18% of the water
- In the 11 western states, national forests are 19% of the area and yield 51% of the water
- In Colorado, national forests are 22% of the area and yield 68% of the water

National forests and other public and private forest lands are a big deal in Colorado. Together they supply over 70% of public surface water supplies. Forests play a significant role in providing water, and the Forest Service plays a vital role in sustaining healthy resilient watersheds.

Most of you know by now that we cannot stop the mountain pine beetle epidemic. We have always relied on periodic fires for forest thinning in lodgepole pine, and on cold winters in the mountains to control the beetle populations (it would take two weeks of sustained temperatures below -40F to kill the bugs, according to Kurt Allen, Regional Entomologist). During previous decades, we eliminated wildfire from these forested systems and never mitigated the effects of removing this critical natural process. Meanwhile, our mild winters mean the beetles will keep killing pine forests until they run out of food. The beetle epidemic has caused nearly two million acres of almost completely dead trees. We have been treating some important but relatively small forest tracts for the past three years to protect communities, facilities, and source watersheds.

So much more needs to be done, and we must use the tools we have to bring more resilience and diversity to the forests in Colorado. This work needs to happen sooner rather than later and on a very large scale.

Good News: Economic Stimulus

There is good news. The various economic stimulus proposals that many of you have seen contain hundreds of millions of dollars to support shovel-ready projects on the ground in the national forests and on other public and private lands. Portions of this money will come to the state of Colorado, the Rocky Mountain region, and other Colorado forests, both public and private. Among our highest priorities will certainly be water. Our emphasis will be on finding ways to spend some of the money to improve forest health and resilience, to deal with the dead and dying trees, and to undertake projects that improve or maintain roads and deal appropriately with other sources of sedimentation.

I believe an important window of opportunity is opening now across the nation. Here in Colorado, leaders like Secretaries Salazar and Vilsack, the Colorado federal delegation, and the state's water leaders will have an opportunity to talk about what makes the most sense to secure reliable supplies of clean water from healthy living forests in Colorado. We need your voice.

The Administration is now searching for ideas on how best to leverage the economic stimulus package to create jobs and work to have a lasting positive effect in every state. It's an exciting time to be working with water policy and forest management in Colorado.

Hopefully, the stimulus package will help, but we must look for other ways to fund the work in our headwaters. Another idea to increase investment in our high country water towers is to ask the estimated three million Front Range water subscribers to step up and contribute directly. Would water users be willing to contribute 50 cents or a dollar per month to invest under the auspices of a vehicle like Colorado Senate Bill 221, which gives water providers the ability to raise money to improve watershed resilience by issuing bonds? Even more, if Las Vegas, Los Angeles, or Phoenix get on board, the amount per customer could be more widely spread across all water users.

I know, I know—the idea of increasing the water bill in these times will be unpopular. But even in tight economic times we must look to protect our water supplies and watersheds, or a tough situation could be far worse and much more expensive for everyone. Let me tell you why. Denver Water can attest to the cost of dredging storage reservoirs after a large fire has denuded the landscape. Similarly, it will be much less expensive for taxpayers to remove beetle-killed trees that will fall on roads, trails, and power lines now than it will be after the trees have fallen down or blown over.

Certainly, governments need help with important investments in our watersheds if we are to succeed. Santa Fe,

New Mexico, has taken timely steps to manage its municipal watershed to ensure clean water for the city. So has Los Alamos, and so have other cities that learned from the past about the importance of resilient and healthy ecosystems as a precondition for adequate clean water. These are not the only ideas, by any means, and I am sure every one of you has great ideas that would help us all.

We are grappling with how best to use, store, and transport water in our forests and grasslands; how much water to leave in our streams to meet the purposes of publicly reserved lands; and how much water is diverted for other uses.

Some key elements that will help us achieve the goals of our shared water emphasis are reflected in a recent publication by the Colorado Foundation for Water Education:

- Conservation: We are upgrading our facilities with water-saving technologies to reduce our own water footprint.
- Forest Health: We continue to treat our source watersheds to fortify the forest against insect and wildfire damage, our eyes firmly fixed on creating the next forest.
- Watershed Restoration: We know healing eroding roads and abandoned mines will increase our supplies of clean water and reduce costs of water treatment and facility maintenance.

I believe cooperation beats confrontation hands-down when it comes to solving problems. Our 2004 Memorandum of Understanding with the State of Colorado put a framework in place for collaboration that has helped us resolve some challenging water issues. Just last year, Senate Bill 221 established a process to help fund forest treatments in source watersheds to protect water supply from wildfire damage. Combined with the tools developed by the Front Range Watershed-Wildfire Protection Group, this funding process positions us all to improve forest conditions and protect water supplies.

Final Thoughts

We live in exciting and challenging times. Our water problems are not simple, and solving them will take all of our collective energy. We have proven that we can work together and get good things done on the ground. As I conclude, I hope you will remember three things:

1. Water is life. As caretakers of our high country water towers, the Forest Service is committed to working with you to meet water challenges, now and in the future—in ways far beyond our traditional approaches.
2. All of us who care about our future water supply and quality will need to join together. Please invite the Forest Service into those conversations to seek smart solutions, to enact helpful laws, to find funding sources, and to build working arrangements that will restore our source watersheds in this century. We are the source.
3. Active forest watershed stewardship on a grand scale is vital to our water future. As Gifford Pinchot said, "No forests, no rivers."

We need your help. Thank you for your time.

Ground Water Summit: April 19–23, 2009

The 2009 Ground Water Summit and 2009 Ground Water Protection Council Spring Meeting in Tucson, Arizona, will bring together a mix of regulators, natural resource managers, practitioners, and those who supply knowledge and technology needed to address our key water issues. The program will focus on the critical role of ground water in the context of a changing climate and will provide insights into the nature of the challenges and opportunities ahead.

Program Highlights

- NGWREF Darcy lecturer: Environmental Tracers in Modern Hydrogeology: Reducing Uncertainty in Ground Water Flow Estimation
- Darcy Forum: Multidimensional Challenges of Aquifer Management
- Birdsall-Dreiss Lecture: Will China Run Out of Water?
- Lower Colorado River Basin and Ground Water Banking

Please visit the National Ground Water Association web site at http://www.ngwa.org/2009summit/index.aspx for more information.

Agricultural to Urban Water Transfers:
Panel of State Water Leaders Responds to Arkansas Basin Roundtable Report at Colorado Water Congress 51st Annual Convention

by MaryLou Smith, *Vice President, Aqua Engineering, Inc.*

Even once the agricultural folks and the city guys put down their boxing gloves, it still took them two years to produce a report on ag-to-urban water transfers they could all agree on. A dozen members of the Arkansas Basin Roundtable who made up the Water Transfers Guidelines Committee put in more than 1,400 hours working through their differences and then meeting with advisors to fill in the gaps in their understanding. Out of that came a template for use by those contemplating ag-to-urban water transfers. The template lists considerations to work through, along with questions and possible mitigation of negative effects for each consideration. A user's guide and a summary of each advisor's key points rounds out the report, titled *Considerations for Agriculture to Urban Water Transfers*. The committee presented the report to the Arkansas Basin Roundtable last November.

