COLORADO WATER
Newsletter of the Water Center of Colorado State University

April/May 2007

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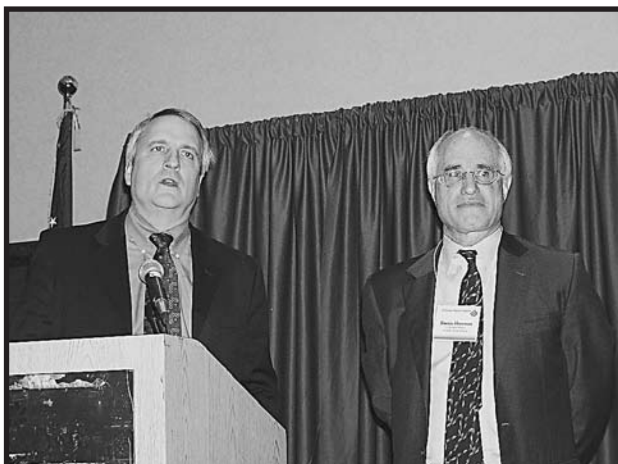

Left: Governor Bill Ritter and DNR Director Harris Sherman address the Colorado Water Congress.

Below: Lewis Entz receives recognition as the recipient of the 2007 CWC Aspinall award.

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EDITORIAL

New Blood, New Leaders: New Thinking?

by Reagan M. Waskom, Director
Colorado Water Resources Research Institute

THE COLORADO WATER CONGRESS ANNUAL CONVENTION is one of my favorite meetings each year, as I find it fascinating to listen and learn from those individuals who have spent a career, in some cases a lifetime, in the water business. As I look around the room and note at each table a hundred or more years of experience in the water business, I can not help but be inspired by the accomplishments, intelligence, and perseverance of these leaders. These men and women have built water projects, changed our laws, fought to protect our compacts, and have lived through drought, political battles and other hard times. But you also cannot help but note the gray hair, or lack of hair, on many at the Water Congress. The fact that so many of our water leaders in Colorado are late in their careers should have us questioning where the next generation of water pioneers and visionaries will come from. The true legacy of great leaders is the next generation of leaders.

To that end, the Colorado Foundation for Water Education (CFWE) established the Water Leader Course in 2006. The first class of leaders included 14 individuals from diverse backgrounds, ranging from professional engineers to directors of environmental organizations. This group provided a debriefing at the January Water Congress meeting, highlighting not only the value of the training and experience they received in the program, but also the importance of the network they created by their participation. Thanks to all of you that supported this first class by your nominations, mentoring and donations. CFWE is presently taking applications for the next class of leaders and we have another opportunity to support this program in multiple ways.

Colorado State University has as a primary mission the education and development of the next generation of water and natural resource professionals. We do this through classroom education and research training, but also through internships, jobs and interaction with the water community. This issue of Colorado Water focuses on the research projects of a few of our students near graduation from our Civil and Environmental Engineering Department, Soil and Crop Sciences Department, and Ag and Resource Economics. They represent just a small fraction of the water-related Master's and Ph.D. students that we matriculate annually. The task of transforming these new graduates into the next generation of leaders is an important one that higher education and the water community must necessarily partner on to succeed. While the university can start the process by instilling knowledge, transformational leaders are honed by overcoming challenges and by the mentoring which, over time, helps turn knowledge and experience into vision.

It does not require much analysis to recognize that Colorado faces a very challenging water future. Indeed, just sustaining the current level of infrastructure will take considerable effort and political will. Finding additional ways to meet growing water demands and environmental needs will require even more from us. Human capital in the form of educated scientists, engineers, lawyers and other related disciplines offers us the basis for meeting these challenges. But the easy solutions to our water needs have all been built - it is going to take more than just the next cadre of trained professionals. It will require extraordinary effort and new thinking from inspired leaders to guide Colorado's water future. Albert Einstein is quoted as saying, "The problems of today will not be solved by the same thinking that produced the problems in the first place." If you accept that premise, then the quality of our future will depend directly on the creativity and quality of our thinking.

The true legacy of great leaders is the NEXT generation of leaders.

MEETING BRIEFS

2007 Lower South Platte Water Symposium

Higher demands for water and prioritization of water use, along with concerns about climate variability prompted approximately 140 participants to attend the Lower South Platte Water Symposium held on March 7, 2007 at Northeastern Junior College in Sterling. This year's theme, Today's Actions for Tomorrow's Livelihood, included a variety of topics relevant to water management in the Lower South Platte.

Conference speaker Brad Udall, Western Water Assessment, answers a reporter.

Rick Brown (Colorado Water Conservancy Board) opened the conference by describing the Statewide Water Supply Initiative (SWSI) and the Roundtable process, noting the contention he has observed over quantifying of even very small amounts of water during these processes. Rick posed four questions to the predominately agricultural audience: Is preservation of Colorado Ag a goal? What is Ag willing to do to achieve the goal? Is new water development preferable to Ag transfers? Should Ag water use continue in all areas that are currently irrigated? Rick observed that the SWSI process is almost 10 years into the 2000-2030 planning horizon and only one new project has been built thus far. He stated that we must be able to make decisions in midst of uncertainty, as we cannot wait for complete certainty in water planning. To move forward in the face of uncertainty Colorado must resolve some key issues, specifically the Black Canyon and Aspinall Unit reauthorization, endangered species issue on the Gunnison, the Colorado River Compact, and growth in areas lacking renewable water supplies. Rick concluded his talk by stating the importance of resolving these issues in order to maintain water in Ag.

Jim Hall, Division 1 Engineer, told the audience that it looked like most Eastern Plains reservoirs will fill this spring before addressing what has happened on the South Platte recently. Jim observed that fear of drought is almost as serious as drought, as people become aggressive about protecting water supplies and acquiring new ones. To date, over 1000 wells have been shut down on the S. Platte and Jim has seen both more conflict and more cooperation. The biggest change is that historically, there was no call on river during winter. During the last 5 years, however, the S. Platte has been under administration for most of year, keeping both junior users and augmentation plans out of priority. The gentlemens' agreements on out of priority storage have broken down and now reservoirs cannot store out of priority unless they can send water back to the river promptly. An increased level of scrutiny over expansion of irrigated acres is also occurring.

Jim observed the following farmer responses to these changes:

- Increased use of surface water rights over wells
- Heavier use of reservoirs for irrigation
- Increased sprinkler installation, thereby reducing return flows
- Change in cropping patterns - more wheat, less corn/alfalfa
- Increased use of S. Platte alluvial aquifer

Frank Jaeger, Parker Water and Sanitation, describes the Parker / CSU project while conference organizer Joel Schneekloth looks on.

- More use of reusable effluent for replacement
- More active in water court

Municipal water suppliers have also responded to the recent changes:

- Purchase of Ag water rights
- Increased use of gravel pits for storage
- More reuse and plans for reuse
- More active in water court

Other conference speakers included Alan Berryman (Northern Colorado Water Conservancy District), who brought the audience up to date on the three-state water agreement between Colorado, Nebraska, and Wyoming. Brad Udall (Western Water Assessment at University of Colorado) provided the state of the knowledge on climate change and speculated on how this may impact water management in the basin.

Former State Representative Diane Hoppe provided the lunch time keynote address.

Diane Hoppe provided a keynote presentation during the lunch hour. She reminded the audience about the history of groundwater law and administration; she then went on to describe current water related bills in the state legislature. The most pressing future legislative need described by Representative Hoppe was more flexibility for the State Engineer to practice common sense water management based upon geography and gravity. Afternoon speakers included Frank Jaeger of Parker Water and Sanitation, Jay Winner of the Lower Arkansas Valley Water Conservancy District, and Dr James Pritchett of Colorado State University.

The 2007 Lower South Platte Water Symposium was sponsored by CSU Extension, USDA-NRCS and the Lower South Platte Water Conservancy District. The organizing committee included Joel Schneekloth, Alan Helm, Bruce Bosley, Joe Frank, Ron Neher and Louie Rinaldo.

AWRA Summer Specialty Conference: Emerging Contaminants of Concern in the Environment: Issues, Investigations, and Solutions.

June 25th-27th, 2007

Vail, Colorado

For more information go to http://www.awra.org/meetings/Vail2007/index.

Colorado Water Congress Annual Convention 2007

THE COLORADO WATER CONGRESS HELD ITS 49TH Annual Convention at the Holiday Inn DIA on January 26 and 27. Highlights included keynote address by Governor Bill Ritter. He noted the severity of disaster caused by blizzards in SE Colorado and the three week ordeal for ranchers. Governor Ritter explained the four core water principles of his "Colorado Promise:"

Gov. Ritter shares a thought with Ted Kowalski of the CWC.

1. *Conservation plays a role in Colorado's future.* Conservation is a statewide need – including agriculture.

2. *Water reuse* – The Governor held up Aurora's Prairie Water Project as an example but recognized impact of reuse on down-stream users.

3. *Encourage sharing of water.* Agricultural/Municipal arrangements such as leasing, rotational following, etc.

4. *Water storage, particularly smaller, multiuse storage projects on the Front Range of Colorado.*

He also mentioned the importance of water quality. Governor Ritter stated that Harris Sherman will serve as Director of Compact Negotiations temporarily while they evaluate Roundtable and IBCC process.

New DNR Executive Director Sherman reflected on his services as DNR director 27 years ago. He noted the changes since his earlier tenure and the issues challenging water in Colorado at this time:

- Population growth will affect water
- Climate change will affect water
- Environmental and recreational water programs more institutionalized and increasingly important.

Above: Past CWC Aspinall Leaders await the newest member of their ranks.

Other highlights of the annual meeting included a historic film of President John Kennedy's speech at the opening of the Fry-Ark Project presented by Ray Kogovsek and a talk by Christo and Jeanne-Claude on their proposed "Over The River Project" planned for the Arkansas River.

The summer meeting of the Colorado Water Congress is scheduled for Sheraton Steamboat Resort on
August 23 - 24, 2007.

Ken Lykens and Diane Hoppe of MWH with Loretta Lohman of

Gigi Dennis congratulates Lew Entz on his receipt of the Aspinall

Members of the 2006 CFWE Water Leaders class present their observations on water leadership in Colorado.

Above: West meets East- John McClow (Upper Gunnison River WCD) and George Sibley (Western State College) visit with David Schneider (Loveland Utility Commission).

Left: Jeanne-Claude and Christo answer questions about the veiling of the Arkansas River.

Advancing a Water Agenda in a Competitive Environment

by Floyd Ciruli, Ciruli Associates

PRESENTED AT THE COLORADO WATER CONGRESS, JAN 26, 2007

THE **2006 NOVEMBER ELECTION REPRESENTS A MAJOR** change in the political landscape in Colorado with one-party Democratic control of state government for the first time since the early 1960s. However, the challenging features of Colorado water policy remain the same.

- Growth continues in lower-basin states that depend on the Colorado River. The impact of global warming, a new factor, enhances the potential shortfall and the competition among basin states.

- Colorado ranks 5th in population growth. The increase is most concentrated along the I-70 West Corridor and Front Range.

- The record 2002 drought appears over, but the aftermath lingers among residents and providers with heightened awareness of water supply vulnerability.

- Environmental and recreation needs and sensibilities continue to grow.

- Vulnerability of rural economies increases as pressure intensifies for agricultural water to meet urban supply gaps.

- The public is aware of water supply problems, but policymakers face considerable polarization and politicization of the issue.

Even though Gov. Bill Ritter's administration will offer changes in approach, emphasis and values, it faces the same challenging environment as former Gov. Bill Owens.

Advancing a Water Agenda in Competitive Environment

Fortunately, the public is aware of water issues due to the recent drought. Analysis of a variety of public opinion polls from Front Range communities, including Denver Water customers, Castle Rock and Pueblo, show that the public remains concerned about drought and shortages and

Floyd Ciruli addresses the Water Congress.

is ahead of many policymakers in supporting conservation and reuse (Figure 1). Although there's no evidence of support for larger-scale storage projects or diversions, there is support for local projects and water acquisition. The public also prefers cooperation over conflict in developing solutions.

Key Events in 30 Years of Water Policy

The reason water policymaking has become more difficult is that drought and public conflicts have made it front-page news. Historically, water politics were conducted behind-the-scenes and dominated by a handful of stakeholders.

