Report as of FY2008 for 2008CO167B: "Water Reallocation and Bioenergy in the South Platte: A Regional Economic Evaluation"

Publications

Project 2008CO167B has resulted in no reported publications as of FY2008.

Report Follows

Water Reallocation and Bioenergy in the South Platte: A Regional Economic Evaluation

Problem Statement: Bioenergy crop production is a potential engine for rural economic growth. Colorado farmers, and especially those in the South Platte River Basin, are well positioned as key energy stock producers for prospective commercial biorefining processes. Farmers in the South Platte Basin are among the most efficient and productive in the United States cropping more than one million irrigated acres.

Bioenergy's bright prospects are in part a result of Colorado's growing cities; however, municipal development is also a significant competitor for crop inputs, especially water and agricultural land. Rapid urban growth increases the competition for water, and agriculture is the primary supplier for increased water demands. Thus, the potential gains from bioenergy cropping must be attractive enough to retain water in irrigated agriculture else the resource will flow to municipal consumption. If profits for bioenergy crop production are limited, then outside investment in bioenergy refining is likely to suffer.

Demand for water is increasing, but supplies in Colorado's South Platte Basin are over-appropriated, meaning that owned rights to water use exceed the actual amount of water in the basin. The Colorado Water Conservation Board's Statewide Water Supply Initiative (SWSI) predicts the South Platte Basin will experience a 61.9 percent increase in water demand by 2030 that will cause an approximately 180,000 irrigated acres to be permanently fallowed. The plans for nearly all South Platte water providers include significant agricultural water right transfers (CWCB, 2004).

Water transfers are likely to reduce the size of the local economic base because fewer irrigated acres are cropped, fewer irrigated crops are sold and fewer crop inputs are purchased. Without other viable, local base industries to generate revenues and provide employment, a reduction in the revenue generated in the agricultural sector will have adverse economic impacts throughout the regional economy. Impacts will be felt by input suppliers and by local governments whose property and sales tax base is eroded. Moreover, downstream users of irrigated crops (e.g., dairies, feedlots, meat packers, cheese manufacturers, sugar processors and ethanol plants) will be forced to seek more costly crops from distant locations.

In contrast, bioenergy crop production may generate many positive economic spillovers for communities; not only through additional crop sales, but also by generating economic activity for local input suppliers (e.g., crop chemical wholesalers) and by downstream users of the crops (e.g., ethanol production facilities). Value-added investment in bioenergy processing is likely to add to a rural community's infrastructure and local supply of labor.

How should community leaders and stakeholders proceed when caught between two rivals – water transfers and bioenergy cropping? Clearly, it is important to weigh the potential economic impact of a growing bioenergy crop industry with increased demands for water resources. Water stakeholders will benefit from a detailed basin level study examining the direct and indirect economic impacts of these rivals, as well as disaggregating these impacts among different industries in the region. This information will be valuable to many water stakeholders including farmers, businesses, water supply administrators, and regional leaders charged with economic development.

Aims/objectives: Can Colorado's agricultural producers meet the challenges of a burgeoning bioenergy industry while still supplying water to growing municipalities? What impacts will be felt by local agribusiness, both suppliers of inputs (e.g., local supply cooperatives) and those who rely on irrigated crops for their livelihood (e.g., sugar processors, dairies and feedlots)? This proposal's overall objective is to provide insights into these important questions. More specifically, the purposes of this study are to:

1. Describe the capacity of South Platte farms to supply bioenergy crops even as the demand for water resources increases. In the context of this study, the South Platte Basin will include farms in Adams, Boulder, Larimer, Logan, Morgan, Sedgwick and Weld counties.

2. Map the existing infrastructure and resources available for bioenergy production in South Platte Basin communities, so that gaps in infrastructure (water, transportation, land, labor) may be identified.