Roundtable Response

The good news is that virtually everyone on the roundtable thought the report was excellent—that it characterized the issues of ag-to-urban transfers in an exemplary way. The other good news (for those who believe the best decisions come when folks with different viewpoints engage in an issue) is that not everyone agreed on what should be done with the report. The dialogue on the topic produced the most engaged conversation the roundtable has generated in its three-year history—and it's still going on. Three distinct points of view have emerged:

- Regulations Needed: Third Parties Need a Guaranteed Place at the Table—the report guidelines need teeth
- No Regulations! It's All About Willing Buyer, Willing Seller—the report guidelines should only be educational
- Farmers Need More Options and Incentives to Keep the Water in Agriculture—the report doesn't go far enough

A panel of state water leaders discusses a report on ag-to-urban water transfers in the Arkansas Basin at the Colorado Water Congress Annual Convention on January 30, 2009. From left to right: John Stulp, Robert Sakata, MaryLou Smith, Ray Wright, Don Schwindt, and Peter Binney.

Panel Members

- **Peter Binney**
  Black and Veatch (formerly with Aurora Water)
- **Robert Sakata**
  Sakata Farms and Colorado Foundation for Water Education Board
- **Don Schwindt**
  Farmer from Cortez, past member of the Colorado Water Conservation Board
- **John Stulp**
  Commissioner, Colorado Department of Agriculture
- **Ray Wright**
  Farmer from San Luis Valley, President of the Rio Grande Water Conservation District, past member of the Colorado Water Conservation Board

State Panel at Colorado Water Congress

Attendees at a recent Colorado Water Congress convention had the opportunity to hear responses to the report from five state water leaders. Colorado Water Institute director, Reagan Waskom, was asked to put together a track of sessions on agricultural water for the Colorado Water Congress 51st Annual Convention, which took place at the Denver Hyatt Tech Center on January 28-30. Waskom asked MaryLou Smith from Aqua Engineering, who was the facilitator of the committee that produced the Arkansas Basin report, to put together a panel of state water leaders to respond to it. Smith asked the leaders to not only verbally respond to the report at the convention, but to put their opinions in writing ahead of time so that each would have the benefit of reading the others' responses, giving the panel dialogue a jump start. Chair of the Arkansas Basin Roundtable, Gary Barber, introduced the panel and gave the audience some background on the report and the process undertaken by the committee. He summed up well the current dialogue when he said, "There are two things we don't like in the Arkansas Basin. The first is change. The second is the way things are."

What The Report Says

Representatives from the agricultural community on the Arkansas Basin Roundtable are not particularly happy about water leaving agriculture for the cities. But knowing it's going to happen, they wanted to come up with a set of guidelines that could be followed to minimize any negative impacts to rural communities, other farmers, water quality and the environment, and even the agricultural way of life. They also wish the cities would figure out some way to control their growth. Once some trust was built in facilitated committee meetings, urban water managers were able to express that they, too, want to see rural Colorado preserved, but strategies to limit urban growth by controlling water transfers don't have much promise. Together, both sides decided the best they could do was raise concern for the considerations that should be addressed when water is transferred.

Some of the issues the committee considered are:

- Cumulative impacts of transfers—it all adds up to more than the sum of the parts
- All areas affected by a transfer, not just the immediate area
- Future impacts, not just immediate impacts
- Rights of owners to sell their water
- Needs of rural jurisdictions to maintain a tax base—and an economic future
- How much water can be transferred without killing agriculture?
- Water is only part of the complex problem of agriculture and rural community viability

What the Panel Said

John Stulp, who had been one of the committee's advisors, sounded the cry for "When is enough, enough?" His concern is that no matter how good the guidelines are, even if the transfers are done responsibly, at some point productive agricultural land may be gone. He supports the alternatives to buy and dry that are being studied statewide.

Don Schwindt reiterated the concern reflected in the report about how we can maintain the habitats we have learned to associate with irrigated agriculture as we are more efficient with the water and as we transfer the water. "What happens to the cottonwood trees, the tall wheat grass, the irrigation seepage wetlands?" he asked. As a board member of the Family Farm Alliance, he supports a streamlined approach to regulation. Maybe, he suggested, "instead of making every contemplated change climb ever higher mountains, we could add some hills while lowering some mountains."

Robert Sakata admittedly took a subjective view of the subject, but a view other panel members agreed is an important one to consider. Noting that only 2% of our population farms, he asked "Will the 98% of the population that are not farmers decide that they value bluegrass over broccoli, pavement over peas, iPods over onions?" Legislative solutions to ag-to-urban transfers are

premature, he thinks, because often "good intentions end up in a tangled web of complexities hindering the potential for creative solutions."

Ray Wright picked up on the report's emphasis of the fact that the demise of rural communities and agriculture is not just because of transfers of water. His thinking mirrored that of one of the Arkansas Basin Committee members who likes to ask "Is agriculture doing badly because water is leaving, or is water leaving because agriculture is doing badly?" Though Wright believes agriculture can be more profitable by changing to higher-value crops and responding to the new interest in locally grown food, he is concerned that bureaucratic reporting requirements, food safety regulations, access to labor, and other constraints are making it impossible for agriculture to effectively take advantage of these trends.

> *Colorado will see a significantly greater reduction in agricultural lands as municipal and industrial water providers seek additional permanent transfers of agricultural water rights to provide for increased urban demand.*
> -Statewide Water Supply Initiative

Peter Binney was the lone urban representative on the panel, but he held his own quite well. As Ray Wright said, "I am a little embarrassed to say that I agree with so much of Peter's response." Binney surprised everyone by asserting that he believes ag-to-urban water transfers are not going to become the panacea for urban water shortages everyone seems to be projecting. He said municipalities need to get busy figuring things out and looking at things like regionalization and reuse because ag-to-urban water transfers, for the most part, will be too expensive, and the water will be too hard to get where it needs to go. He made a case for going a bit easier on urban Colorado, reminding us that more than two-thirds of the state's tax base is generated in the metropolitan Denver area and that all of us in Colorado—rural areas included—have become highly dependent on what those taxes provide.

Considerations for Agriculture to Urban Water Transfers can be downloaded from the CWI web site, www.cwi.colostate.edu/other_files/Ag_Urban_Report_Jan09.pdf or contact MaryLou Smith at mlsmith@aquaengr.com.

To read responses from roundtable members and the panel, download *The Future of Colorado Agricultural Water: A Panel's Response* from the CWI web site at www.cwi.colostate.edu/other_files/CWC_Ag_Urban_Panel_Report_Jan09.pdf or contact MaryLou Smith at mlsmith@aquaengr.com.

