2024

COLORADO

2021 OGALLALA (VIRTUAL) SUMMIT-INSPIRED ACTIVITIES

The 2021 Ogallala Summit inspired the strengthening of irrigation training and research programs across Colorado and the expansion of these efforts into multi-state collaborations. Key highlights include the work of the Irrigation Innovation Consortium, establishment of the Colorado State University (CSU) Testing Ag Performance Solutions (TAPS) program, expansion of the Colorado Master Irrigator Program, and the extended impacts of the Ogallala Water Coordinated Agricultural Project that helped organize the 2018 and 2021 Ogallala Summits.

The CSU-hosted **Irrigation Innovation Consortium (IIC)** supported applied research to improve a wide range of irrigation system hardware, software, algorithms, and models, related to smart water conservation management strategies for irrigated agriculture and turf settings across the west. The IIC has convened diverse partners including researchers and industry, producers, water managers and others to facilitate integration and adoption of advanced irrigation strategies.

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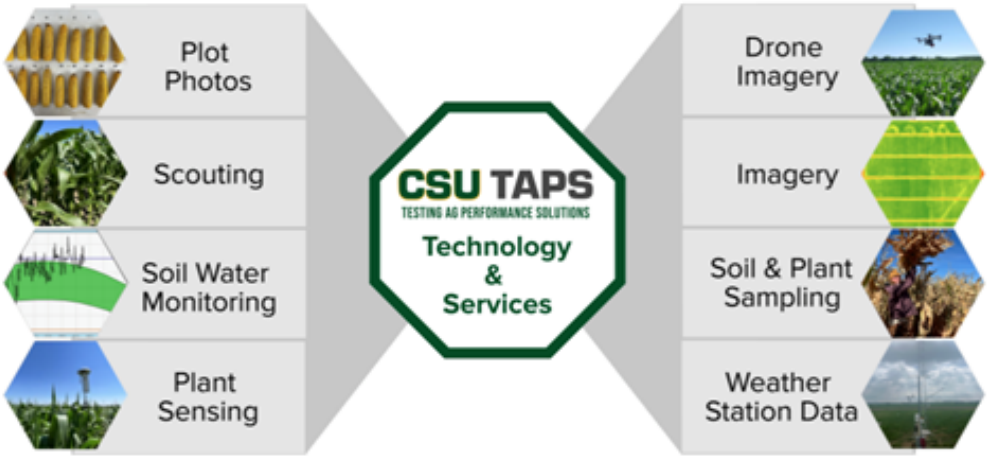
In January 2024, the IIC completed a 6-year period of work supported by the Foundation for Food and Agriculture and other partners. The IIC will continue in a new phase of work with major support from the Natural Resources Conservation Service (NRCS) and others to strengthen and expand chapters of the TAPS program and Master Irrigator program in Colorado, Kansas, Nebraska, Oklahoma, and Texas. In addition to supporting producers in testing the use of decision support technologies and smart farm agronomic and marketing management strategies, this applied, multistate effort will also work to benchmark the relationship of conservation-oriented management to greenhouse gas emissions and link together crop and livestock production sectors as a holistic community of practice. For more information, see https://www.irrigationinnovation.org/.

Colorado hosted its first **Testing Ag Performance Solutions (TAPS)** program in 2023, modeled after the successful University of Nebraska and Oklahoma State University TAPS programs. The 2023 TAPS participant cohort involved 42 individuals across 18 teams.

