

WRRI Programs and Projects

69th Annual New Mexico Water Conference

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Outline

1. History, missions, and metrics
2. Understanding water budgets
3. Spatial analysis
4. Transboundary Aquifer Assessment Program
5. System dynamics
6. Community-based research

NM WRRI history, mission, and metrics



NEW MEXICO WATER RESOURCES

RESEARCH INSTITUTE

<https://nmwrri.nmsu.edu/>

The NM WRRI was established in 1963 by the New Mexico legislature and approved under the federal Water Resources Research Act of 1964, as amended. Introduced by New Mexico Senator Clinton P. Anderson modeled on NM WRRI, there is a WRRI in every state plus three territories and the District of Columbia.

It is one of 54 national water institutes supported by the USGS (US Water Resources Research Act), is the water research institute of NM (Statute NMSA 1978 21-8-40); NM WRRI's purpose was defined in Public Law 88-379.2 and enacted by the Legislature of the State of New Mexico 2005, House Bill 193. NM WRRI has received NM General Fund support for 55 years.

NM WRRI supports research and training conducted by faculty and students from universities across the state, transfers water information, and provides expertise and specialized assistance in addressing water problems critical to New Mexico and the Southwest. NM WRRI also cooperates with local, state, and federal agencies to solve water-related problems.



Senator Clinton P. Anderson (right), who sponsored Saline Water Conversion Plant legislation in Congress, at the Third Annual New Mexico Water Conference with Rogers Aston (left), South Springs Foundation (1958).

NM WRRI Missions

1. **Federal:** Department of the Interior, USGS. Appropriations approved under the Water Resources Research Act states that each institute shall:
 - (1) plan, conduct, or otherwise arrange for competent applied and peer-reviewed research that fosters— (A) improvements in water supply reliability;
 - (B) the exploration of new ideas that—
 - (i) address water problems; or
 - (ii) expand understanding of water and water-related phenomena;
 - (C) the entry of new research scientists, engineers, and technicians into water resources fields; and
 - (D) the dissemination of research results to water managers and the public.
 - (2) cooperate closely with other colleges and universities in the State that have demonstrated capabilities for research, information dissemination, and graduate training in order to develop a statewide program designed to resolve State and regional water and related land problems.
2. **State:** State of NM General Fund Appropriations for Research and Public Service Projects. Public Law 88-379.2 and in 21-8-40 NMSA 1978 and enacted by the Legislature of the State of New Mexico 2005, House Bill 193 defines the purposes of the institute are to:
 - (1) provide research and training in water conservation, planning and management; atmospheric-surface groundwater relations; and water quality;
 - (2) transfer water information through the use of technical and miscellaneous publications, newsletters, conferences and presentations;
 - (3) provide expertise, specialized assistance and information to address water problems; and
 - (4) cooperate with local, state and federal water agencies

NM WRRRI Missions

3. NMSU (LEADS 2025)

- Goal 1: Enhancing Student Success and Social Mobility
- Goal 2: Elevating Research and Creativity
- Goal 3: Amplifying Extension and Outreach
- Goal 4: Building a Robust University System
- Goal 5: Building an Online Global Campus
- Goal 6: Build, Elevate, and Strengthen Sustainable Systemwide Equity, Inclusion and Diversity Practices

4. Cooperative Agreements, Grants and Contracts: objectives and deliverables are developed in each proposal in response to competitive, collaborative, and externally funded initiatives



NM WRRRI Metrics & Reporting

Some examples of NM WRRRI metrics & reporting include, but are not limited to the following:

Train the next generation of water professionals

NM WRRRI supports graduate student research, MS and PhD degrees in the WSM and other statewide programs, and early career researchers. In FY24, NM WRRRI awarded 15 Student Water Research Grants supporting 43 students through its grant program. Nine faculty and researchers across the state through the institute's faculty water grant

Solving New Mexico's water problems through university-level research

In FY24, NM WRRRI directed 21 externally funded projects and administered 30 subcontracts. NM WRRRI supported five Statewide Water Assessment research projects. Statewide Water Assessment research projects produced 76 maps, 3 reports, 11 databases, and 2 models. In FY24, NM WRRRI published four technical completion reports.

Disseminate knowledge to assist New Mexico in solving our water problem

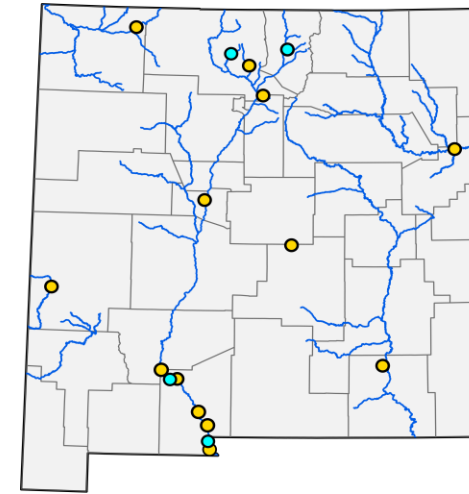
Seventy-five researchers including high school students, undergraduates, and graduates, statewide presented their research projects at the 68th Annual New Mexico Water Conference. Fifteen WRRRI Student Research Grant recipients completed and published their funded research project. In FY24, NM WRRRI met with communities and stakeholders, conducting 106 meetings and workshops to gather stakeholder needs for water resources management. Fifty-one presentations and research documents in FY24 were coordinated for user needs across the state.

NM WRRI PROGRAMS

- The **Strategic Community Water Management Program (SCWMP)** serves communities, water users, and water managers with research-based water information to meet their needs. The SCWMP creates strategic approaches and management scenarios to mitigate water scarcity including new water smart technology, irrigation alternatives, acequia upland valley water interactions, mutual domestic supply well dynamics, machine learning estimates of impacts on groundwater, rangeland hydrology assessments, reservoir source water budgets, and watershed restoration for improved surface water and groundwater interactions.

The **SCWMP** is collaborating with communities such as Placitas and La Union, in Dona Ana County; and Canjilon, in Rio Arriba County; and Valdez in Taos County to deliver up-to-the-minute water information for water management needs and serves the state by building on the technical understanding developed by the Community Hydrology Program.

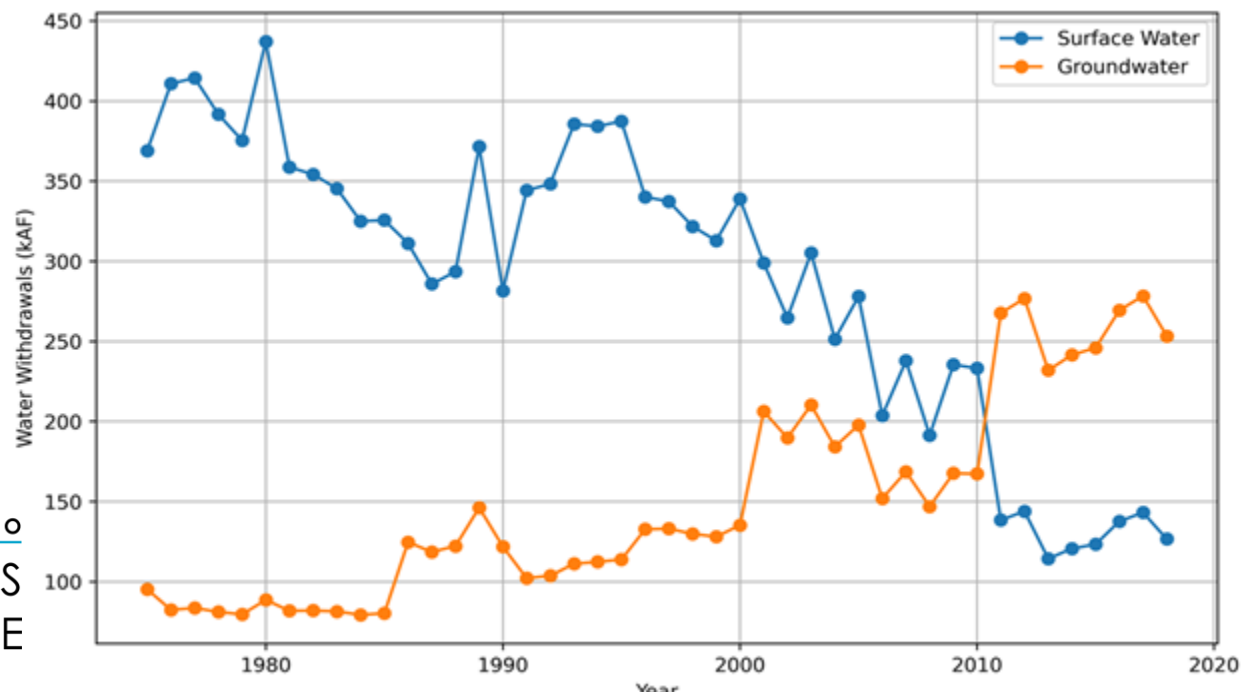
- The **Community Hydrology Program** supports fundamental research on New Mexico water management and hydrology to serve communities of northwest New Mexico, Upper Rio Grande, Central New Mexico, Lower Rio Grande, Hatch/Rincon and other critical sites where communities continue to face issues related to water scarcity and drought.



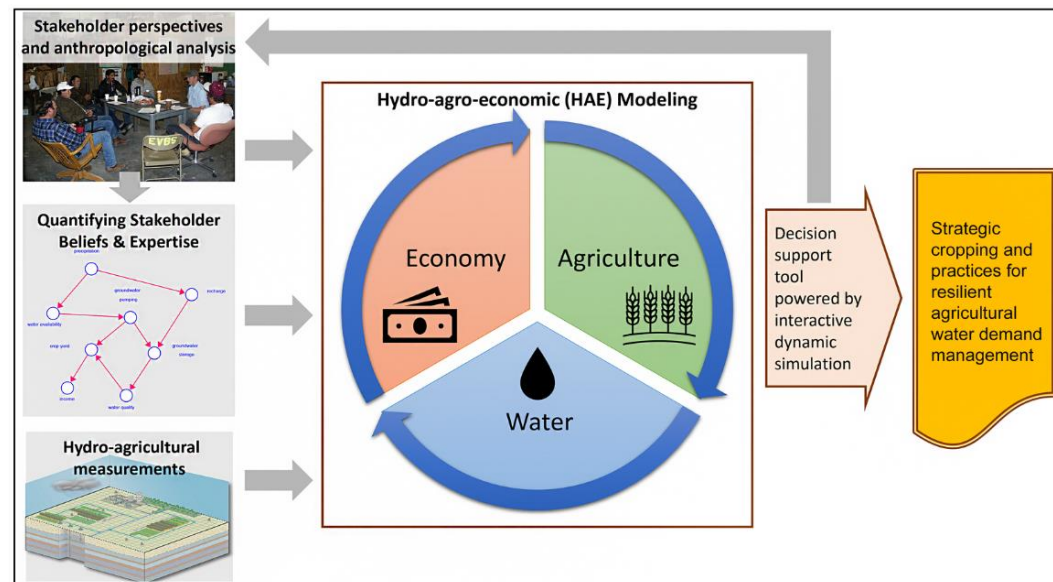
- Active and Future Projects
- Current SCWMP Communities



- The **Statewide Water Assessment** (SWA) continues to provide quantitative information and data for water planning across the state. The **New Mexico Dynamic Statewide Water Budget (NMDSWB)** is used for water planning by stakeholders by providing water supply and demand information at four spatial scales.
- The **NMDSWB** provides outputs for analysis such as Lower Rio Grande (LRG) water planning region models. The LRG is experiencing a shift in water supply resources, with reduced surface water withdrawals and increased groundwater withdrawals. This change is driven by factors such as statewide drought conditions, climate change, and policy directives. The NMDSWB provides inputs for the conceptual framework for the systems model of following effects.



- The **Clean Drinking Water Technology Project** is developing and characterizing a clay pellet technology to purify contaminated household water. The clay pellets treat and remove uranium and heavy metals from water to produce potable water.
- The **New Mexico Universities Alternative Water Supplies and Produced Water Synthesis Project** coordinates and supports research statewide. Project applies a novel hybrid systems modeling approach to examine treatment technologies, spatial variability of produced water volumes, effects from injection, and the legal implications of the Produced Water Act.
- The **Groundwater Conservation Project's** goal is to conserve groundwater by developing strategic cropping and practices for resilient agricultural land use strategies on water budgets and agricultural economies to long-term water supply.



The Hydro-Agro-Economic (HAE) Model is an integrated decision tool .