The Arkansas Basin Roundtable is one of the nine roundtables formed as part of the legislature's Colorado Water for the 21st Century Act, commonly known as the HB1177 process or the IBCC/Roundtable Process. The roundtables are charged by the state legislature with convening a wide array of stakeholders in each basin to make decisions about how best to meet the water challenges faced by the basin. The legislature has made Water Supply Reserve Account (WSRA) funds available for the roundtables to support processes and projects to help achieve that goal—subject to approval by the Colorado Water Conservation Board (CWCB.) WSRA funds were used to support the facilitation of the committee that produced the Arkansas Basin Roundtable report titled *Considerations for Agriculture to Urban Water Transfers.*

AGU Hydrology Days 2009
March 25–27, 2009

Hydrology Days, which has been held on the campus of Colorado State University each year since 1981, is a unique celebration of multi-disciplinary hydrologic science and its closely related disciplines. The Hydrology Days vision is to provide an annual forum for outstanding scientists, professionals, and students involved in basic and applied research on all aspects of water to share ideas, problems, analyses, and solutions. The Hydrology Days 2009 Award presentation will take place during the luncheon on Thursday, March 26, in the North Ballroom of the Lory Student Center. Professor George F. Pinder of the College of Engineering and Mathematical Sciences, University of Vermont, will present the award lecture.

For information regarding this event and registration please visit www.hydrologydays.colostate.edu.

Domestic Rainwater Harvesting in Ethiopia and Kenya, Africa

by Joel G. Murray and Melinda J. Laituri, Warner College of Natural Resources, Colorado State University

Introduction

World-wide pressure on water resources is increasing due to population growth, limited access to fresh water due to groundwater mining, over-allocation of water resources, water quality issues, and climate change. Domestic and agricultural water usage is a significant component of water demand. Rainwater harvesting (RWH) is a viable alternative to meet this growing demand, with a specific emphasis on meeting domestic needs. Rainwater collection is an important option for freshwater supplies in places that lack alternative water sources. Analysis of digital data (i.e., seasonal precipitation, population density, socio-economic factors) in a Geographic Information System (GIS) can be used to identify sites that are suitable for domestic RWH. When supported with a market-based approach, domestic RWH has the potential to be an affordable and sustainable option for populations that have limited access to groundwater or other reliable water supplies.

As a mission for GISCorps, we partnered with EnterpriseWorks/VITA (EWV), an international not-for-profit organization based in Washington, D.C., that works to combat poverty through economic development programs based on sustainable, enterprise-oriented solutions. EWV has undertaken desk studies in 20 countries/regions to consolidate information and lessons learned from former and current RWH programs. Our task was to conduct a pilot project in Ethiopia and Kenya to determine if data were available to accurately map and identify domestic RWH potential in the region and the feasibility of using these data for similar studies elsewhere. The aim of this project is to develop a market-based approach that includes developing a sustainable supply chain to support the delivery of RWH goods and services, stimulating demand for such services by leveraging consumer preferences and applying sustainable business models with user fees that ensure full cost recovery. This model has been successful in other sectors, and this project will examine whether and how such an approach using spatial analysis can be successful for domestic RWH.

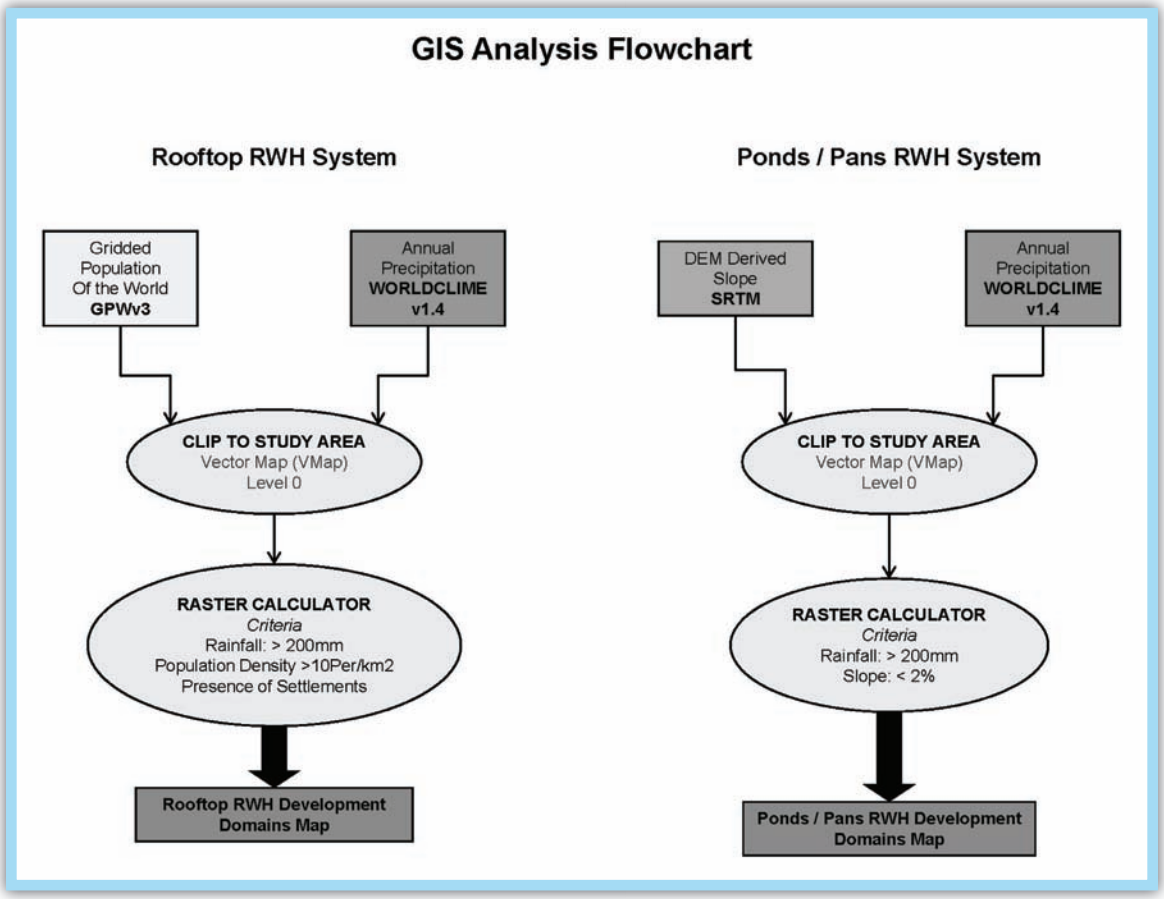


Figure 1. This GIS Analysis Flowchart illustrates the analysis steps used to create the rainwater harvesting potential maps for Ethiopia and Kenya.