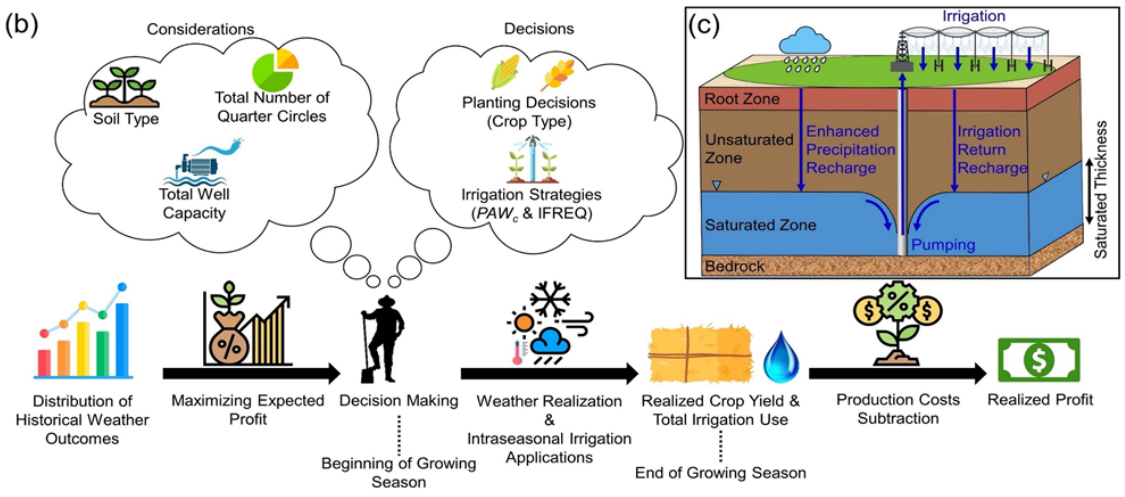


CSU-TAPS competitors had access to multiple sources of data to inform their management decisions.

The **Colorado Master Irrigator** program expanded from 1 to 3 regional programs across the state in 2024 with planning efforts underway to expand further in the near future, impacting water management decisions across thousands of irrigated acres. Since its inception in 2020, the Colorado Master Irrigator program has made significant strides in promoting sustainable water management practices across the state.

With nearly 200 producers and ag-affiliated individuals completing the program, representing a collective responsibility for well over 200,000 irrigated acres, the initiative has had a profound impact on the agricultural landscape. Graduates of the program have reported gaining the confidence and knowledge needed to implement minor yet impactful changes on their farms. These changes have not only enhanced the overall efficiency of water usage but have also resulted in substantial water savings. The Colorado Master Irrigator program stands as a testament to the positive outcomes that can be achieved through targeted education and training, contributing to a more sustainable and resilient agricultural sector in the region.

The **Ogallala Water Coordinated Agricultural Project (OWCAP)** wrapped up its work funded by USDA-NIFA in 2021. However, the impact of the OWCAP has continued to grow, with project team member publications still forthcoming. The team published a high-profile summary in Nature Water in 2023 outlining the importance for groundwater governance to move beyond incentivizing individual producers to change their irrigation management methods toward a more strategic, collaborative effort that links locally-defined commitments to groundwater conservation to state, regional, and federal policy and incentive programs. This paper and the OWCAP team's work have then generated invitations to present at the University Council of Water Resources and the American Association for the Advancement of Science meetings. The integrated agronomic-hydrologic-economic models developed during the OWCAP have continued to be refined and improved by researchers.



The OWCAP team developed an agent-based model that simulates the interplay between farmers' planting and irrigation decisions, crop growth, irrigation requirements, and the groundwater system in an integrated fashion (Nozari et al. 2023).

Another notable OWCAP advancement is the development of a hydro-economic model for a portion of the Ogallala Aquifer beneath the Republican River Basin in eastern Colorado and northwest Kansas. This model is the product of interdisciplinary collaboration among researchers in agronomy, soil and crop science, agricultural economics, and hydrology from Colorado State University, Kansas State University, Texas A&M University, and the University of California, Davis. The model's performance was tested by comparing its outputs with historical data, demonstrating its effectiveness in simulating the coupled human-natural system under various future climate scenarios, with and without policy intervention. This paves the way for formulating effective groundwater management policies. See: https://ogallalawater.org/modat-our-integrated-crop-econ-hydro-climate-model/