3. Measure the profitability of biofuel crops (e.g., corn for grain) against the profitability of traditional crops (e.g., corn silage, alfalfa, sugar beets) to better understand the farm level tradeoffs of supplying a bioenergy crop to a local purchaser vis a vis a crop designated for local, downstream agribusiness. Likewise, compare the returns from selling water off of the farm to maintaining irrigated agricultural production.

4. Perform extensive in-person interviews with agribusiness managers/owners in the South Platte Basin. The purpose of the interviews will be to collect the managers' assessment of water transfers and returns to bioenergy cropping, a description of the firm's current purchasing behavior with an emphasis on local vs. purchases outside the region, and the proportion of sales that are exported versus those held within the region.

5. Using data collected and validated in Objective 4, along with existing secondary data, create a social accounting matrix (SAM) for the South Platte Basin. The SAM captures the current financial interaction of sectors within an economy including activities, commodities, transactions costs, household income, taxes and government expenditures. The SAM is a baseline against which other economic scenarios might be measured.

6. Create a South Platte Basin computable general equilibrium model (CGE) from the SAM. While the SAM is a snapshot of the current activity within a region, a CGE model explains all of the transactions in the SAM and indicates how important variables (e.g., the price of water, price of land, size of the workforce, capital investment) are altered when resources such as water flow in and out of an economy.

7. Assess the potential regional economic impacts of bioenergy crop production and water transfers to rural economies when measured against a backdrop of current production. Economic scenarios will include incremental bioenergy crop adoption and reduction in irrigated crop acreage. The aforementioned SAM and CGE model will be used to quantify and measure these effects.

8. Interpret and deliver the study's results via meetings with water stakeholders including the South Platte Forum, the Lower South Platte Forum, the Colorado Water Congress, the basin roundtables, etc. Prepare CWRRI completion reports as appropriate and write short study summaries for the CWRRI newsletter.

The proposal's objectives are tightly aligned with the FY 2008 Priority Research Topics identified by the CWRRI Advisory Committee. Specifically, this proposal seeks to answer the question "What are the direct and indirect water related impacts and needs surrounding bioenergy production in Colorado?" To the authors' knowledge, no study has considered both the regional economic impacts of bioenergy crops and expected water transfers on Colorado's rural communities. This research proposal extends previous work on the economic activity generated by irrigated agriculture in Colorado, but now considers the impact of biofuels and biorefining on irrigated cropping profits and rural economic vitality.

Rationale, Significance and Project Benefits:

Without question, a growing population will lead to increased demand for M&I water use. The South Platte and Arkansas Basins represent about 80% of the total projected increase in Colorado's future gross M&I demands. Table 1 indicates the Statewide Water Supply Initiative (SWSI) projections of M&I water use in the year 2000 and for the year 2030.

Table 1. Projected Growth in Municipal and Industrial Water Demand Basins*

Basin	2000 Gross Water Demand (AFY)	2030 proj. Gross Water Demand (AFY)	Projected Increase (AFY)
Arkansas	256,900	373,500	98,000
Rio Grande	17,400	23,100	43,000
South Platte	772,400	1,250,800	409,700

In Colorado, a 68,000 acre foot shortfall exists between projected demands from Table 1 and identified water supplies. Shortfalls are greatest in the South Platte and Arkansas Basins, which supply most growing Front Range communities with water (Table 2). History indicates M&I providers will find avenues to meet customers' needs, and in these basins increasing pressure will be placed on agriculture to urban water transfers

Table 2. Shortfall Between Projected M&I Demands and Firm Supplies in 2030*

Basin	Supply Needed (AFY)	Supply Identified (%)	Shortfall (%)
Arkansas	98,000	82%	18%
Rio Grande	4,300	99%	1%
South Platte	409,700	78%	22%

Agriculture represents approximately 91 percent of water used in Colorado and SWSI projections indicate that it will make up 86 percent of the water use in 2030 (Lower South Platte Forum: Valuing your Water, *Colorado Water, Colorado State University,* April 2005). As population grows, increased M&I demands are met with transfers from irrigated agriculture. Clearly, irrigated agriculture will shrink in Colorado, and SWSI forecasts these reductions as summarized in Table 3.