Figure 1: Public concerned about drought and shortage; supports action, conservation, reuse, local storage and water purchases, and cooperation

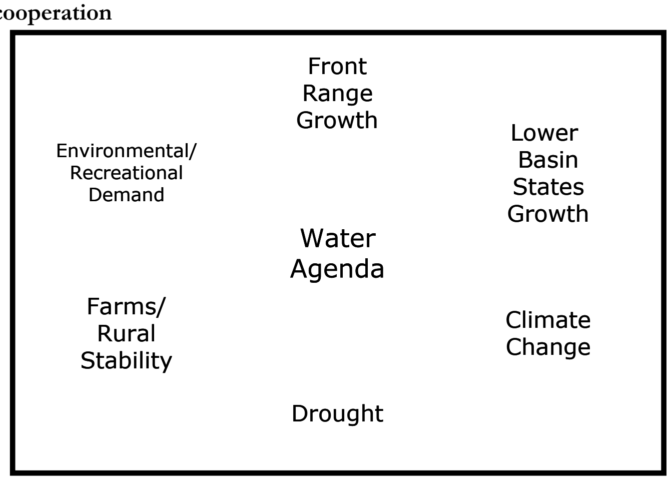


Figure 2: Key Events in 30 Years of Colorado Water Policy and Politics

1977	Budget "hit list." Newly elected President Carter issues budget with no funding for several western water projects. End of significant federal financing of reclamation.
1990	EPA veto of Two-Forks. Long-planned Denver metro area dam and reservoir of 1.1 million ac-ft is stopped. End of big reservoir development.
2002	Drought of 2002. Record-breaking drought after decade of rapid growth. End of municipalities and water policy-makers' confidence in continuing supply.
2003	Referendum A on water bonds defeated. Water policy is polarized and politicized.
2004	Statewide Water Supply Initiative study completed. Identifies 630,000 ac-ft gap.
2005	HB 05-1177 begins water roundtables and technical committees.
2006	HB 06-1124 Rotational Crop Management legislation approved

In Colorado, three decades of water policy have recorded only a handful of high-profile water dramas (Figure 2). President Carter's 1977 budget hit list, where several Colorado reclamation projects were de-funded, galvanized local opposition, but dramatized the end of federal funding for state water projects.

The Environmental Protection Agency veto of the proposed Two Forks Dam in November 1990 shifted Denver metropolitan and state water providers from proposing large-scale, region-wide storage to managing current supplies, increasing dependence on groundwater, building small off-stream projects or enhancing current reservoirs.

The drought of 2002 altered the planning assumptions for all of Colorado's water districts, including those such as Denver Water, believed to be the most secure. A dramatic increase in investment in conservation and reuse began. Prices surged as water became a valuable asset and an expensive commodity to acquire.
Although the drought shifted water priorities, it was not able to affect significant state policy changes. The defeat

Figure 3: Population and water demand, 2000-2030.

Basin	2000	2030	Increase in Population	Percent Change 2000 to 2030	Increase in Water Demand AF	Increase in Water Demand AF
Arkansas	835,100	1,293,000	457,900	55%	98,000	38%
Colorado	248,000	492,600	244,600	99	61,900	84
Dolores/San Juan/ San Miguel	90,900	171,600	80,700	89	18,800	80
Gunnison	88,600	161,500	72,900	82	14,900	72
North Platte	1,600	2,000	400	25	100	20
Rio Grande	46,400	62,700	16,300	35	100	20
South Platte	2,985,600	4,911,600	1,926,000	65	409,700	53
Yampa/White/Green	39,300	61,400	22,100	56	22,300	76
Total	4,335,500	7,156,400	2,820,900	65	630,000	53

of Referendum A, the 2003 water revenue issue, had a chilling effect on new initiatives. Gov. Owens, in an effort to move policy in the polarized environment, began the Statewide Water Supply Investigation (SWSI), which identified a 630,000 acre-foot need by 2030, only part of which will be met by projects currently on the table.

Dialogue and roundtables were started by the then Department of Natural Resources (DNR) chief, Russell George, in an attempt to depolarize the issue with a shared set of data and procedure for consensus building.

Finally, some specific initiatives related to solutions, such as farm/urban water-sharing arrangements, passed the legislature and began to be studied.

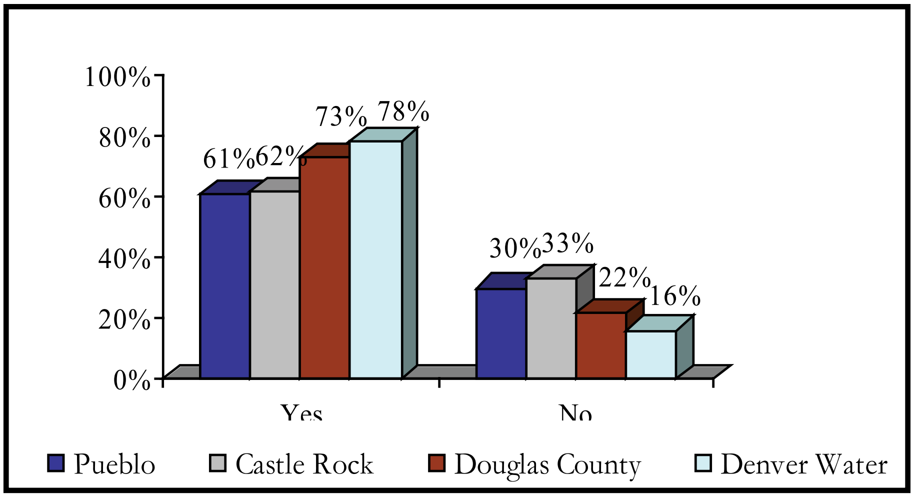
The Mountain West began the decade with more record-setting population growth. Arizona and Nevada, downstream on the Colorado River from Colorado, were the nation's first and second fastest growing states respectively. While California's growth was average (25th nationally), it added 2.58 million people in the first six years of the decade simply because its base is so large.

Complicating water sharing along the river is global climate change. As a recently completed study on the Colorado River Basin concludes, "rapidly increasing populations, warmer regional temperatures and the specter of recurrent drought point to a future in which the potential for conflict…will prove endemic."

Within Colorado, the SWSI provided the first comprehensive inventory of water assets and needs in light of the expected population increase and demand for water. It pegs the population in 2030 at 7.1 million, an increase of 2.8 million, or 65 percent. Water needs are expected to increase by 630,000 acre-feet, or 53 percent.

> **Colorado Promise**
>
> *"My vision for the 21st century calls for maximizing supplies through a responsible mix of conservation, re-use, efficiency, cooperation and voluntary crop-to-city water agreements."*

Figure 4: Residents' belief that Colorado is still in a drought by area.



Population Projections by Basin and Increase in Water Demand

Figure 3 combines SWSI population and water data for each basin. The study projects that, if 80 percent of all the projects and processes, such as storage and reuse, conservation and water efficiency are implemented, there will still be a gap of more than 100,000 acre-feet. The largest gap will be in the Platte River Basin, specifically a 50,000 acre-foot shortfall in the south-Denver metropolitan area.

Governor Bill Ritter and Water Policy

Gov. Ritter's first two major initiatives affecting water policy were the selection of experienced attorney and former DNR head, Harris Sherman, to serve another term leading the department. His first water legislation signing ceremony was in Pueblo and made as law a water-quality bill long promoted by Arkansas Valley interests to strengthen the hand of opponents to water diversion.

The bill was amended sufficiently in its final passage to win the support of many original suburban Denver opponents. But its passage and signing are illustrative of the emphasis of the new administration on "conservation, reuse, efficiency, cooperation and voluntary crop-to-city water agreements" before water diversion or big new storage projects (Colorado Promise).

Public Opinion Supports Conservation, Action on Water Policy

When asked in 2005 and 2006 if the state was in a drought, residents of much of the Front Range said "yes" (Figure 4.) From the Denver metropolitan area to Pueblo, more than 60 percent of residents believed the drought was still on.

A majority of residents in a variety of cities believed water shortages were possible in 10 years in their local areas. About a fifth of Pueblo, Castle Rock and Douglas County residents said they had significantly reduced their water use, with reduced water bills, the fear of drought and water shortage the main motivators.

Figure 5: Residents' support for water conservation actions.

	Strongly/Somewhat Agree			
Type of Action	Castle Rock	Douglas County	Denver Water	Pueblo
Limit lawns for new homes	77%		71%	69%
Increase public education	93	--	--	89
All new developments must have adequate water	96	97	--	--
Increase rates to conserve	27	42	--	--
Reuse for drinking water	46	51	33	--

Are We Still in a Drought?

Residents supported taking action to curtail water use, including limiting lawns for new homes; increasing public education; and in high growth areas, like Douglas County, ensuring all new developments have adequate water. However, resistance continues to the use of treated wastewater for drinking.

Also, residents are rate-sensitive, and the surveyed publics did not support increasing rates to achieve conservation goals (Figure 5). However, various constituencies said they would support increased rates for specific objectives, such as building a local reservoir, like Rueter-Hess Reservoir near Parker, expanding Pueblo Reservoir, or buying Arkansas River water for Pueblo and the Basin's future development.

Support More Water Conservation Actions

Residents support long-range water planning and prefer cooperation over conflict. For example, Castle Rock and Pueblo water utilities tested a variety of initiatives proposed between now and 2050 for water acquisition and project development and received substantial support. Also, Douglas County residents preferred water providers work together and Pueblo residents endorsed cooperation between Pueblo and Colorado Springs to solve problems.

Figure 6: Key questions.

- ? Can Colorado secure its share of compact water
- ? Can supplies get to where demand is
  - Can agreements be reached between Front Range and Western Slope
  - Can a solution be structured for Arkansas Valley in- and out-of-basin stakeholders
  - Can Colorado develop a fallowing program that is significant, fair and secure
  - Can south metro area reduce aquifer dependence
- ? Can new water entering metro area be shared
- ? What is contribution of new technology, new engineering and new conservation ethic
- ? What is the state's role; studies, facilitation, financing, other

Making Progress on the Key Questions

Population is rapidly increasing and the population centers, even after aggressive conservation, will require more water. The cost of the new storage, reuse, more efficiency and even conservation will be steep. But doing nothing will be worse. Draconian drought restrictions, tourism and business losses, and trucked-in water for human consumption in some areas are distinct possibilities.

At Gov. Owens final press conference, he said his biggest policy regret was the lack of resolution of the state's major water disputes. The key water questions have not changed with the November election outcome nor has the difficulty of implementing solutions (Figure 6).

The Ritter Administration does have the advantage of the first well-conducted state water inventory, a couple of years of dialogue within and among basins, and considerable good will from the major stakeholders. Now the new administration must join those stakeholders to make real progress on some of the key questions.

Comments and PowerPoint presented at the 2007 Colorado Water Congress 49th Annual Convention. Floyd Ciruli is president of Ciruli Associates, a research and consulting firm that provides services to Colorado water providers.

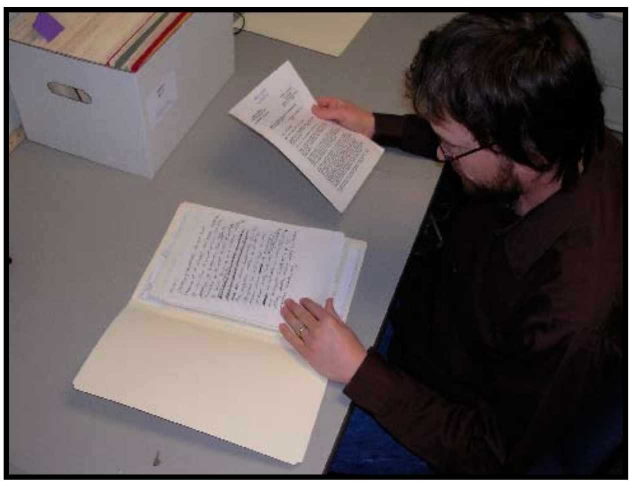
Indispensable for History Graduate Student's Research: the Water Resources Archive

by Nicolai Kryloff, Graduate Student, Department of History

Good historical research depends upon good resources. For graduate students, quality primary-source material can breathe life into a difficult topic. Without it, even a promising idea can become dull and arduous. I have been fortunate. As a graduate student in history, Colorado State University's Water Resources Archive has provided the raw material that has made my historical investigations possible.

Living in the West, I have long been intrigued by the special importance attached to water. In Colorado, much of this resource's fascinating history has been well documented, yet some stories remain untold. In the parched summer of 2006, an old issue resurfaced in a new way. The South Platte valley made national headlines when hundreds of irrigation wells were ordered to stop pumping.

