Retrospective Review of ARS National Program 211 – Water Availability and Watershed Management

Based on the NP211 2011-2015 Action Plan

http://www.ars.usda.gov/SP2UserFiles/Program/211/NP211%20FY11-15%20Action%20Plan%20Final%20110408.pdf

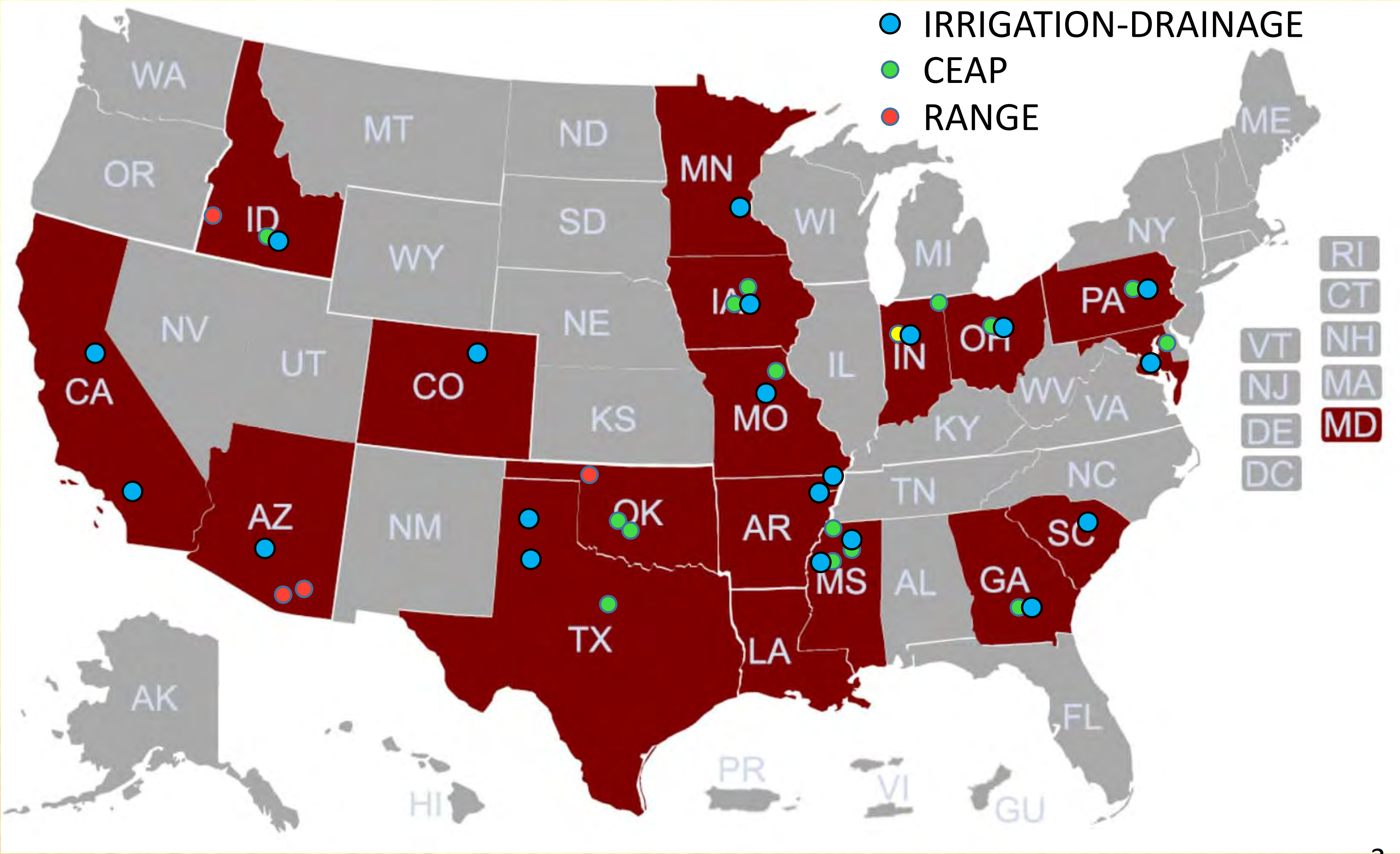
September 14, 2016, 12:30 pm – 4:30 pm, GWCC Rm 4-2223

Sequence of Presentations

- Problem Area 1: Effective Water Management in Agriculture.
- Problem Area 2: Erosion, Sedimentation, and Water Quality Protection.
- Problem Area 3: Improving Conservation Effectiveness.
- Problem Area 4: Improving Watershed Management and Ecosystem Services in Agricultural Landscapes.