Table 3. Shortfall Between Project M&I and Firm Supplies in 2030*

Basin	Projected Reduction In Irrigated Acres by 2030
Arkansas	↓23,000-72,000 acres
Rio Grande	↓60,000-100,000 acres
South Platte	↓133,000-226,000 acres

Economic activity is reduced in rural communities as irrigated crop acres are permanently fallowed. The direct and indirect economic activity generated by irrigated cropping has been quantified to a limited extent by Thorvaldson and Pritchett (2006). As indicated in Table 4, irrigated agriculture's economic activity is substantial in the South Platte Basin generating $690 per acre, which includes the direct activity from crop sales; the indirect activity of farm input suppliers; and the induced activity of wages spent by employees.

Table 4. Economic Activity of Irrigated Agriculture in Colorado Basins

Basin	Farm Gate Receipts Relative to Regional Sales	Economic Activity Generated per Acre of Irrigated Cropland
Arkansas	31 %	$ 428
Rio Grande	48 %	$1,127
South Platte	2 %	$ 690

The research by Thorvaldson and Pritchett (Pritchett is PI on this proposal) is an important first step; however, their analysis has several limitations. First, Thorvaldson and Pritchett completed their study prior to recent expansion of bioenergy cropping and the subsequent increased demand for crop inputs. Second, the authors limited their economic activity assessment to irrigated farms and input suppliers, while neglecting downstream agribusiness firms such as sugar processors, dairies, feedlots, and ethanol facilities. As a result, the economic activity generated by these firms is omitted. Finally, the input-output model used in Thorvaldson and Pritchett's research is merely a snapshot of current economic activity. In contrast, the proposed CGE model is dynamic and will trace the flow of resources (e.g., water and land) and their prices as the regional economy responds to increased bioenergy cropping and large scale transfers of water rights. The proposed research is a forecast of likely outcomes rather than a description of existing activity. It should be noted that *the proposed CGE model will be available for future economic analysis of policy change, so the research objectives an important step in building future capacity for answering water related, regional economic questions.*

Importantly, the Thorvaldson and Pritchett effort resulted in more than fifty presentations to stakeholder groups, eight additional requests for impact analysis, a related study focusing on the changing property tax base, two CWRRI completion reports, four articles in popular press, three academic poster presentations and a pair of academic working papers. It is expected that the proposed CGE model will have a similar outreach impact. Stakeholders have asked for, and continue to ask for, information about how agribusiness will be impacted by increasing demands for water resources and the growth of bioenergy cropping. Unfortunately, these questions have yet to be answered concretely.

Bioenergy has the potential to become an important base industry in Colorado. However, the industry's success depends importantly on a local supply of energy crops grown by irrigated agriculture. The number of acres devoted to irrigated agriculture is likely to decrease in the next twenty-five years as water is transferred to M&I use. Will bioenergy crops alter the flow of water resources from rural regional economies? Will a sufficient number of irrigated crop acres be available to support the energy industry? As irrigated agriculture evolves, how will the size and number of irrigated farms change? Moreover, how will the downstream businesses, including feedlots, dairies, meat packers and cheese processors be impacted? This study seeks to provide tools to water resource and community stakeholders confronting these challenges. In particular, a basin level CGE model will be used to generate information for stakeholders. The following section describes the proposed research model.

Methodology and Previous/Related Research:

