



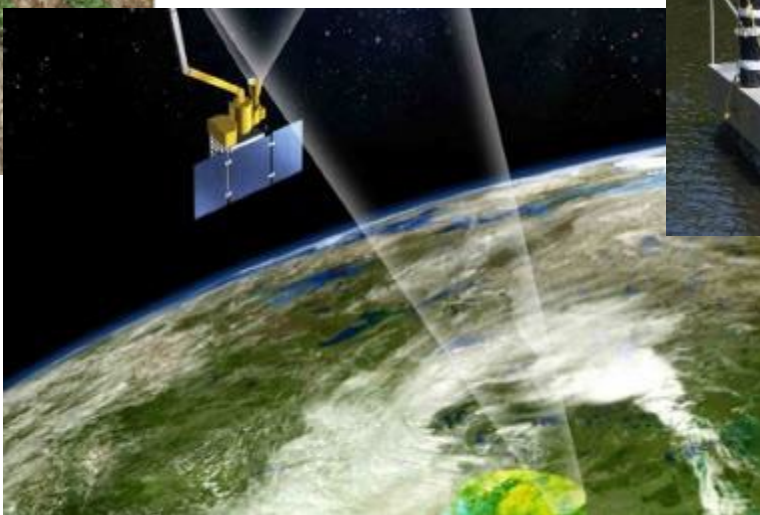
United States Department of Agriculture

Agricultural Research Service

Teferi Tsegaye, PhD
National Program leader for Water Resources
&
Lead for CEAP and LTAR Networks
OARP
Lubbock, TX
February 26, 2025

National Program 211

Water Availability and Watershed Management

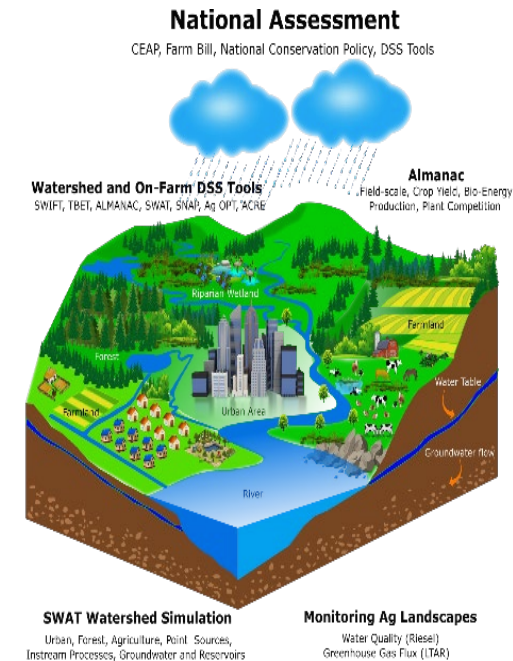
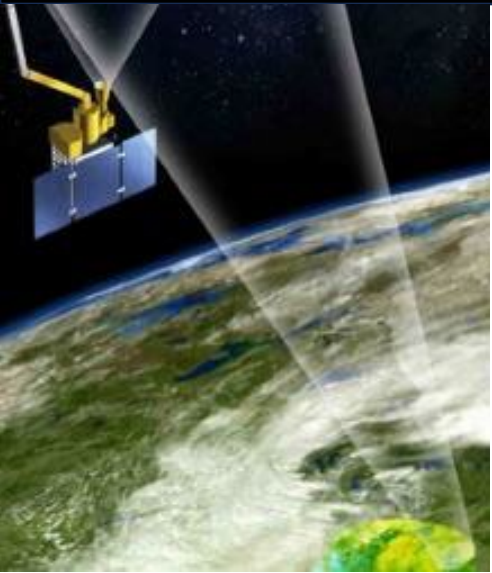


NP211 - Vision

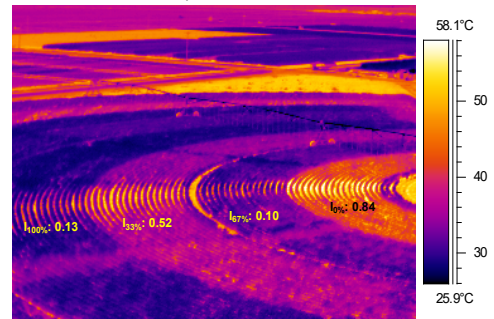
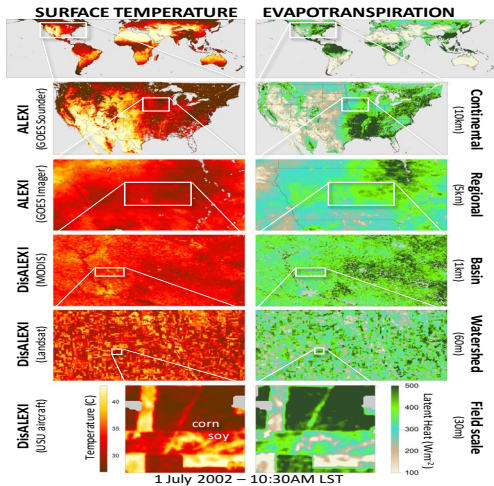
- Integrated, Effective, and Safe Water Resource Management

NP211 - Mission

- The mission of the Water Availability and Watershed Management National Program is to effectively and safely manage water resources to sustain and increase agricultural production and water use efficiency while protecting the environment and human and animal health.
- **The National Program accomplishes this mission by:** (1) conducting fundamental and applied research on the processes that control water availability and quality for the health and economic growth of the American people; and (2) developing new and improved technologies for managing the Nation's agricultural water resources.



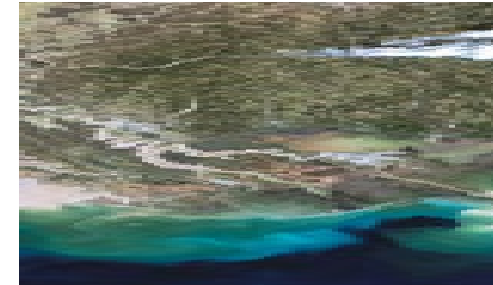
Water Quantity



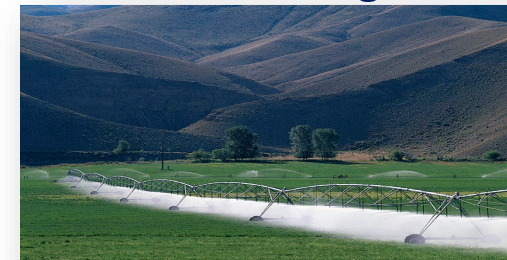
NP211 - Research Components:

1. Effective water management in agriculture (5PS)
2. Erosion, sedimentation, & water quality protection (4PS)
3. Conservation Practices in Agricultural Watersheds (3PS)W
4. Watershed Management to Improve Agroecosystem Services (3PS)

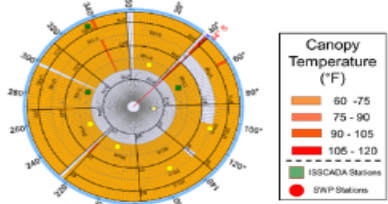
Water Quality



Watershed Management



Spatial Canopy Temperatures for VRI Management



Impacts:

Water Quantity:

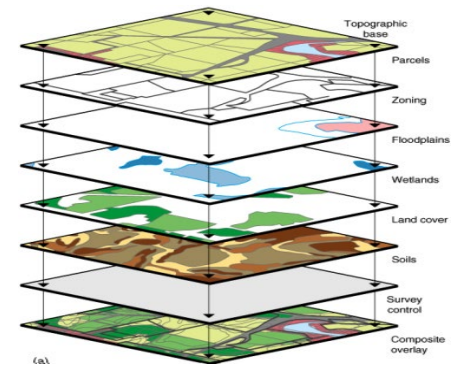
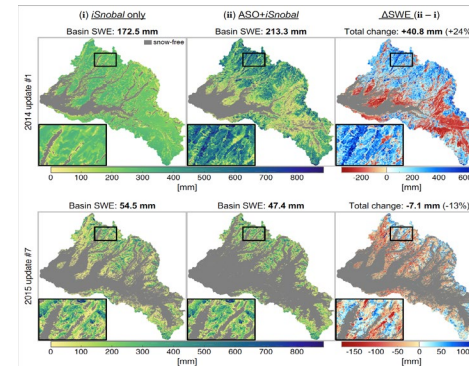
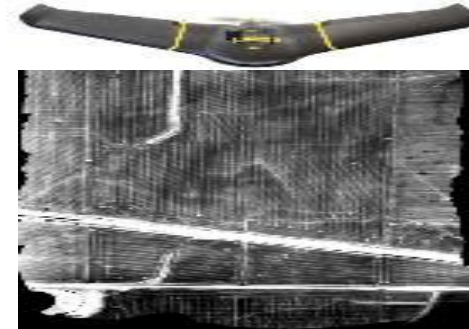
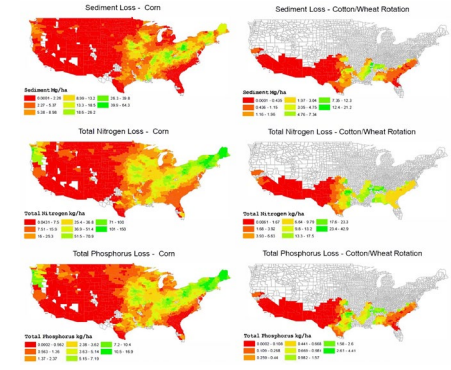
- Demonstrated sub-surface river-water filtration can recharge a depleted aquifer.
- Improved technologies for precision irrigation application
- Proved irrigation scheduling can be automated via infrared thermometers and soil moisture probes.

Water Quality

- Growing corn & soybean in kura clover living mulch increases infiltration (11-19x) & reduces soil loss (13x).
- Using Variable Rate Irrigation (VRI) technology improved irrigation and nutrient management on highly variable soils
- Developed Engineering Tools for the Design and Rehabilitation of Safe, Efficient Embankment Protection Alternatives, Hydraulic Structures, and Channels

Watershed Management

- Using Snowtopgraphy quantified effects of forest cover on net water input to soil at ephemeral and seasonal snowpack sites
- Developed and transferred the ARS iSnobal model to California DWR for water supply forecasts of Sierra Nevada Mountains.
- Improved assessment of groundwater resources and the simulation of irrigation impacts on streamflow and aquifer levels using ARS SWAT+ model.



NP211 – Northeast Area

2 Projects

Buda, University Park, PA. 7.8 SY.

Managing Water Resources to Foster the Sustainable Intensification of Agroecosystems in the Northeastern U.S.

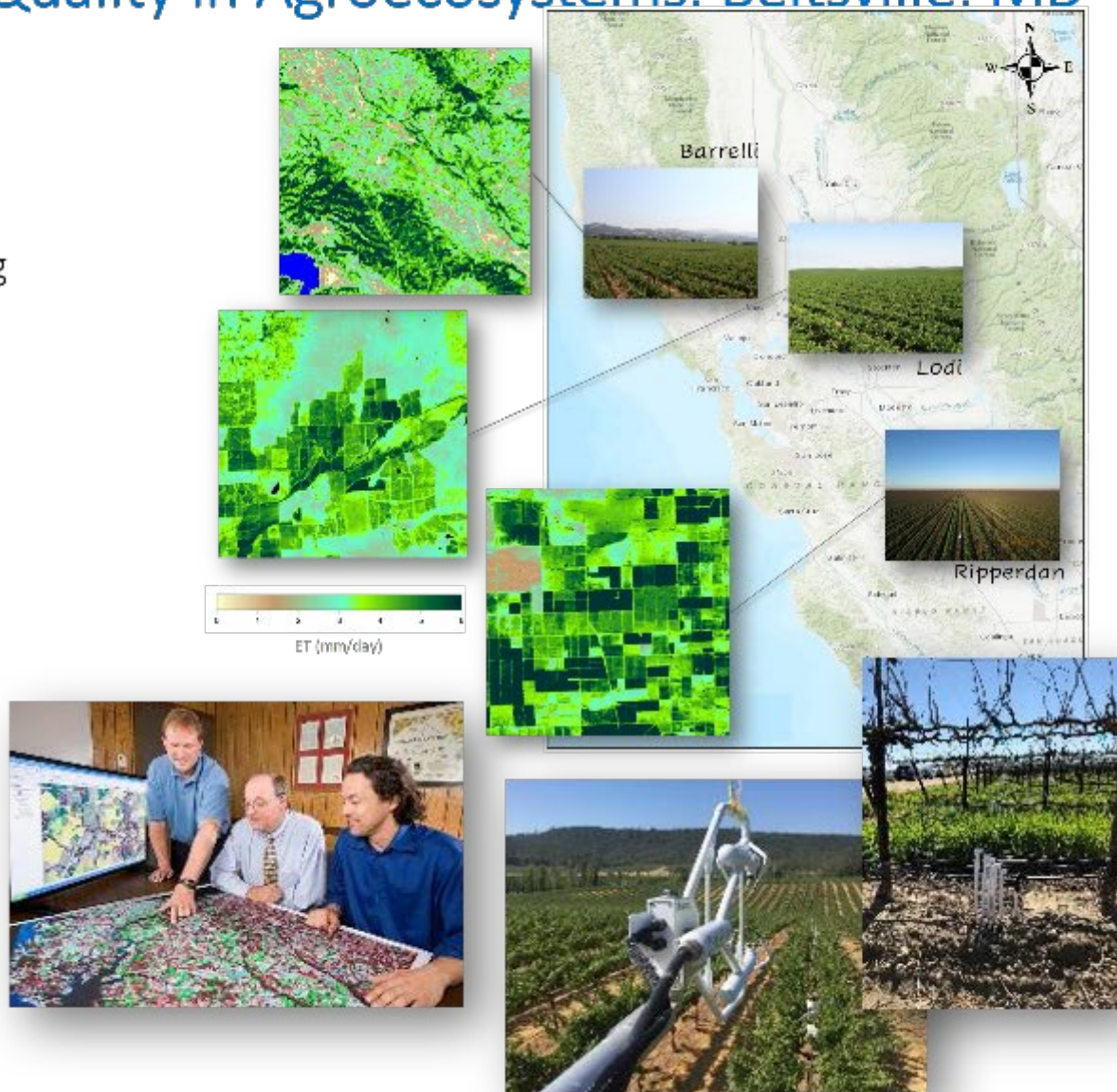
Anderson, Beltsville, MD 5.8 SY.