In a follow-up study, the model was utilized to assess the effectiveness of groundwater conservation policies amidst climate change. The model explicitly accounts for the effects of climate change on crop yields and the economic motivations behind farmers' planting and irrigation decisions. The study incorporates 32 future climate scenarios spanning 2019 to 2099. It evaluates three policy instruments: irrigated land retirement, irrigation well retirement, and reducing maximum pumping rates. The findings challenge the common assumption that climate change will increase groundwater usage over time. Instead, increased summer temperatures are projected to limit water-intensive corn production. In fact, corn becomes less economically viable, while winter wheat becomes more profitable, prompting a shift from irrigated corn to irrigated winter wheat across the region over the century. As a result, groundwater extraction is reduced under the more severe greenhouse gas emission scenario. This shift diminishes the economic incentives for groundwater conservation, as the water conserved early on is more likely to be used for irrigating winter wheat in later years, a crop with lower irrigation value than corn. These findings highlight the need to account for both how crops respond to climate change and farmers' subsequent adaptations when designing and evaluating groundwater management policies.

OTHER KEY ACTIVITIES UNDERWAY

The Colorado Water Conservation Board (CWCB), an agency within the State's Department of Natural Resources, updated the Colorado Water Plan in 2023 including 10 agriculture-focused actions (listed below). The Colorado Water Plan provides a framework for helping Colorado meet its water challenges through collaborative action around water development and water conservation.

Progress on the Water Plan is made through agency action and the water community in Colorado with help from CWCB grants. The Colorado Water Plan Grant Program has grown to support $5 Million each year in agriculture projects that advance the Colorado Water Plan.

Agriculture Actions in the 2023 Colorado Water Plan:

1. Expand agricultural water conservation, education, and peer-to-peer programs that enhance innovation
2. Integrate capacity-building efforts to support agriculture
3. Expand the scale of collaborative water sharing agreements
4. Streamline collaborative water sharing agreement guidance across agencies
5. Support the integration of robust agriculture into local government planning
6. Assess the economic opportunities of avoided buy and dry to communities, ecosystems, and recreation
7. Engage Federal Partners to streamline assistance for groundwater-dependent regions
8. Streamline agricultural infrastructure funding
9. Assess agricultural best practices for water quality protection
10. Integrate soil health, water conservation, and adaptive practices that increase economic outputs with less water use.

Water Quality. The Colorado Agricultural Water Quality Program (AWQP) plays a pivotal role in supporting farmers' voluntary efforts to implement water quality Best Management Practices (BMPs). In 2012 the Colorado Water Quality Control Commission (WQCC) passed Regulation 85, which increased regulation on point sources (i.e. wastewater treatment plants) and proposed voluntary measures for the agricultural sector to improve nutrient pollution in lakes and rivers. In 2023, the WQCC deemed sufficient progress had been made in the agricultural sector. The commission has requested ongoing demonstration of continued progress and has paused discussions on regulatory measures for non-point pollution. In addition to the work of the AWQP, this success is due to the agricultural community's active engagement in protecting water quality statewide.

The Colorado State University branch of the AWQP is responsible for providing research, education and training on agricultural BMPs statewide to minimize the impact of fertilizer and pesticide applications on Colorado's water sources. As one example, the establishment of perennial grass filter strips can slow water down and remove potential contaminants. While filter strips are a common BMP in other parts of the United States, they have not yet been widely used in Colorado.

The AWQP established a proof of concept in Colorado and preliminary findings suggest that filter strips are effective at removing sediment and nutrient pollution, particularly non-soluble particulates, like phosphorus. One of the current focus areas of the AWQP is expanding agricultural research technologies including 3D printing parts, NDVI drone flights, and optimizing low-cost water quality monitoring equipment and other environmental sensors. The edge of field data generated by the AWQP is used to help calibrate models on nutrient transport. The AWQP continues to work side by side with producers to implement BMPs that are environmentally and economically sustainable.