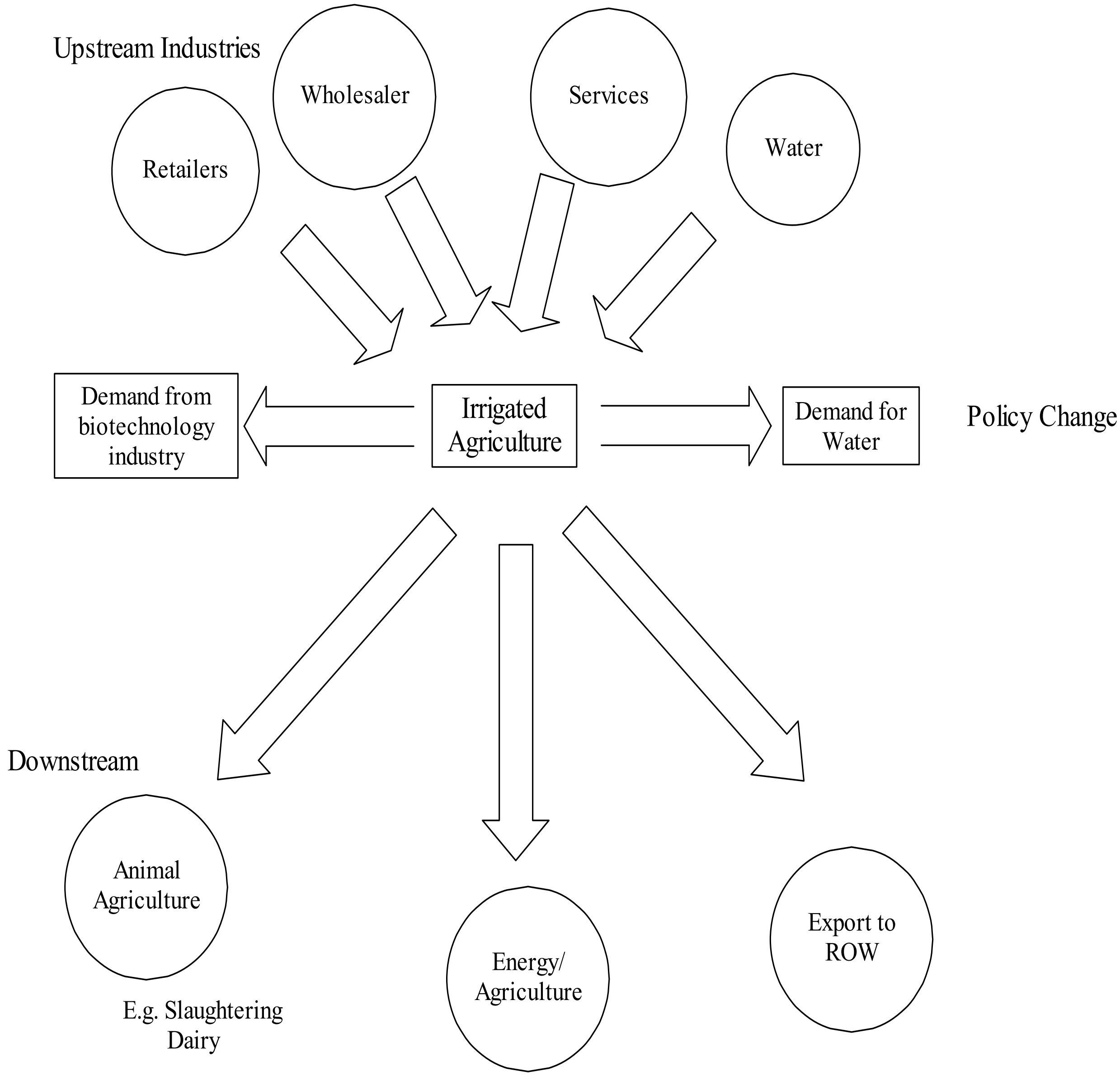
A computable general equilibrium (CGE) model captures the interactions of economic agents as resources are allocated. As illustrated in Figure 1, our South Platte Basin model will first capture the economic interaction of agents in the basin, and then examine how economic activity is altered with additional bioenergy cropping and water transfers. Important players in the upstream portion of the model include retailers that supply farm inputs (e.g., fertilizer, seed, and petroleum products), wholesalers, service providers (crop consultants, real estate services, and banking) and water suppliers. In the next stage of the model, irrigated agriculture represents a production unit that combines factor inputs from upstream businesses to generate products (irrigated crops) that are used by downstream industries. Important downstream industries include animal agriculture (e.g., feedlots, dairies), agricultural energy (ethanol), further processing and fabrication (cheese manufacturers and slaughter plants). Goods are used locally or may be shipped outside the region to the rest of the world (ROW). Likewise inputs may be purchased locally or from abroad. The CGE model will also capture the changing prices of resources as they are reallocated.