From Field to Watershed: Enhancing Water Quality and Management in Agroecosystems through Remote Sensing, Ground Measurements, and Integrative Modeling



Integrating Remote Sensing, Measurements and Modeling for Multi-Scale Assessment of Water Availability, Use, and Quality in Agroecosystems. Beltsville. MD

- **Research focus areas:** water quantity and quality, drought and crop stress, productivity, remote sensing, CEAP, LTAR
- **Problems addressed:**
 - Water quantity: Improved evapotranspiration and soil moisture products through remote sensing and modeling
 - Drought/stress: Improved yield estimation using remotely sensed evaporative stress and phenology
 - Water quality: Improved SWAT capabilities to quantify water quality effects from winter cover crops and other conservation measures
- **Major research findings and impact:**
 - Developed integrated water use and soil moisture mapping system for vineyard irrigation management in collaboration with CA wine grape growers
 - Implemented Landsat-based ET model in OpenET for western U.S. water management applications
 - Developed new nitrate tracer methods to estimate ground water age and assess conservation practice effectiveness for the Maryland Department of Agriculture



MAnure PHosphorus EXtraction (MAPHEX) system removes manure P

ARS and University scientists at University Park, PA developed a jointly patented system that removes greater than 95% of phosphorus from liquid dairy and swine manures.

FINDINGS AND IMPACT:

- > 96–99% P is removed
- > 90% of N is retained
- > 99% of solids are removed



All solids are stackable
Liquid is ideal for fertigation
pH is unchanged by process



15% P in Solids

Screw Press



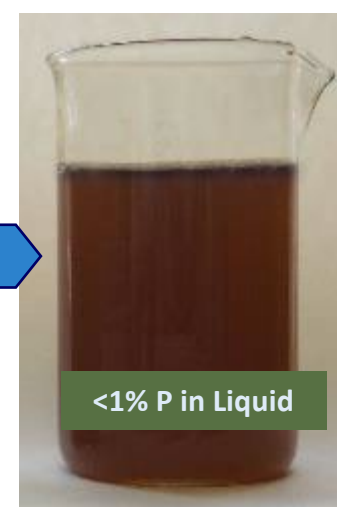
45% P in Solids

Centrifuge



40% P in Solids

DE Filter



<1% P in Liquid

Effluent

Church, C. D., A. Hristov, R. B. Bryant, and P. J. A. Kleinman. 2017. Processes and treatment systems for treating high phosphorus containing fluids. US Patent 9,790.110B2.

Church, C. D., A. N. Hristov, P. J. A. Kleinman, S. K. Fishel, M. R. Reiner, and R. B. Bryant. 2018. Versatility of the MAAnure PHosphorus Extraction (MAPHEX) System in removing phosphorus, odor, microbes, and alkalinity from dairy manures: A four-farm case study. Applied Eng. Ag. 34: 567 – 572.

Sustaining Agroecosystems and Water Resources in the Northeastern U.S. -- University Park, PA & East Wareham, MA

Research focus areas: water quality, productivity, remote sensing, CEAP, LTAR

Problems addressed:

- Flood harvest is a primary source of phosphorus (P) from cranberry bogs.

Major research findings and impact:

- Adding alum ($\text{Al}_2(\text{SO}_4)_3$) to irrigation retention ponds reduces P losses during cranberry harvest – removes one-fifth of the phosphorus (P) loss from cranberry bogs.



NP211 – Southeast Area

9 Projects



Stone, Florence, SC. 2.7 SY.
Innovative Technologies and Practices to Enhance Water Quantity and Quality Management for Sustainable Agricultural Systems in the Southeastern Coastal Plain

Coffin, Tifton, GA. 5.35 SY.
Shifting the Balance of Water Resources and Interacting Agroecosystem Services Toward Sustainable Outcomes in Watersheds of the Southern Coastal Plain

Reba, Jonesboro, AK. 3.0 SY.
Optimizing the Management of Irrigated Cropping Systems in the Lower Mississippi River Basin

Nelson, Stoneville, MS. 9.0 SY.
Development of Best Management Practices, Tools, and Technologies to Optimize Water Use Efficiency and Improve Water Distribution in the Lower Mississippi River Basin

Moore, Oxford, MS. 6.7 SY.
Enhancing Long-Term Agroecosystem Sustainability of Water and Soil Resources Through Science and Technology

Wren, Oxford, MS. 0.0 SY.
Acoustic and Geophysical Methods for Multi-Scale Measurements of Soil and Water Resources

Bingner, Oxford, MS. 0.0 SY.
Computational Tools and Decision Support System Technologies for Agricultural Watershed Physical Processes, Water Quality and Ground Water Management

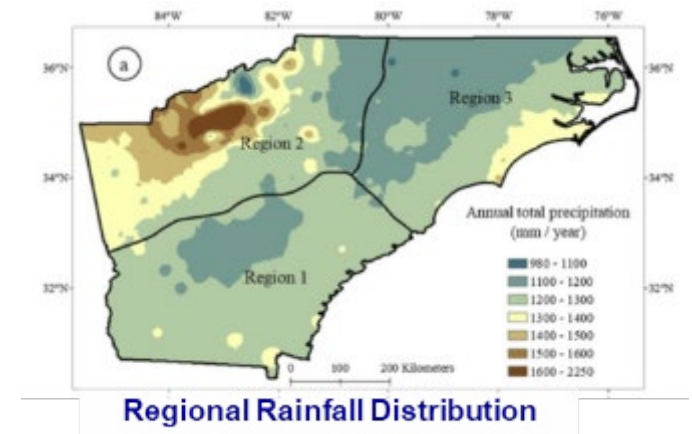
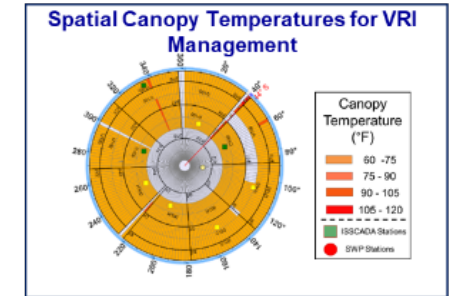
Langendoen, Oxford, MS. 7.3 SY.
Science and Technologies for Improving Soil and Water Resources in Agricultural Watersheds

White JR, Houma, LA. 1.9 SY.
Water and Soil Resources in Sustainable Sugarcane Production Systems for Temperate Climates

Managing Water Availability and Quality for Sustainable Agricultural Production and Conservation of Natural Resources in Humid Regions

Florence, SC

- **Research focus areas:** Irrigation, Water Quantity, Water Quality
- **Problems addressed:**
 - Improve irrigation and nutrient management on highly variable soils using Variable Rate Irrigation (VRI).
 - Improve rainfed crop production with improved information and management practices.
- **Major research findings and Impact:**
 - Documented higher grain yields and improved water use efficiency using a USDA-ARS Developed VRI decision support system using crop and soil feedback.
 - A VRI decision support system not only effectively managed spatial irrigation but also improved crop nutrient use efficiency.
 - Developed regional rainfall probability tables to inform producers for rainfed crop management decisions.



Shifting the Balance of Water Resources and Interacting Agroecosystem Services toward Sustainable Outcomes in Watersheds of the Southern Coastal Plain. Tifton, GA

- **Research focus:**

- water quality, water quantity, modeling, remote sensing, ground water, surface water, CEAP, LTAR.