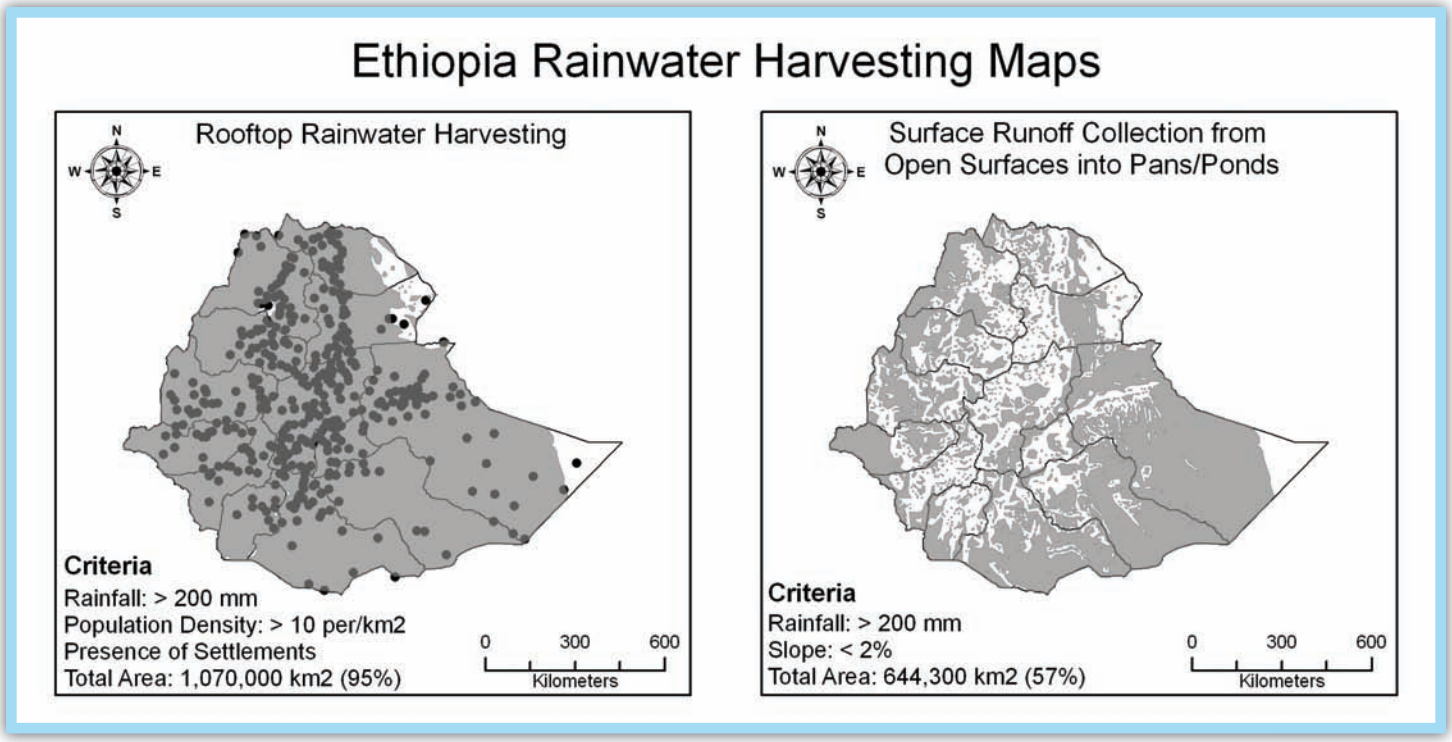


Figure 2. These maps display the rainwater harvesting potential for Ethiopia. Gray shading indicates areas that are suitable for rainwater harvesting, and the points indicate the presence of settlements.

Justification

The overall potential market for domestic RWH is governed by several factors, including rainfall distribution and seasonality, population density, and roofing materials. An estimation of the potential for RWH is possible by overlaying the population density, precipitation, and distribution throughout the year. This first stage analysis provides an initial assessment of the overall potential for identifying locations for developing a domestic RWH market. Other criteria (i.e., existing water supply system, proximity to water supplies, roofing materials, access to water storage tanks) must be used as additional filters to provide a better estimation of the actual potential market. Socio-economic data (i.e., household income, education levels, number of household members) are also needed to understand the potential domestic RWH market; however, these data are often difficult to obtain in developing countries.

Factors that relate to the relative competitiveness of domestic RWH systems with alternative sources of water also provide an indication of the actual potential market. These factors would include the cost of water from other sources, the distance that water must be transported, the quality of water from an alternative source, and the time required to fetch water (travel time and time in queues). The cost of a domestic RWH system will influence the market size, as will the purchasing power of households. The cost of the system will be lower if the roof is suitable for use as a catchment surface; therefore, the percentage of homes with hard roofs will influence the actual market size.

Methods and Results

An exhaustive internet search for global precipitation, population, and elevation data was conducted to identify data sets to be used for the preliminary RWH analysis. Table 1 lists the data that were chosen for the pilot project.

All data were projected to Africa Albers Equal Area Conic, WGS84, and data analysis was conducted using ESRI ArcGIS software (version 9.2). Figure 1 illustrates the analysis steps used to create the RWH potential maps for Ethiopia and Kenya. The Rooftop RWH model requires

Table 1. Data Sets Identified for RWH Analysis

Data Type	Data Set
Global Population	Gridded Population of the World, version 3 (GPWv3)
Global Precipitation	WORLDCLIM, version 1.4
Global Elevation	Shuttle Radar Topography Mission (SRTM)