- Fallowing alfalfa has the greatest water savings with the lowest economic cost compared to cotton and chile

- Through an annual competitive process the **Faculty Water Research Grant Program** provides funding through the Institute's federal base grant (Section 104b of the Water Resources Research Act) and state appropriations for water-related research to tenure-track faculty across the state. Utilizing a diverse advisory committee, proposals are reviewed and selected for funding based on their relevance to local water issues.
 - These "seed money" projects allow New Mexico university faculty to pursue critical areas of water resources research while providing training opportunities for their students
 - The grants generally provide about \$40,000 per project
 - Grants are available to tenure-track faculty members in any department at one of the state's six research universities (UNM, NM Tech, NMSU, NMHU, WNMU, and ENMU)
- The **Student Water Research Grant Program** appropriates funding to help students initiate research projects or to supplement existing student water-related research projects through its biannual competitive application process.
 - Provided 15 student water research awards across the state in FY24 and FY25
 - Prepared students for real-world research proposal development, budget monitoring, reporting, and submitting publications as a result of Student Water Research Program funding



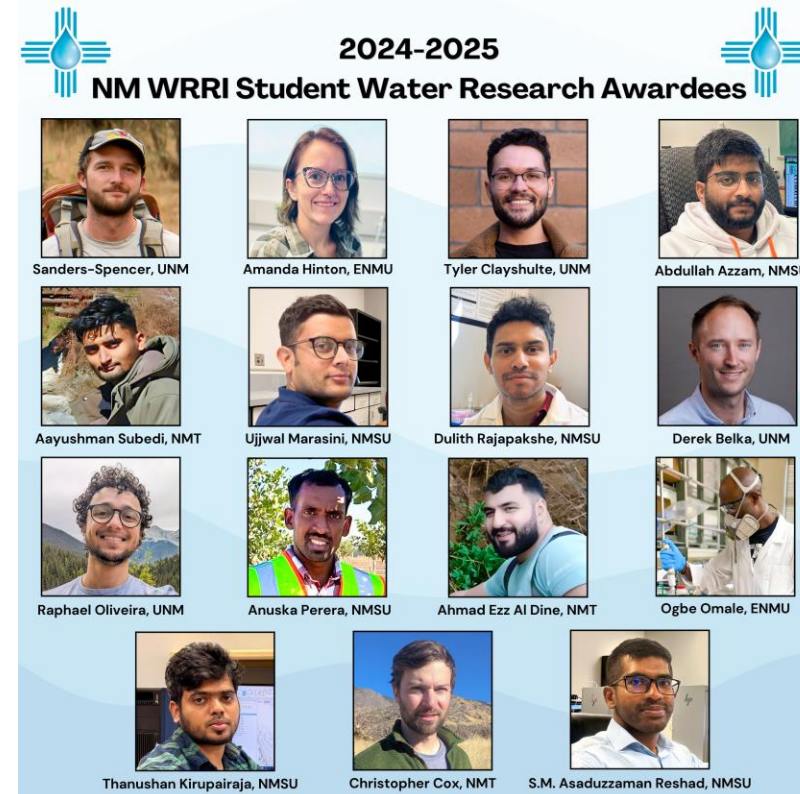
Runwei Li, NMSU,
Civil Engineering



Rajan Ghimire, NMSU,
Plant & Environmental Sciences



Huidae Cho, NMSU,
Civil Engineering



- **Outreach and Technical Support.** NM WRRRI hosts the New Mexico Annual Water Conference in addition to other specialty conferences and workshops e.g., Animas and San Juan Watershed Conference, Tribal Capacity with Water Research Partnerships, and New Mexico Nonpoint Source Management Plan Workshop in collaboration with NMED, to name a few. NM WRRRI publishes a technical completion report to its website as a result of every completed research project funded. NM WRRRI publishes an electronic monthly newsletter, “NM Water eNews”.



Understanding water budgets

NM WRRI's Dynamic Water Budget for Decision Support

One of the most critical factors in making decisions related to water and hydrogeology is the availability of information data and ease of access to it.

In this context, the New Mexico Water Resources Research Institute (**NM WRRI**) has made significant efforts by developing the **NM DSWB** (Dynamic State Water Budget) model.

The NM WRRI, in **collaboration** with UNM, NMT, USGS, SNL, INTERA, and OSE, worked together to develop the NM DSWB model.

This model provides modeling capabilities and water data that cover **all spatial scales across the state**, significantly contributing to the improvement of water resource management and addressing the challenges of water scarcity and groundwater depletion.



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New Mexico Dynamic Statewide Water Budget (NMDSWB)

Spatial scales:

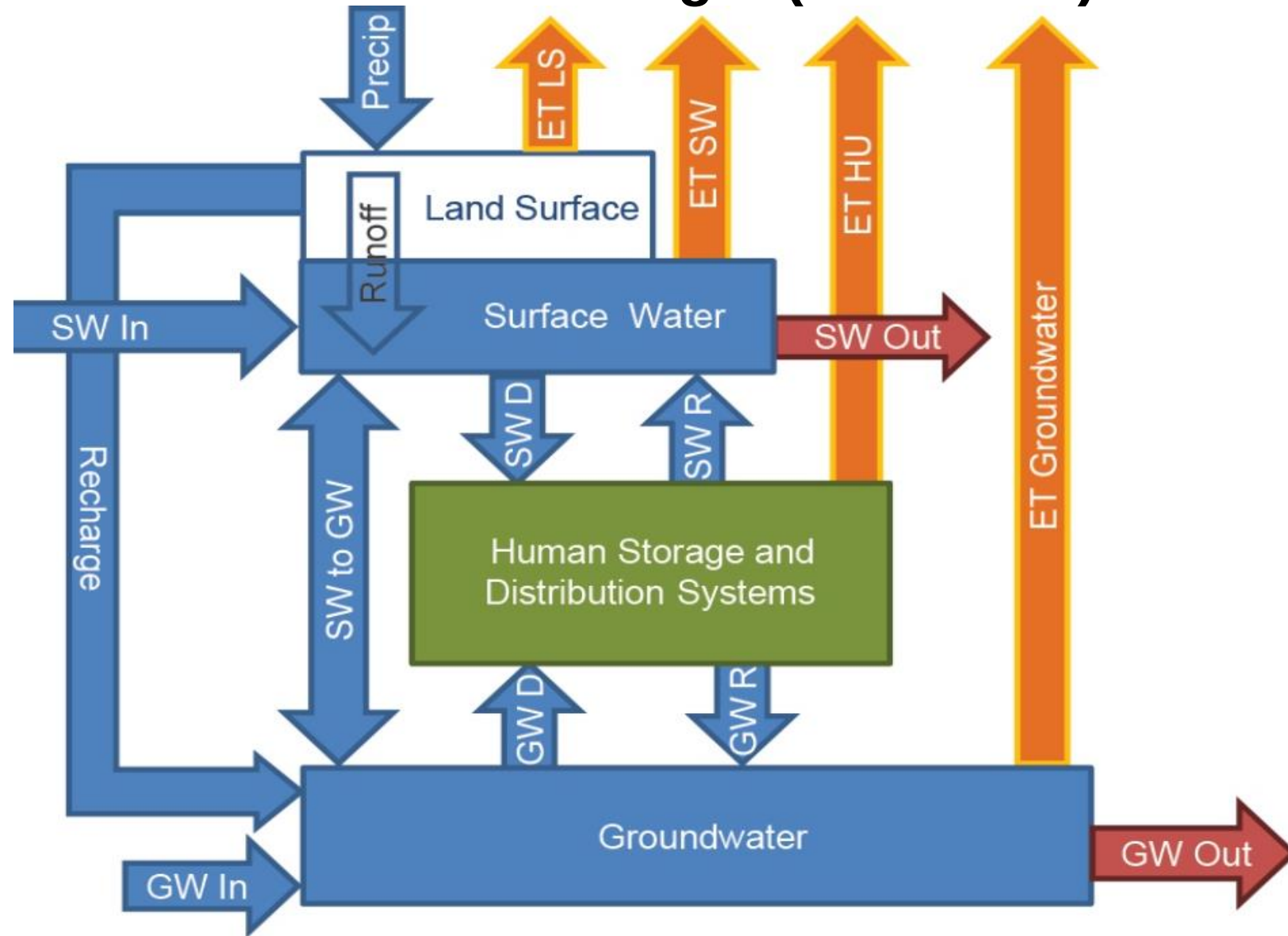
- Counties (33)
- Water Planning Regions (16)
- Major river basins (7)
- Statewide (1)

Modeling periods:

- Historic period (1975-2018)
- Future period (2019-2099)

Future scenario options:

- Climate models
- Population growth
- Water use efficiency
- Agriculture land acreage