As I learned more about this development, I was surprised to discover that the origins of groundwater use and regulation in Colorado have been relatively unexplored by historians. I became determined to reverse the oversight- to reconstruct groundwater development and management along the South Platte within a social, cultural, and environmental context.



Nicolai Kryloff, History Graduate Student.

But historical accounts of this subject proved to be few, and consensus among them was elusive. Without a clear roadmap to guide my way, I plunged into primary-source research: firsthand accounts of the farmers, lawmakers, and engineers who made history as it happened.

When relying on materials of this type, the holdings of repositories such as the Water Resources Archive become indispensable. Among the more than forty collections housed by the archive, three provide particular insight into the state's groundwater development and management: the papers of Delph Carpenter, the Groundwater Data Collection, and the papers of Robert E. Glover.

Delph Carpenter was most famous for his leading role in crafting many of Colorado's interstate water compacts, but his papers provide surprising information about groundwater. This collection reveals descriptions of the South Platte as early settlers found it, while also clarifying their understandings of the groundwater beneath it. A series of notarized testimonials were recorded by Carpenter during research on river compacts, illuminating how human activity changed the river and the aquifer below.

The Groundwater Data Collection consists of reports, data, and correspondence compiled by a group of CSU investigators over several decades. Attitudes and findings of prominent engineers reveal the trajectory of scientific knowledge regarding water underground – both its use and regulation. Included in this collection is a copy of the famous Bittinger-Wright report, instrumental in the crafting of Colorado's Water Rights Determination and Administration Act of 1969, which remains the basis of the state's groundwater administration today.

Robert E. Glover, a prominent engineer and CSU professor, helped develop formulas for charting the movement of groundwater and analyzing the effects of depletions upon surface streams. His papers include a variety of correspondence concerning the resource's development and regulation. These documents often represent both engineering and legal perspectives. The collection contains recommendations from lawyers to policy-makers, complete with Glover's critiques and suggestions of legislative proposals.

Much of this material has only recently become available. There is a certain thrill in conducting research with documents that have remained untouched for decades. As the Water Resources Archive acquires and inventories more collections, it promises to become an even more valuable resource for anyone seeking to understand more about water's history in Colorado.

Antibiotic Resistance Genes as Water Contaminants: Effect of Manure Management

by Heather Storteboom, PhD Student,
and Dr. Amy Pruden, Assistant Professor, Civil and Environmental Engineering

Background

The problem of antibiotic resistance is not a new one. Antibiotic resistant pathogens have been plaguing the medical world since the 1940s, only a few years after antibiotics began to be used widely. In the past century, the problem was deferred to pharmaceutical companies, which have worked to introduce newer, better antibiotics. However, not long after new antibiotics leave the shelves, bacteria adapt and quickly develop resistance. This leaves society in a very precarious position: antibiotics have revolutionized human health, yet their misuse has the potential to diminish their effectiveness. Multiple-resistant pathogens are already becoming a major concern, especially in the hospital environment where immuno-compromised patients are extremely vulnerable.

So what does this have to do with water? In fact, many people are realizing that it may have a lot to do with water. Several studies in the past decade have shown that pharmaceuticals, including antibiotics, are present in our rivers, lakes, and streams. More recently, new technologies allowing direct quantification of antibiotic resistant genes (ARG, pieces of DNA that allow the bacteria to survive in the presence of an antibiotic) in environmental samples have revealed that ARG are also present in surface water and sediments and have both urban and agricultural inputs. In particular, the Cache La Poudre River has served as an excellent model for understanding the behavior of ARG in the watershed.

Composting is often used to treat animal waste.

ARG are often carried on mobile pieces of DNA, meaning that they can be passed from one bacterium to another, even between very different types of bacteria. A novel aspect of this research is that, because of this property, DNA itself is viewed as a contaminant.

Research suggests that the natural environment is serving as a reservoir for ARG, allowing them to persist and potentially be transferred to harmful pathogens. The most likely sources for the antibiotics and ARG in water are human and animal wastes. Just like in humans, animals are given high (therapeutic) doses of antibiotics to treat or prevent bacterial infections. Many food animals are also given small (subtherapeutic) doses of antibiotics for growth promotion. When either humans or animals are given antibiotics, only part of the antibiotic is metabolized, the remainder is excreted unaltered. The fecal environment is highly suitable environment for the persistence and spread of ARG. Therefore, it is crucial to understand what is happening to the antibiotics and the ARG when human and animal wastes are treated.

Purpose

The major goal of this research is to better understand the sources, pathways, and treatment of ARG in the natural environment. Because human and animal wastes are a major source of ARG, we are carrying out several studies to monitor the response of ARG to various water and waste treatment processes. The results of this research will be useful in establishing best management practices for reducing the persistence and spread of ARG into the watershed, especially to drinking water sources.

One process often used to treat animal waste is composting. Manure is amended with dried leaves, grass, alfalfa, or other field/yard waste and is then mixed and watered regularly. When the conditions for optimal composting have been met, high temperatures are achieved (>80°C), which are capable of killing harmful pathogens and results in a manageable, marketable product. The purpose of this

"The most likely sources for the antibiotics and ARG in water are human and animal wastes."

particular study was to determine the response of antibiotics and antibiotic resistance genes (ARG) to high-level and low-level manure management.

Methodology

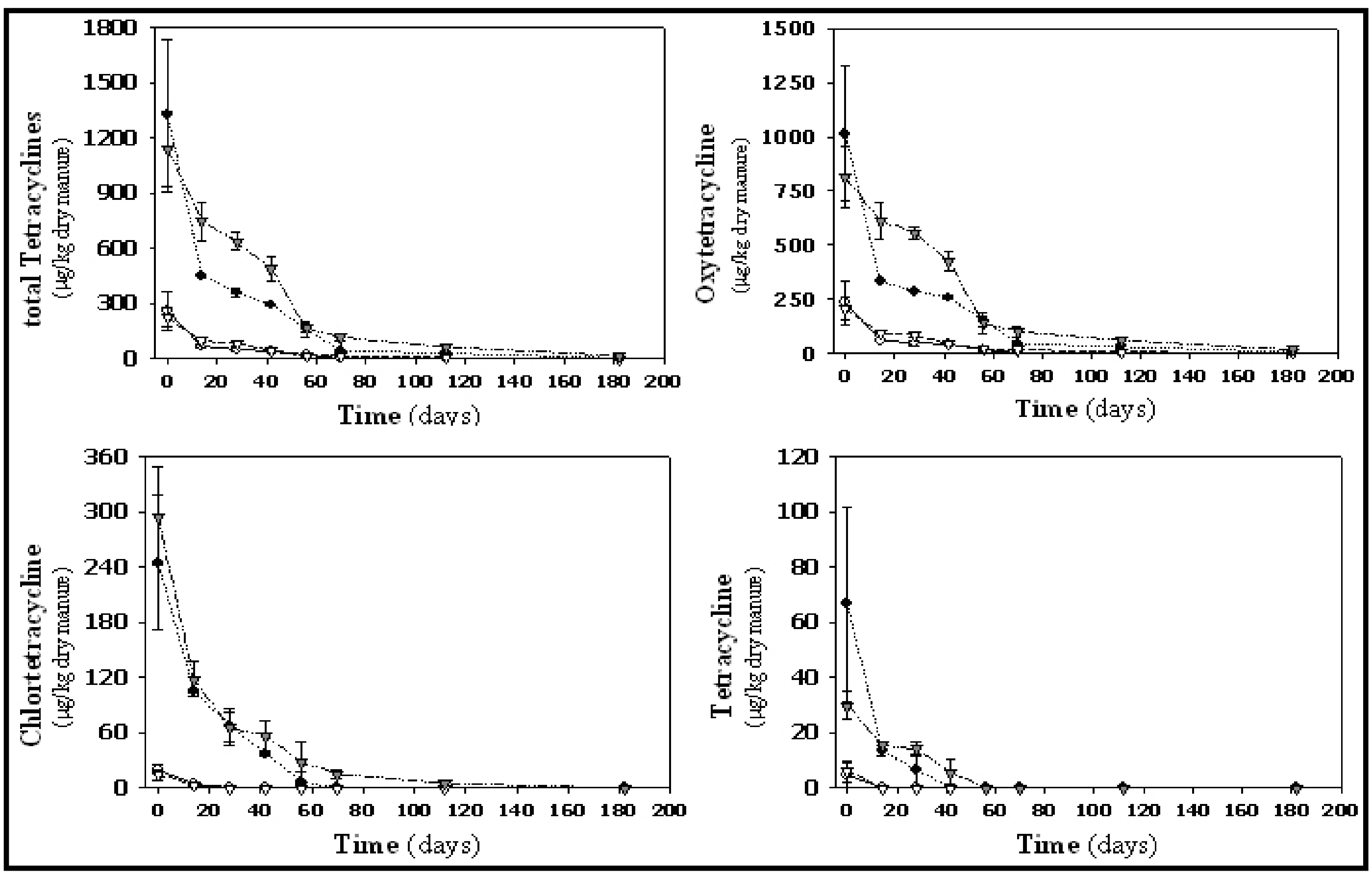
Two types of manure were collected: manure from a dairy with minimal use of antibiotics and manure from a feedlot with regular subtherapeutic use of antibiotics. Each type of manure was divided into two windrows that were subjected to either high-level (amending, watering, and turning) or low-level (no amending, watering, or turning) manure management. Each windrow was divided into triplicate sampling regions and monitored for 6 months. Samples were collected weekly during the first 10 weeks of the study, once every three weeks during the following 10 weeks, and finally on Days 161 and 182. Samples were homogenized and then DNA was extracted from the compost/manure sample. Concentrations of antibiotics and levels of two tetracycline ARG (tet(W) and tet(O)) were monitored.

Results

The response of the tetracycline compounds (tetracycline (TC), oxytetracycline (OTC), and CTC) to treatment are shown in Figure 1. The average half-lives observed were 22.9±12.2 days for TC, 18.3±3.3 for OTC, and 26.5±3.2 for CTC. In dairy manure the initial concentrations of these antibiotics was too low for half-lives to be determined. In all samples, the trend observed with respect to tetracycline concentrations was OTC > CTC > TC. It was not surprising that OTC and CTC were found at the highest concentrations, because they are the most commonly used tetracyclines in animal agriculture. Initial concentrations of OTC, CTC, and TC were significantly higher in the feedlot manures than the dairy manures.

The overall responses of tet(W) and tet(O) were relatively similar. Results from quantitative polymerase chain reaction (Q-PCR analysis of tetracycline ARG are shown in Figure 2. The initial levels of tet(W) and tet(O) were significantly higher in the feedlot manure treatments than in the dairy manure. The high-level managed dairy manure treatments maintained significantly lower levels of tet(W) and tet(O) compared to the feedlot manure treatments through Day 28 of the study. Levels of tet(W) in the low-

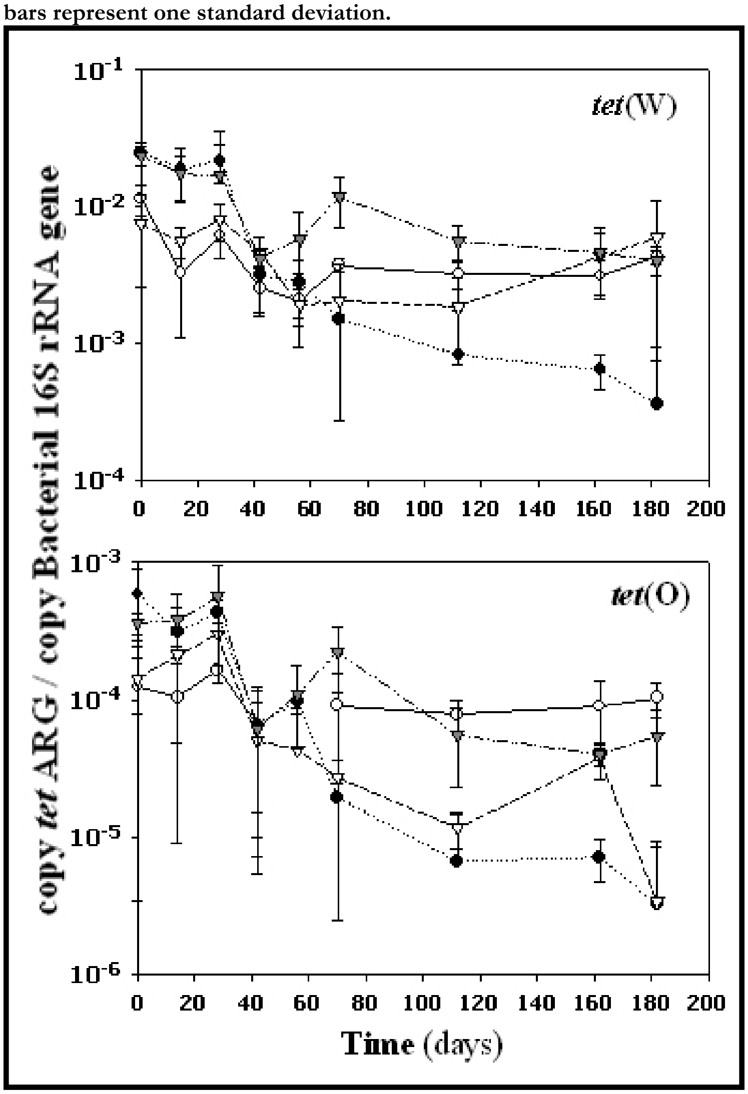
Figure 1: Concentrations of total tetracyclines, and the individual tetracycline compounds (oxytetracycline, chlortetracycline, and tetracycline) quantified in the treatment windrows with respect to time. Data points represent average values of all measurements (performed in triplicate for each sampling region) for the specified windrow. Error bars represent one standard deviation.



level managed dairy manure were significantly lower than the feedlot manure through Day 14. After Day 28 of the study, the levels of tet(W) and tet(O) appeared consistent among all treatments.