- **Problems addressed:**

- Water availability (quantity and timing) does not always meet the timing for crop irrigation demands
- Methods needed to link observations at field and watershed levels with experimental results from plots

- **Major research findings and impact:**

- Long term hydrologic and meteorological data collections
- Improvements to the Soil and Water Assessment Tool (SWAT+)
- Validation of national SMAP soil moisture data products



Science and Technologies for Improving Soil and Water Resources in Agricultural Watersheds – Watershed Physical Processes Research Unit, Oxford, MS

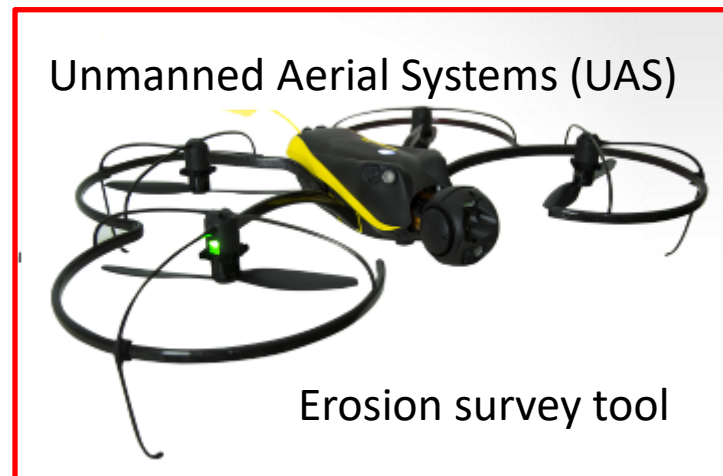
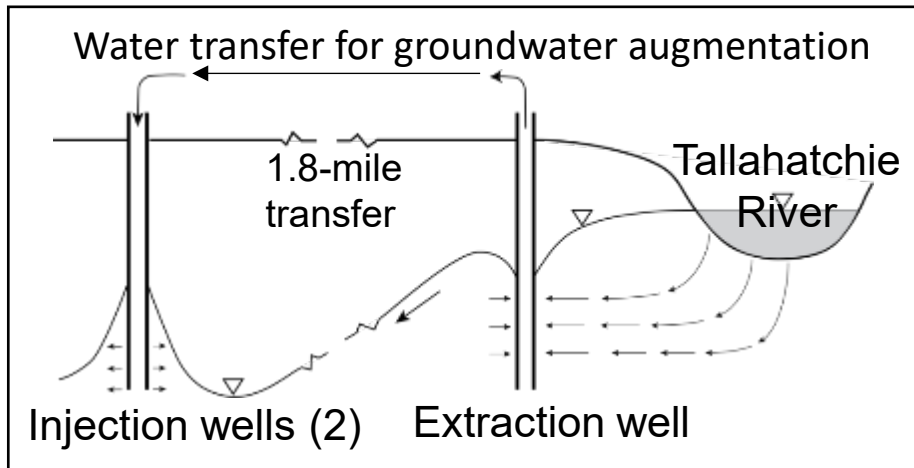
Research Focus Areas: Water Management, Erosion Science, LTAR, CEAP, Modeling

Problems Addressed:

- Innovative strategies are needed to manage water resources for sustainable agriculture.
- Cultivation of highly-erodible lands impacts on-farm management systems with excess sediment.

Research Findings and Impact:

- Transfer and injection of water supplied by sub-surface river-water filtration can recharge a depleted aquifer.
- Improved UAS and computer technology developed to effectively manage our Nation's water and soil resources.



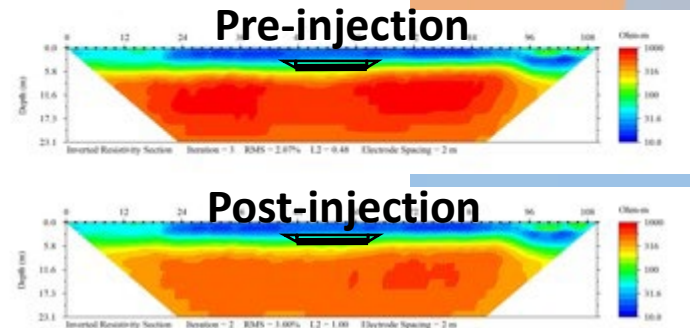
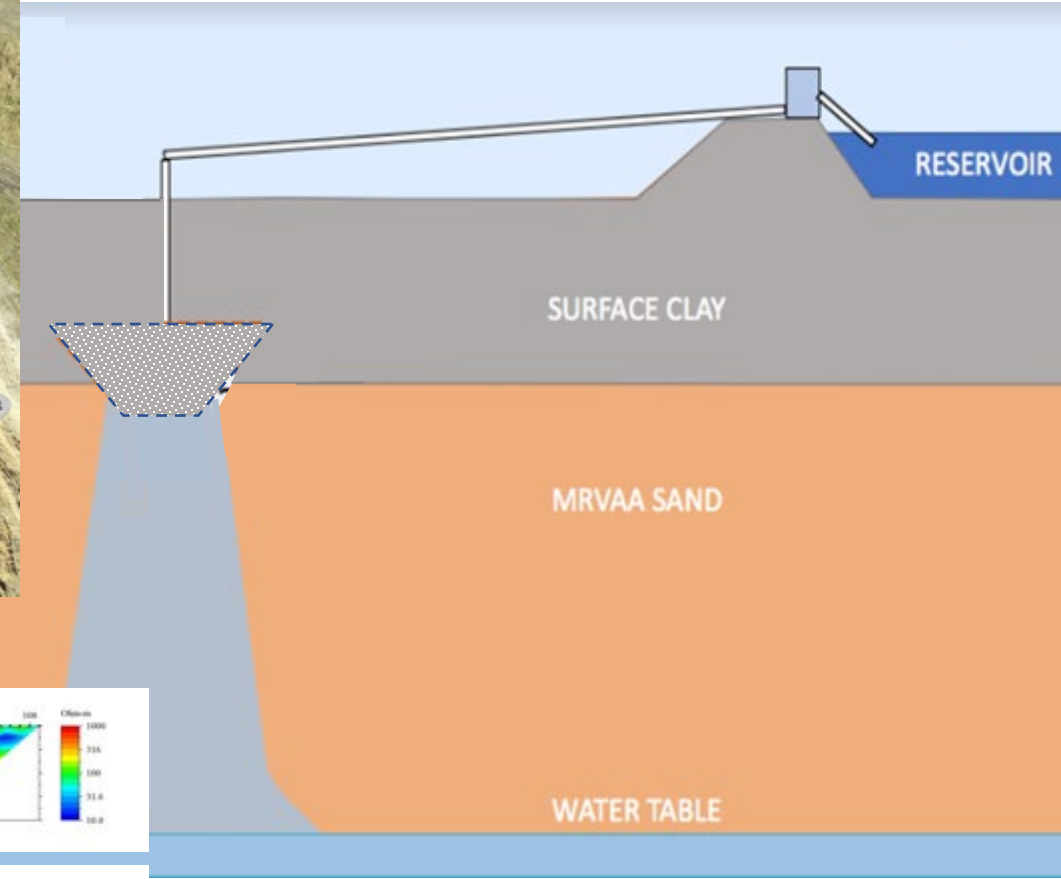
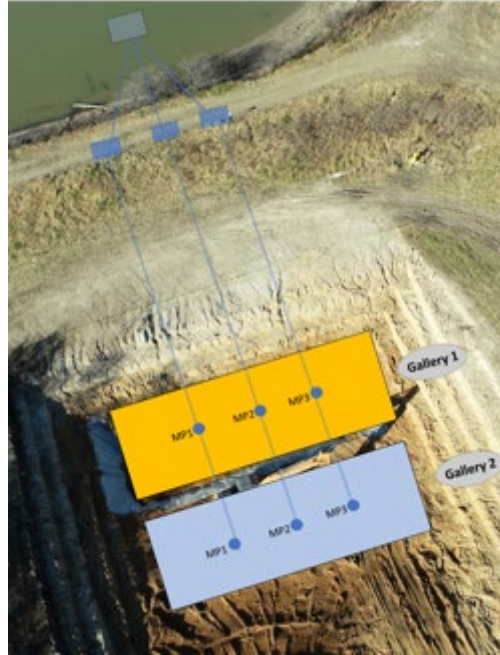
UAS surveys detect spatial and temporal soil erosion loss