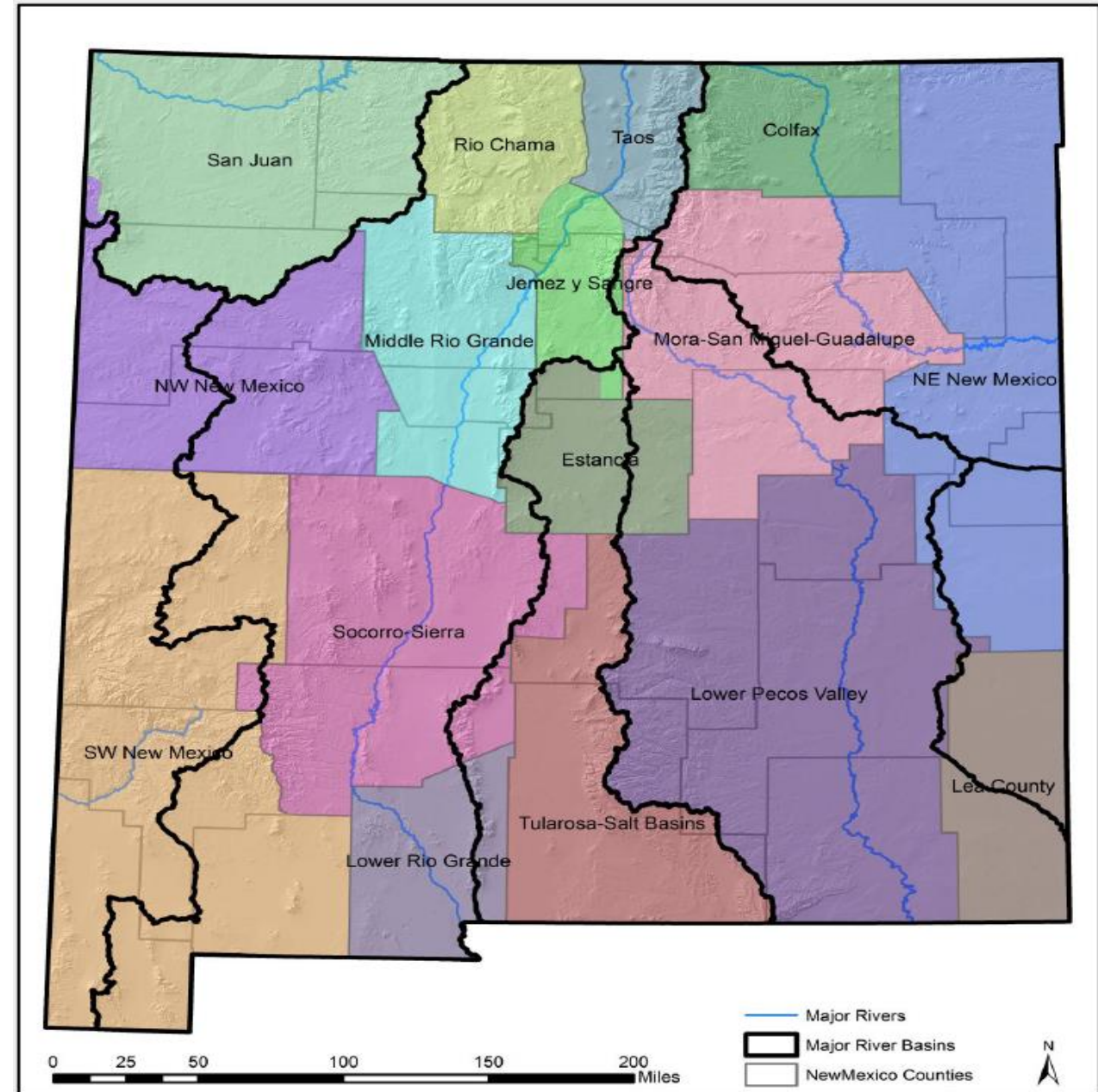


Importance of NM DSWB

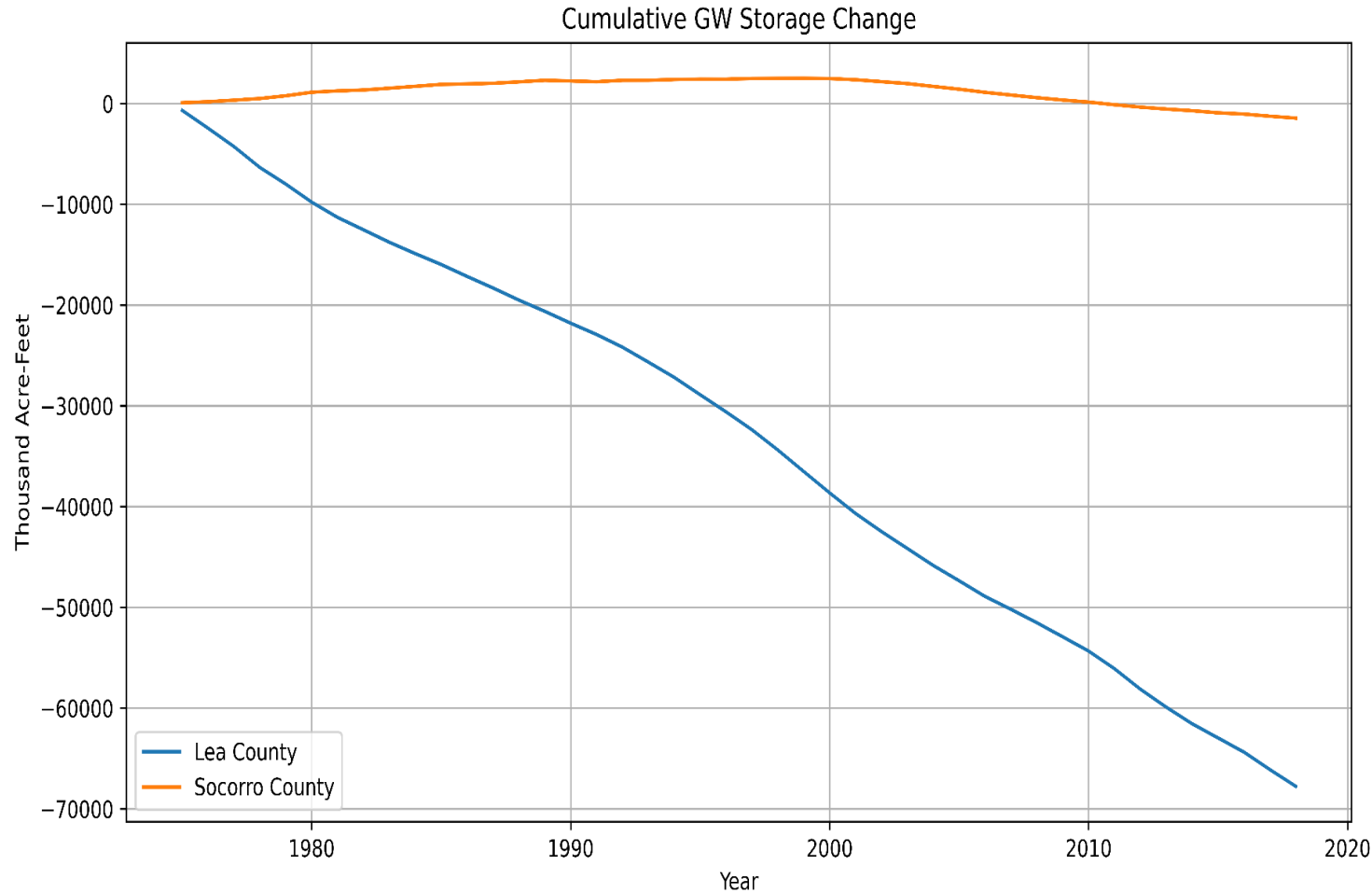
Through data and trends analysis, NM DSWB can give us an overview about the regions **vulnerable to severe water scarcity** in different spatial scales in NM.

Next slides are some **analytical examples** that highlight the use of this model as an effective data tool in **different spatial scales**.

These examples demonstrate the NM DSWB model's capability to support important water-related decisions and enhance **water management in New Mexico**.

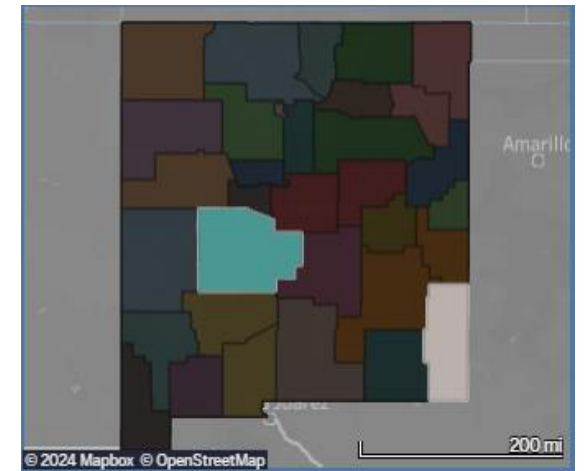


Fossil GW v Recharged GW

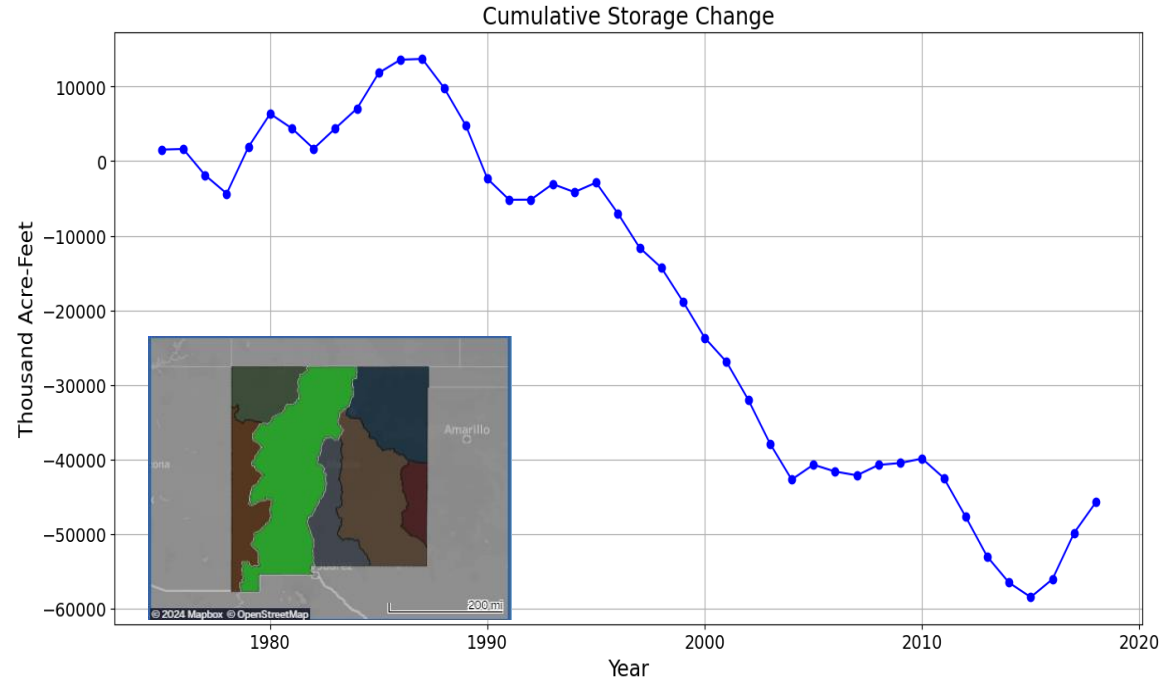
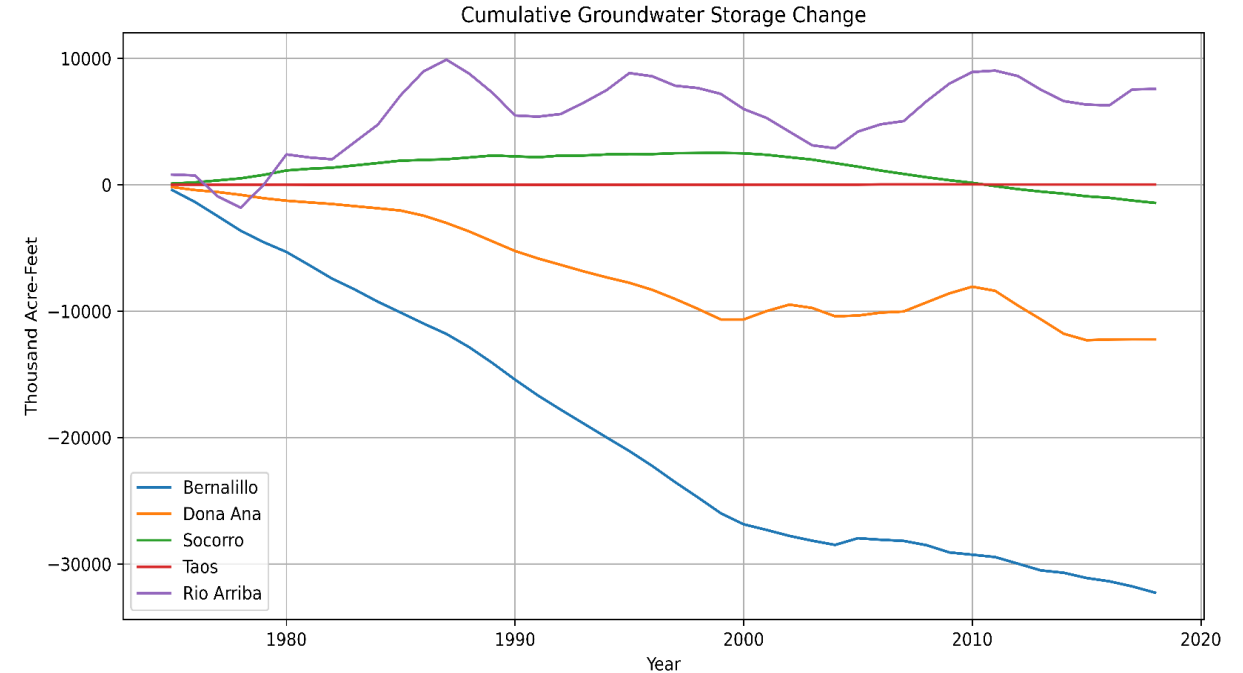


In Socorro County during the '80s and '90s, there is an impact of SW recharge on GW. After 2000 GW trends negatively.

In Lea County during the whole period there is a steady decline in GW storage. This is because Lea County overlies parts of the Ogallala Aquifer, a fossil water aquifer, and receives negligible recharge.



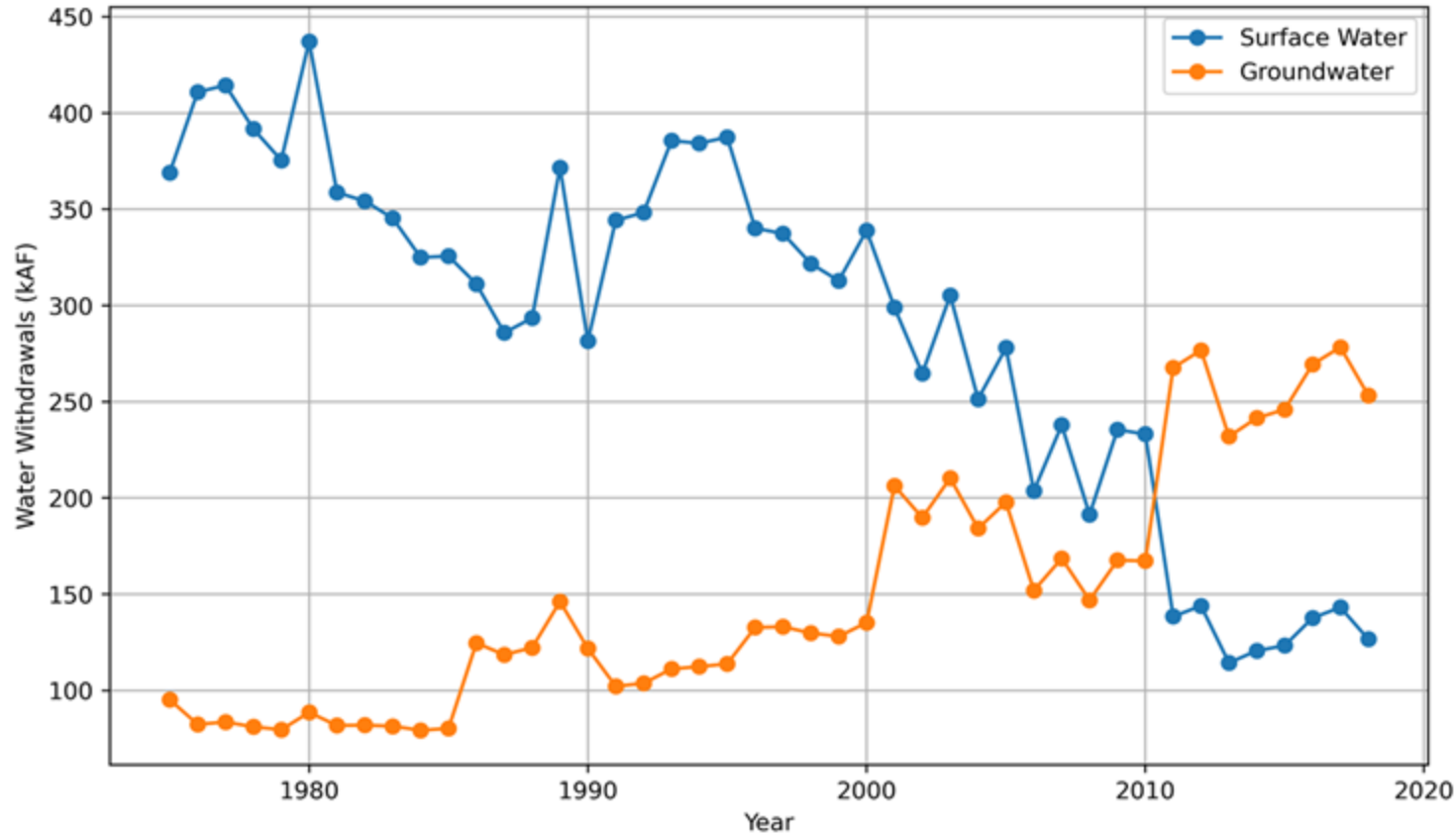
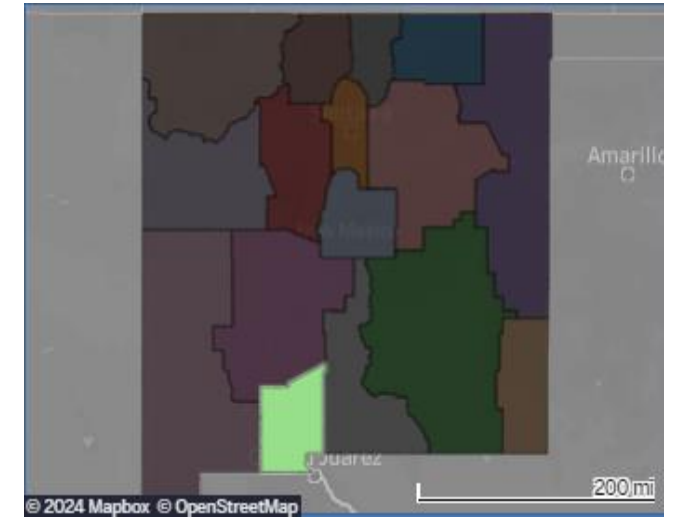
GW Depletion in RG River Basin and Counties