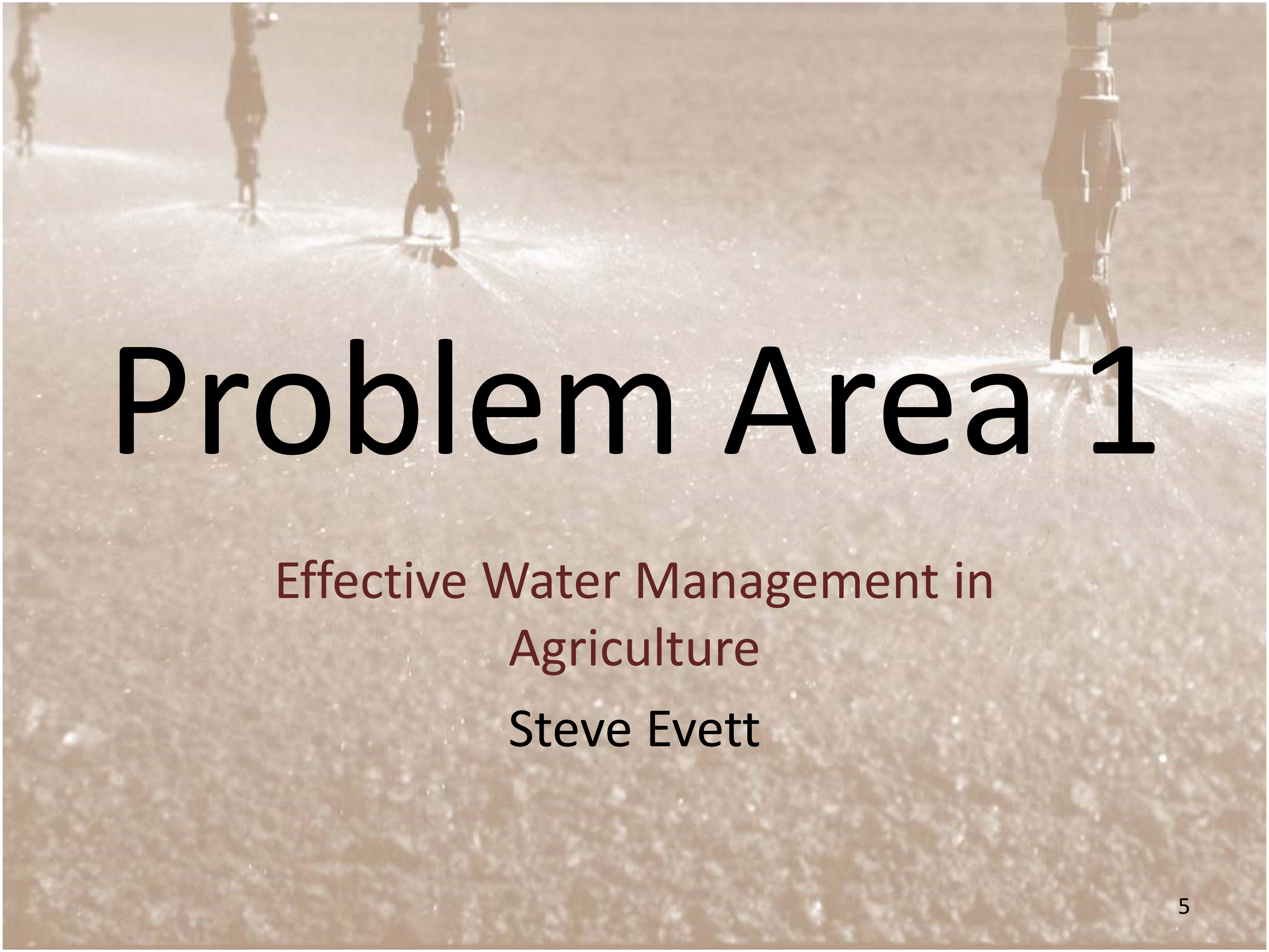
- Within each problem area, the several **Problem Statements** (PS) will be addressed.