Food Systems. Colorado State University food systems research team and the Denver's Office of Public Health and Environment completed their project to understand the tradeoffs associated with Denver's food procurement policies through a Foundation for Food and Agricultural Research (FFAR) funded project. The team studied the City and County of Denver's integrated food policy plan called the Denver Food Vision, a program facilitated by the Denver Sustainable Food Policy Council, as a case study. The team worked with stakeholders to define the system boundaries and built an agent-based model that integrated economic data, nutritional indices, decision-making factors, biophysical models, ecological data, and life cycle assessment. The agent-based model was particularly helpful in identifying the tradeoffs expected to occur from different policy implementation scenarios. Specifically, the research used potatoes as a case study to understand ways in which Denver Public Schools might shift their procurement strategies (e.g., from non-local to local potatoes, from processed to unprocessed potatoes, from conventional to organic potatoes). The project's work supported new opportunities for urban-rural dialogue, including the creation of the first regional (as opposed to city-based) coalition, which changed the way that Denver is implementing the Good Food Purchasing Program (GFPP), a program that prioritizes city food purchasing based on sustainability standards.

Colorado

Key findings:

1. Farmers make decisions that are not profit-maximizing for many reasons. Integrating producers early on into urban food policy discussions can thus be key if the success of a policy or market intervention requires a particular type of producer response (e.g., crop shifting, certification, change of rotation, investment in soil health).
2. One size does not fit all when looking at the impacts of various third-party certification programs on farmers, communities, and the environment. Accordingly, establishing clear goals is critical and there needs to be careful consideration as to whether or not a particular verification program will achieve local goals.

Additional key outcomes of the food systems work include: 1) The development of a Colorado food system mapping and reporting tool: https://cofoodsystemsmap.org/; and 2) Organization of the Colorado Food Summit, a semi-annual collaborative event, led by CSU, the Colorado Department of Agriculture, the Colorado Food Systems Advisory Council, and all 12 of the state's local food policy councils and coalitions. The summit brings together almost 700 diverse Coloradan food and agricultural practitioners, including young leaders, to build shared understandings of the challenges and opportunities facing our food system.
https://foodsystems.colostate.edu/events/food-summit-2023/

Soil Health. Colorado Department of Agriculture's Soil Health Program is a state-wide program administered locally by conservation districts and other conservation entities to provide technical and financial support for agricultural producers interested in improving their soil health and operational resiliency in light of drought and unpredictable weather events. The program secured substantial funding in the past two years to offer this assistance to farmers and ranchers across the state. In addition, program staff are working to expand the adoption and use of the Saving Tomorrow's Agriculture Resources Tool (STAR) in Colorado and in several other states. The STAR tool is a practice-based rating system that assigns points for the following soil health practices: cropping, tillage, nutrient application, grazing changes, and other best management practices.
https://sites.google.com/state.co.us/soil/participate/star

Further, the Integrated Rocky Mountain-region Innovation Center for Healthy Soils (IN-RICHES) is developing a network of 35 research fields across six Rocky Mountain States in partnership with other Rocky Mountain land grant universities. These sites will collect data on the impacts of conversation practices soil health, soil carbon sequestration, and water dynamics. Based on this data and the ~400 fields to be enrolled in the Colorado Soil Health Program, IN-RICHES is creating a regional soil health inventory and the "Soil Health Discovery Platform," which will provide producers and agricultural professionals with information to assist in context-specific decision making.

Colorado Open Soil Moisture Monitoring and Infrastructure Initiative. In April of 2023, the Integrated Rocky Mountain-region Innovation Center for Health Soils (IN-RICHES) at CSU launched a soil moisture monitoring program to rapidly deploy infrastructure in critical, underrepresented areas of the state and to develop an open knowledge platform that will provide access to real-time and historic soil moisture data from existing and new networks. This project will assist in climate risk prediction and management, including drought, wildfire, and flooding, and assist producers in managing irrigation. Through stakeholder engagement, IN-RICHES will present a gap analysis and draft deployment plan for feedback in April and hopes to begin infrastructure augmentation in Spring/Summer 2024. A congressionally directed spending request to support this effort is before Congress, and IN-RICHES will be seeking additional funding for this effort.

The Colorado Water Center (CoWC) at Colorado State University has initiated a new program to diversify and expand Colorado's water workforce to better address current gaps and needs. The focus is on identifying and inventorying existing water workforce initiatives and resources, building synergies across sectors and organizations, and scaling up successful pipeline programs. To kick off the program, the CoWC is hosting the first ever Colorado Water Workforce Summit April 2-3, 2024 in Denver. The Summit will bring together water industry & employers, water-related educators & trainers, workforce development specialists, and students to determine collaborative paths forward to advance water workforce development across Colorado.