- The GW storage of the **Rio Grande Basin** fluctuates and has largely declined since the mid 80s.
- Within the **Rio Grande Basin** there is a spatial variability in GW storage change where it changes and varies from north to south.
- **Rio Arriba** county GW fluctuates with small overall increases.
- **Taos** county's GW was stable from 1975 to 2018.
- **Socorro** GW change trends slightly negatively after 2000.
- **Bernalillo and Dona Ana** county GW storage has declined with agricultural and municipal uses.



Lower Rio Grande Region WPR



- LRG is experiencing a shift in water supply resources, with reduced surface water withdrawals and increased dependence on groundwater.
- This change is driven by factors such as statewide drought conditions and climate change.

Field-scale Water Budgets

Alfalfa

Pecan

In the Mesilla valley (Doña Ana County)

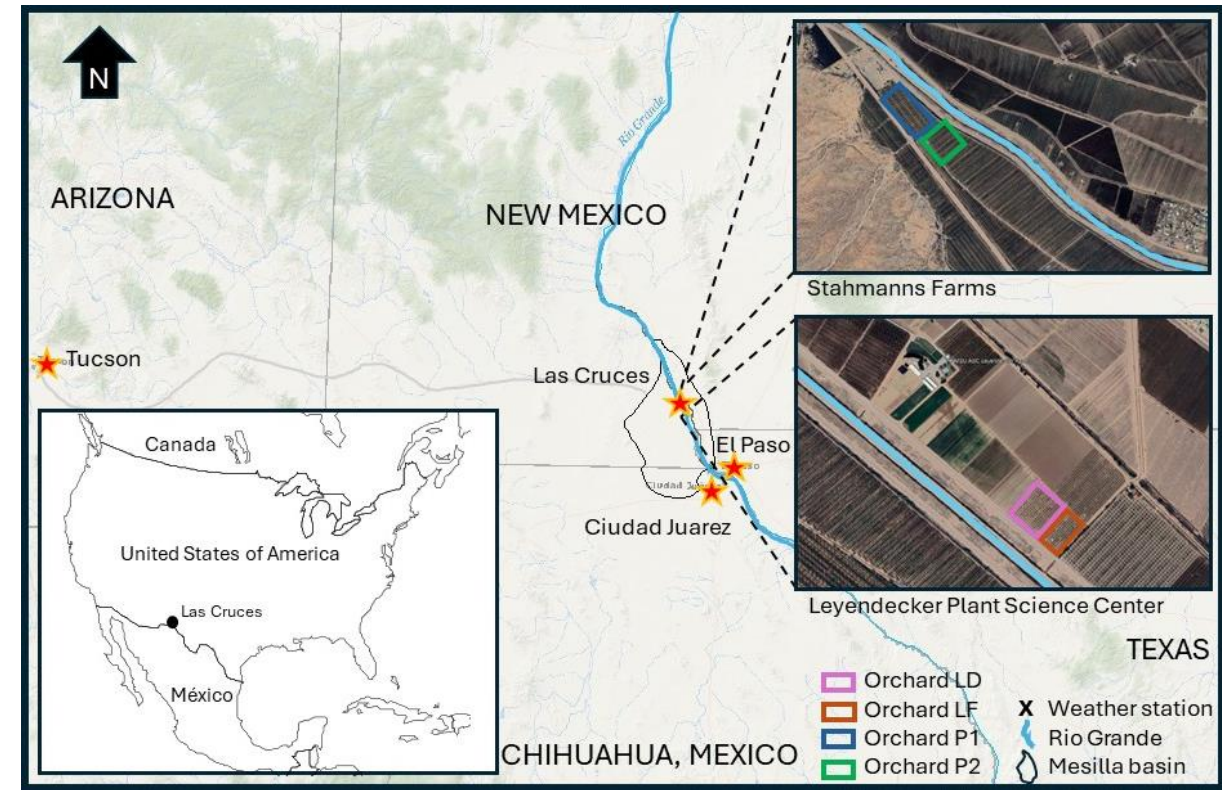
Other crops

Field water budgets on other crops in Northern New Mexico

Methods of irrigation used in Mesilla Valley
pecan orchards: flood, drip, and sprinkler.



Main crops in New Mexico



Collaboration with different farmers across the state



Soil moisture sensors installed in the fields

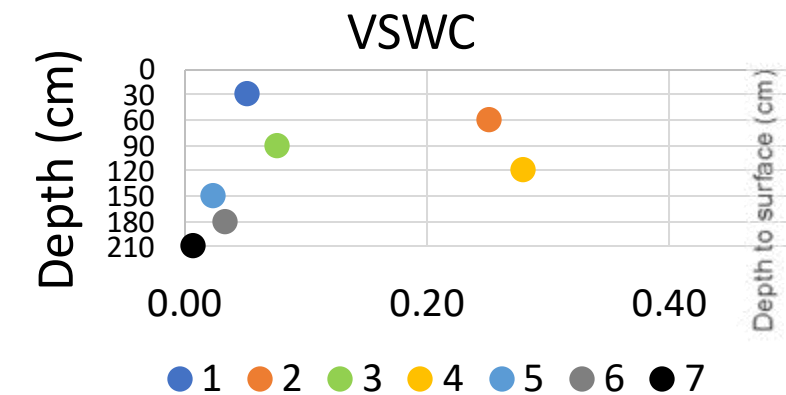
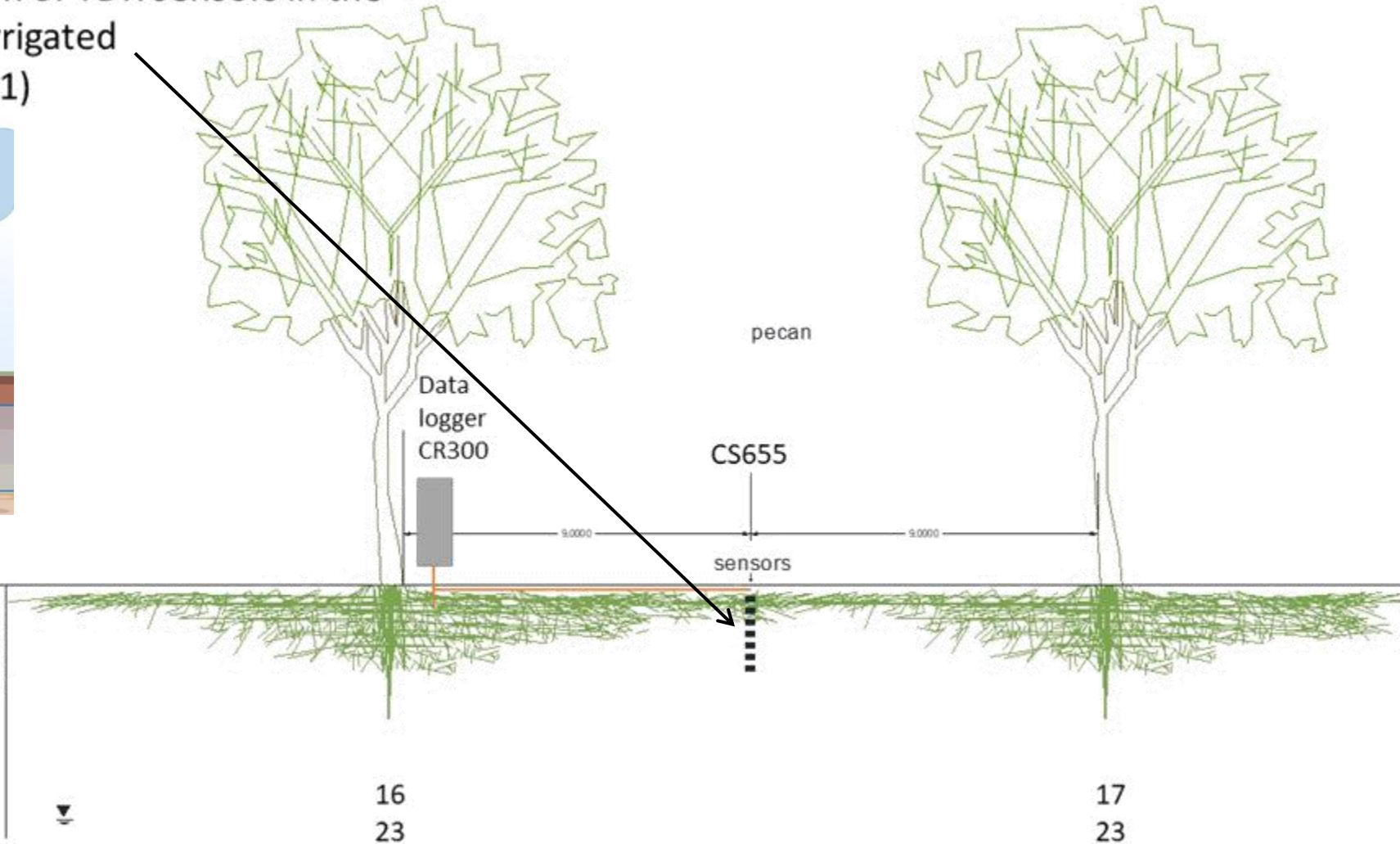
Measure changes in water content in the soil

Other sensors measure rain, irrigation, and evapotranspiration

Water balance components
at field scale:
 $I + P - ET - P_n = \Delta S$



Location of TDR sensors in the
flood irrigated
field (P1)