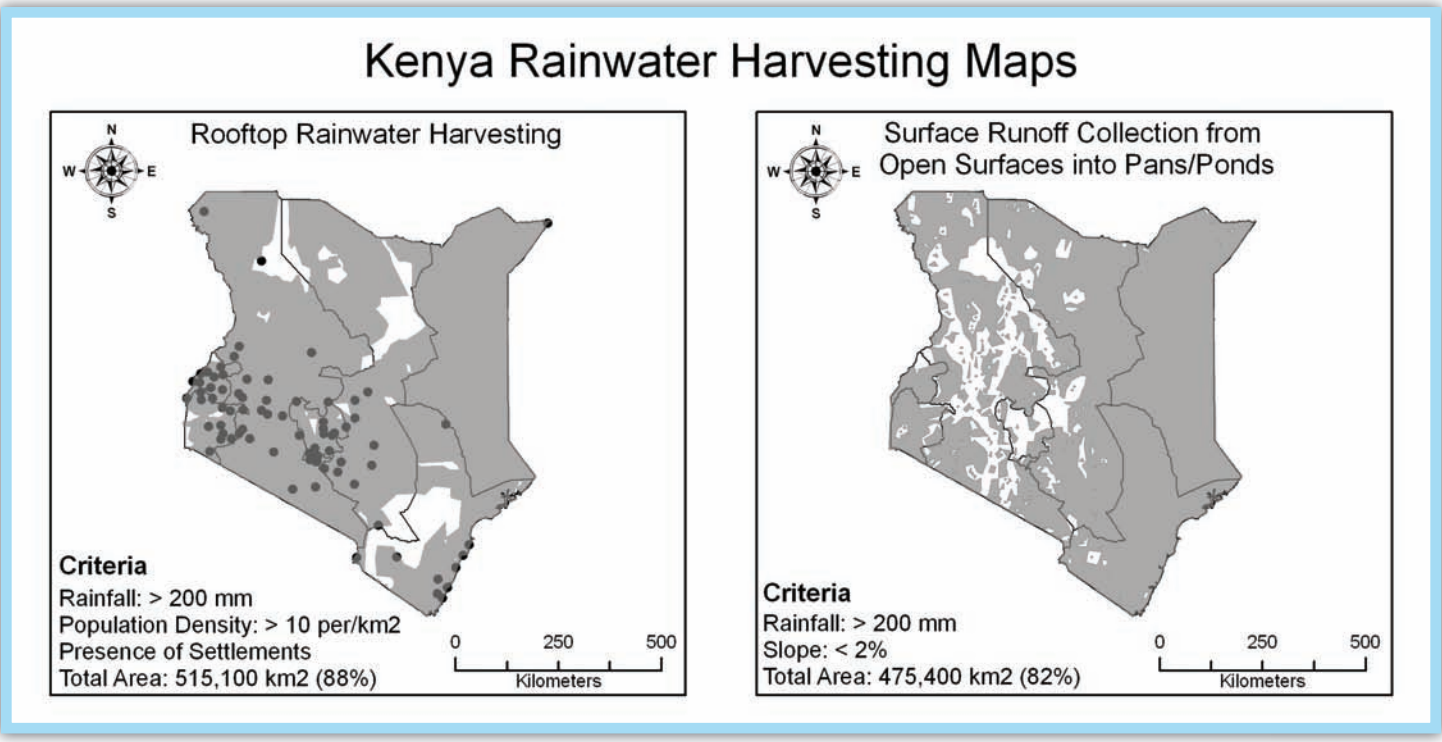


Figure 3. These maps display the rainwater harvesting potential for Kenya. Gray shading indicates areas that are suitable for rainwater harvesting, and the points indicate the presence of settlements.

precipitation and population data and can be limited to areas where settlements exist. Rooftop RWH refers to collection of rooftop runoff into storage vessels. The Ponds/Pans RWH model requires precipitation and elevation (slope) data. RWH storage in small ponds and pans refers to collection of runoff from open surfaces, such as roads, home compounds, hillsides, and open pasture lands and may also include runoff from watercourses and gullies.

Criteria (Table 2) were obtained from the World Agroforestry Centre (ICRAF) and were chosen to target locations where a large incremental benefit would result from implementing RWH. Areas with rainfall below 200 mm are usually deserts with low population and high risks of production. Mathematically, 200 mm of rainfall can provide the daily allotment of drinking water, assuming a per capita rural water consumption of 20 liters/day and a roof catchment of 36.5 square meters. The lower limit of one household per square kilometer and slopes of less than 2% were empirically determined to be optimum for this assessment.

Table 2. Criteria for RWH Analysis

RWH System	Criteria
Rooftop	1. Presence of Settlements 2. Rainfall > 200mm 3. Population Denisty > 10/km^2
Ponds / Pans	1. Rainfall > 200mm 2. Slope < 2%

Figures 2 and 3 display the RWH potential maps. Gray shading indicates areas that are suitable for RWH, and the points indicate the presence of settlements. Preliminary results indicate that more than 95% of Ethiopia is suitable for Rooftop RWH, but only 57% is suitable for Ponds/Pans RWH. More than 80% of Kenya is suitable for both Rooftop and Ponds/Pans RWH.

Conclusions

This initial series of RWH maps for Ethiopia and Kenya is extremely simplistic due to limitations in the data needed to fully develop the RWH model. Data sets related to land use, proximity to water supply, and rooftop type, along with RWH system installation costs, can be added as model parameters to improve accuracy. The Normalized Difference Vegetation Index (NDVI) and higher resolution temporal data, such as monthly precipitation grids, can also be used to examine seasonality effects. A full description of the ongoing project and outputs can be accessed at: http://welcome.warnercnr.colostate.edu/~murrayj/

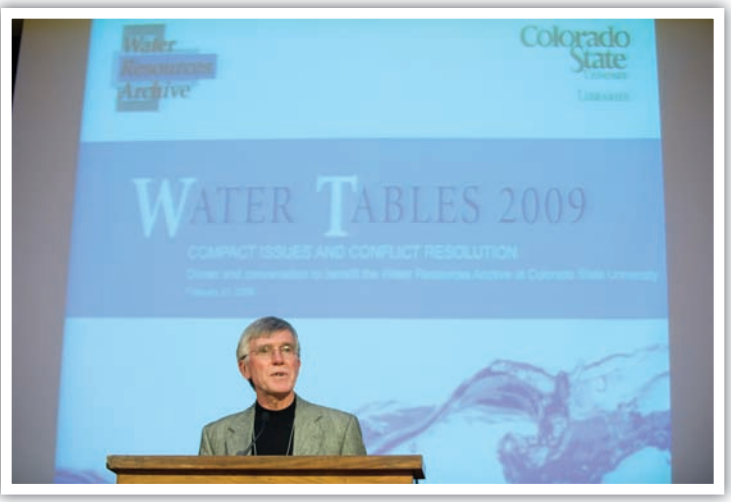
Water Tables Raises $29,000 for Water Resources Archive

by Colorado State University Libraries staff

On February 21, 2009, more than 160 water experts and honored guests gathered to support the Water Resources Archive at Colorado State University Libraries. *Water Tables 2009: Compact Issues and Conflict Resolution* was a huge success, raising more than $29,000. The donation of Maury Albertson's papers to the Water Resources Archive was also announced.

Water engineers, ranchers, lawyers, professors, and students kicked off the event, now in its fourth year, with a reception at Morgan Library and tours of the Water Resources Archive. Dinner and a night of conversation were then hosted at the Lory Student Center ballroom at CSU. Thanks to the generosity of many individual and corporate sponsors, 25 graduate students were able to attend the event and interact with current leaders in the water industry.

The Archives featured two exhibits: one discussed the *Wyoming v. Colorado* court case of 1911, and the other featured highlights from the Maurice Albertson Papers. The first exhibit, *Headlines of History: Exploring the Evolution from Conflicts to Compacts*, contained original Supreme Court documents that led to a change in water law philosophy for Colorado's lead attorney on the case, Delph E. Carpenter. On display from the Delph Carpenter Papers were materials related to the case, which showed his efforts with the 11-year-long court battle and how he came to the conclusion that water compacts would better serve states and water users.



Robert Ward, former director of the Colorado Water Institute and CSU Faculty Emeritus, speaks to attendees at Water Tables 2009.

Ruth and Ken Wright look at an historic water document exhibit at Water Tables 2009.

The second exhibit, a table display of documents and artifacts from the Maurice Albertson Papers, reflected on the former CSU professor's achievements in teaching, research, and international development. Following a moment of silence for Albertson, who passed away in January at age 90, it was only fitting that his widow, Audrey Faulkner, discussed her husband's contribution to water resources at CSU and around the globe. While over 200 boxes had been donated by Albertson before he passed away, Faulkner assured head archivist Patty Rettig that many more boxes will be donated to the archive—a testament to Albertson's contribution to water resources research and education. Faulkner told guests how her husband's passion for water arose during the Great Depression when his father took him on tours of previously drought-ridden areas that were suddenly flooded. Her remarks about his life's dedication to water solutions in the West and throughout the world truly fit the evening's theme of conflict and compacts and were well received by all who attended.

At dinner, esteemed hosts at each table discussed past and current water conflict and compact issues, including topics related to climate, habitat, population, agriculture, law, and management. The hosts' expertise and insight made for lively, entertaining, and enlightening conversation. A tremendous success for both the CSU Libraries and the Water Resources Archive, Water Tables 2009 will provide the Archive with much needed funding for student assistants, supplies, and outreach activities. As a true testament to an enjoyable evening, guests left the event already anticipating Water Tables 2010.