Infiltration Gallery Case Study

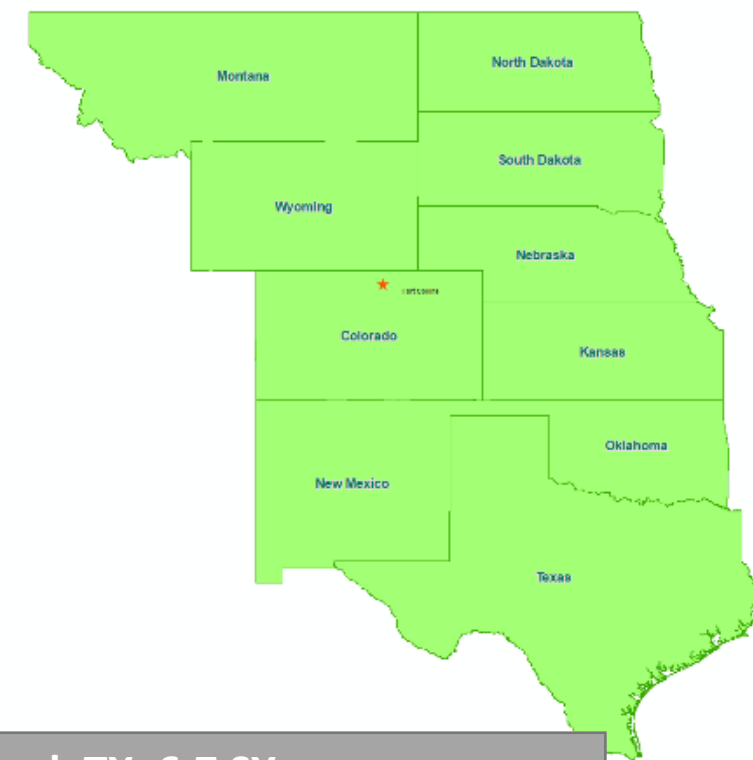
USDA-ARS-Delta Water Management Research Unit, Jonesboro, AR

- Site evaluation
 - Past confining clay layer
 - On-farm storage reservoirs
- DEQ permission
- Construction 2020-2022
- Infiltration: winter months
 - 2022 Solar pumps
 - 2023 Solar pumps + Short-term max flow
- Electrical Resistivity Surveys show movement of water
- No appreciable response at deeper monitoring wells (42 m below ground surface) to date



NP211 – Plains Area

8 Projects



Gleason, Fort Collin, CO. 4.5 SY.

Improving Crop Performance and Precision Irrigation Management in Semi-Arid Regions through Data-Driven Research, AI, and Integrated Models

Barnard, Fort Collin, CO. 4.5 SY.

Improving Resiliency of Semi-Arid Agroecosystems and Watersheds to Change and Disturbance through Data-Driven Research, AI, and Integrated Models

Zhang, El Reno, Ok. 2.2 SY.

Adapting Agricultural Production Systems and Soil and Water Conservation Practices to Climate Change and Variability in Southern Great Plains

Zhang, El. Reno, OK. 3.8 SY.

Impacts of Variable Land Management and Climate on Water and Soil Resources

Hunt, Stillwater, OK. 3.0 SY.

Development of a Monitoring Network, Engineering Tools, and Guidelines for the Design, Analysis, and Rehabilitation of Embankment Dams, Hydraulic Structures, and Channels

Evelt, Bushland, TX. 6.7 SY.

Dryland and Irrigated Crop Management Under Limited Water Availability and Drought

Martinez, Lubbock, TX. 7.0 SY.

Developing Strategies for Resilient and Sustainable Crop, Water, and Soil Management in Semi-Arid Environments

White, Temple, TX. 4.25 SY.

Development of Enhanced Tools and Management Strategies to Support Sustainable Agricultural Systems and Water Quality

Strategic Deficit Irrigation (DI) – More crop per drop using phenology

Watershed Management & Systems Research Unit, Fort Collins, CO

Research Focus Areas: Water Management, Limited Irrigation Management

Problems Addressed:

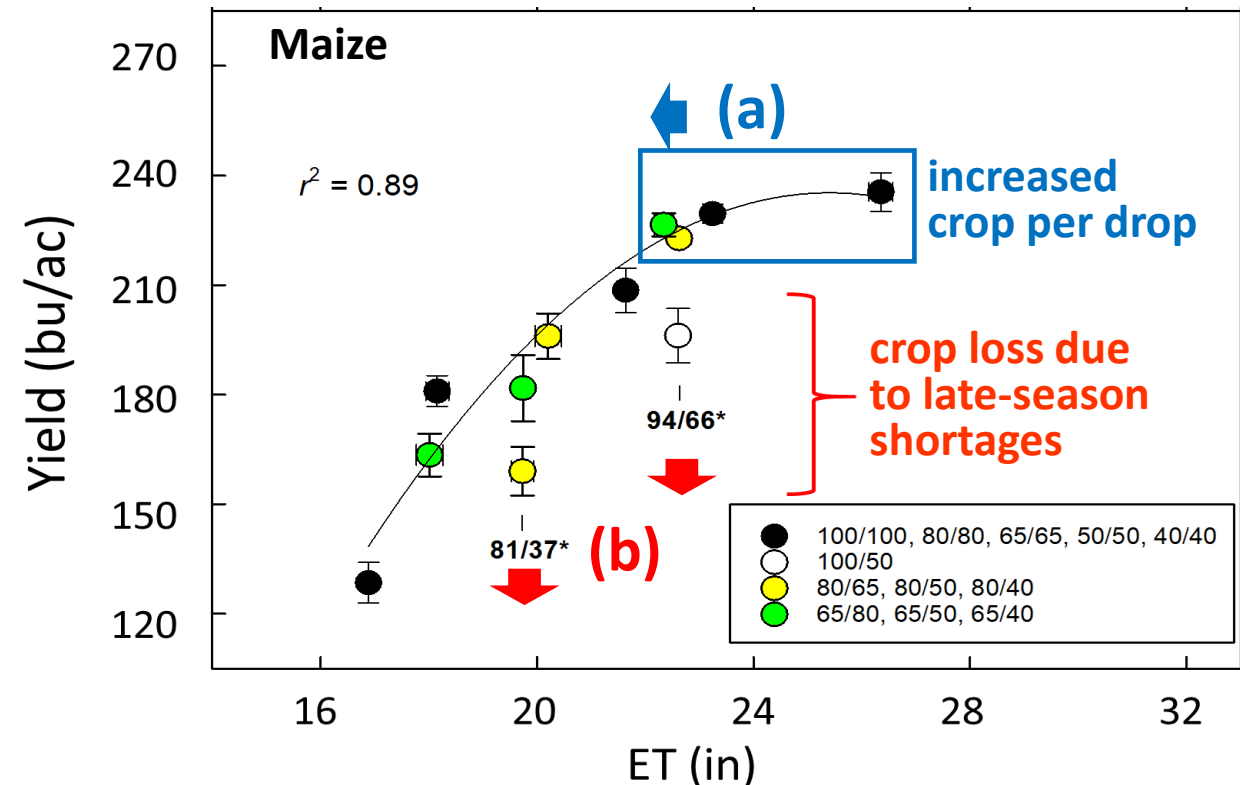
- How do we “bend” the crop production curve using DI to produce higher yields per unit of irrigation in limited-water corn production?