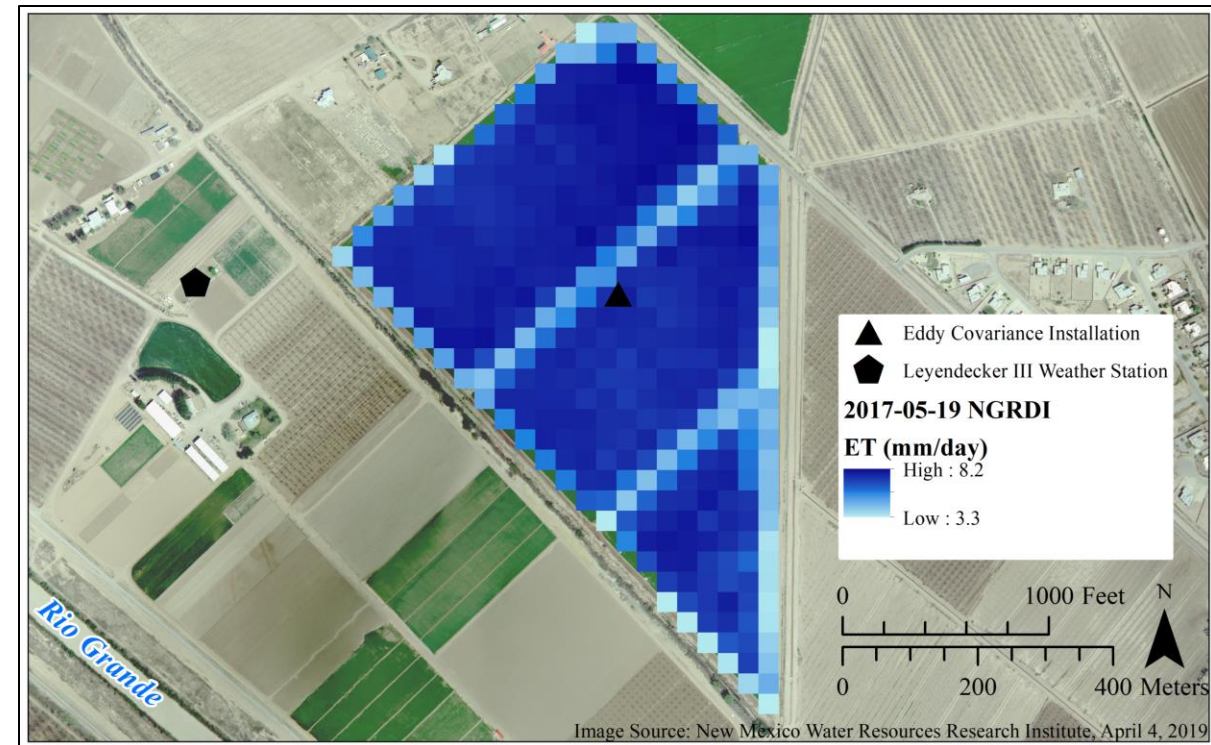
Spatial analysis

Calculating Vegetation Index-Based Crop Coefficients for Alfalfa in the Mesilla Valley, New Mexico Using Harmonized Landsat Sentinel-2 (HLS) Data and Eddy Covariance Flux Tower Data

Problem: Remote sensing evapotranspiration (ET) models that use thermal for field scale ET estimates lack the temporal resolution for capturing alfalfa ET due to the rapid grow/cutting cycles

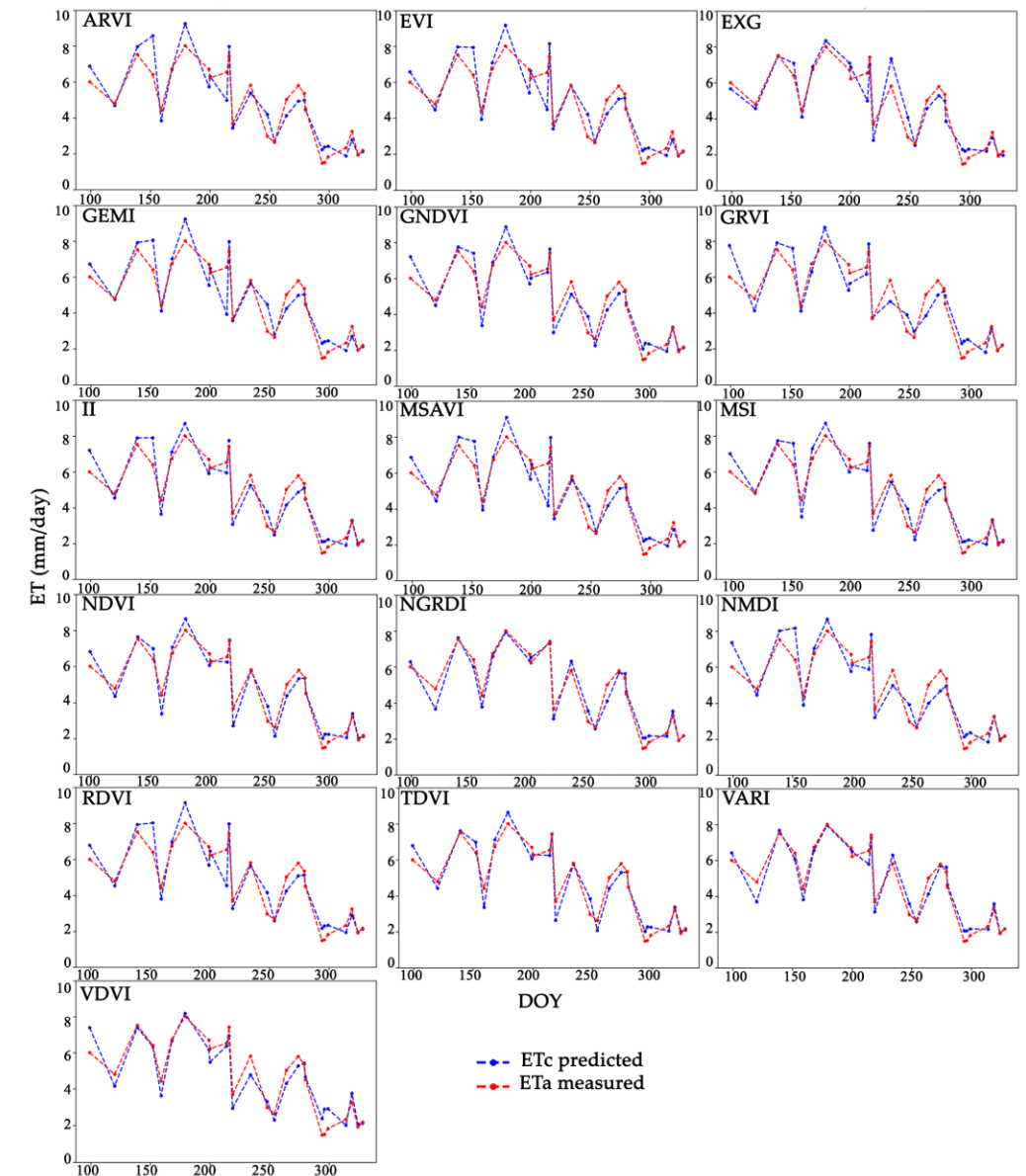
Vegetation indices (VI) such as the Normalized Difference Vegetation Index (NDVI) and others can be correlated to crop coefficient data to create VI-based crop coefficients

The Harmonized Landsat Sentinel-2 dataset provides spectral data at 30 m spatial resolution at a < 5-day return interval



Example of K_{CVI} output map showing estimated ET (mm day^{-1}) using NGRDI for 19 May 2017.

- Tested 16 commonly used VIs
- Predicted values closely followed the field measured values
- Several models were had a mean average error under 15% for daily ET
- The models were comparable to results from OpenET r^2 0.68-0.79 suggesting this approach could be used to fill data when thermal imagery is missing
- Research still needed on additional crops

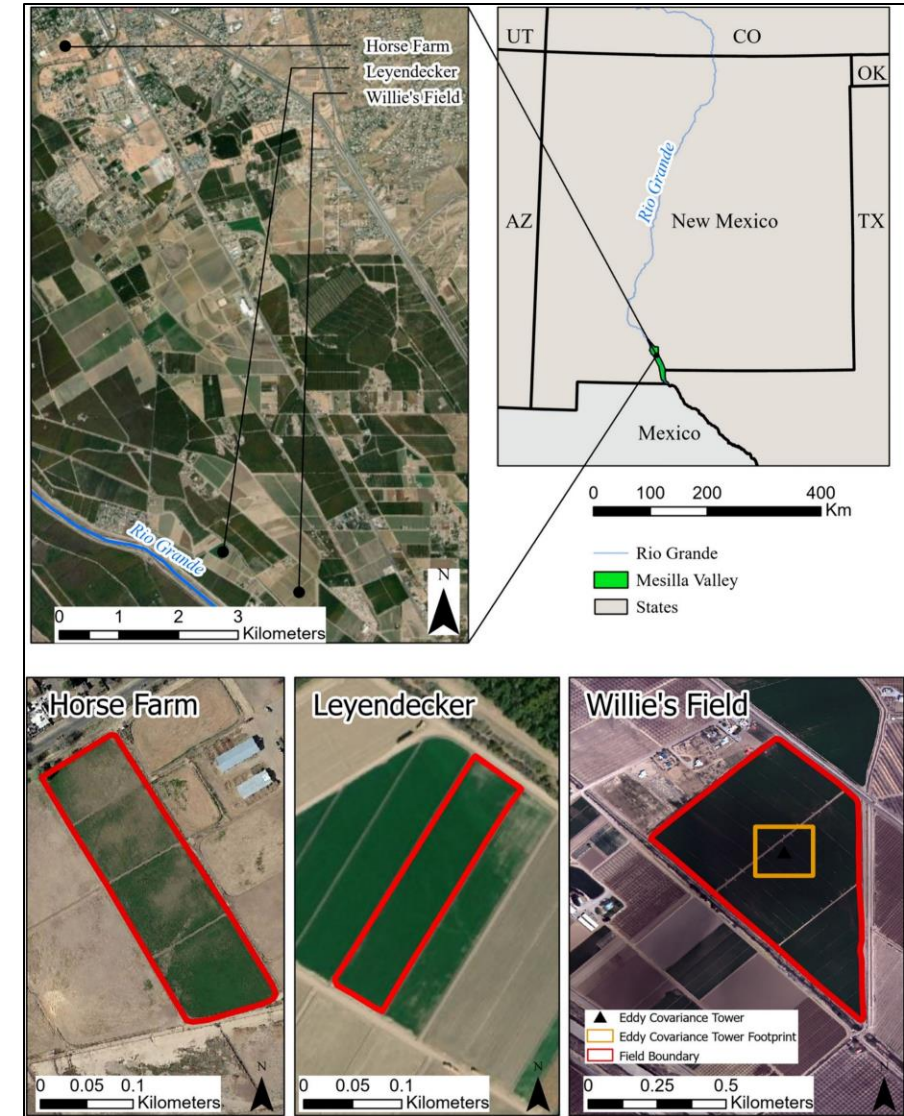


Comparison of predicted crop ET (ET_c) using the K_{CVI} method and measured ET_a from an eddy covariance tower for alfalfa.

Comparing field-scale eddy covariance measurements and crop coefficient estimates of alfalfa evapotranspiration to OpenET model estimates and exploring water budget implications in a dryland environment

- OpenET is a new water management tool and needs additional evaluation for crops grown in New Mexico
- compared satellite-based OpenET estimates of ET_a from three alfalfa fields in the Mesilla Valley, New Mexico, USA—one field with measurements of ET_a from an eddy covariance tower and two fields with estimated crop evapotranspiration (ET_c)
- Found that all but one OpenET model produced lower ET values relative to field measurements
- Results were comparable to other validation studies
- More research needs to be completed on smaller fields

Sabiston, L., Sabie, R., Buenemann, M., Stringam, B. and Fernald, A., 2024. Comparing field-scale eddy covariance measurements and crop coefficient estimates of alfalfa evapotranspiration to OpenET model estimates and exploring water budget implications in a dryland environment. *Irrigation Science*, pp.1-18.



Transboundary Aquifer Assessment Program



Mesilla Conejos Medanos Aquifer within the Rio Grande River Basin



NEED FOR UNIFIED MODEL

- Separate modeling since 2009
- New binational work group started Sept. 2023 to build transboundary groundwater model together with US and Mexico involvement