CWI Mourns the Loss of a Colorado Water Legend

by Laurie Schmidt, Colorado Water Institute

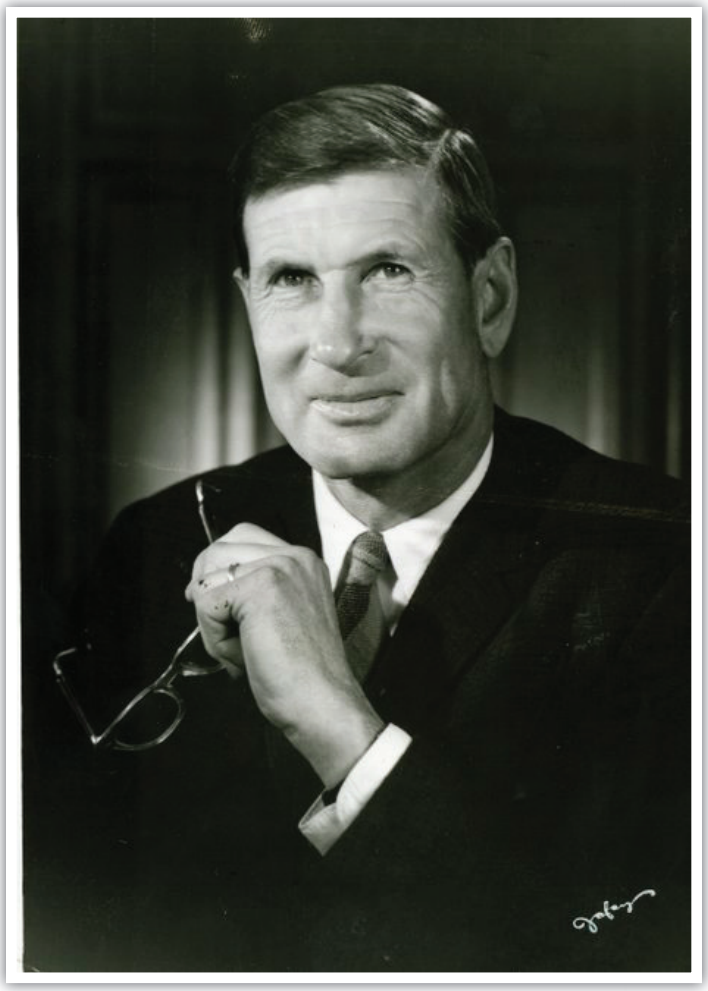
John Fetcher was a man who didn't take "no" for an answer. Legend has it that he once stranded the Chairman and ranking member of the House Appropriations Subcommittee on Energy and Water on the Steamboat Gondola on the way up to their lunch appointment at the top of Mount Werner. No one seems quite sure exactly how Fetcher managed to pull off that stunt, but it gave him a captive—and cornered—audience to whom he could pitch funding for Stagecoach Reservoir. It was his tireless dedication to projects that he believed in that make Fetcher's recent death a sobering loss to the Colorado water resources community.

Fetcher came to northwestern Colorado in 1949 when he and his brother moved their families to a ranch they had bought on the Elk River. His drive to preserve the region's water for its own benefit led him to guide many water projects, including working with the Colorado Division of Wildlife to create Steamboat Lake and leading the efforts to build Stagecoach Reservoir, which was completed in 1989. But according to a February 6, 2009, article in *The Steamboat Pilot*, the accomplishment Fetcher was most proud of was his role in building Yamcolo Reservoir on the headwaters of the Yampa River in the late 1970s. Yamcolo served much of the region's irrigation needs and was perceived as a windfall after the devastating drought of 1977.

In 1965, Fetcher founded the Upper Yampa Water Conservancy District (UYWCD), serving as its manager until finally turning over the reins to Kevin McBride in December 2008. According to Janice Illian, office manager at the UYWCD, he was also involved in numerous Upper Yampa ditch projects. "John always used to say: You can't conserve any water if you don't have it," said Illian.

According to Robert Ward, director of the Colorado Water Institute (CWI) from 1991 to 2005, Fetcher was a strong supporter of college students seeking careers in water resources fields. "John assisted students with their senior design projects and in the early years of their careers," said Ward. "His efforts help assure that future Colorado water managers are well grounded as they address the water challenges of the 21st century."

In 2002, Fetcher contacted Ward about establishing the Upper Yampa Water Conservancy District Scholarship, which would be awarded by the CSU Water Center and would provide funding each year to a CSU student majoring in a water resources-related field. The first recipient of the new scholarship was Josh Duncan, who



A 1978 portrait of John Fetcher.

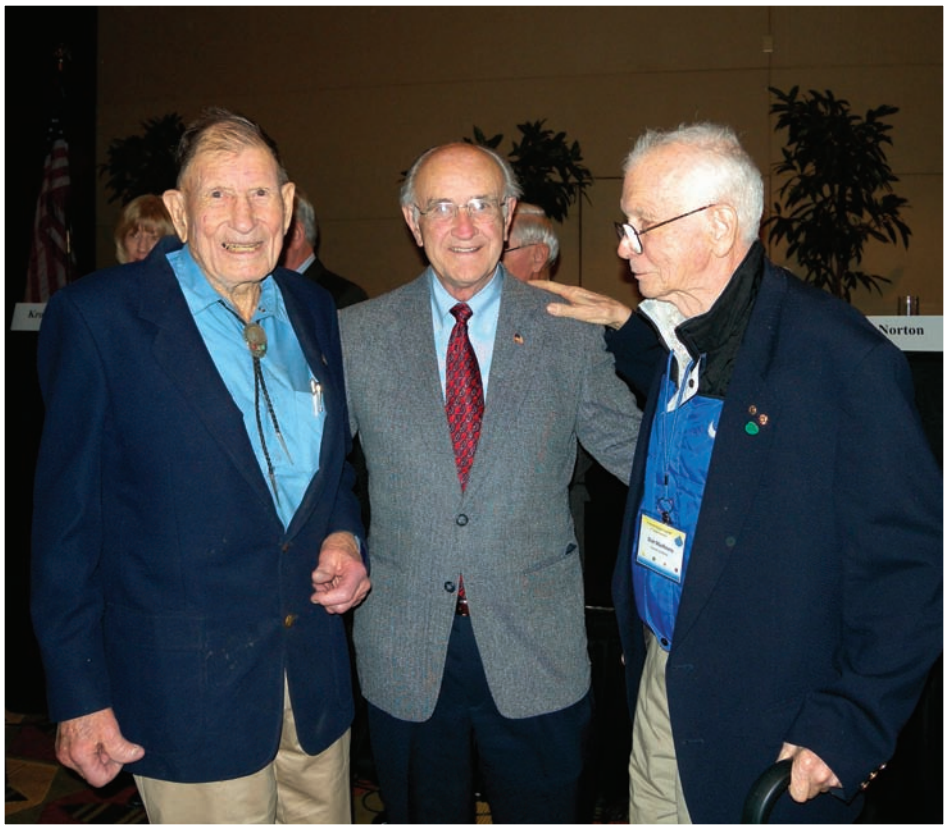
is now an engineer with J3 Engineering Consultants, Inc. in Aurora, Colorado. Duncan worked with Fetcher on a graduate research project that investigated the expansion of water reservoirs for the Steamboat Springs area. "John's understanding of water's importance influenced Colorado in so many ways, especially in the Yampa Valley," said Duncan. "He naturally impacted people and had a direct and profound influence on my life and career—I feel truly blessed to have known such an exceptional man." In Fetcher's honor, the Upper Yampa Board has now renamed the scholarship the UYWCD John Fetcher Scholarship. The Water Center is pleased to have this scholarship to honor one of Colorado's great leaders by helping to train new water professionals at CSU.

