Collaborative, engaged research for groundwater conservation and sustaining agricultural communities in the Ogallala aquifer region

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The Ogallala aquifer, the largest unit of the hydrologically connected High Plains aquifer system, is one of the world's largest fresh groundwater resources. Most of the water pumped from the Ogallala aquifer is used for agriculture, by far the chief driver of the region's economy. Decades of pumping at rates greater than natural recharge from precipitation has led to significant water level declines across many parts of the aquifer. Stakeholder concerns regarding groundwater use provides a natural opportunity to convene diverse perspectives, interdisciplinary research, and build multi-state partnerships and approaches.

The Ogallala Water Coordinated Agriculture Project (OWCAP) received funding from USDA-NIFA in 2016 to address the multi-faceted challenges facing the aquifer region through interdisciplinary and cross-institutional research and outreach. This 70-member interdisciplinary team from 10 institutions and six states catalyzed new understanding to identify and promote management of the scarce Ogallala resource and support the region's communities.

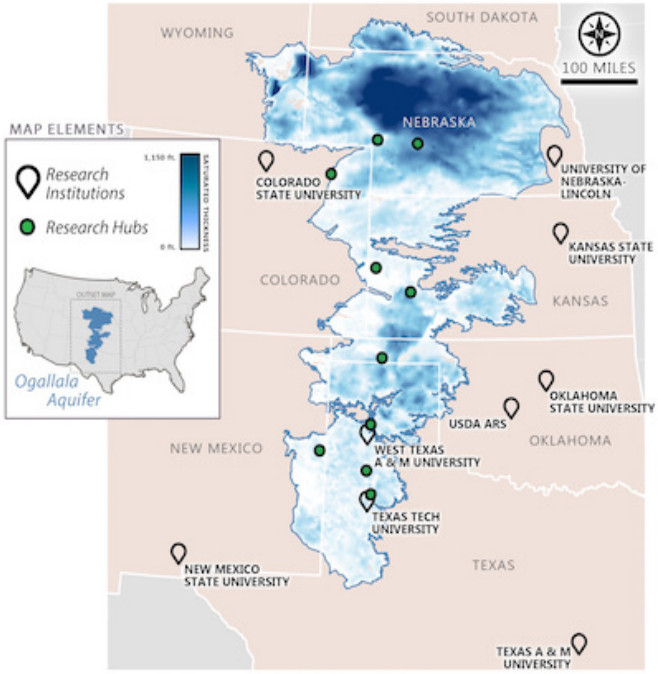

Figure 1. The Ogallala aquifer underlies parts of eight states of the High Plains region. Blue shading demonstrates the high spatial variability in groundwater saturated thickness and symbols mark the institutions and research centers that collaborated through the Ogallala Water Coordinated Agriculture Project (OWCAP).

Key Outcomes to Address Water Conservation

The team's work focused on multiple scales of water management, including 1) individual producers, 2) local and regional areas, such as groundwater management districts, 3) the broader multi-state aquifer region, and 4) cross-scale programs. Through this integration, the team developed new tools, approaches, and partnerships to inform future water management research and outreach.

Key Outcomes at the Individual Producer Scale

1. Improvement of freely available irrigation scheduling tools, integrating soil moisture sensor and short-term weather forecast data to improve water use efficiency.

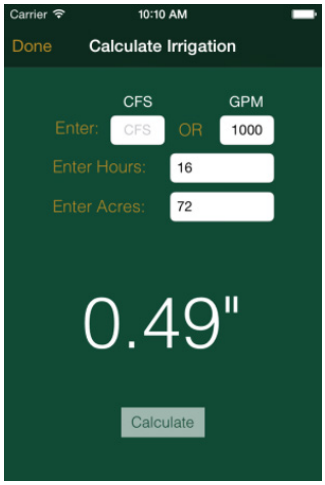

Figure 2. The Water Irrigation Scheduler for Efficient Application (WISE) app helps Colorado growers with irrigation scheduling.

2. Synthesis of soil, crop, and water management research, including integration of irrigation technologies, soil health, residue management, and crop choice into a broad suite of strategies available to producers to improve whole-system water conservation.