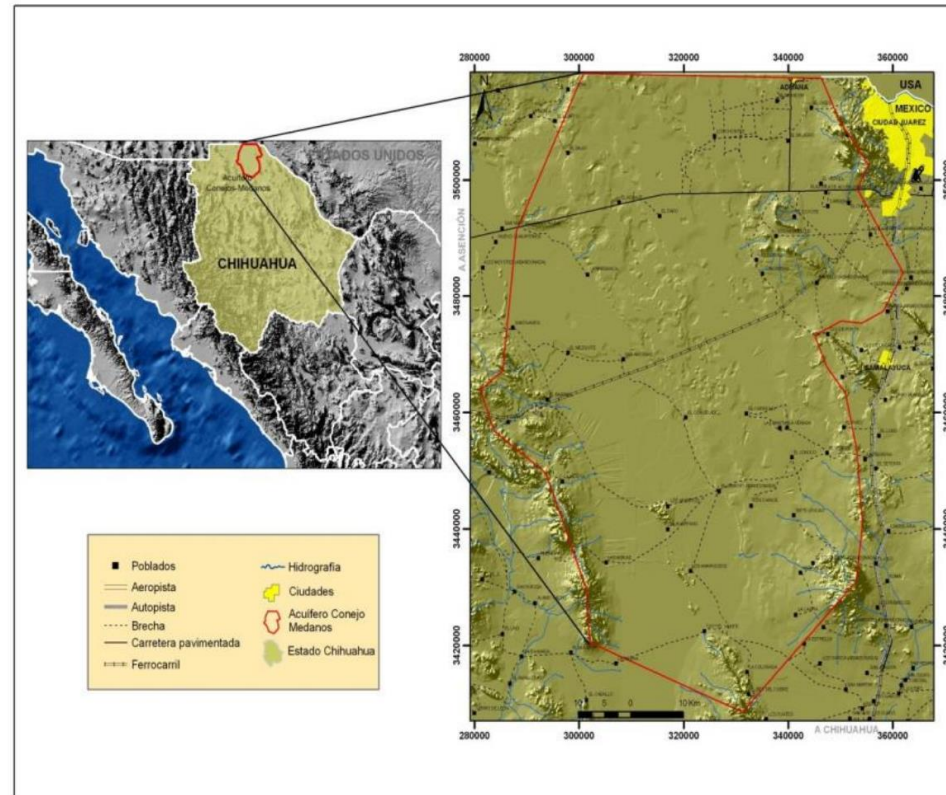
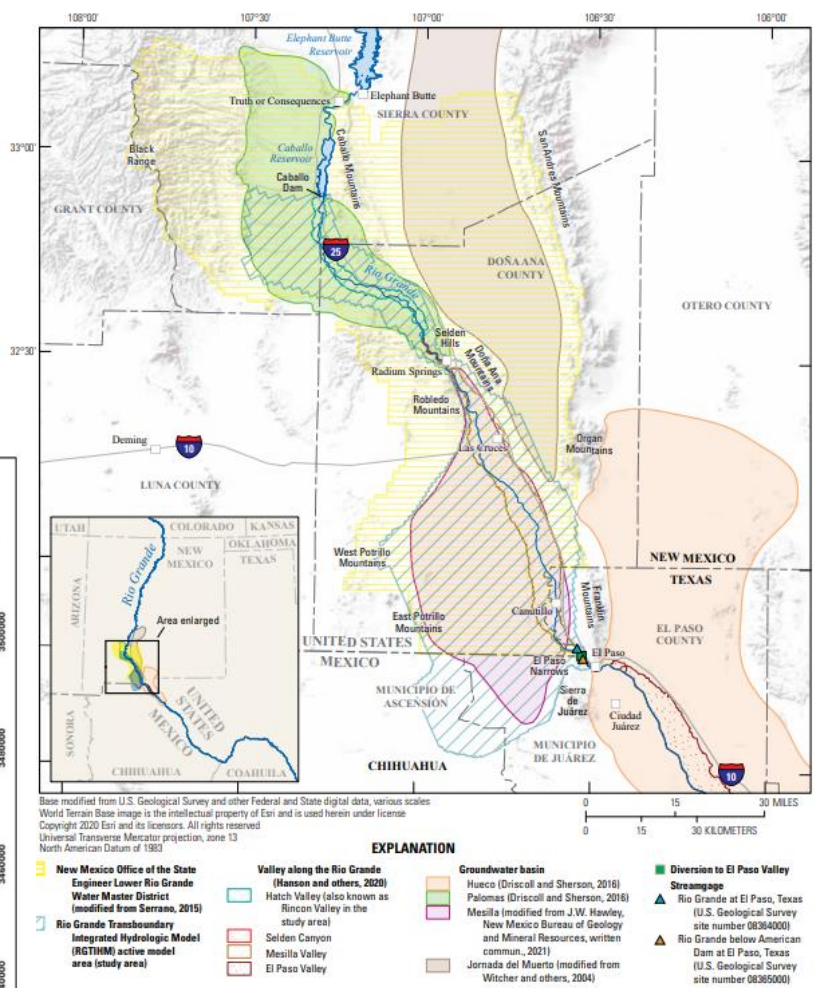


Figure 1. Study area and active model area of the Rio Grande Transboundary Integrated Hydrologic Model (RGTIM; Hanson and S, 2020) in the Hatch Valley and Mesilla Basin, New Mexico and Texas, United States, and northern Chihuahua, Mexico.

WHITE MAP SYNDROME

*Estimate the average gradient to
know the recharge component*

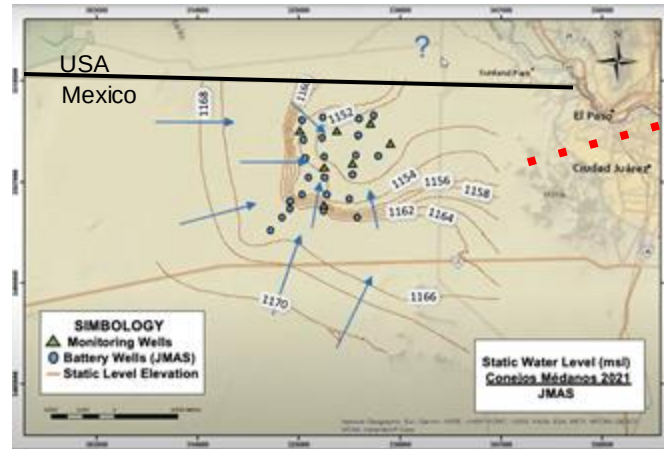
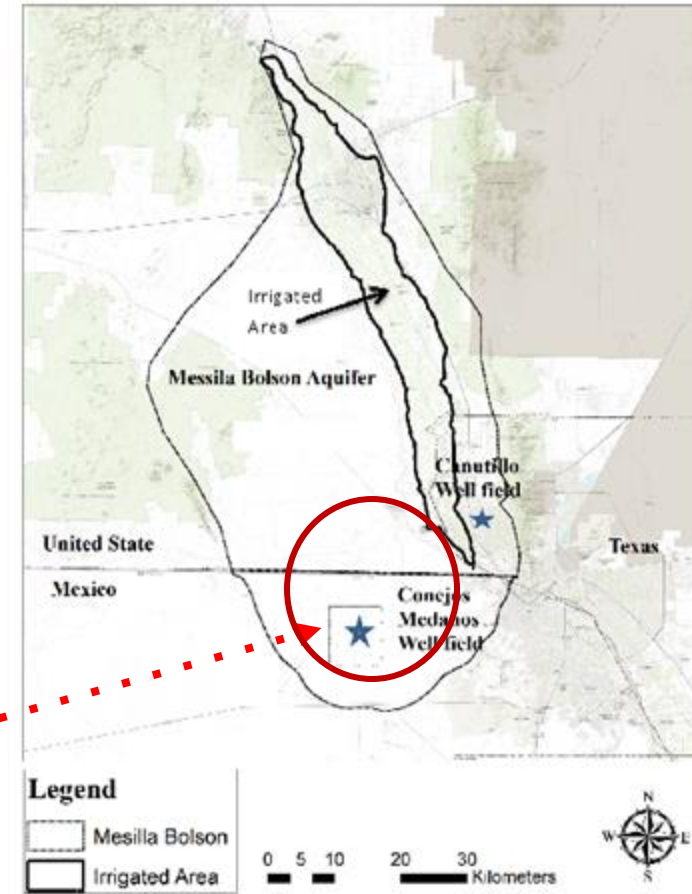


Figure by Zohrab Samani. Boundaries of Mesilla Bolson Aquifer within New Mexico, Texas and México

Selected TAAP Accomplishments

- Over 24 binational meetings held
- Furthered the development of Mesilla Valley Hydrologic Model with Farm Process module (NM, TX, MX)
- Published articles related to TAAP and presented TAAP materials at many conferences (AZ, NM, TX, MX)
- Conducted extensive fieldwork on the Mesilla Aquifer (AZ, NM, TX, MX)
- Conducted binational Mesilla aquifer isotope studies
- Initiated US-Mexico binational shared data portal; shared approach with Ukraine project
- Initiated Mesilla Aquifer binational work group – first meeting Sept. 2024



Networking and Educational Activities



- Systems mapping at the virtual TGR Annual Workshop
- Virtual data panel on FAIR data principles, spatial analysis and CUAHSI's Hydroshare
- Career development panelists from water, data, social and systems science
- System Modeling for Transboundary Groundwater Resilience course
- Stakeholder engagement at the TGR Town Hall in-person breakfast at UN Water 2023



Ali Saysel



Karen Villholth



Karin Kemper



Nick Martorano



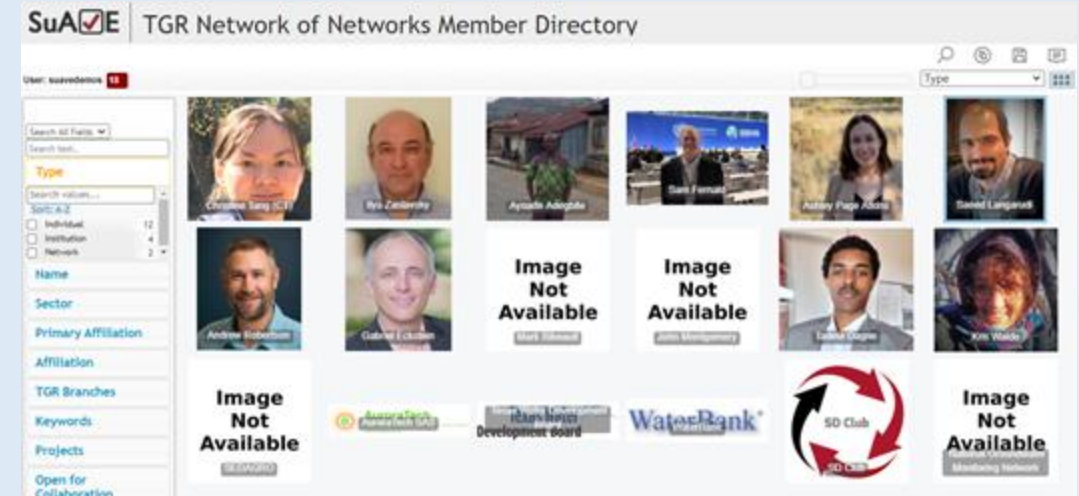
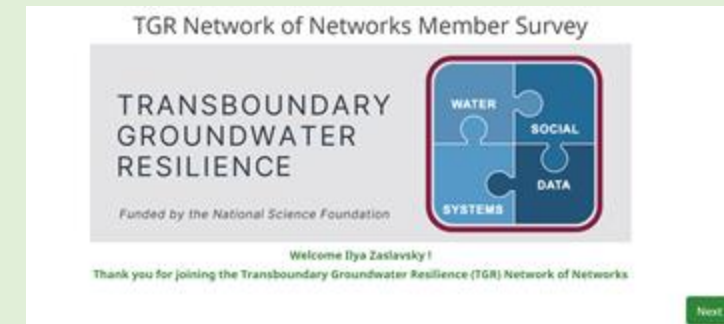
TRANSBOUNDARY GROUNDWATER RESILIENCE

Funded by the National Science Foundation



- Seminar series
- Supporting students and early career researchers
- Peer mentoring
- Volunteer opportunities
- Integration of open-source software tools for network building and analysis

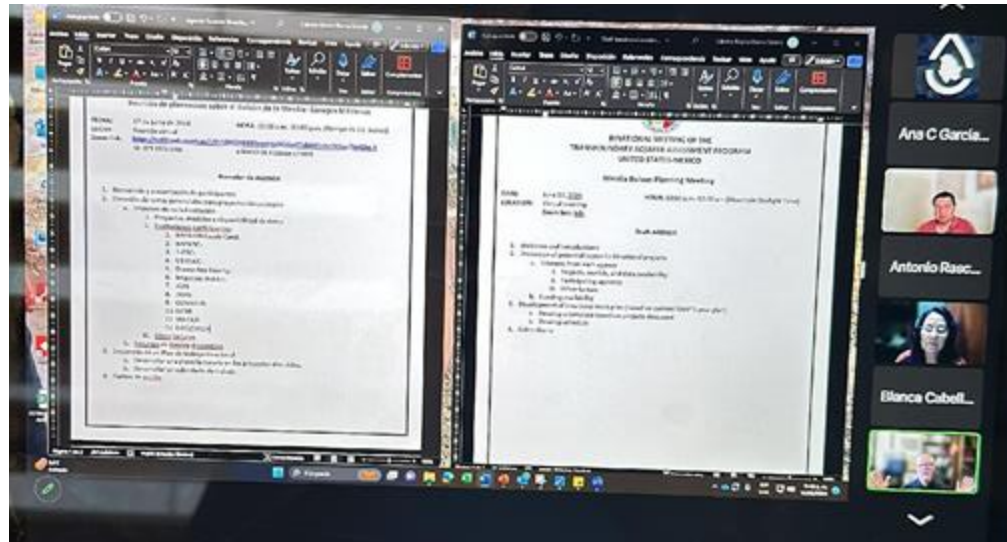
SuAVE (Survey Analysis via Visual Exploration
<http://suave.sdsc.edu>)