Final levels of tet(W) were significantly lower than the initial levels in both the feedlot manure and dairy manure. The final levels of tet(O) were significantly lower than initial levels in all of the treatments, except high-level managed dairy manure, which maintained relatively low levels throughout the study. Levels of tet(W) were initially an order of magnitude higher than tet(O) and maintained higher levels throughout. However, further reduction was observed in most treatments.

Figure 2: Copies of tetracycline ARG normalized to copies of 16S bacterial rRNA gene present in the field samples with respect to time. Data points represent average values of all measurements (performed in triplicate for each sampling region) for the specified windrow. Error bars represent one standard deviation.



Summary and Conclusions

This study demonstrates that appropriate management of animal manures could help reduce antibiotic and ARG inputs into the greater environment. The overall results suggest that the manure type and treatment time are the main factors in achieving low levels of antibiotics and ARG in manure before land application. The level of manure management was not observed to be a significant factor, though future studies comparing more contrasting management approaches would be of interest. With respect to manure type, the feedlot manure had significantly higher levels of ARG than the dairy manure. This is reasonable given that cattle from the feedlot were routinely fed subtherapeutic concentrations of antibiotics, whereas the dairy cattle were only given therapeutic antibiotics during non-lactating periods. With respect to time, six months of treatment was necessary for reduction of ARG levels and antibiotic concentrations in feedlot manure to below 10µg antibiotic/kg dry manure. In the dairy manure, antibiotic concentrations fell below the detection limit after only four months.

While no comprehensive data is available on the minimum concentration of antibiotics that causes selection in the environment, these studies show that at least four months was necessary for the reduction of total tetracycline concentrations below 10µg/kg in a manure with initial concentration of ~400µg/kg, while a manure with initial concentration ~2000µg/kg required treatment times of at least six months. On the final day of the study, levels of tet(W) and tet(O) were still above the detection limit in both manures. In addition, levels of tet(W) and tet(O) often did not directly correlate with a decrease in antibiotics. This provides evidence that ARG may be maintained for extended time periods following the dissipation of the antibiotics; therefore, longer treatment times may be necessary to further reduce levels of ARG.

This research takes an important step in establishing an understanding of ARG as environmental contaminants. Future efforts by water researchers are needed in order to develop a comprehensive understanding of the fate, transport, and appropriate treatment strategies for ARG in the environment.

Phosphorus Recovery in Colorado Agriculture

by Michael Massey, MS Student,
and Jessica Davis, Professor, Department of Soil and Crop Sciences

Michael Massey and Jessica Davis.

Introduction

Struvite (magnesium ammonium phosphate hexahydrate, $MgNH_4PO_4 \cdot 6H_2O$) precipitation in municipal wastewater treatment systems with high phosphorus (P) loading has traditionally been considered a difficult problem in wastewater treatment plant (WWTP) management. To reduce maintenance issues and downtime caused by spontaneous struvite precipitation, and to respond to increasingly stringent regulations on P discharge from WWTPs, wastewater is commonly dosed with iron or aluminum salts to reduce effluent P concentration by binding phosphate in minimally soluble forms. Chemical precipitation, while very effective in reducing P concentration in the treated effluent, also significantly increases the volume of sludge generated in the treatment process. Increased sludge volume increases disposal costs. Furthermore, the insoluble nature of the iron and aluminum phosphates generated by the treatment process makes them unusable for other applications, making disposal the only practical option. In addition to the short-term costs of disposal, the world's dwindling supply of economically extractable phosphate rock makes disposal an increasingly unattractive option for the long term, as well (for more information on P reserves, P recycling, and the commercial P industry, see Schipper et al., 2001, Driver et al., 1999, and Driver, 1998).

Interest in forced struvite precipitation as part of the treatment process has increased in the past ten years. Rather than allowing costly spontaneous precipitation, relatively new processes allow for phosphate to be removed from the waste stream as struvite in a controlled fashion. Other technologies, such as processes for P recovery as calcium phosphates, have also been developed (Van Dijk and Braakensiek, 1984). These technologies can be used to decrease effluent P concentration while simultaneously generating a relatively pure, useful, potentially marketable product; they can also effectively treat effluent without increasing sludge volume and associated disposal costs. However, there are still many barriers that must be overcome before P recovery becomes commonplace in municipal WWTPs. Unresolved issues include P recovery technologies that are still relatively expensive, and markets for recovered P that are not yet well developed.

Agricultural wastewater, such as that found on dairy and swine operations shares many of the same characteristics of municipal wastewater. In Colorado, agricultural wastewater is often applied to fields directly from anaerobic storage and treatment lagoons. The high nitrogen (N) to P ratio of typical agricultural wastewater when compared to plant nutrient needs, however, results in a significant over-application of P to cropland if the effluent is applied at a rate calculated to meet plant N needs. Over the long term, a buildup of P could become a significant risk to water quality through soil erosion or runoff, and contribute to eutrophication of P-enriched surface water bodies. One potential solution to this difficult waste management conundrum is to lower the concentration of P in agricultural wastewater prior to land application, so that wastewater could be applied to meet plant N needs without applying P in excess of biological requirements.

Due to the similarities between agricultural and municipal wastewater, techniques for municipal wastewater treatment might also be used in the treatment and management of agricultural wastewater. However, there are other constraints that must be met in order to create practical treatment solutions for agricultural settings. A viable technology must be robust, simple, practical on a smaller scale than most WWTPs, and relatively inexpensive to install and operate. Increased sludge volume, such as by chemical precipitation, would likely drastically shorten a waste treatment lagoon's useful lifespan and so is not an optimal solution. P recovery is one possible alternative. Successful application of P recovery processes in agriculture would decrease environmental risk while potentially providing a livestock operation with an additional source of revenue (the product of the treatment process). However, the treated effluent must remain suitable for land application, which precludes the use of certain chemicals such as sodium hydroxide commonly used in existing P recovery processes at WWTPs. Clearly, the additional economic and practical constraints on agricultural wastewater treatment make finding a solution to this already complicated problem even more difficult.

We have been investigating the feasibility of P recovery on Colorado dairy farms since the spring of 2006 thanks to a grant provided by the USDA NRCS through the Farm Pilot Project Coordination, Inc. and Applied Chemical Magnesias Corporation of Loveland, CO. During the summer of 2006, we used a demonstration scale cone-shaped fluidized-bed reactor built by Dr. Ron Sheffield of the University of Idaho to treat anaerobic waste lagoon effluent at two northern Colorado dairy farms. Analysis of the reactor's performance is ongoing, as is examination of the product harvested from the treatment process. In addition, a greenhouse study to assess the potential effectiveness of recovered struvite as fertilizer in Colorado soils began in March 2007. If recovered struvite is shown to be an effective fertilizer, P recovery as struvite for use on local farms and in local gardens might one day become a reality.

The fluidized-bed reactor was used to treat anaerobic waste lagoon effluent.

Wastewater Treatment

The University of Idaho struvite crystallizer is a cone-shaped fluidized-bed reactor similar to the one designed, built, and tested by Bowers and Westerman (2005). The primary components of the fluidized-bed crystallizer system are a 250 gal holding tank and a large, inverted conical reactor vessel. The reactor cone is initially seeded with a bed of finely ground rock phosphate material to provide sites for the growth of struvite crystals. During operation, wastewater is acidified in the holding tank and pumped into the base of the reactor cone through a manifold. Inside the manifold, other substances such as magnesium (Mg) solution, hydroxide solution, or gaseous ammonia can be combined with the effluent stream. Effluent then enters the cone, and passes through the bed of material at its base. Treated effluent drains back into the waste treatment lagoon from the top of the cone. Bowers and Westerman (2005) used this system along with pH alteration and Mg addition to remove up to 81% of the orthophosphate (OP) and 80% of the total phosphorus (TP) in swine lagoon wastewater.

Our initial experiments used the "conventional" treatment process, which utilizes hydrochloric acid (HCl) to lower the pH of the wastewater in the holding tank, and anhydrous ammonia (NH3) to raise the pH as the effluent enters the cone. Acidification increases the concentration of OP in the effluent by dissolving inorganic phosphate complexes already present in the water, and rapidly raising the pH encourages the precipitation of phosphates as the effluent passes through the seed material. Though supplemental Mg is added in many existing struvite recovery processes, the dairy wastewater at both locations for this study was very high in Mg, so none was added in our experiments. After initial tests with the conventional method, we developed and field-tested a new process that uses acetic acid in place of HCl and potassium hydroxide (KOH) solution rather than NH3. The chemicals in the new process are allowed for restricted uses in certified organic food production, and in the future it is hoped that struvite recovered using this process will also be certifiable for organic production. This would improve the economics of P recovery, as well as the environmental sustainability of livestock agriculture and organic food production in Colorado.

During the field experiments, wastewater was pumped from an anaerobic lagoon into the holding tank, and adjusted to a pH of 5.2. Liquid in the tank was continuously mixed by a pump at its base, and electrodes were used to monitor pH. Once the target pH was reached, acidified wastewater was pumped at a rate of 1.8 to 2 gal min-1 through the manifold, where either NH3 or KOH solution was added to rapidly increase the pH to 7.5-8.3. The rapid pH increase resulted in the precipitation of phosphates on the seed material.

Wastewater Treatment Results

The experiments were performed at two northern Colorado dairies. Samples of the raw lagoon wastewater, acidified reactor input, and treated effluent were taken and analyzed at the CSU Soil, Water, and Plant Testing Laboratory. Selected results of the wastewater analysis are shown in Table 1.

Both the conventional and new processes demonstrated similar performance for TP and Mg removal, though the performance did not match that of Bowers and Westerman (2005) using swine wastewater. The conventional process removed a greater percentage of OP than the new process, suggesting that the new process would benefit from further work in order to achieve optimization. There are a number of potential culprits for the relatively low P removal efficiency observed in our experiments, including interference from high levels of calcium, interference from suspended organic matter present in the waste stream, or a flow rate that was too high, which would have caused incomplete reaction in the reactor vessel.

In addition to low P removal efficiency, X-ray diffraction analysis of the products did not identify crystalline struvite in the reactor material from Colorado. Subsequent examination with an electron microscope did find amorphous Mg phosphate particles in the harvested product. Any of the factors that may have resulted in low P removal efficiency could also have contributed to the amorphous (rather than crystalline) nature of the product.

Though our field tests of the cone-shaped fluidized-bed reactor for P recovery on Colorado dairy farms did not yield ideal results in terms of P removal efficiency or product characteristics, we were able to successfully remove P from lagoon effluent. Further adaptation and refinement of this or other P recovery technologies to suit local conditions may soon enable effective P recovery from agricultural wastes. Successful application of P recovery processes could significantly improve P cycling in agriculture, provide livestock operations with an additional source of revenue, and protect surface waters from pollution risks associated with the over-application of P to cropland.