Fetcher's many contributions to Colorado water resources earned him several prestigious accolades. In 1992, he received the Wayne Aspinall Water Leader of the Year Award, presented to him by the Colorado Water Congress,

and in 1998 he was honored with the Colorado Water Workshop's "Living Legend" award.

Fetcher passed away due to complications from pneumonia on February 6, 2009, at the age of 97. Just one week earlier, he had traveled to Denver to attend the 51st Annual Convention of the Colorado Water Congress. Such was the dedication of John Fetcher.

On Sunday, March 8, hundreds of people, including family, friends, and colleagues, gathered at the Sheraton Steamboat Resort in Steamboat Springs to celebrate Fetcher's life. Fetcher's son Jay Fetcher led the service, and speakers included Tom Sharp—water attorney, vice president of the Colorado River District Board of Directors, and Fetcher's close friend. "You come across people like John so rarely in life that you need to savor and treasure the moments you have with them," Sharp said. "I'll miss him a lot."



John Fetcher (left) with Tillie Bishop (center) and Dick MacRavey (right) at the Colorado Water Congress Annual Convention on January 30, 2009.

River Rally 2009
May 29–June 1, 2009

The National River Rally is River Network's premier annual event that brings together over 500 river conservationists for an extra-long weekend of education, inspiration, and celebration. The location of the River Rally moves each year: in 2008, we were on the banks of Lake Erie; in 2010 we will be in the Wasatch Mountains outside of Salt Lake City.

For information regarding this event please visit http://www.rivernetwork.org

This year, River Rally will take place on the shores of Chesapeake Bay. Staff, board members, volunteers, tribal representatives, and individuals working for watershed conservation should plan to join us in Baltimore this May.

The 10th National River Rally will host over 70 workshops, intensive trainings, field trips, and many networking opportunities. The River Heroes Banquet is an inspirational night of celebrating river leaders. Like the nine River Rallies preceding it, River Rally 2009 is sure to be an event you won't want to miss.

Location
Hyatt Regency Baltimore
300 Light Street
Baltimore, MD 21202

Faculty Profile

Sybil Sharvelle, Assistant Professor, Department of Civil and Environmental Engineering

I joined the department of Civil and Environmental Engineering at Colorado State University in the fall of 2007 with an appointment that includes responsibilities in research, teaching, and extension. My expertise is in biological waste processing. While pursuing a M.S. degree at the University of Colorado at Boulder, I worked on a project funded by NASA to develop a biological processor for treatment of urine-soap wastewater expected to be generated at the International Space Station. The focus of this work was optimization of the nitrification and denitrification steps for complete removal of nitrogen from the wastewater. This research led me to my Ph.D. program at Purdue University where I was part of the NASA Specialized Center for Research and Training (NSCORT) focused on advanced life support (ALS) research. This was a multidisciplinary center composed of 21 primary investigators from different departments. The center's goal was to recycle valuable resources such as water and air during space missions, while recovering important nutrients that could be used to enhance crop production for food supply. My specific project was a biological processing unit for simultaneous treatment of graywater (laundry and hygiene wastewater) and waste gas contaminated with high levels of ammonia and hydrogen sulfide. The waste gas was a byproduct of a solids treatment unit. The multi-component ALS system proposed was a completely closed loop system. As resources continue to become scarce on earth, technologies such as those developed for NASA advanced life support systems will become crucial to human survival. My previous research experience in closed loop life support led me to my current field of interest—sustainable water and waste management. I am currently working on projects related to graywater reuse and anaerobic digestion for methane capture and use.

Graywater Reuse

As water supply becomes more limited throughout the world, there is a growing interest in innovative approaches to water resources sustainability. One approach that is gaining popularity is household graywater reuse for residential landscape irrigation or toilet flushing. Nearly 50% of the wastewater generated in a typical household is graywater. This water requires very little treatment for reuse applications, thus providing the opportunity to generate substantial water savings. In addition, energy savings are realized when graywater is reused because both water and wastewater treatment are minimized. I am currently working on a project funded by Water Environment

Research Foundation (WERF) to examine the long-term effects of application of untreated graywater to landscape irrigation. Soil quality, plant health, and persistence of pathogen indicator organisms will be assessed at eight homes in four states throughout the United States where graywater has been applied for irrigation.

Another potential on-site reuse of graywater is toilet flushing. Colorado State University (CSU) has constructed an entire floor of a residence hall with separate graywater/blackwater plumbing. The potential to reuse graywater for irrigation and toilet flushing will both be evaluated at this residence hall. After success and safety are demonstrated, CSU may implement graywater reuse on a large scale.

Conversion of Waste to Energy

Anaerobic digestion involves biological conversion of high carbon waste material to methane under anaerobic conditions. Methane can be utilized as a fuel to generate energy. Some high organic wastes that are suitable for anaerobic digestion include animal manure, blackwater, food waste, and some industrial wastes. Much of this waste currently contributes to greenhouse gas emissions and water quality problems and is thus viewed as nuisance. Anaerobic digestion of waste material offers the opportunity to convert wastes into a valuable source of renewable energy. While many domestic wastewater

treatment plants have incorporated anaerobic digestion into their process train, animal manure and food wastes serve as a large source of untapped energy potential. I am currently working on developing decision-making tools for livestock producers to use as they consider installation of waste-to-energy technology. A massive opportunity to generate renewable energy lies within centralized anaerobic digesters that process food waste, animal waste, and other industrial wastewater. Waste combinations such as these have been found to generate more energy than any of the contributing waste could alone. Increased installation of anaerobic digester for waste management has the potential to improve water and air quality, even while providing a source of renewable energy.

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Web: www.cwi.colostate.edu/CSUWaterFaculty/?WF_ID=141

Spring 2009
Interdisciplinary Water Resources Seminar

Sponsored by: CSU Water Center, USDA-ARS, Civil and Environmental Engineering, and Forest, Rangeland, and Watershed Stewardship

Thursdays from Noon to 1:00 PM

All seminars are held in the Lory Student Center on the main campus of Colorado State University.

April 2 LSC 222	**Ginger Paige**, University of Wyoming **Rangeland Water Resources: Management Opportunities**
April 9 LSC Virginia Dale	**Mike Ronayne**, Geosciences, CSU **Solute Transport in Fluvial Aquifers**
April 16 LSC 222	**Pieter Johnson**, University of Colorado - Boulder *Topic To Be Announced*
April 23 LSC 226	**Jack Morgan**, ARS **Global Change: It's Essentially About Water**
April 30 LSC 222	**Katie Walton-Day**, USGS Denver **Use of Isotopes to Identify Surface-Groundwater Connections**
May 7 LSC 222	**Marie Livingston**, University of Northern Colorado *Topic To Be Announced*

All interested faculty, students, and off-campus water professionals are encouraged to attend.
For more information, contact Reagan Waskom at reagan.waskom@colostate.edu
or visit the CWI web site.