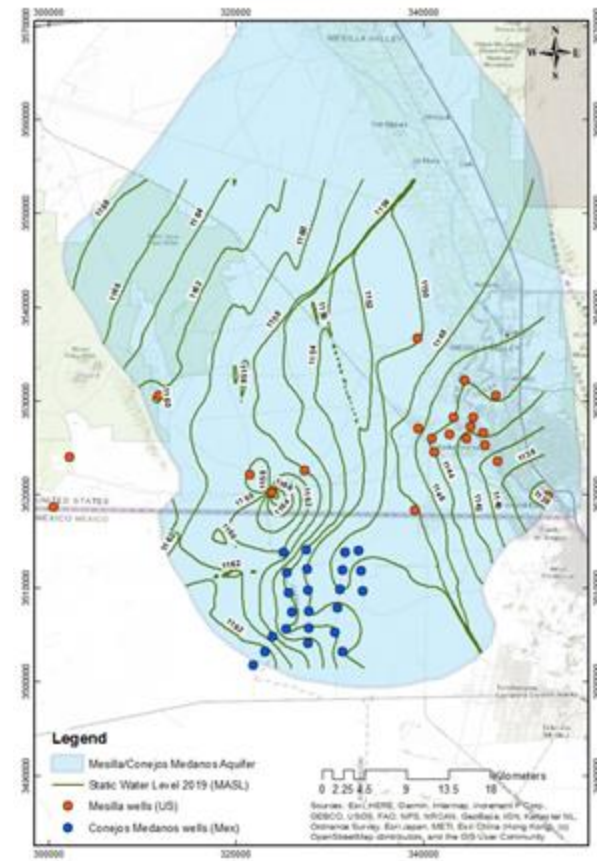
LimeSurvey
<https://www.limesurvey.org/>

- Continue binational Mesilla aquifer isotope studies

- Mobilize the Mesilla Aquifer binational work group – second meeting ~ late Oct. 2024

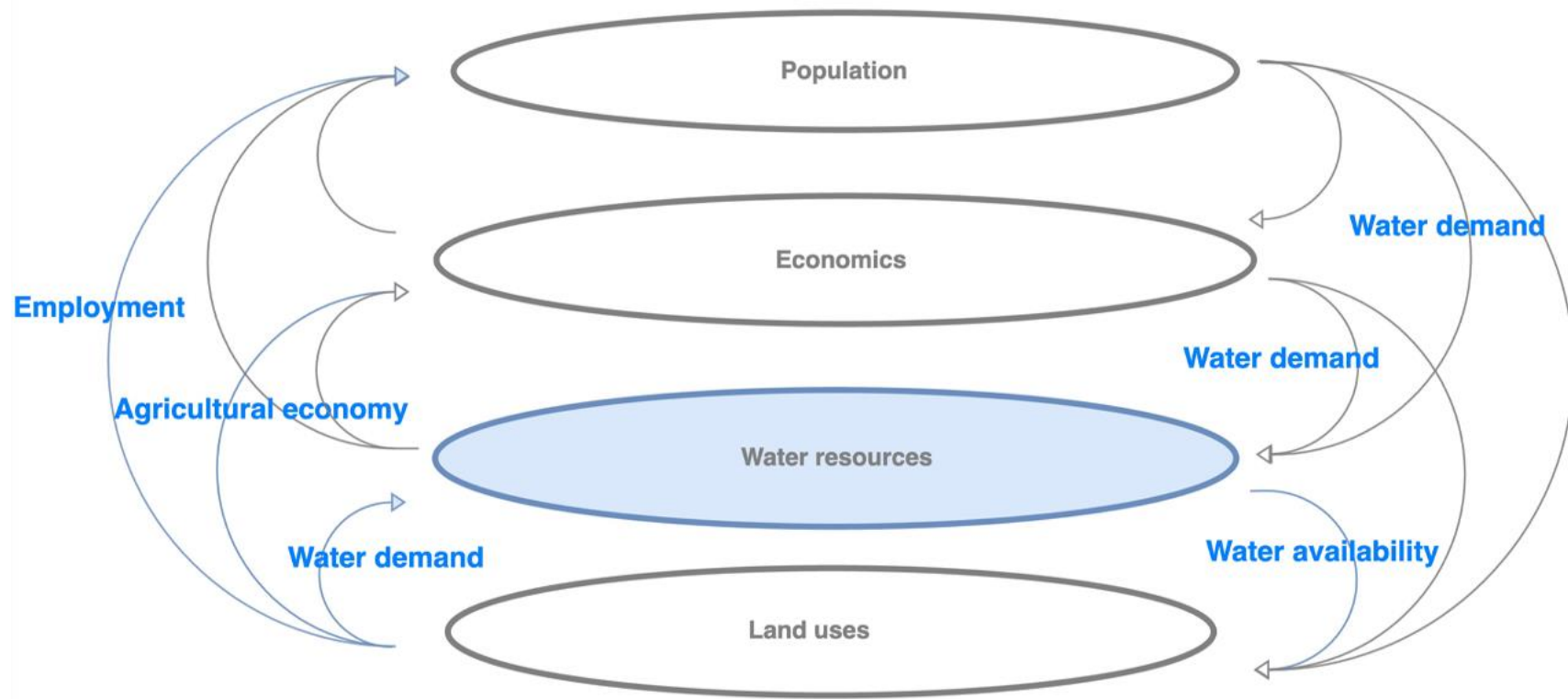


Binational meeting working on database, models, and collaboration between the US and Mexico.



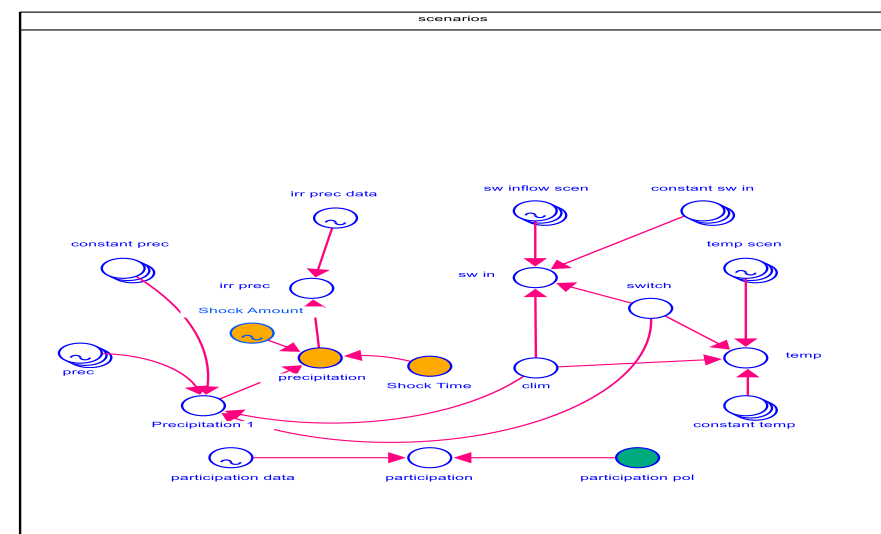
System Dynamics

System dynamics integration capability



System Dynamics Modeling Advantages

- **Understanding and modeling complex Dynamic systems:**
Coupled Water-Agriculture-Community-Environment Systems
- **Making better decisions and policy making:**
Serving as a tool for decision support in testing strategic policies
- **Community-engaged study:**
Stakeholders engagement in model building, decision support tools, policy making
- **Risk analysis including climate change analysis:**
The approach can help identify, analyze, and plan responses to risks
- **Considering feedback loops and Dynamics of the systems**

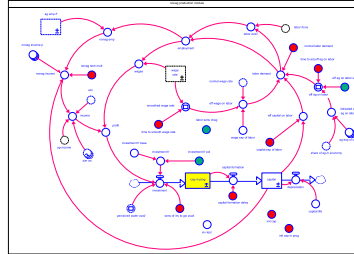


System Dynamics Model for LRG:

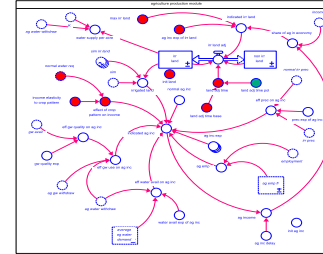
This model include:

- Agriculture production module
 - Non-Agriculture module
 - Agriculture Water Use Module
 - Non-Agriculture Water Use Module
 - Water Module
 - Population Module
 - Labor Module
 - Wage Module
- This SD model encompasses 205 variables, excluding the details related to policy and scenario designs.
 - Among these variables, 97 are considered endogenous variables, while 9 serve as exogenous variables, representing data inputs.

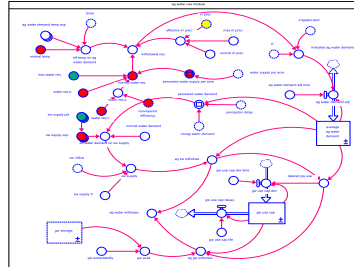
Non-Agriculture Production



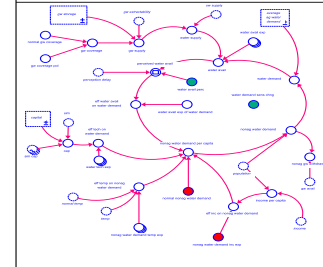
Agriculture Production Module



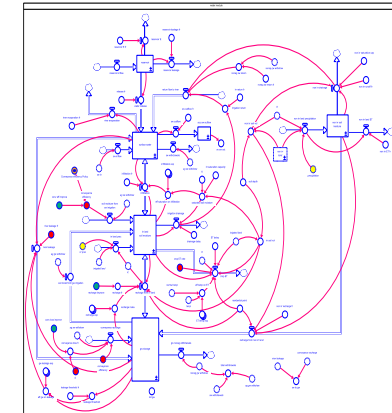
Agriculture Water Use Module



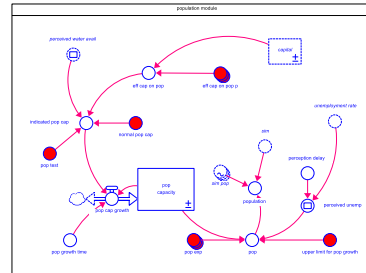
Non-Agriculture Water Use Module



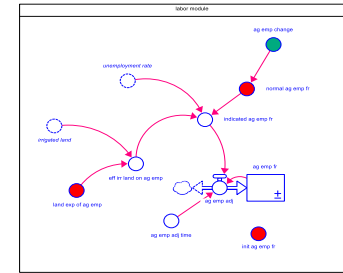
Water Module



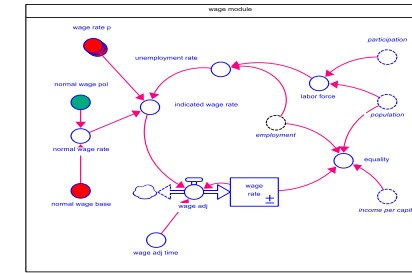
Population Module



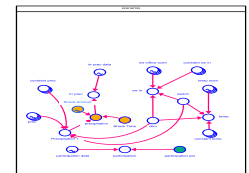
Labor Module



Wage Module



Scenarios



New Mexico Regional Social Hydrology System Dynamics Models (OFSHOOT), NMWRRI,
(Langarudi et al, 2021)

Results

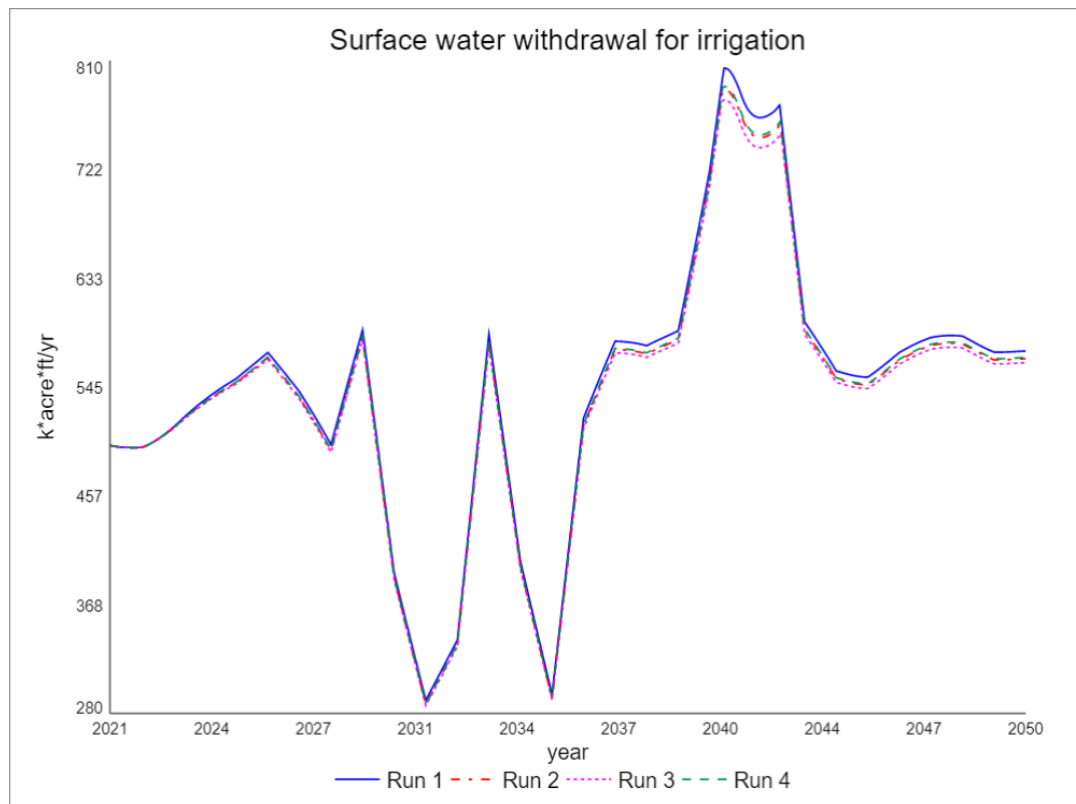


Figure 11. Surface water withdrawal, UKMO scenario (Run 1: base case; Run 2: following cotton; Run 3: following alfalfa/hay; Run 4: following chile).