Fertilizer Evaluation

Because of its chemical composition, recovered struvite is not currently usable as a feedstock by the commercial P industry. The N in struvite would cause serious emission problems during the sintering stage of "dry" P production (Schipper et al., 2001), and the Mg interferes with the chemistry of "wet" phosphoric acid production (Driver et al., 1999). However, several investigators have evaluated recovered P for direct use as a slow-release P fertilizer (for example, see Johnston and Richards, 2003). There are full-scale P recovery facilities at several WWTPs throughout the world, most notably in the Netherlands and Japan. Some of these WWTPs even sell the treatment byproduct in fertilizer mixes (Ueno and Fujii, 2001).

In all cases, however, the effectiveness of struvite has been evaluated on soils of acidic to neutral pH. There is no information regarding struvite use as a fertilizer on alkaline or calcareous soils common to Colorado and the western United States. If economical P recovery from agricultural or municipal wastewater in Colorado is to be realized, local uses must be found for the recovered product.

To that end, a greenhouse trial comparing recovered phosphates with conventional P fertilizers began on March 2, 2007. An acidic (pH 6.4-6.5) rangeland soil with moderate P availability from northern Colorado was treated with powdered CaCO3 to raise its pH to approximately 7.5, equivalent to that of a slightly calcareous soil. Fertilizers were applied to both the low pH and high pH soils, to evaluate their performance as P sources for wheat ("Zeke" hard red spring variety).

"P recovery from agricultural and municipal wastewater in Colorado is already a technologically feasible and **ENVIRONMENTALLY ATTRACTIVE**

Recovered product made in Colorado from the new water treatment process was applied, as was struvite recovered in Washington using the conventional treatment process, and magnesium ammonium phosphate hydrate (dittmarite, MgNH4PO4•H2O) removed from a food processing plant during cleaning. Certified organic rock phosphate and triple superphosphate fertilizer treatments were also included to compare the performance of recovered phosphates against that of more conventional P fertilizers. Monitoring and analysis of plant growth and P uptake is planned through July of 2007. If the recovered phosphates demonstrate satisfactory performance, the use of P recovered from municipal or agricultural sources as fertilizer on Colorado soils may indeed be practicable.

Conclusion

P recovery from agricultural and municipal wastewater in Colorado is already a technologically feasible and environmentally attractive water treatment alternative. It may become an economically attractive one in the relatively near future, as well, as supplies of P dwindle and strict water quality standards designed to protect surface waters compete with rising waste disposal costs. Struvite production is one option for P recovery, but its effectiveness as a fertilizer on the alkaline, calcium-rich soils commonly found in Colorado is untested. If struvite is found to be an effective fertilizer under local conditions, then P recovery in Colorado, with its associated economic and environmental benefits, will be that much closer to becoming a reality.

We would like to thank the NRCS, Farm Pilot Project Coordination, Inc., and Applied Chemical Magnesias Corp. for financial support. We are also grateful for the assistance of Dr. R. Sheffield of the University of Idaho, dairy owners in northern Colorado, Dr. J.A. Ippolito, Dr. J.R. Self, K. Doesken, A. Elliott, and M. Smith.

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Economic Impacts of Reduced Irrigated Agriculture in Eastern Colorado: A Summary of Three Studies

by Jenny Thorvaldson, PhD Student
and James Pritchett, Assistant Professor, Department of Agricultural and Resource Economics

Irrigated agriculture is a primary water user in the West, but rapid population growth is driving a reallocation of water use. As Colorado's population grows, water will shift from agriculture to municipal and industrial (M&I) uses. Indeed, it is expected that 428,000 acres of irrigated farmland will dry up to meet future needs (Colorado Water Conservation Board, 2004), and these estimates may be quite conservative (Smith, 2005). In addition, evolving legal institutions and groundwater depletions have significantly decreased available irrigation water and have reduced irrigated cropland.

Jenny Thorvaldson

Initial Research

Colorado's Evolving Irrigated Agriculture: Economic Accounting and Impact Analysis

The primary goal of this research project was to estimate the short-term regional economic impacts associated with a reduction in irrigated agriculture as a result of increasing population and urbanization in Colorado. The study involved four river basins in eastern Colorado (the Arkansas, Republican, Rio Grande, and South Platte basins). Each basin was analyzed separately because of the unique economic base and idiosyncratic water demand/supply conditions in each basin. Specific outcomes included:

- Establishment of economic demographics for each basin, including a description of irrigated agriculture's contribution to the local economy.

- Development of an Input-Output (I-O) model for each basin, representing the financial interactions between all of the sectors in that basin's economy.

- "Shocking" each I-O model to approximate the short-term economic effects of a reduction in irrigated agriculture. Acreage reductions were based on projected population growth and were provided by the SWSI report publicly released in December 2004. All formerly-irrigated acres were assumed to be fallowed, with the original crop-mix being maintained (i.e., acres were assumed to be taken out of irrigation proportionately). A summary of the output impacts can be seen in Table 1.

- Multiple outreach presentations to stakeholders, a presentation in the CSU Department of Agricultural and Resource Economics seminar series, and a presentation to the annual Western Agricultural Economics Association meetings in Anchorage, Alaska.

- Four fact sheets published on the Colorado State University website and a Completion Report (# 207) published on the CWRRI website

Table 1: Output Impacts by Basin

Basin	Estimated Acres Lost	Total Economic Impact	Impact as % of Total Output	Impact as % of Agriculture	Impact as % of Irrigated Crop Sales	Economic Activity per Acre
East South Platte	159,500	-$110,065,962 1	.02% 3	.20% 1	3.87%	$428
East Arkansas	47,500	-$20,333,467 0	.12% 5	.64% 5	2.28%	$690
Republican 2	0,000	-$13,550,801 0	.43% 0	.82% 2	.08%	$678
Rio Grande	80,000	-$98,783,450 3	.95% 8	.16% 8	.72% $	1,235

and in print.

- A Master's thesis.

Current Research

Some Economic Effects of Changing Augmentation Rules in Colorado's Lower South Platte Basin: Producer Survey and Regional Economic Impact Analysis

The previous research project focused on building the capacity to examine the economic contribution of irrigated agriculture, and then quantifying the economic impacts of reduced irrigated acres due to the growth and urbanization of Colorado's population, based on the forecasts from SWSI. It focused on four basins in eastern Colorado, where the majority of the state's agricultural production takes place and where the majority of water transfers are expected to originate. Economic demographics have been established in each basin for building the appropriate model, resulting in a baseline value for the impacts in each basin.

The current project focuses on agricultural producers in the Lower South Platte (LSP) basin[1] that had GASP wells. To fine-tune the model and estimates from the initial study, the current project began by administering a survey of these producers to better gauge producers' responses to the increasingly limited water supply in Colorado. Thus, rather than assuming that all formerly-irrigated land is fallowed and that cropping patterns remain unchanged, the survey provides more-precise estimates of changing acreages and cropping patterns. As irrigated acres are reduced, different cropping patterns may result, suggesting alternative impacts to the regional economy. For instance, the impact will likely be greater if the lost irrigated acres are all converted to grassland (i.e., taken out of production) than if they are converted to dryland crops (those reliant on rainfall).

Furthermore, if the acres are all converted to dryland crops, the magnitude of the impact will depend on which dryland crops are chosen (e.g., winter wheat vs. sunflowers), as each of these crops will bring in varying amounts of revenue and will require different inputs from local agribusiness. Specific objectives include:

- Development of an Input-Output (I-O) model for the LSP basin, representing the financial interactions between all of the sectors in the regional economy.

- "Shocking" the I-O model to approximate the regional economic effects of changes in irrigated agriculture based on two scenarios:

  1. The high-end scenario assumes acreages change exactly as estimated by the survey.

  2. The low-end scenario makes the assumption that the high-valued crops taken out of production by GASP farmers are replaced elsewhere in the LSP basin by farmers that have irrigation sources other than GASP wells. These non-GASP producers are assumed to replace some of their lower-valued crops with the higher-valued crops, such that the net loss of acreage in the LSP is the same as estimated by the survey but the lost acres are composed of lower-valued crops.

- Multiple outreach presentations to stakeholders and a presentation in the CSU Department of Agricultural and Resource Economics seminar series.

- A fact sheet published on the Colorado State University website and a Completion Report published on the CWRRI website and in print.

Preliminary results (as of yet unpublished) are shown in Table 2.

Table 2: Output Impacts by Scenario

Scenario	Acreage Change	Total Impact	Impact as % of Total Output	Impact as % of Agriculture	Impact as % of Irrigated Crop Sales	Economic Activity Generated by Lost Acres
High-End	-29,190	-$28,209,654	0.8%	3.4%	18.7%	$966.42 / ac.
Low-End	-29,190	-$10,752,816	0.3%	1.3%	7.1%	$368.37 / ac.

[1]For the purposes of this study, the Lower South Platte Basin is defined as Logan, Morgan, and Sedgwick counties.

Forthcoming Research

Preparing for Drought: A Survey of Producer Adoption of Limited Irrigation Practices and Dynamic Optimization of Limited Irrigation Cropping Patterns

In the West, the economic sustainability of agricultural producers is tightly woven with water availability. Irrigation is an important risk-reducing input that shelters farm income from drought and boosts crop yields. In addition, irrigation permits farmers to produce crops that otherwise could not be grown competitively in our semi-arid environment. As irrigation was developed, farms generated important economic activity for rural communities and regional economies.

Irrigated agriculture is a primary water user in the West, but rapid population growth is driving a reallocation of water use. As Colorado's population grows, water will shift from agriculture to municipal and industrial (M&I) uses. Indeed, it is expected that 428,000 acres of irrigated farmland will dry up to meet future needs (Colorado Water Conservation Board, 2004), and these estimates may be quite conservative (Smith). In addition, evolving legal institutions and groundwater depletions have significantly decreased available irrigation water and have reduced irrigated cropland.

Specific objectives of this research project include:

- Analyzing the feasibility and profitability of potential irrigation systems. In particular, comparing cropping systems according to the ability to meet a financial need is central to farmers' ability to make strategic cropping decisions.

- Estimating current and future adoption rates of such systems and the resulting changes in crop ping patterns and irrigated acreages.

- Using the adoption rate estimates, provide initial examination of the impact of changing cropping patterns on regional economies.

The procedure begins by calculating whole farm net returns based on different cropping patterns and irrigation systems. These financial data will be presented to agricultural producers in eastern Colorado, after which a survey of these same producers will be administered to gauge the adoption rates of limited irrigation practices and any corresponding changes in cropping patterns. The IMPLAN software will then use the most recently available data to create an Input-Output (I-O) model for each of the major water conservation districts in eastern Colorado. The baseline I-O model will be used to gauge irrigated agriculture's relative importance to rural communities in the study area and the spillover effects that irrigated agriculture's sales create for local economies. The changes in cropping patterns and irrigated acreage estimated by the survey will then be used to "shock" the I-O model in order to estimate the economic impacts of these changes on regional economies. Significant economic effects will result as cropping patterns evolve from full irrigation to innovative cropping systems and dryland agriculture.