Problem Area 1
Irrigation - Drainage Locations - 20



Problem Area 1: Effective Water Management in Agriculture

- PS 1.1: Irrigation Scheduling Technologies for Water Use Efficiency
- PS 1.2: Water Productivity at Multiple Scales
- PS 1.3: Irrigation Application Methods
- PS 1.4: Dryland/Rainfed Water Management
- PS 1.5: Drainage Water Management and Control
- PS 1.6: Use of Degraded Waters



Problem Area 1

Effective Water Management in Agriculture

Steve Evett

PS 1.1. Irrigation Scheduling Technologies for Water Use Efficiency

- Sensor network based irrigation management
  - Wireless sensor networks developed at **Bushland, Maricopa and Stoneville** improve water use efficiency
  - Technology Commercialized:
    - **CRADA** for wireless infrared thermometer (IRT)
    - **CRADA** for patented True TDR soil water sensor – used by major agribusinesses
    - **Multi-location CRADA** for patented site-specific Irrigation Scheduling SCADA (ISSCADA) system – in-field beta testing
  - Applications
    - **Ft. Collins**: Alternative canopy temperature methods for field crop irrigation management
    - **Parlier**: 50% post harvest water savings in peach with IRTs
    - **Kimberly**: CWSI method for precision irrigation of wine grape

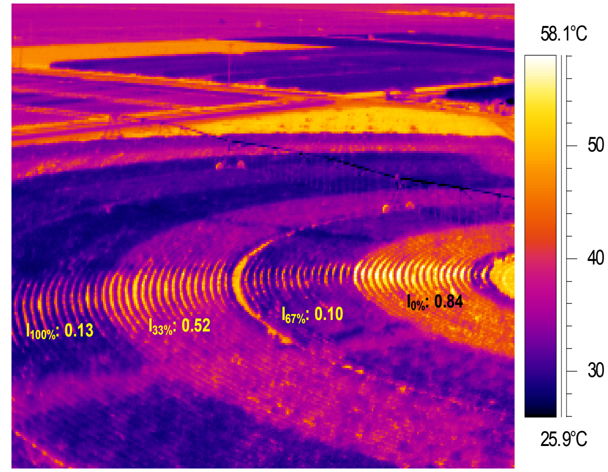
Sensor Development and Tech Transfer

- Low-cost, low-power, wireless or wireless capable
- Accurate soil water content, bulk electrical conductivity and temperature sensing
- Accurate canopy temperature sensing

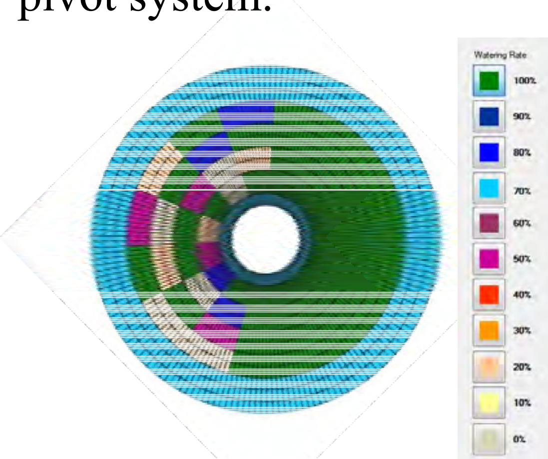
Sensors integrated with patented irrigation systems

Site-specific Irrigation Management with a Supervisory Control and Data Acquisition (SCADA) System

A wireless network of infrared thermometers is mounted on a variable rate irrigation center pivot system.