Soil, Crop, and Water Management Research Findings

- Early season irrigation, a common practice in cotton systems, actually decreases profitability and does not significantly increase yield.
- Water and nitrogen productivity are interrelated and affected by cultivar choice and precision management, contributing to reduced N applications by some Nebraska producers.
- Soil health research highlighted the increased value of soil management with dwindling irrigation capacity.
- Soil carbon is likely to decline with transitions from irrigated to dryland crops in the Central Great Plains, but these losses can be reduced with perennial grassland plantings.
- Maintaining residues can significantly improve soil water availability during corn vegetative growth, presenting an opportunity to irrigate less in normal to wet production years.

Key Outcomes at the Local and Regional Scale

1. Development of a novel, 4-part integrated model (MOD$$AT) to evaluate potential hydrologic and economic impacts of real-world policy and management scenarios.

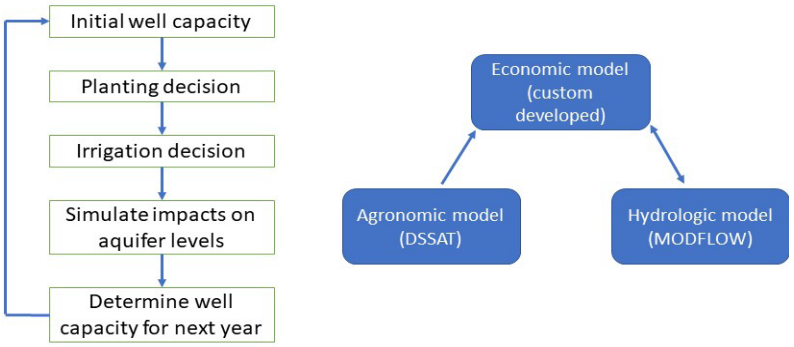

Figure 4. The MOD$$AT model integrates models from hydrology, agronomy, and economics to produce a groundwater decision-making tool.

Integrated Model (MOD$$AT) Findings

- Reducing competition for the shared groundwater resources by taking some wells out of production can improve conservation in the short-run, but over time, as aquifer levels increase in response to conservation, groundwater use can increase.
- Groundwater value is not uniform. Willingness to pay to increase well capacity for production is higher in hotter and drier counties across the aquifer.

2. Analysis of crop and economic data from the first Local Enhanced Management Area (LEMA) established in Kansas. The Sheridan #6 LEMA was a voluntary commitment by all producers in the region to reduce groundwater use by 26% from 2012-2017.

Sheridan #6 LEMA Findings

Producers reduced their total and average groundwater use by more than 30% over a 5-year period without reducing profitability by making shifts in crop choice, rotations, and a small decrease in irrigated land area. This example has been influential in encouraging other groundwater management districts to explore similar collective efforts to engage in voluntary conservation.

Key Outcomes at the Multi-State Aquifer Region Scale

1. Comprehensive irrigator survey across the six main aquifer states for the first time since the 1980's with 1,200 respondents sharing how they view, value, and approach water management and conservation.

Ogallala Region Irrigator Survey Findings

- Irrigators have altruistic and practical interests in maintaining groundwater stocks to sustain their communities and manage drought risk.
- Most irrigators feel they are already doing all they can to conserve water.
- A minority of irrigators volunteer in efforts and programs focused on conservation management.

2. Integration of spatial datasets including, land suitability classifications and groundwater level changes, with economic analyses to predict future land use transitions and associated regional economic implications of groundwater depletion.

Dataset Integration Findings

- Increasing groundwater declines and hotter, drier growing years due to climate change are likely to increase groundwater's value over time.
- Advanced planning to establish perennial pasture prior to irrigation loss in many areas will help maintain some agricultural production and avoid another future Dust Bowl.

Key Outcomes at the Cross-Scale Level

1. Convening 8-state summits in 2018 and 2021 brought together more than 200 stakeholders to identify groundwater management strategies.

2. Development and expansion of innovative extension programs, including *Master Irrigator* and *Testing Ag Performance Solutions (TAPS)*, which build communities of practice amongst research, extension, and private industry partners.

Extension Program Findings

- *TAPS* engaged 126 teams in Nebraska from 2017-2020, and 23 teams in Oklahoma from 2019-2020. Along with *Master Irrigator*, these innovative programs are influencing management on hundreds of thousands of acres.
- Multi-state network of Extension professionals was formed to share successes and challenges in groundwater-dependent areas of the High Plains, California, and the Delta region.
- OWCAP's work informed policy, including: 1) legislation in Oklahoma to establish the state's first groundwater management district in the Panhandle, 2) new discussions in Colorado to modify "use it or lose it" statutes that dampen producers' willingness to reduce water use, and 3) establishment of new NRCS Targeted Conservation Programs.