Hydrogeomorphic Characterization and Classification of Pacific Northwest Mountain Streams for Biomonitoring

by Christopher O. Cuhaciyan, PhD Graduate,
Department of Civil and Environmental Engineering

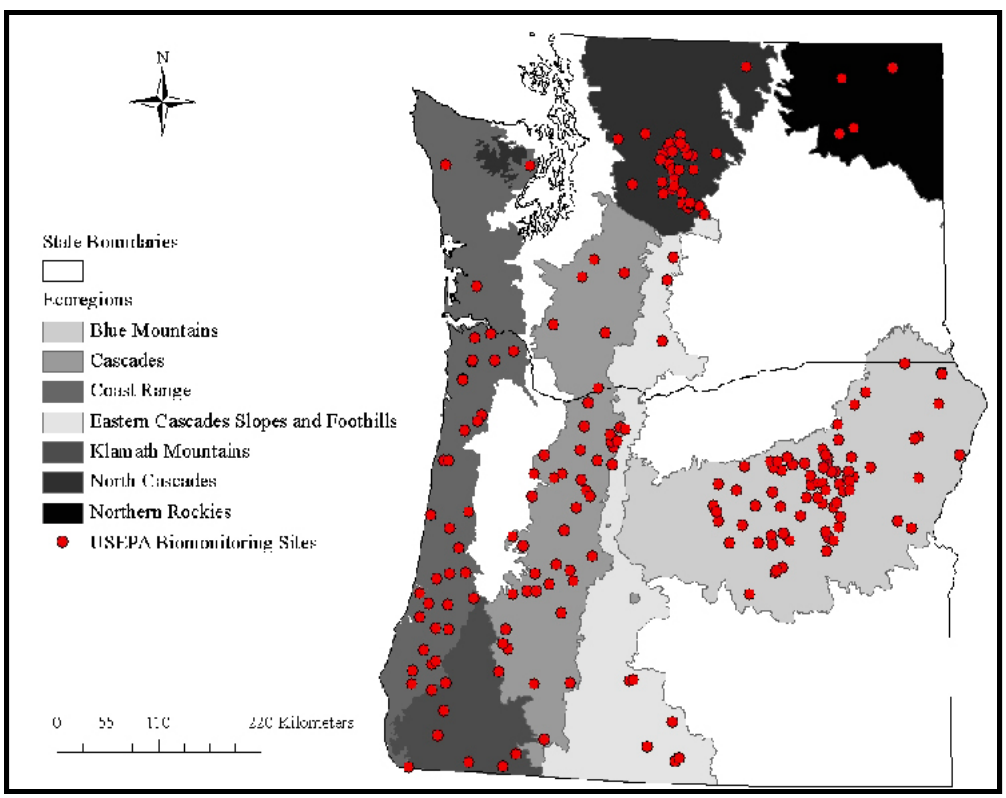
The Clean Water Act of 1972 requires that states monitor, maintain, and restore the ecological integrity and aquatic life uses of waters in the United States. Biomonitoring (and bioassessment), the examination of environmental condition and ecological integrity using field monitoring of aquatic biota, is a common technique for gauging ecosystem health. This technique involves comparing observed biotic assemblages to those that would be expected if ecological integrity was intact (Barbour et al. 1999, Karr 1999, Bonada et al. 2006). This is no trivial task as there is often little or no available information regarding the pre-disturbance condition (Hawkins and Norris 2000).

Regional or geographic classifications are commonly used as frameworks for developing reference conditions and conducting comparisons of streams of presumably similar ecological potential (Hawkins and Norris 2000, Stoddard 2005). Such classifications often take into account several landscape characteristics such as topography, geology, vegetation, climate, and soils (Stoddard 2005). Ecoregions are the predominant spatial units within which stream reference conditions are developed, but they neglect important valley- and reach-scale influences on stream habitats. Further, few existing classifications integrate hydrologic and geomorphic (i.e., hydrogeomorphic) typologies and none explicitly describe physical processes and boundary conditions of relevance to stream biotic assemblages. The strong gradients and spatial heterogeneity in hydrologic, climatic, and lithotopographic characteristics occurring in some regions can confound bioassessments. This issue is perhaps most relevant to mountainous regions that encompass a variety of precipitation regimes, geologic contexts, and vegetation zones.

A better understanding of how multi-scale hydrologic and geomorphic characteristics influence and constrain biological potential could provide significant improvement in our understanding of spatial and temporal patterns in stream insect assemblages and other stream communities. A landscape-scale stream classification based on influential physical habitat characteristics could prevent spurious biological comparisons among streams with critical differences in physical processes and improve our ability to detect water-quality impairment in a defensible manner.

In this study, United States Environmental Protection Agency (USEPA) biomonitoring data collected from

Figure 1: USEPA biomonitoring sites in Pacific Northwest mountainous ecoregions.



mountainous ecoregions of the Pacific Northwest were used to develop and test hydrogeomorphic classifications of stream insect communities (Figure 1). Biomonitoring sites were screened using reach-specific water quality and riparian disturbance characteristics to remove sites that were heavily impacted by human influence. Cluster analyses were used to group biomonitoring sites by similarity in insect assemblages, which provide the basis for "spatially-neutral" classifications that represent the "best" achievable classifications.

A geographical information system (GIS) was used to characterize hydrologic regimes and geomorphic boundary conditions at each of the biomonitoring sites. A total of 29 innovative watershed-, network-, and valley-scale metrics were developed to characterize major geomorphic boundary conditions with the potential to influence stream insect community composition. Few, if any, of the biomonitoring sites were located on gauged stream reaches, therefore hydrologic metrics were extrapolated from U.S. Geological Survey stream gauges with relatively unaltered flow regimes (Sanborn and Bledsoe 2006). Field-measured descriptions of biomonitoring sites were also used to develop classifications and provide a means for comparing GIS metrics to observed field data. A total of 29 USEPA metrics (Kaufmann et al. 1999) were selected, including measures of channel geometry, channel substrate, large woody debris, riparian characteristics, and various habitat types.

These multi-scale metrics were then used to develop a priori (without biological calibration) and a posteriori (biologically calibrated) classifications of biomonitoring sites. A priori classifications were developed using professional judgment and regional knowledge of potential physical drivers. Classification Trees (CTs, Breiman et al. 1984) were used to develop the a posteriori models. These models were trained using the physical metrics developed in GIS to decide which class (cluster) a site belongs to from the cluster analysis. All classifications were compared to the spatially-neutral model and to geographically-dependent classifications including Level III ecoregions. Similarity of stream insect assemblages within and among classes was used to develop quantitative measures of classification strength for comparing classification performance.

Several a priori classifications resulted in higher classifications strengths than ecoregions, including two hydrologic and two geomorphic classifications which had fewer classes than ecoregions, and nine of 18 hydrogeomorphic models, five of which had fewer classes than ecoregions. A posteriori models were robust and explained as much as 90% of the biological variation indicated by spatially-neutral models, as compared to 57% for a priori models.

The most important metrics in a priori models were based on a valley-form metric and low-flow classification. Valley form has a strong influence on stream-channel condition (Hynes 1975), including local habitat and disturbance regimes. The presence and extent of floodplains is correlated with many stream characteristics that could be directly influencing stream assemblages, including energy dissipation, slope, potential for hyporheic exchange, stream type (e.g., Montgomery and Buffington, 1997), large woody debris, and adjacent riparian communities. Low-flow conditions constrain biota by reducing habitat availability and applying strong selective forces on biota (Lytle and Poff 2004). Low flows may also be associated with increased pollutant concentrations and elevated stream temperatures.

A posteriori models developed using both hydrologic and geomorphic metrics generally outperformed and were more consistent in attaining high classifications strengths than models using either type of metric alone. Metrics describing the presence and extent of floodplains, channel slope, surrogates for stream power, and watershed area were among the most common geomorphic metrics in models, whereas common hydrologic metrics included those describing peak flows, low flows, and rate of change in flows.

A posteriori classifications confirmed at least three important results of a priori classifications. First, they confirmed that valley form is a powerful and robust metric by which to partition relatively homogeneous stream habitats. Second, they confirmed the importance of hydrology as a key influence on aquatic insects, and underscored the importance of metrics describing low flows. Finally, they consistently suggested that substrate characteristics, measured as D50 or percent sand and fines, have surprisingly little association with stream insect assemblages in minimally-disturbed mountain streams of the Pacific Northwest.

The classification strengths of hydrogeomorphic models have important implications for biomonitoring relative to ecoregions. Ecoregions were determined to be a moderately strong and consistent classifier of stream insect assemblages; however, ecoregions provided relatively little understanding of specific relationships between stream assemblages and key environmental influences, especially when compared to the potential of hydrologic and geomorphic characterizations of habitats. The predictive power of the CTs developed in this study suggests that combining geospatially-derived metrics with CT modeling provides a more physically-based, yet straightforward and interpretable, means of classifying and mapping key physical influences on benthic community structure.

The importance of multi-scale processes and boundary conditions to stream assemblages is widely recognized (e.g., Frissell et al. 1986, Parsons et al. 2003, Snelder et al. 2004) and clearly supported by the models developed in this study. The relevance of valley-scale morphology in describing stream insect assemblages was a central finding of this work. Although valley context has long been recognized as a highly influential control on stream character (Hynes 1975), previous studies have generally shown weak correlations between valley-scale morphology and stream benthic macroinvertebrates (Parsons et al. 2003, Snelder et al. 2004).

Hydrogeomorphic classifications provide a framework for identifying relatively homogeneous habitat types and enhance stream-habitat restoration by providing hydrologic and geomorphic habitat endpoints to strive for in ecological restoration efforts. GIS-derived hydrologic and geomorphic metrics provide a basis for mapping multi-scaled hydrogeomorphic settings and putative habitat types across entire landscapes, and a platform for process-based stratification in biomonitoring designs. The hydrogeomorphic classifications developed in this study may be used to improve biomonitoring network design and reduce spurious comparisons of biomonitoring sites, while providing a scientifically defensible basis for quantifying departures from reference conditions.

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Riparian Forest Restoration Initiative Project Proposed for the North and South Platte Rivers

by Dennis Adams, Nebraska Forest Service,
Mark Hughes, Wyoming State Forestry Division,
Greg Sundstrom, Colorado State Forest Service

Protecting the Platte River System

Colorado is home to the headwaters of the North and South Platte Rivers. The North Platte River flows through Wyoming, and joins the South Platte River in North Platte, Nebraska. The Platte River system is part of the Missouri River Watershed. Riparian areas of the Platte River and its tributaries are valuable areas that may have been degraded by a general lack of management or protection, and by the invasion of exotic plant species that frequently out-compete and may significantly reduce—or eliminate—populations of native species. Lack of flooding has largely eliminated the establishment of new stands of cottonwood and willow.

The Riparian Forest Restoration Initiative Project proposal recommends a variety of actions, including strategic planning, education and demonstrations, re-vegetation and restoration, and policy and programs, that can be taken to encourage and support riparian forest restoration where woody invasive species management has or may be implemented in the Platte River watershed.

Eradicating Noxious Weeds

Tamarisk (Tamarix spp.), also known as salt cedar, has encroached into the riparian gallery forests along the Platte River and its tributaries in Colorado, Wyoming and Nebraska. Woody invasive species management could be considered a required first step for initiating large-scale restoration of these valuable riparian forest systems. Whether eradicating or controlling the spread of individual plant species is the goal, restoration of the Platte River riparian forest system will require cross-boundary, watershed-scale efforts to be effective. State foresters in Colorado, Nebraska and Wyoming are committed to addressing this issue and are proposing an initiative to involve forestry agencies, interested partners and stakeholders in restoring the Platte River riparian forest where it has been impacted by tamarisk.

Tamarisk has been declared a noxious weed in all three states, and Russian olive (Elaeagnus angustifolia) has been declared noxious in Colorado and Wyoming. Other woody species also may have encroached into riparian areas, but the states involved have not declared them noxious weeds. Actions proposed by the three state foresters will focus primarily in areas associated with tamarisk, but also may include areas where Russian olive is associated with tamarisk. All three state forestry agencies recognize that both species in riparian ecosystems degrade certain functions of those systems.

Within the Platte River Watershed, tamarisk generally is associated only with riparian areas, but Russian olive has been used extensively for community forestry and conservation plantings in both upland and riparian areas. Any action taken in individual states will need to be done in compliance with state weed laws. In addition, practicality and economic feasibility must be considered when determining what actions to employ.

Tamarisk changes site characteristics by accumulating salt on the soil surface. This degrades the quality of soils and surface water run-off. Tamarisk has a relatively short seed viability period (45 days) compared to Russian olive (3 years), which makes tamarisk eradication more feasible. For these reasons, a primary goal of most actions involved with Platte River riparian forest restoration is to eradicate tamarisk in the watershed. A secondary goal is to help control the spread of Russian olive where it is associated with tamarisk. State weed management agencies have, or may have, strategies in place to deal with these invasive species within their states, and any activity in the proposed initiative should be consistent with and support those strategies.

Local programs and partnerships are the most appropriate means of getting on-the-ground work accomplished, and any project proposed by federal and state agencies should support those actions and partnerships. State forestry agency personnel in all three states have been engaged in several projects at the local level.

It is well understood that eradicating and/or controlling the spread of invasive species is only one step in achieving restoration of this riparian forest system. Federal, state and local agencies, working in collaboration with landowners, have primary responsibility for eradication and control of invasive species. The proposed initiative recognizes that re-vegetation, monitoring and maintenance, along with implementation of a sustainable forest resource management system in the Platte River Watershed, will involve the participation and coordination of additional stakeholders and partners. Involvement by state forestry organizations in this process is critical to success of the initiative.