Research Findings and Impact:

(a) Same yield with 15-17% *less irrigation*

...translates into 30% *more farm profit*

(b) *Less irrigation* during Late Vegetative stage *protects against yield loss* if there is a late-season water shortfall (less investment in extra leaves).



NOTE: 00/00 = ET Target (Late Vegetative/Mid Reprod.)

[e.g., 80/65 = 80% during V8-VT (late veg),

65% during R4-R6 (grain fill)].

Avoid stress during V7 (row formation), VT-R3 (anthesis).

Optimizing crop production with limited water -Bushland, TX

- **Research focus areas:**

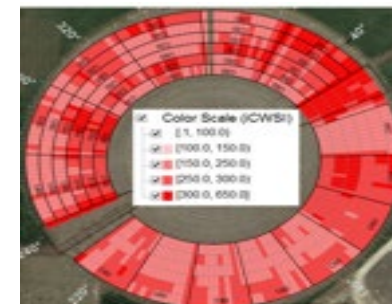
- Efficient use of precipitation and irrigation water in a semi-arid climate

- **Problems addressed:**

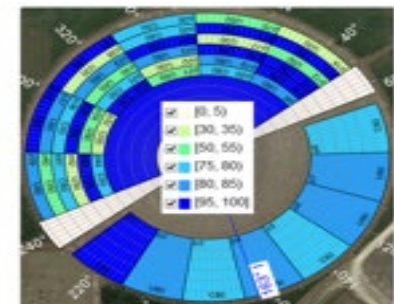
- Improve use of precipitation to support both irrigated and dryland systems
- Improve technologies for precision irrigation application

- **Major research findings:**

- Demonstrated irrigation scheduling can be automated via infrared thermometers and soil moisture probes.
- Irrigation applications based on leaf temperatures resulted in similar yields, and water applied as manually scheduled plots.



Crop Water Stress Map
July 2, 2016



Prescription Map
July 3, 2016

Resilient Management Systems and Decision Support Tools to Optimize Agricultural Production and Watershed Responses from the Field to National Scale - Temple, TX

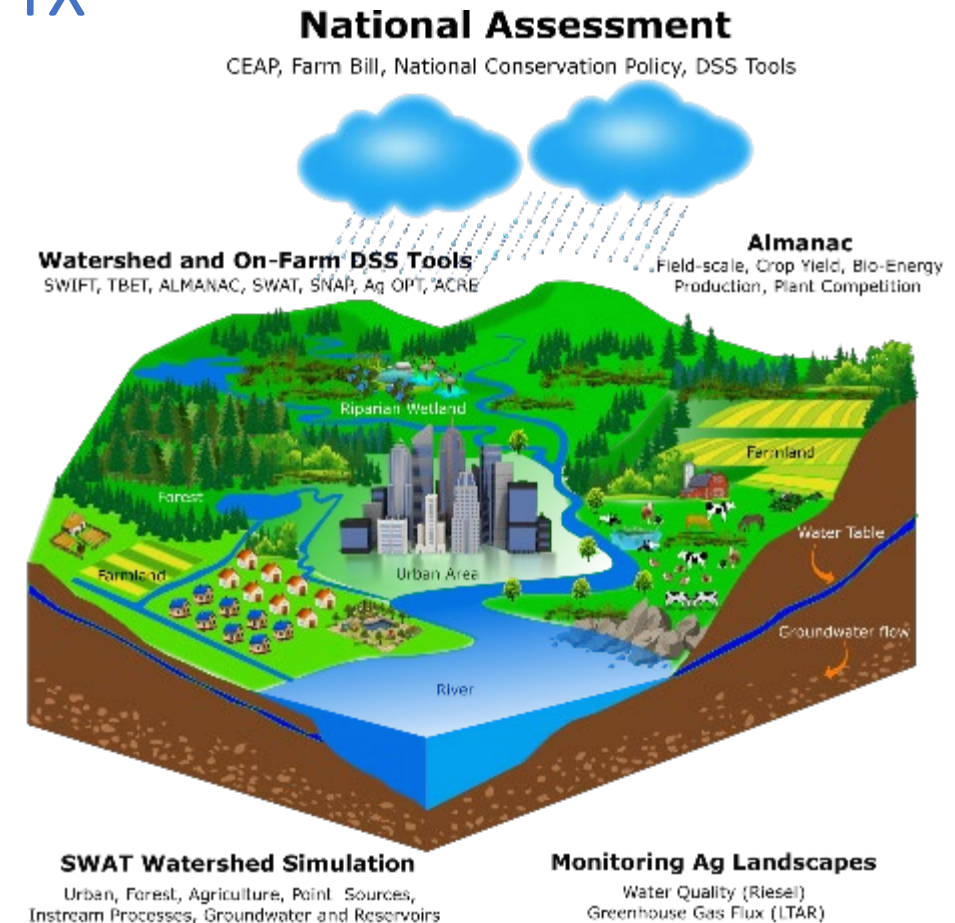
Project Focus - Water Quality Monitoring & Modeling

Problems addressed:

- Evaluating the Effectiveness of Conservation Practices and Programs
- Decision Support for Watershed Programs and Conservation Planning
- Open-Source Watershed Model Development (SWAT+)

Findings and Impact:

- Predicted Environmental Benefits of USDA Conservation Programs Through CEAP
- Developed and Released Improved SWAT+ Modeling Engine and Field-scale National Modeling Data Framework



Development of Engineering Tools for the Design and Rehabilitation of Safe, Efficient Embankment Protection Alternatives, Hydraulic Structures, and Channels – Stillwater, OK

- **Research focus area – Water Quantity**
- **Problems –**
 - Embankment dam erosion process and failure prediction.
 - Rehabilitation design alternatives for aging dams.
- **Impact –**
 - WinDAM (Windows Dam Analysis Modules) expansion with internal erosion breach prediction algorithms.
 - WinDAM adopted worldwide by consulting engineers and federal agencies.
 - For risk studies to assess existing embankment dams and earthen spillway performance.
 - To prioritize embankment dams for rehabilitation.
 - Stepped spillway and stilling basin standardized design adopted by federal agencies and worldwide consulting firms.
 - **Anticipated construction cost-savings up to \$1.2 billion by USDA-Natural Resources Conservation Service.**



NP211 – Midwest Area

6 Projects



Rice, St. Paul, MN. 4.1 SY.

Developing and Evaluating Strategies to Protect and Conserve Water and Environmental Resources While Maintaining Productivity in Agronomic Systems

Malone, Ames, IA. 5.1 SY.

Sustainable Intensification in Agricultural Watersheds through Optimized Management and Technology

Baffaut, Columbia, MO. 4.25 SY.

Linkages Between Crop Production Management and Sustainability in the Central Mississippi River Basin

Sudduth, Columbia, MO. 1.0 SY.

Improving Irrigated Crop Management System for Humid and Sub-humid Climates

Williams, West Lafayette, IN. 3.50 SY.

Assessment of Sediment and Chemical Transport Processes for Developing and Improving Agricultural Conservation Practices

King, Columbus, OH. 4.0 SY.