In order to construct a CGE model a Social Accounting Matrix (SAM) must be constructed first. A SAM is an all-inclusive, economy-wide data framework, typically representing the economy of a regional unit (e.g., a county or river basin). In practice, the social accounting matrix is a square matrix in which each account is represented by a row and a column. Each cell shows the payment from the account (economic sector) of its column to the account (economic sector) of its row. Thus, the incomes (sales) of an account appear along its row and its expenditures (demand) along its column. The underlying principle of double-entry accounting requires that, for each account in the SAM, total revenue (row total) equals total expenditure (column total). Data in the SAM are expressed in monetary terms.

The variables that will be in the SAM are grouped into the following sectors:

- Activities: The activities sector includes the following sub-sectors: large scale irrigated agriculture, small scale irrigated agriculture, dryland agriculture, industry, transportation, and other services such as utilities, wholesale, and housing
- Commodities: Commodities include crops, farm inputs, processed foods, industrial or manufacturing goods, transportation, and other services' commodities
- Transaction costs: Transaction costs include costs from domestic sales, imports and exports
- Factors: Primary inputs in the production process including water, land, labor and financial capital.
- Household income: households' income and wages in the regional economy, and
- Other institutions: This includes government, taxes, and an agglomerated rest of world.

Figure 1. Illustration of a Computable General Equilibrium Model



An advantage of a SAM is that the researcher can segment important or relevant sectors into different sub-sectors in order to thoroughly describe the impacts of external shocks. As an example, the proposed SAM splits the cropping sector into dryland and irrigated farm subsectors, and then further separates the farm subsector in those that sell water rights and those that retain water rights.

The Social Accounting Matrix is constructed in Microsoft Excel and is the base data that will be used in the Computable General Equilibrium (CGE) model. The CGE model will be constructed within the General Algebraic Modeling System (GAMS) program, and the SAM data will be imported into the model. GAMS is the mathematical optimization software that is typically used to perform CGE simulations.

Since the SAM data is exclusively monetary transactions, other values such as the number of farmers or the number of households have to be added to the SAM to construct the CGE model. The standard CGE model explains all of the payments recorded in the SAM. The model therefore follows the SAM disaggregation of factors, activities, commodities, and institutions. It is written as a set of simultaneous equations, many of which are nonlinear. The equations define the behavior of the different sectors. In part, this behavior follows simple rules captured by fixed coefficients (for example, ad valorem tax rates). Production and consumption decisions are driven by the maximization of profits and utility, respectively. The equations also include a set of constraints that have to be satisfied by the system as a whole but are not necessarily considered by any individual sector. These constraints cover markets (for factors and commodities) and macroeconomic aggregates.

CGE models have been used to assess the interaction of water resources and regional economics in other studies. Chapter 2 of Phil Scott Watson's dissertation "Of Golf and Grains: Three essays of resource use in the new American West (2006) focuses on the effects of increased population growth on water demand in agricultural and urban sectors using a CGE model. The CGE model proposed in this study will use the same methodology as Watson, but will instead represent the South Platte Basin and focus more intently on downstream agribusiness and irrigated cropping.

Goodman's examination of a proposed Pueblo reservoir expansion and temporary water transfers in the Arkansas basin suggest how a CGE model may be used to examine the impacts of water reallocation. Like Goodman, the proposed research considers water transfers, but will also consider the rivalry for resources represented by bioenergy, as well as a more extensive look at downstream agribusiness. In addition, published drought research (Horridge, Madden and Witwer) and a CGE model of agriculture (Adelman and Robinson) are important foundational literature describing the method of creating SAM's and CGE models.