The Platte River.

Findings and Proposed Actions

Currently, several strategic planning activities involving woody-invasive species management are occurring at the watershed, state (Colorado, Kansas and New Mexico) and multi-state levels. Resultant plans to address this issue are comprehensive, but do not include forestry agency involvement.

An example of a multi-state level plan is the San Juan Watershed Woody-Invasives Initiative Strategic Plan, which includes Arizona, Colorado, New Mexico and Utah along with four tribal units. The plan was released on October 25, 2006. (The plan can be viewed at http://www.southwestcoloradowetlands.org/SJWWII/Strategic%20Plan.htm)

In September 2006 and again in May 2007, the Missouri River Watershed Coalition met in Spearfish, South Dakota. At the September meeting, Janet Clark of the Center for Invasive Plant Management in Missoula, Montana, distributed a draft of the Missouri River Tamarisk Management Plan. That plan involves Nebraska, South Dakota, North Dakota, Montana and Wyoming, and is accomplished through a Memorandum of Agreement among the respective State Departments of Agriculture. In addition, a report was provided on activities occurring on the North Platte River in Wyoming. Platte River segments, both North and South, along with such tributaries as the Republican River Watershed in Colorado, are located within the Missouri River Watershed. A draft of the "Missouri River Watershed Coalition Salt Cedar Management Plan" was distributed in February 2007.

In addition, the Tamarisk Coalition, which is headquartered in Grand Junction, Colorado, actively promotes tamarisk eradication. A wealth of information is available on their website at http://www.tamariskcoalition.org/tamariskcoalition/index.php. The Tamarisk Coalition and the Center for Invasive Plant Management are available to facilitate meetings and write strategic plans.

The proposed initiative recommends the following actions for future strategic planning efforts:

- Contact the Colorado Department of Agriculture to encourage their participation in the Missouri River Watershed Coalition Memorandum of Agreement.

- Encourage state forestry agencies from all states in the upper Missouri River Watershed (Montana, South Dakota, North Dakota, Wyoming, Nebraska and Colorado) to participate in future meetings of the Missouri River Watershed Coalition.

- Seek State and Private Forestry funding provided by the U.S. Forest Service to assist Colorado, Nebraska and Wyoming in ongoing planning efforts to help ensure that restoration and sustainability of riparian areas are integral parts of written plans. This strategy is consistent with the interest the USFS Rocky Mountain Region has exhibited in the White Water to Blue Water Partnership Initiative. And invasive species is a priority resource concern for the chief of the U.S. Forest Service. (For more information, visit http://www.publicaffairs.noaa.gov/worldsummit/blueandwhitewater.html.)

Educational Activities and Demonstration Projects

Most educational activities and demonstration projects associated with invasive woody species management and included in strategic plans deal with informing the public of the issues, species ecology and invasive plant eradication. However, most educational activities and demonstration projects do not include much information on site restoration and sustainability of riparian areas after invasive plants are eradicated.

Knowledge of the potential for the development and utilization of forest products derived from these riparian forests also is limited. Experts do not expect wood from tamarisk and Russian olive to be a sustainable resource, so cottonwood and willow establishment and utilization should be explored. Wood from nearby plains community forests also should be considered a resource that can be utilized.

It's important to note that natural cottonwood regeneration is not occurring in many riparian areas due to changes in water regimes and grazing.

The proposed initiative recommends the following actions to create effective educational programs and demonstration projects:

- Encourage state forestry agencies to participate in demonstration activities so that reforestation occurs following the removal of invasive plants.

- Conduct feasibility studies to assess wood availability, product potential and biomass production that support large-scale wood utilization from riparian corridor and community forests. Initially, small-scale biomass utilization facilities for heating public buildings/campuses should be developed as demonstration projects along riparian corridors.

- Identify demonstration sites where conditions favor cottonwood regeneration and exclude live stock to demonstrate that natural regeneration is possible to achieve with proper grazing management.

The Platte River.

Re-vegetation and Restoration Challenges

Although some personnel within state forestry agencies possess extensive knowledge about riparian forest restoration and management, technical knowledge on this topic among state forestry agency personnel is somewhat limited. In addition, supplies of native woody plant materials often are inadequate to accomplish large-scale restoration plantings.

Re-vegetation and restoration challenges can be addressed through the following actions:

- Develop one or more riparian forest restoration and management training sessions for state forestry agency personnel and other interested parties.

- Support conservation seedling nurseries and plant materials centers in their efforts to develop capacity for riparian forest restoration. For example, the Colorado State Forest Service Nursery could establish stooling blocks of native plains cottonwood for a cost of approximately $40,000 to produce 100,000 seedlings per year in 5 years.

"Colorado, Nebraska and Wyoming are committed to... proposing an initiative to involve forestry agencies, interested partners and stakeholders in **restoring** the Platte River riparian forest where it has been impacted by tamarisk."

Policies and Programs that Support the Proposed Initiative

A multitude of federal agencies, non-governmental organizations, state agencies and other groups have proclaimed the value of riparian forests and identified invasive woody species as a priority resource concern.

In 2006, Congress passed H.R. 2720, entitled the Salt Cedar and Russian Olive Control Demonstration Act, which authorizes funding to support many invasive species control and eradication activities identified in strategic plans, and many strategic plans appear to be geared toward this Act.

The proposed initiative suggests taking the following actions to capitalize on established policies:

- State forestry agencies in partnership with appropriate western states coalitions should support appropriations to fund the Salt Cedar and Russian Olive Control Demonstration Act and, where appropriate, participate in funded activities.

- Initiate a Plains Riparian Forests Conservation Initiative, similar to the Grazing Lands Conservation Initiative.

- Support the establishment of a Riparian Forest Reserve Program, similar to the Wetlands Reserve Program and Grazing Lands Reserve Programs.

The Platte River.

- Encourage a Continuous Conservation Reserve Program Practice specific to forested riparian areas and require management of those areas on "marginal pasture lands."

- Establish a Natural Resources Conservation Services practice standard specific for riparian forest restoration, rather than just riparian forest buffer establishment, and make available financial assistance to landowners in USDA-administered conservation programs.

- Investigate and apply for USDA Conservation Innovation Grants for riparian area restoration on a multi-state basis.

Colorado State University Agricultural Experiment Station

Research/Outreach Team to Develop Rural-Urban Water Model

Colorado State University is partnering with the Parker Water and Sanitation District in a research and outreach project aimed at developing ways to sustain irrigated agriculture in rural Colorado while meeting the increasing water demands of urban areas.

This three-year, $1 million-plus project is a first of its kind in Colorado. Results are expected to provide crucial information that can be used in the development of water policy and ways to establish rural-urban water partnerships.

The study will develop and investigate cropping system options -- techniques in crop planting and watering -- to determine how much water can be saved. The water saved can be made available for possible urban use, while at the same time sustaining viable economic returns to the agricultural and rural communities.

The 14 member multidisciplinary research and outreach team comes from three departments in the College of Agricultural Sciences, the Water Resources Research Institute, and Cooperative Extension offices in eastern Colorado. Individual team members include Neil Hansen and Dwayne Westfall (Soil & Crop Sciences), James Prichett (Agricultural & Resource Economics), and Frank Peairs (Bioagricultural Sciences and Pest Management), Reagan Waskom (Water Resources Research Institute), Bruce Bosley (Cooperative Extension, Logan County), and Joel Schneekloth (Cooperative Extension, Northern Region). Parker Water and Sanitation District will provide over $850,000 plus the use of more than $200,000 in equipment for the research. Experiments will be carried out on land owned by PWSD near Iliff, CO, at CSU's Agricultural Research Development and Education Center north of Fort Collins, and in on-farm demonstrations performed by local farmers near Iliff. The combination of small scale experimental studies, larger scale controlled experiments, and on farm demonstrations, are designed to more quickly and efficiently provide robust results.

"We believe this project is going to provide valuable information for both rural and urban communities in the development of optimal water policy in Colorado," said Tom Holtzer, the head of the department of Bioagricultural Sciences and Pest Management, who is coordinating the project. "It is also going to offer terrific opportunities for our graduate and undergraduate students in agricultural economics, cropping systems, soil science, irrigation management and pest management to gain experience working with agronomic and economic principles in a real-world situation."

Cropping system options to be investigated include rotational cropping (fallowing of a portion of the land); limited irrigation (applying less water, but gaining maximum yield from the water applied); using drought-tolerant crops and crop varieties; and adoption of optimal irrigation technology and alternative farming practices that

reduce demand for water. All three of these methods would make water available for urban use. Various strategies will be characterized and compared from the perspectives of farm profitability and economic activity in the agricultural and rural sectors, the amount of water made available for other uses, and practical feasibility.

"This is a big investment for us, but finding a win-win model that can keep our farmers farming and sustain our rural communities while at the same time finding a way to help meet our urban water needs is what we are after," said Frank Jaeger, director of PWSD. "This is just one piece of the puzzle in finding a solution to meet our community's growing water needs, but it is an important one."

The first phase of the study -- the discovery phase -- is already underway. The first year of the demonstration phase, in which crops will be planted and irrigation strategies tested and evaluated, will begin later this spring.

Project results will be made available during demonstration field days, and as part of the CSU Cooperative Extension fact sheets and technical reports. Decision support tools, such as crop rotation profit calculators, will be developed and distributed via the cooperative extension system.

South Platte Forum 2007

October 24th-25th, 2007

Longmont, Colorado

For more information visit http://www.southplatteforum.org/

Emerging Issues in Soil and Water

GARY A. PETERSON AND DWAYNE G. WESTFALL ANNUAL LECTURE

Colorado State University

"ON THE SUSTAINABLE MANAGEMENT OF SOIL AND WATER RESOURCES: HISTORICAL AND CONTEMPORARY PERSPECTIVES."

Please join us on April 19, 2007 in the Lory Student Center, North Ballroom from 2:00 - 3:30 p.m. for this year's lecture.

Presented by

DR. DANIEL HILLEL

Daniel Hillel is an international authority on sustainable management of land and water resources. He is Senior Research Scientist at the Goddard Institute for Space Studies of the Columbia Earth Institute and Professor of Plant, Soil, and Environmental Sciences at the University of Massachusetts.

A world-renowned environmental scientist and hydrologist, Dr. Hillel is known especially for his work on soil-water relations in arid and semiarid ecosystems. He has worked in over 30 countries in Europe, Asia, Africa, the Americas, and Australia. A major focus has been on the Middle East, where he served as a consultant to the governments of Israel, Pakistan, the Sudan, Iran, Egypt, Jordan, Cyprus, and elsewhere; and as advisor to the World Bank and to the United Nations.

His twenty-plus books include definitive works on arid-zone ecology, low volume irrigation, and soil and water physics, which are widely adopted as standard texts in universities and research institutions around the world and which have been translated into at least thirteen languages.

Among the honors Dr. Hillel has received are a Guggenheim Award and several honorary doctorates. He has been elected Fellow of the American Geophysical Union, American Association for the Advancement of Science, the Soil Science Society of America, and the American Society of Agronomy.

Also attend the evening lecture:

The Natural History of the Bible: An Environmental Exploration of the Hebrew Scriptures.

7-8:30 P.M.

32nd Colorado Water Workshop: To Look at the Whole Colorado River

**"Equalizations, Equity and Environment:
A Watershed Wide Look at Colorado River Opportunities"
May 22-24, 2007, at Western State College of Colorado in Gunnison**

Can the Seven-State Agreement - and the whole Law of the River - survive the predicted consequences of climate change?

How do the "reserved rights" for Native Americans, National Parks and endangered species fit into the management of an over-appropriated river?

How can the issues with Mexico and the river delta be best resolved?

What are the three best opportunities for improving environmental quality and cultural/international equity in the Colorado River watershed?

These are some of the questions that an exciting array of speakers will explore at the 32nd Colorado Water Workshop in Gunnison, May 22-24, focusing on "Equalizations, Equity and Environment: A Watershed Wide Look at Colorado River Opportunities."

Dan Beard, former Commissioner of the Bureau of Reclamation will be the keynote speaker at the opening night banquet and other invited speakers include former Hopi Tribe Chair Ferrell Secakuku, Richard Ingebretsen of the Grand Canyon Institute, current Bureau of Reclamation Commissioner Bob Johnson, Black Mesa Water Coalition Executive Director Enei Begaye, Jennifer Pitt, Pat Mulroy of the Southern Nevada Water Authority, Tijuana and San Diego professor Carlos de la Parra, former federal water planner Mark Bird, and many returning speakers including Justice Greg Hobbs, Eric Kuhn, and Don Glaser.