Water Research Awards

Colorado State University (December 15, 2008 to February 14, 2009)

Antolin, Michael F, NSF-Biological Sciences, Shortgrass Steppe Long Term Ecological Research VI, $820,000

Berrada, Abdelfettah, Texas A & M, Improving Canola Adaptation using Deficit Irrigation and Cropping Management in the Southern High Plains, $25,110

Bestgen, Kevin R, DOI-Bureau of Reclamation, Abundance Estimates for Colorado Pikeminnow in the Green River Basin, Utah & Colorado, $38,623

Bestgen, Kevin R, DOI-Bureau of Reclamation, Annual YOY Colorado Pikeminnow Fall Monitoring, $19,027

Bestgen, Kevin R, DOI-Bureau of Reclamation, Evaluating Effects of Non-Native Predator Fish Removal on Native Fishes in the Yampa River (Project No. 140), $80,101

Bestgen, Kevin R, DOI-Bureau of Reclamation, Monitoring Effects of Flaming Gorge Dam Releases on the Lodore & Whirlpool Canyon Fish Communities (Project No. 115), $63,092

Bestgen, Kevin R, DOI-Bureau of Reclamation, Yampa & Middle Green CPM & RBS Larval Survey (Project No. 22f), $94,208

Bledsoe, Brian, NSF-GEO-Geosciences, CAREER: Stream Restoration, Ecological Engineering and Nutrient Retention of Streams in Urban and Agricultural Settings, $88,560

Cheng, Antony S, USDA-USFS-Forest Research, Colorado Forest Restoration Network, $246,000

Collett, Jeffrey L, NSF - National Science Foundation, Cloud Chemistry Measurements in the Southeast Pacific during VOCALS-REx, $119,022

Cotton, William R, NSF - National Science Foundation, Collaborative Research: Inhibition of Snowfall by Pollution Aerosols, $157,490

Garcia, Luis, Various "Non-Profit" Sponsors, Developing a Decision Support System for the South Platte Basin, $10,000

Hawkins, John A, DOI-Bureau of Reclamation, Middle Yampa Smallmouth Bass & Northern Pike, $241,395

Henry, Charles S, EPA-Environmental Protection Agency, Rapid and Continuous Analysis of the Water-Soluble Portion of Aerosols Using Lab-on-a-Chip Technology, $8,475

Jayasumana, Anura P, Colorado School of Mines, Wireless Sensor Network Based Subsurface Contaminant Plume Monitoring, $6,534

Johnson, Brett Michael, DOI-Bureau of Reclamation, Chemically Fingerprinting Nonnative Fishes in Reservoirs (Project No. C-18/19), $29,680

Johnson, James Bradley, Colorado Department of Transportation, Phase 3 Development of the Functional Assessment of Colorado Wetlands (FACWet) Methodology: Calibration, Validation, and Program Implementation, $69,999

Julien, Pierre Y, Korea Institute of Construction Technolo, Restoration of Abandoned Channels, ($18,749)

Julien, Pierre Y, USDA-USFS-Rocky Mtn. Rsrch Station - CO, Hydraulic Feometry and Sediment Transport of the Rio Grande, $45,255

Kummerow, Christian D, Princeton University, Developing Consistent Earth System Data Records for the Global Terrestrial Water Cycle, $41,079

Liston, Glen E, NSF - National Science Foundation, IPY: Collaborative Research: A Prototype Network for Measuring Arctic Winter Precipitation and Snow Cover (Snow-Net), $95,000

Rondeau, Renee, The Nature Conservancy, Identifying Important Fish & Wildlife Areas Associated with Colorado Forests, $25,162

Thornton, Christopher I, USDA-USFS-Rocky Mtn. Rsrch Station - CO, Hydraulic Modeling of Stabilization Techniques 02-JV11221602-145, $92,000

Calendar

March

22-26 **2009 International Master Gardener Conference; Las Vegas, Nevada**
Water conservation, proper plant selection, soil enrichment, and pest control.
http://www.unce.unr.edu/imgc/

25-27 **Hydrology Days; Fort Collins, Colorado**
Annual celebration of multi-disciplinary hydrologic science.
http://hydrologydays.colostate.edu

27-29 **Watershed Science 50th Anniversary Celebration; Fort Collins, Colorado**
Three-day celebration of science, reflection, and looking to the future.
http://cfwe.org/Events/calendar.asp?id=3

30-1 **NWRA Federal Water Seminar; Washington, D.C.**
http://www.nwra.org/index.cfm

30-2 **WaterEC International Water Efficiency Conference & Exposition; Newport Beach, California**
The first annual International Water Efficiency Conference.
http://www.waterec.net/wec.html

31-1 **Arkansas River Basin Water Forum; Pueblo, Colorado**
This year's theme is "Water to Fuel our Future."
http://www.arbwf.org

April

2-3 **Colorado WaterWise Conference; Denver, Colorado**
Learn how to set goals, identify resources, and measure success.
http://www.coloradowaterwise.org

8-11 **2009 Water Security Congress; Washington, D.C.**
Provides current information on how to address emerging challenges in water security.
http://www.awwa.org/Conferences/

17 **Colorado AWRA Annual Symposium; Golden, Colorado**
The symposium theme is "Compacts, Politics, and the Future."
http://www.awra.org

19-23 **2009 Ground Water Summit; Tucson, Arizona**
Will focus on the critical role of ground water in the context of a changing climate.
http://www.ngwa.org/2009summit/index.aspx

24 **Ditch Hazards Awareness and Safety; Canon City, Colorado**
Will focus on safety issues and drowning prevention.
http://www.darca.org

May

4-6 **2009 Spring Specialty Conference Preliminary Program; Anchorage, Alaska**
Will cover a wide range of climate change and water resource topics.
http://www.awra.org/meetings/Anchorage2009/index.html

18-19 **13th Annual Water Reuse and Desalination Research Conference; Huntington Beach, California**
Interact, network, and discuss current and future research needs and trends.
http://www.watereuse.org/foundation/conferences/09Research

29-1 **River Rally 2009; Baltimore, Maryland**
This annual event brings together over 500 river conservationists.
http://www.rivernetwork.org/rn/rally/

June

3-6 **Irrigation District Sustainability—Strategies to Meet the Challenges; Reno, Nevada**
Professionals can exchange and learn from the experiences of others in their field.
http://www.uscid.org/09wdconf.html

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Colorado Water Institute
http://www.cwi.colostate.edu

CSU Water Center
http://www.watercenter.colostate.edu

Colorado Water Knowledge
http://www.waterknowledge.colostate.edu

The mountains reflect in the waters of Sprague Lake in Rocky Mountain National Park.
(Image courtesy of Andy Cook, Rocky Mountain Reflections Photography, Inc.; www.rockymountainreflections.com)