Expected outcomes: A number of deliverable outputs are associated with the project. These outputs include:

- A social accounting matrix that accurately chronicles the economic activity of the South Platte Basin and is calibrated to the latest economic data.
- A computable general equilibrium model capable of examining water resource and bioenergy cropping questions for the South Platte Basin region.
- Presentations to stakeholder groups including the Colorado Water Congress, the South Platte Forum, the Lower South Platte Forum, the Agricultural Water Forum, the Northeastern Colorado Association of Local Governments annual meeting, the annual meeting of Colorado Soil and Water Conservation Districts, basin roundtables, and others.
- CWRRI completion reports and newsletter articles.
- Academic journal articles.

Timeline: Proposed project activities begin on January 1, 2008 and will be completed on July 1, 2009. A PhD candidate, Leonard Gwanmesia, has been identified for the project and has completed all of his academic coursework. The proposed research represents a significant portion of his PhD dissertation. Specific mileposts in the research include:

January 1, 2008 through March 1, 2008

Create the SAM model using secondary data.

March 1, 2008 through June 1, 2008

Validate the SAM model with in-person interview of agribusiness and the Colorado Department of Local Affairs.

June 1, 2008 through September 1, 2008

Create and validate the CGE model. Financial information and flows will be liberated form the SAM, but allocation of water and the flow of crops to bioenergy facilities must be added to the model. Use the CGE model to establish a benchmark of economic activity for the South Platte Basin.

September 1, 2008 through January 1, 2009

Design scenarios to be considered with the CGE model.

January 1, 2009 through March 1, 2009

Simulate scenarios and compile results from the CGE model.

March 1, 2009 through July 1, 2009.

Draft, edit and complete a CWRRI completion report, newsletter article and present results.

Training Potential A PhD graduate student will be trained in regional economic analysis and CGE models in this study. While the student (Leonard Gwanmesia) has completed extensive coursework in regional economics, he has had few opportunities to apply these tools.

Congressional District: Research activities will take place in the 4th Congressional District.

References

Adelman, I and S. Robinson, 1986. U.S. Agriculture in a General Equilibrium Framework: Analysis with a Social Accounting Matrix. American Journal of Agricultural Economics, 68 (5), 1196-1207.

Colorado Water Conservation Board. 2004. Statewide Water Supply Initiative. Available at http://cwcb.state.co.us

Goodman, D.J., 2000. More reservoir or transfer? A Computable
General Equilibrium Analysis of Projected Water Shortages in the Arkansas River Basin. Journal of Agricultural and Resource Economics, 25 (2), 698–713

Horridge, M., J. Madden, G. Wittwer, 2005. The impact of the 2002–2003 drought on Australia. Journal of Policy Modeling, 27, 285–308.

Thorvaldson, J. and J. Pritchett. “Economic Impact Analysis of Irrigated Acreage in Four River Basins in Colorado.” Colorado Water Resources Research Institute Completion Report # 207. December 2006. Fort Collins, CO.

Watson, P., 2006. Golf and Grains: Three essays of resource use in the new American West. Dissertation, Department of Agricultural and Resource Economics, Colorado State University.

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Education

PhD	University of Minnesota, Agricultural and Applied Economics	1999
MS	Colorado State University, Agricultural and Resource Economics	1995
BS	Colorado State University, Agriculture Business	1993

Professional Experience

Colorado State University, Fort Collins, CO July 2007 to Present
Associate Professor, Department of Agricultural and Resource Economics
Applied Research (25%), Outreach (25%), Teaching (50%)

Colorado State University, Fort Collins, CO May 2001 to June 2007
Assistant Professor, Department of Agricultural and Resource Economics
Applied Research (25%), Outreach (25%), Teaching (50%)

Purdue University, West Lafayette, IN October 1999 to May 2001
Assistant Professor, Department of Agricultural Economics
Extension (45%), Research (25%), Teaching (30%)

Relevant Recent Grant Awards

2007. J. Pritchett (co-PI), A Bright (co-PI), R. Waskom, M. Niebauer and T. Bauder. "Public Attitudes and Perceptions Regarding Agricultural Water Use in the West
Water Use/Reuse and Water Security: What Do Households Value?" USDA-CSREES-National Facilitation Project. $171,773.