Practices and Technologies for Sustainable Production in Midwestern Tile Drained Agroecosystems

Conservation Practice Impacts on Water Quality at Field and Watershed Scale West Lafayette, IN

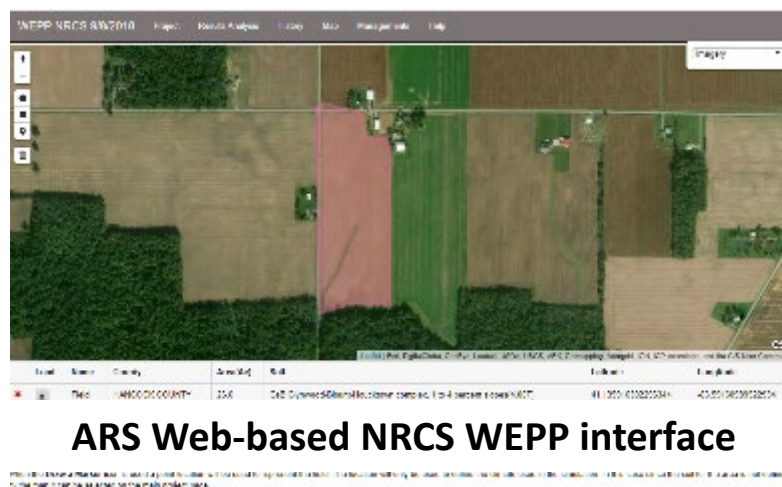
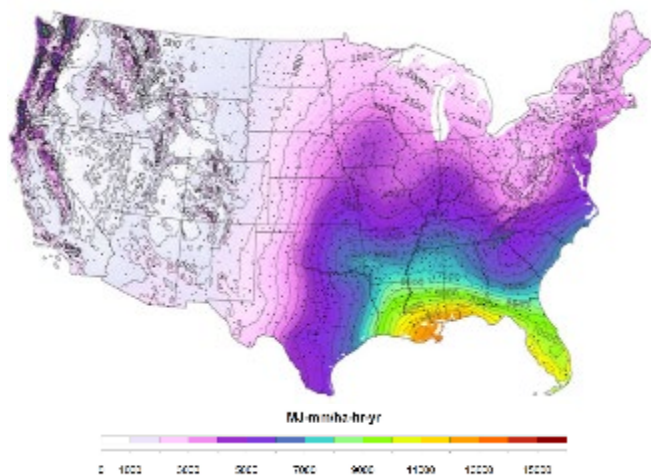
Research focus area: Water Quality, Erosion Science, Modeling, CEAP, LTAR

• Research Areas Addressed

- Develop methods to reduce pollutant losses from fields & watersheds.
- Increase understanding of hydrology, sediment, & chemical transport processes.
- Improve erosion & water quality modeling systems.

• Major research findings and Impact

- Updated erosivity maps indicate changing climate impacts on water erosion.
- Phosphorus removal structures can be designed to reduce P in water.
- Web-based models/interfaces are effective tools for erosion & WQ predictions.



In-field and/or in-stream treatments or structures treat polluted water (P-removal structure here).

Agricultural Water Management in Poorly Drained Midwestern Agroecosystems, Columbus, OH

- **Research Focus:** water quality, water quantity, drainage, remote sensing, ecology, CEAP, LTAR
- **Problem Addressed:** Management of excess water on agricultural lands to reduce or prevent detrimental on-site and off-site impacts
 - Phosphorus and nitrogen cycling
 - Locating tile drainage
 - Biogeochemical processes
 - Ecology
- **Major research findings/accomplishments**
 - Quantified nutrient balances and water quality impacts from crop production and conservation practices
 - Unmanned aerial vehicle (drone) surveys prove effective in mapping agricultural drains
 - Conservation practices that improve physical habitat and water quality benefit the biota of agricultural headwater streams



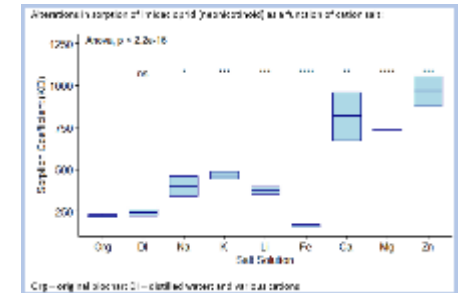
Practices to Protect Water Quality and Conserve Soil and Water Resources in Agronomic and Horticultural Systems in the North Central US (St. Paul, MN)

Research focus areas: water quality, drainage, LTAR, surface water, groundwater



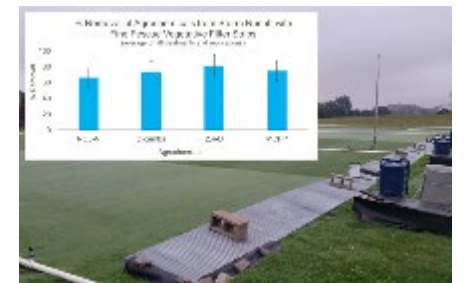
- **Problem:** Excessive storm runoff from corn and soybean fields negatively impacts water quality.
- **Findings:** Growing corn & soybean in **kura clover living mulch increases infiltration (11-19x) & reduces soil loss (13x).**

- **Problem:** Pesticide transport in soil influences pesticide efficacy and surface water and groundwater quality.
- **Findings:** **Biochar's capacity for pesticide sorption** is altered as a function of cation salts.



- **Problem:** Nitrate-N export from tile-drained cropland contributes to the Gulf Hypoxic Zone.
- **Findings:** **Carbon addition to woodchip bioreactors enhances nitrate-N removal from tile effluent (3.7x).**

- **Problem:** Off-site transport of fertilizer and pesticides with storm runoff threatens surface water quality.
- **Findings:** **Fine fescue vegetative filter strips removed 43-95% of nitrate-N and herbicides from surface runoff.**



NP211 – Pacific West Area

8 Projects



Nouwakpo, Kimberly, ID. 3.5 SY.
Improving Water Productivity and Quality in Irrigated Landscapes of the Northwestern United States

Flerchinger, Boise, ID. 3.0 SY.
Ecohydrology of Sustainable Mountainous Rangeland Ecosystems

Hale, Parlier, CA. 4.0 SY.
Improving Soil and Water Productivity and Quality in Irrigated Cropping Systems

Skaggs, Riverside, CA. 3.5 SY.
Water Management for Crop Production in Arid and Semi-Arid Regions and the Safe Use of Alternative Water Resources

Bradford, Davis, CA. 7.0 SY.
A Systems Approach to Improved Water Management for Sustainable Production

Scott, Tucson, AZ. 7.0 SY.
Understanding Ecological, Hydrological, and Erosion Processes in the Semiarid Southwest to Improve Watershed Management

Williams, Maricopa, AZ. 1.0 SY.
Increased Water Security through Safe Reuse of Reclaimed Water

Williams, Maricopa, AZ. 4.0 SY.
Improving Water Management for Arid Irrigated Agroecosystems

Understanding Snow and Hydrologic Processes in Mountainous Terrain with a Changing Climate, Boise, ID

- **Research focus area:** water quantity, modeling, surface water, LTAR
- **Problems addressed:**
 - Water supply management from mountain snowpacks under a changing climate
 - Impacts of climate and management on rangeland hydrology and productivity
- **Major research findings and Impact:**
 - Transfer ARS iSnobal model to California DWR for water supply forecasts of Sierra Nevada Mtns.
 - Modeling and mapping productivity and carbon storage of rangeland ecosystems for better informed management decisions