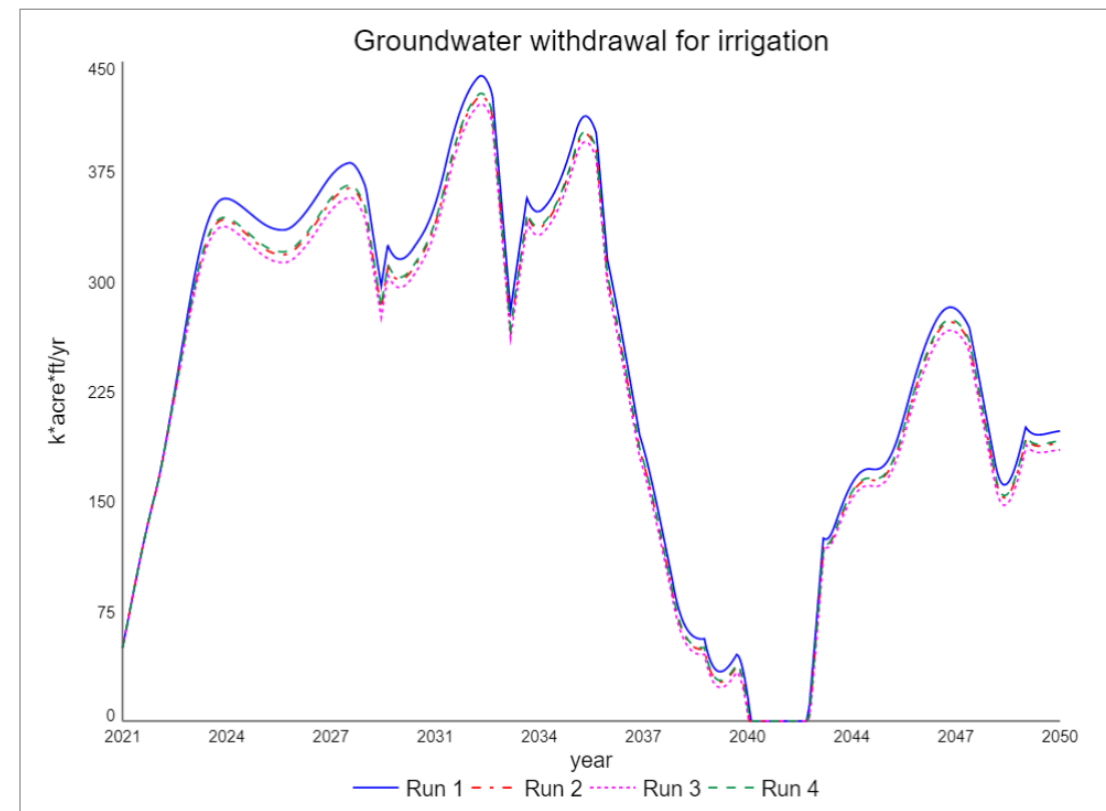


Figure 12. Groundwater withdrawal, UKMO scenario (Run 1: base case; Run 2: following cotton; Run 3: following alfalfa/hay; Run 4: following chile).

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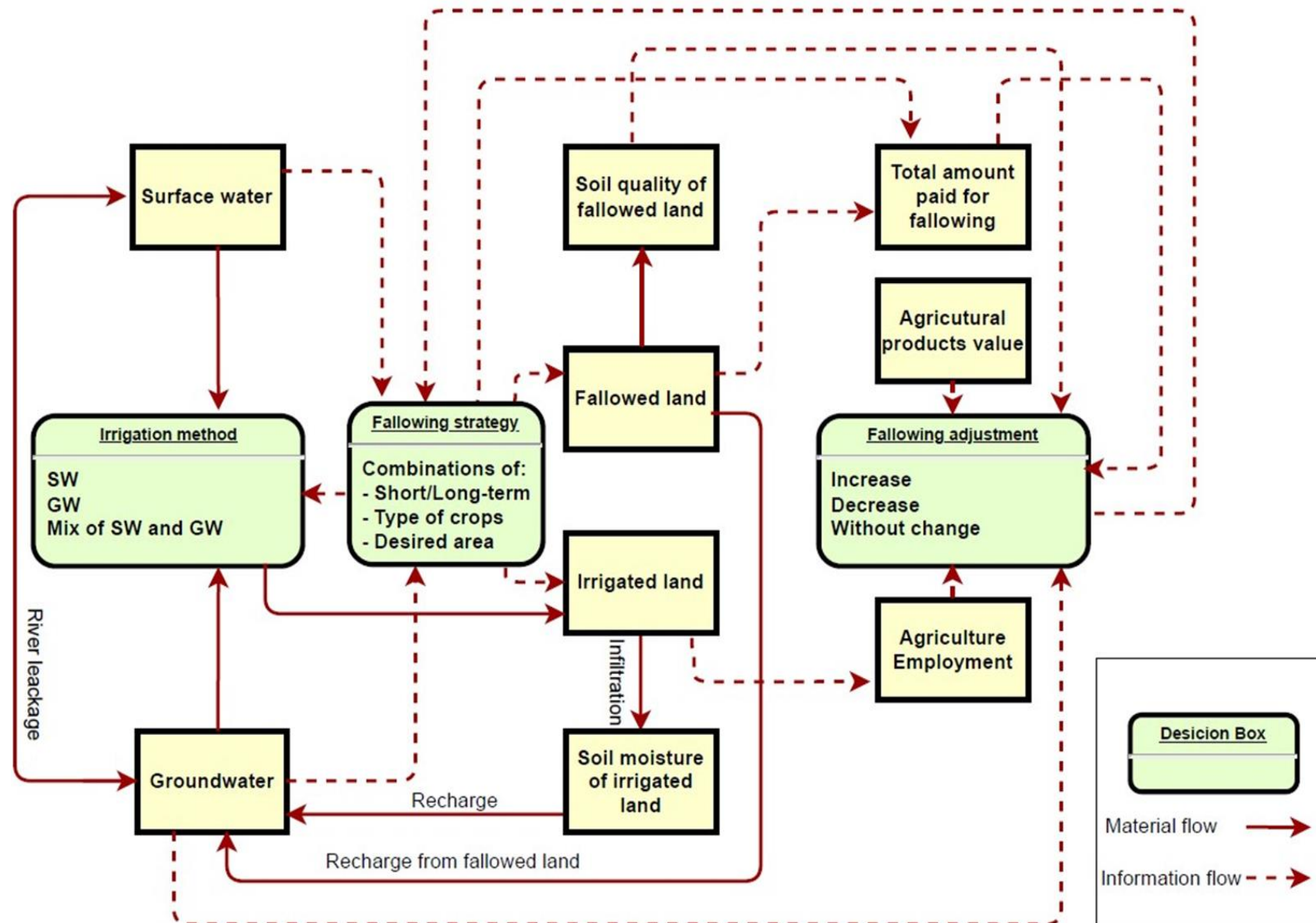


Table 1. Percentage of deviation for Surface Water Withdrawal and Groundwater Withdrawal from the base case in terms of different climate scenarios and fallow strategy.

Scenario	Cotton		Alfalfa/Hay		Chile	
	Surface Water Withdrawal	Groundwater Withdrawal	Surface Water Withdrawal	Groundwater Withdrawal	Surface Water Withdrawal	Groundwater Withdrawal
GFDL (2022–2050)	−1.63	−7.87	−2.19	−10.81	−1.38	−6.65
UKMO (2022–2050)	−1.84	−9.00	−2.56	−12.39	−1.58	−7.78
NCAR (2022–2050)	−1.85	−14.93	−2.49	−20.44	−1.57	−12.62

- Fallowing reduces surface water and groundwater withdrawal.
- Fallowing reduces agricultural income
- Economic incentives can counterbalance the potential adverse economic impacts on farmers.
- Alfalfa provides more water saving with less economic cost.

Table 2. Percentage of deviation for Total Water Withdrawal and Agriculture In-come from the base case in terms of different climate scenarios and fallow strategy.

Scenario	Cotton		Alfalfa/Hay		Chile	
	Total Water Withdrawal	Agriculture Income	Total Water Withdrawal	Agriculture Income	Total Water Withdrawal	Agriculture Income
GFDL (2022–2050)	−3.21	−2.25	−4.37	−1.55	−2.72	−1.83
UKMO (2022–2050)	−3.15	−2.03	−4.36	−1.53	−2.71	−1.77
NCAR (2022–2050)	−3.20	−2.26	−4.34	−1.59	−2.69	−1.82

Community-based research

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Adapted from: Maxwell, C.M., M. Sheely, L. Conrad, K. Perez, A. Hanson, S. Langarudi, A.G. Fernald. 2022. *Community Conversations for the NM 50-Year Water Plan: Managing Water for Future Resilience*. New Mexico Water Resources Research Institute. Miscellaneous Report No. 34

U.S. Department of Agriculture (USDA), Organic Transitions Program - Project title: The Future of Agriculture and Water in NM: Building Resilience through Organic and Traditional Approaches

What are the holistic solutions, and what do organic and traditional approaches tell us about how to conserve water? Paired field and water budget studies, landscape-scale resilience scenarios (visions to the left), integrated decision-support models

New Mexico Environment Department (NMED) River Stewardship Program - Project title: Improving Watershed Hydrologic Function to Restore Health of River Ecosystems alongside Farming and Rangeland Communities of the Rio Grande Basin in New Mexico

Project with 3 restoration locations: At the headwaters of the Rio Chama, in Canjilon, NM; along the Rio Grande north of Espanola in the villages of Estaca and El Guique; and along the Rio Grande in southern New Mexico at the Placitas Arroyo, which drains into Hatch.

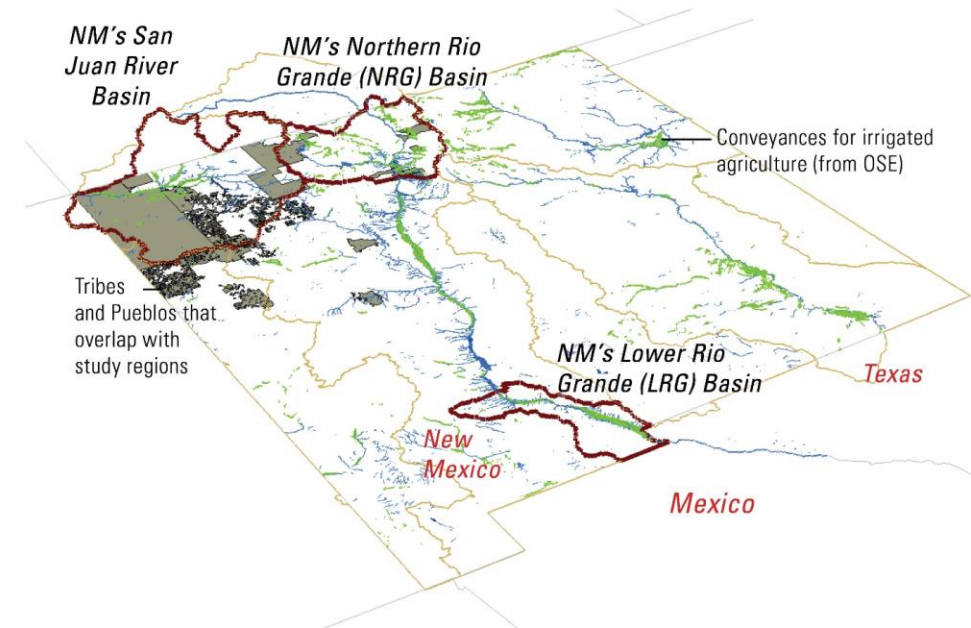
U.S. Bureau of Reclamation - Project Title: Acequia Drought Resiliency Project (DRP).

Facilitate the creation and implementation of flexible water sharing and resilience strategies; convene regional working groups to collaboratively develop water budget models integrated with water and community resilience indicators and identify triggers for drought mitigation management and actions

U.S. Bureau of Reclamation – Project title: Collaborative Assessment-based Planning of a Comprehensive Portfolio of Multi-benefit Projects to Improve Groundwater Resiliency, Riparian Habitat, and Watershed Health in the Lower Rio Grande Region.

The current goal of project is to achieve a foundation that demonstrates real change on the ground for communities in this Lower Rio Grande region through improved groundwater resiliency, riparian habitat, and watershed health

Water and Community Collaboration Lab Selected Projects



THANK YOU!