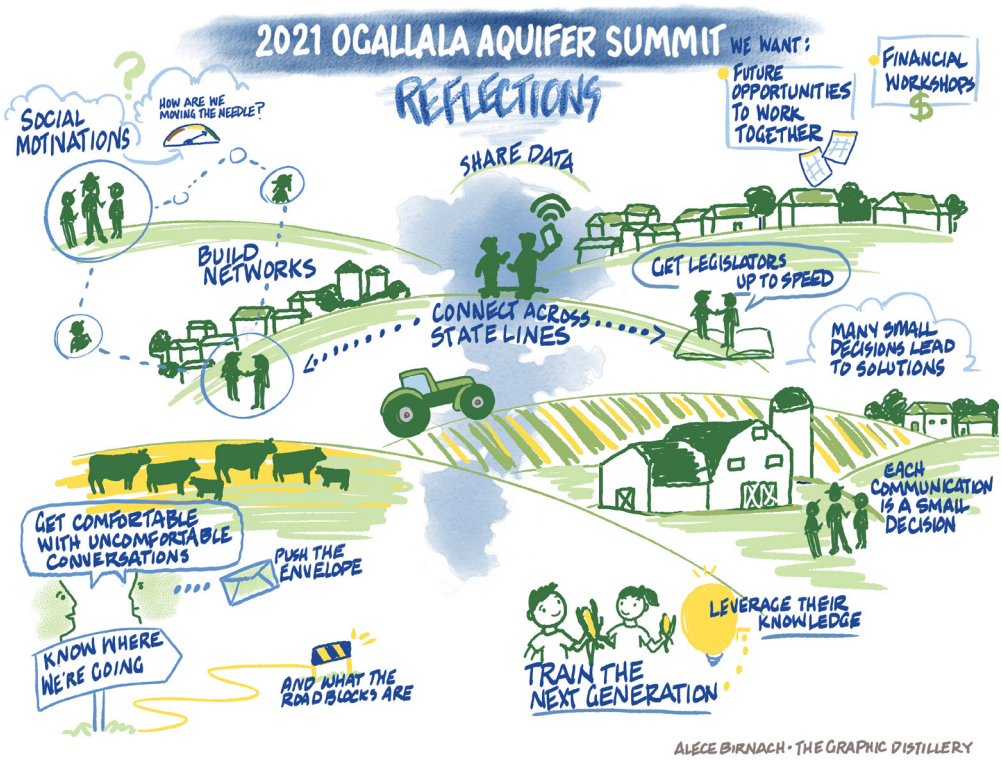

Figure 5. The 2021 Ogallala Aquifer Summit brought together stakeholders from across the aquifer region that resulted in a wide variety of summit reflections.

Figure 6. Amando Cano (USDA-ARS, Texas Tech University), top, and Verónica Acosta-Martínez (USDA-ARS), bottom, sample soils in irrigated cotton near Lubbock, TX, to compare fields transitioning to dryland sorghum or grasses. Top photo: Diane Vargas Bottom photo: Jon Cotton

Key Project Takeaways

While there is no "one-size-fits-all" solution to address the water challenges facing the Ogallala aquifer region, many sound strategies and tools exist to support more profitable and climate resilient production systems. The Ogallala Water CAP team's efforts have identified how water managers in this unique semi-arid production area can benefit from flexible state policies and access to state and federal programs that reward groundwater stewardship, including voluntary collective commitments to limit pumping, new limited irrigation crop insurance options, and programs that help producers prioritize net profitability over maximizing yield to extend the life of the aquifer and rural communities.

The Ogallala aquifer creates social, cultural, and economic value for the region, the nation, and the world. Any advances in water conservation extend the use of this vital resource, extending the timeline for planning and adaptation to a changing climate and increased water scarcity. There are innovative and strategic approaches to conservation that are economically viable today and in the future. Larger land use changes will require additional incentives, support, and forethought to support communities to transition to more diversified economies. Research funding can support these advancements and planning through continued emphasis on stakeholder-engaged, system-based, multi-scalar and multi-disciplinary research, education, and outreach.

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