2006. T. Holtzer (PD) N. Hansen (co-PI), J. Pritchett (co-PI), D. Westfall, M Frasier, E. Schuck, T. Bauder, J. Schneekloth and J. Brummer. "Developing a Model to Sustain Irrigated Agriculture While Meeting Increasing Urban Water Demand in Colorado. Cooperative Proposal with Parker Water and Sanitation District. $984,127

2006. Pritchett, J., R. Waskom, N. Hansen, D. Westfall, C. Bond, E. Schuck, D. Hoag. USDA-NRI-Agricultural Prosperity of Small and Medium Sized Farms. "Developing Economically Sustainable Cropping Strategies for Small and Medium Sized Farms in an Increasingly Scarce Water Environment." $499,113.

2006. N. Hansen, J. Pritchett, D. Westfall, T. Bauder, J. Schneekloth, R. Waskom, and J. Brummer "Sustainable Cropping Systems for Transition from Full Irrigation To Limited Irrigation and Dryland." Natural Resources Conservation Service – Conservation Innovation Grants. $275,000.

Recent Relevant Research

2007. J. Pritchett and J. Thorvaldson. "Some Economic Effects of Changing Augmentation Rules in Colorado's Lower South Platte Basin: Producer Survey and Regional Economic Impact Analysis." Colorado Water Resources Research Institute Completion Report # 209. Fort Collins, CO.

2006. J. Pritchett and J. Thorvaldson. "Economic Impact Analysis of Irrigated Acreage in Four River Basins in Colorado." Colorado Water Resources Research Institute Completion Report # 207. Fort Collins, CO.

2006. Waskom, R. J. Pritchett, and J. Schneekloth. Outlook on the High Plains Aquifer: What's in store for irrigated agriculture?" Great Plains Soil Fertility Conference Proceedings. Denver, CO.

2005. J. Pritchett, P. Watson, J. Thorvaldson, and L. Elingson. 2005. "Economic Impacts of Reduced Acres: Example of the Republican River Basin." *Colorado Water.* February:4-6.

2003. J. Pritchett, M. Frasier and E. Schuck. "Third Party Compensation for Out-of-Basin Water Transfers: Comments on HB 03-1113." Agricultural and Resource Policy Report. APR 03-08. Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, Colorado. August 2003.

Synergistic Activities:

Previous CWRRI fellowship funds have been used in outreach presentations and educational efforts. The focus of these activities is on the regional economic contribution of irrigated agriculture and includes a symposium titled "Enhancing Understanding of Agricultural Water Management" delivered in eleven Colorado locations to clientele including Arkansas River Basin Roundtable, Colorado River Basin Roundtable, Colorado Water Congress, Colorado State University Cooperative Extension, Southwestern Colorado Water Conservation District, South Platte Forum, Lower South Platte Forum, Morgan County Economic Development Corporation, Northeastern Colorado Association of Local Governments, Rio Grande River Basin Roundtable, South Platte Basin Roundtable, Western Association of Rural Conservation and Development Districts.

I'm part of an interdisciplinary team interested in enhancing agricultural production, profitability and sustainability with limited irrigation supplies. We have been successful in creating research and demonstration sites focusing on the techniques. The sites are located near the Colorado cities of Akron, Berthoud, Fort Collins, and Iliff. Field days for stakeholders are planned.

I hold a teaching appointment at Colorado State University and have the opportunity to bring research into the classroom. The classes that I currently teach and/or have been responsible for include: AGRI 192 Orientation to Agriculture Systems, AREC 510 Agriculture Marketing, AREC 428 Agribusiness Management (capstone course), AREC 408 Agriculture Finance, AREC 310 Agriculture Marketing, AREC 305 Enterprise Analysis, BUS 635 World Economics for Business.