Water Workshop Director Pete Lavigne says the Workshop will be a diverse and interesting group this year representing the interests of the Colorado water districts, a variety of Colorado River organizations, ranchers, tribes, Mexico, and the basin states.

"We're expecting a packed audience this year and we have had a lot of early registration interest; a great sign with the move from July to May," says Lavigne.

The Applegate Group will again be sponsoring the H2O Benefit Golf Tournament and college apartments and dorm housing will again be available for the conference. Local hotels will have plenty of space available as well.

For further details as they become available check the Western State college website at www.western.edu/water.

A RIVER OF CHANGE

The 18th Annual South Platte Forum

October 24-25, 2007—Radisson Conference Center—Longmont, Colorado

A Change of Pace—*projects*

Peter Binney, City of Aurora
Alan Berryman, Northern Colorado Water Conservancy District
Carl Brouwer, Northern Colorado Water Conservancy District
Lisa McVickers, P.C.

An Inconvenient Climate

Brad Udall, CU-NOAA Western Water Assessment
Greg McCabe, U.S. Geological Survey
Marc Waage & Bob Steger, Denver Water
David Clow, U.S. Geological Survey

Changing Faces

Harris Sherman, Department of Natural Resources
John Stulp, Department of Agriculture

Changing Hearts and Minds—*education*

Don Glaser, Colorado Foundation for Water Education
Curry Rosato, Keep It Clean Partnership
Brent Mecham, Northern Colorado Water Conservancy District

Fields of Change

James Pritchett , Colorado State University
Frank Jaeger, Parker Water and Sanitation District
Neil Hansen, Colorado State University

Change Your Ways—*regulations*

Patti Tyler, U.S. Environmental Protection Agency
Amy Woodis, Metro Wastewater Reclamation District
Gabe Racz, Trout, Raley, Montano, Witwer & Freeman P.C.

Modeling the Change

Suzanne Paschke, U.S. Geological Survey
Chris Goemans, Western Water Assessment
Ray Alvarado, Colorado Water Conservation Board

Call for Posters

You are invited to submit a one-page abstract to the organizing committee by Aug. 1, 2007. Selected posters will be displayed throughout the forum with a staffed poster session from 4:45—6:00 p.m., Wed., Oct. 24. Authors will be notified of acceptance by Sept. 1. Send your abstract to Jennifer Brown, Jennifer@jjbrown.com.

Registration Fees

Registration fees include meals, breaks and reception.

Early Registration - by Oct. 1....................$100
Registration after Oct. 1...........................$115

Register at www.southplatteforum.org.

For More Information

Visit www.southplatteforum.org to see schedule updates, register and get more information. Or, contact Jennifer Brown, 402-960-3670, Jennifer@jjbrown.com

Sponsored By

Northern Colo. Water Conservancy District
Colo. Water Resources Research Institute
Metro Wastewater Reclamation District
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Parker Water and Sanitation District
U.S. Fish and Wildlife Service
City of Aurora
Colo. Division of Wildlife
Denver Water
U.S. Geological Survey
U.S. Bureau of Reclamation

www.southplatteforum.org

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Integrated Decision Support Consumptive Use and Alluvial Water Accounting System

One Day Training Course

May 17, 2007

Colorado State University

The Integrated Decision Support Group at Colorado State University will conduct a one day hands-on training course on the use of the IDS Consumptive Use model (IDSCU) and the IDS Alluvial Water Accounting System model (IDS AWAS). These models were developed as a part of the South Platte Mapping and Analysis Program (SPMAP), a collaborative effort between IDS and water users in the South Platte Basin. The models are data driven and being used around Colorado. This training course will instruct users on how to create and use templates to develop data sets; use diversion records from HYDROBASE; and access weather data from HYDROBASE, COAGMET, and NCWCD. Features of the IDSCU model that will be discussed include: 1) computing a complete water budget, 2) using the model to compare CU values computed with different ET methods (this will be used to demonstrate how a user might develop calibrated Blaney-Criddle crop coefficients), and 3) evaluating the application efficiencies of wells by comparing depletions of groundwater computed using a water budget with pumping records multiplied by a presumptive depletion factor.

The training course will include an introduction on how to export depletion of groundwater information to the IDS AWAS model or generate input files for the IDS AWAS model. Participants will then be shown the major features of the IDS AWAS model. The participants will be introduced to a number of GIS tools that IDS has developed to calculate the input parameters for the IDS AWAS model such as distance to river, distance to boundary, and transmissivity. The training course will be conducted on Thursday May 17, 2005 at Colorado State University.

The cost of the registration is $250. Course registration will be limited due to the availability of computers for hands-on training.

Obtain more information and register at www.ids.colostate.edu.

RESEARCH AWARDS

Colorado State University, Fort Collins, Colorado
Awards for February 2007 to March 2007

A Modeling & Remote Sensing Study of the Radiative Heating of Clouds in Support of ARM. Graeme L Stephens, DOE - US Department of Energy. $172,000

Continued Lidar Observation of Mesopause Region Over Fort Collins in Concert with TIMED Science: Tidal and Solar Cy. Chiaoyao She, NASA. $34,482

Assess the Condition of the Pecos River Riparian Corridor Prior to Implementation of a Public Fishing Program. David Jonathan Cooper, DOI-NPS. $35,735

New Satellite Energy Balance and Water Cycle Products for the Study of Interactions between Atmospheric Hydrology. Tristan S L'Ecuyer, NASA. $50,000

REU Site: Research Experiences for Undergraduates: Program in Water Research at Colorado State University Jorge A Ramirez, NSF-EHR-Education & Human Resources. $105,520

IPY: Collaborative Research: A Prototype Network for Measuring Arctic Winter Precipitation and Snow Cover (Snow-Net). Glen Liston, ENSF - National Science Foundation. $78,000

Introgression in Rio Grande Cutthroat Trout. Marlis R Douglas, Turner Enterprises, Inc. $9,649

Measurement of Rain and Mixed Phase Precipitation in the Sub-Tropics using Dual-Polarized/Dual-Wavelength Ground Radar. Viswanathan N Bringi, NASA. $121,779

Carbon Cycling in a Tropical Rain Forest. Daniel E Binkley, USDA-USFS-Rocky Mtn. Rsrch Station, CO. $32,000

Investigating Competition Among Lineages of T. Tubifex and the Potential for Biological Control of Whirling Disease. Dana Winkelman, Montana State University. $2,500

Follow-On Treatability Studies for Solar Ponds Plume at Rocky Flats. David M Gilbert, S M Stoller Corporation. $98,344

Effects of 3D Cloud Morphology on Retrievals of Optical Depth. Philip Mitri Gabriel, NASA. $74,152

Invasive Species Survey and Report. Mohammed Kalkhan, DOI-USGS. $36,975

Irrigation Audit Project for the Grand Valley of Western Colorado. Curtis E Swift, DOI-Bureau of Reclamation. $10,000

CAREER: Three-Dimensional Measurements of Atmospheric Water Vapor Using Miniaturized Microwave Radiometers. Steven C Reising, NSF. $80,000

Multiple Stress Tolerance, Seed Dormancy Breaking, and Establishment of Seeded Saltgrass. Yaling Qian, Golf Association/U.S. Green Section. $22,852

NSF Graduate Teaching Fellows in K-12 Education (GK-12). John C Moore, NSF. $319,375

Development of Stress Tolerant, Turf-Type Saltgrass Varieties. Dana K Christensen, Golf Association/U.S. Green Section. $26,274

Evolutionary and Ecological Aspects of Plant Selenium Hyperaccumulation. Elizabeth Pilon-Smits, AH, NSF. $159,031

Sludge Application to Dryland Wheat Fields. Kenneth A Barbarick, City of Littleton. $84,125

Biological Resource Management in National Parks-Invasive Species Information Management and Delivery. Nicholas Thompson Hobbs, DOI-NPS. $37,365

Native Seed Production for Crop Diversification. Ronald E Godin, Utah State University. $60,729

ERC: The Center for Collaborative Adaptive Sensing of the Atmosphere. Chandrasekaran Venkatachalam, UMASS-University of Massachusetts. $295,834

Part 2, Monitoring and Modeling Toward Optimal Management of the Lower Arkansas River. Timothy K Gates, Southeastern CO Water Conservancy Distr. $100,000

Native Trout. Christopher A Myrick, University of Washington. $37,317

Drill Pad Restoration. Edward F Redente, Williams Production RMT Company. $81,620

Flume Testing for Kootenai River Substrate Enhancement Project. Christopher I Thornton, MEI-Mussetter Engineering, Inc. $64,824

RESEARCH AWARDS

CAREER: Stream Restoration, Ecological Engineering and Nutrient Retention of Streams in Urban and Agricultural Settings. Brian Bledsoe, NSF-GEO. $100,519

New Generation High Efficiency RO and NF Membranes. Sumith Ranil Wickramasinghe, Chembrane Research & Engineering, Inc. $40,000

Quantifying the complex hydrologic response of an ephemeral desert wash. Jorge A Ramirez, DOD-ARMY-ARO-Army Research Office. $79,393

CAREER: Antibiotic Resistance Genes (ARG) as Emerging Pollutants in Our Water: Pathways, Mitigation, and Treatment. Amy Pruden-Bagchi, NSF. $72,068

Collaborative Research: Norwegian-United States IPY Scientific Traverse: Climate Variability and Glaciology in East. Glen E Liston, NSF. $53,347

Bridging the Divide: Linking Genomics to Ecosystem Responses to Climate Change. Alan Keith Knapp, Yale University. $66,492

Use of ARM Data to address the Climate Change Problem. David A Randall, DOE - US Department of Energy. $400,000

The Nature of the Crust Beneath the Deep Gulf of Mexico and Development of the Syn-Rift and Early Post-Rift Gulf Basin. Dennis L Harry, American Chemical Society. $54,128

Irrigation, Tillage, and Weed Management to Maintain Agricultural Profitability with Limited Water. Neil Hansen, USDA-ARS. $48,456

CALENDAR

March 26-28	**NWRA Federal Water Seminar.** Washington, DC. For more information visit http://www.nwra.org/meetings.cfm
April 12-13	**Arkansas River Basin Water Forum.** Rocky Ford, CO. For more information and/or to print out a registration form visit www.arbwf.org
May 18-22	**River Networks 2007 National River Rally.** Stevenson, Washington. For more information about the rally visit www.rivernetwork.org/rally
May 22-24	**Colorado Water Workshop: A Watershed Wide Look at Colorado River Controversies.** Gunnison, CO. For more information online visit http://www.western.edu/water/. Information by email please contact Peter Lavigne (Director Colorado Water Workshop) at plavigne@western.edu or pete@igc.org. Contact by phone: 970-641-2579
June 6-9	**USCID Second Conference on SCADA and Related Technologies for Irrigation System Modernization.** Denver, CO. For more information or to register visit www.uscid.org/07scada.html
Jun. 24-28	**AWWA 125th Annual Conference & Exposition: Explore the Future of Safe Water at World's Water Event.** Toronto, Ontario, Canada. For more information and/or to register visit http://www.awwa.org/
Jun. 25-27	**AWRA Summer Specialty Conference: Emerging Contaminants of Concern in the Environment: Issues, Investigations, and Solutions.** Vail, CO. For more information go to http://www.awra.org/meetings/Vail2007/index.html
July 24-26	**2007 UCOWR/NIWR Conference: Hazards in Water Resources.** Boise, ID. For more information visit http://www.ucowr.siu.edu
July 25-27	**NWRA Western Water Seminar.** Monterey, CA. For more information visit www.nwra.org
Aug. 23-24	**Colorado Water Congress 2007 Summer Convention.** Steamboat Springs, CO. For more information visit www.cowatercongress.org or call 303-837-0812
Sep. 30 to Oct. 5	**USCID Fourth International Conference on Irrigation and Drainage: Role of Irrigation and Drainage in a Sustainable Future.** Sacramento, CA. For more information about conference and call for papers go to http://www.uscid.org/
Oct. 24-25	**South Platte Forum 2007.** Longmont, CO. For more information visit http://www.southplatteforum.org/
Nov. 7-9	**NWRA Annual Conference.** Albuquerque, NM. For more information visit www.nwra.org

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