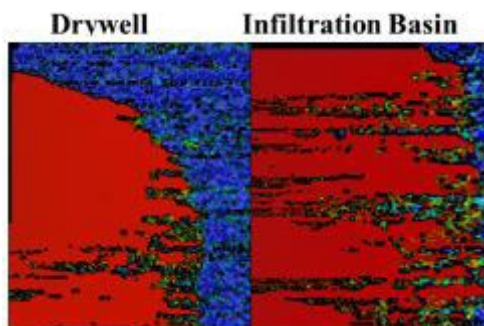
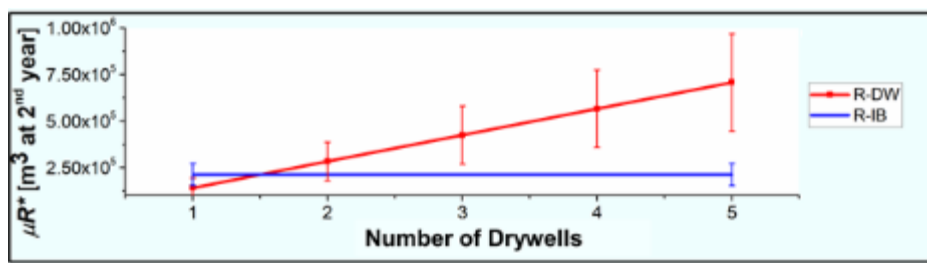
Stakeholders:

California Department of Water Resources (CDWR)
 Natural Resources Conservation Service (NRCS)
 United States Bureau of Reclamation (USBR)

Improved Agroecosystem Efficiency and Sustainability in a Changing Environment, SAWS Unit, Davis, CA

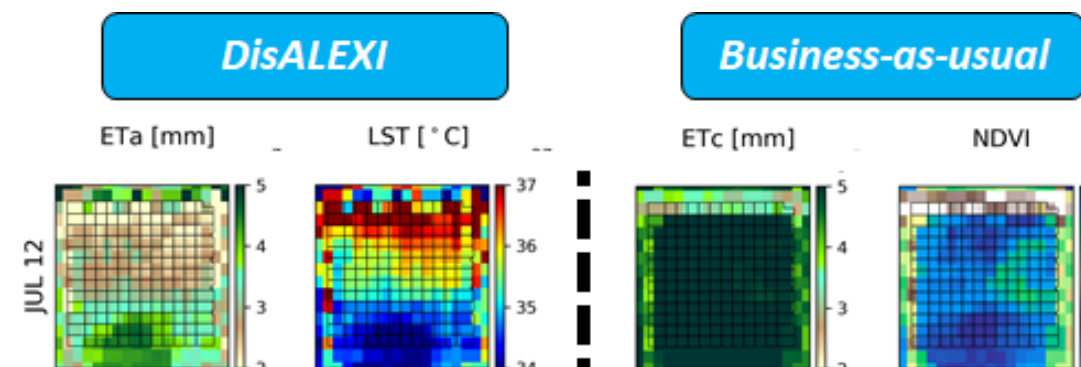
Research Focus Areas: Managed Aquifer Recharge (MAR), Remote Sensing, and LTAR

MAR: Optimize capture and recharge of stormwater in aquifers without adversely impacting groundwater quality



- Drywells can be used to recharge large volumes of water without adversely impacting crops or leaching root zone contaminants

Remote Sensing: Use satellite and meteorological data to estimate crop evapotranspiration (ET) to improve irrigation efficiency



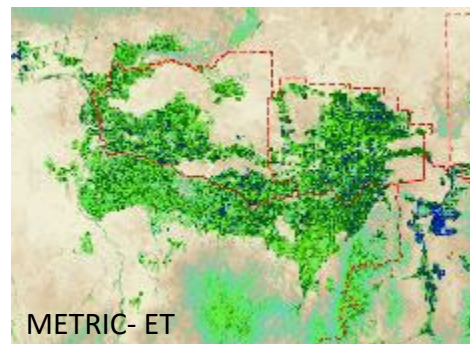
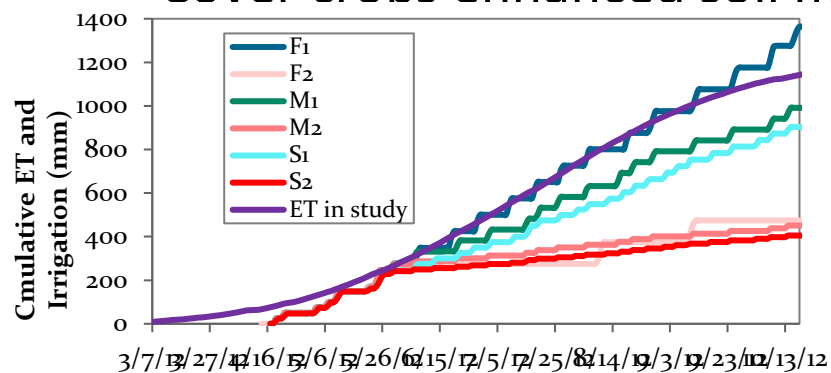
- Improved predictions of spatial and temporal variability of ET in vine and tree orchard crops

LTAR: Assessing the long-term impacts of irrigated agriculture on crop production, soil health, and groundwater quantity and quality.

- Hydroeconomic modeling of land fallowing, MAR, and improved irrigation efficiency

Developing Sustainable Cropping Systems to Improve Water Productivity and Protect Water and Soil Quality in Irrigated Agriculture (Parlier, CA)

- **Research Focus Areas:** (water quantity, water quality, modeling, drainage, salinity, irrigation, remote sensing, ground water, surface water, CEAP)
- **Problems addressing:**
 - Development of irrigation strategies to save water under drought conditions
 - Reuse of saline drainage water for irrigation of pistachios, agretti, Opuntia –cactus, and guayule
 - Irrigation and conservation practices (biochar, cover crop, orchard biomass recycling) to improve soil and water quality
- **Major research findings and Impact:**
 - Significant water savings achieved with deficit irrigation in tree crops
 - Strong interactions found between irrigation and conservation practices on N transport and soil C sequestration
 - Cover crops enhanced soil microbial biomass and other soil health properties

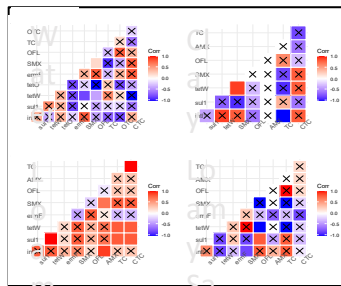


The Use of Treated Municipal Wastewater as a Source of New Water for Irrigation -Maricopa, AZ

- **Research focus area** (water quality, water quantity, wastewater reuse)
- **Problems addressed**
 - Environmental fate and transport of pharmaceuticals
 - Antimicrobial resistance in the environment
 - Low input treatment and removal of pharmaceuticals from water
- **Major research findings and Impact**
 - Pharmaceutical transport depends on soil pH, compound pKa, soil organic matter, and temperature
 - Antimicrobial presence leads to development of antimicrobial resistance
 - Biochar can efficiently remove pharmaceuticals from water



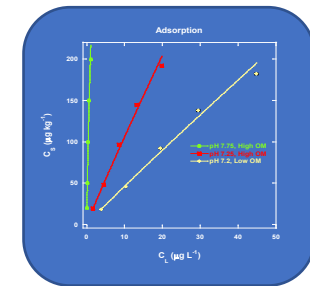
Groundwater recharge



Antimicrobial resistance



Wastewater treatment



Soil sorption

Let us protect & properly manage our water
resources.

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