Water Workforce
2024 SUMMIT

KEY CHALLENGES

The Republican River Basin in Colorado continues to strive towards achieving compact compliance in the face of recent episodic droughts. Compact compliance requires the retirement of irrigation on 25,000 acres by 2029. The Republican River Water Conservation District has facilitated the retirement of over 12,000 acres since 2016. However, even with achieving compact compliance targets, the region's groundwater levels are still projected to continue to decline. Climate change in Colorado will continue to pose a challenge to agricultural water use in Colorado. Warmer temperatures will contribute to more frequent and severe droughts and decrease the benefit of wet years. Programs like Colorado Master Irrigator and CSU-TAPS seek to address this broader challenge to support irrigator's water conservation efforts to extend the life of the aquifer and the associated livelihoods of communities over the aquifer.

PARTNERSHIPS, INTERSTATE INTERACTIONS, AND COLLABORATIVE EFFORTS

Many of the highlighted activities involve cross-scale (e.g. local to state) and interstate partnerships. The TAPS and Master Irrigator programs have partnered with NRCS to continue to strengthen and expand these programs across state lines. This partnership will enhance alignment between NRCS incentive programs and the outcomes of these industry- and irrigator- engaged research and outreach programs. The CWCB coordinates the Water Conditions Monitoring Committee, a partnership between Federal, State, Municipal, and University partners to monitor conditions that affect Colorado's water supply, including snowpack, reservoir storage, streamflow, historical climate norms, long term precipitation and temperature outlooks, and climate variations. From the food systems team's work it is clear that coalitions of urban and rural stakeholders operating in alignment are needed to define and address food and water management solutions, but the governance mechanisms required for this to occur are unclear. Additional work is needed to figure out what and who can drive effective regional collaboration today to pave the way for short and long term agricultural resilience and productivity.

REFERENCES AND RESOURCES

Nozari, S., Bailey, R. T., Rouhi Rad, M., Smith, G. E., Andales, A. A., Zambreski, Z. T., ... & Schipanski, M. E. (2024). Groundwater Conservation Amidst Climate Change: Coevolution of Crops, Cultivation Strategies, and Natural System in Semi-arid Regions. To be submitted to Water Resources Research.

Nozari, S., Bailey, R. T., Rouhi Rad, M., Smith, G. E., Andales, A. A., Zambreski, Z. T., ... & Schipanski, M. E. (2023). Capturing Human-Crop-Groundwater Interactions: Modeling Real-world Agents in an Intensively Irrigated Region of the US High Plains. Available at SSRN 4705465.

Kashyap, P., B.B.R. Jablonski, and A. Bauman. 2024. Exploring the Relationship between Stocks of Community Wealth and the Intensity of Farm to School Program Activities. Food Policy 122:102570. https://doi.org/10.1016/j.foodpol.2023.102570

Schipanski, M. E., Sanderson, M. R., Méndez-Barrientos, L. E., Kremen, A., Gowda, P., Porter, D., ... & Auvermann, B. (2023). Moving from measurement to governance of shared groundwater resources. Nature Water, 1(1), 30-36.

Wentworth, C., M. Torres Arroyo, R. Cavalcanti Lembi, B.J. Feingold, D. Freedman, S. Gray, B.B.R. Jablonski, K.M. Janda, P. Lemoine, A. Nielsen, X.X. Romeiko, D. Salvo, L. Schmitt Olabisi, A.E. van den Berg, O. Yamoah. 2024. Responsive Community Engagement in Participatory Urban Food Systems Modeling: Examples from five U.S. cities. Environmental Science and Policy 152:103645. https://doi.org/10.1016/j.envsci.2023.103645

Bolinger, R.A., J.J. Lukas, R.S. Schumacher, and P.E. Goble, 2024: Climate Change in Colorado, 3rd edition. Colorado State University, https://doi.org/10.25675/10217/237323.