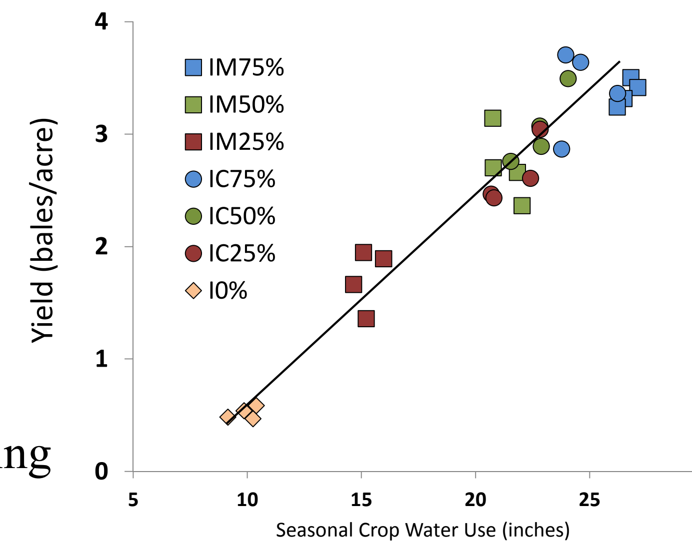


The SCADA system quantifies the stress level of the crop using canopy temperature and weather data.



Dynamic prescription maps are built throughout the growing season to manage irrigation using stress index thresholds.

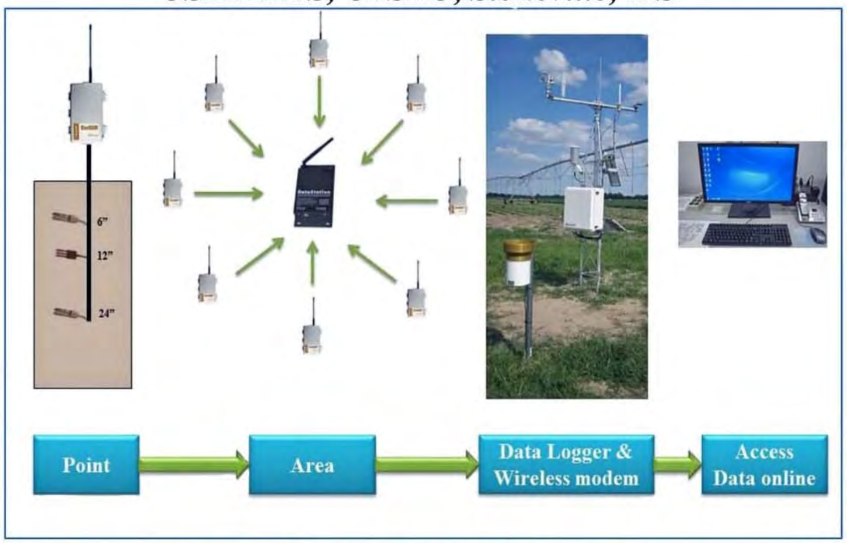
Yields and water use were similar between manual and plant feedback irrigation methods

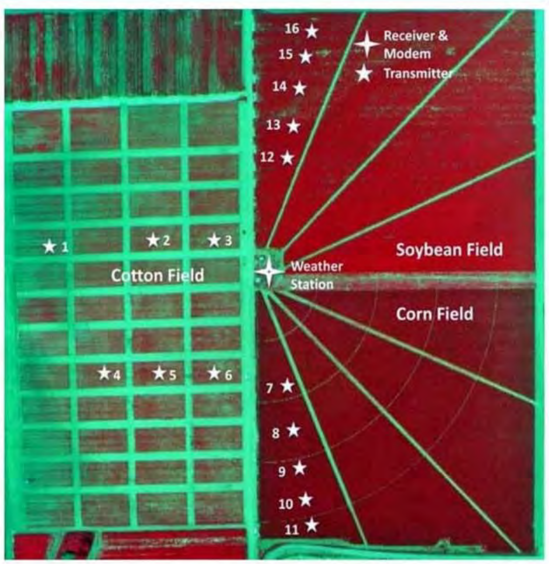


Development of Wireless Sensor Network for Irrigation Scheduling in Humid Climates

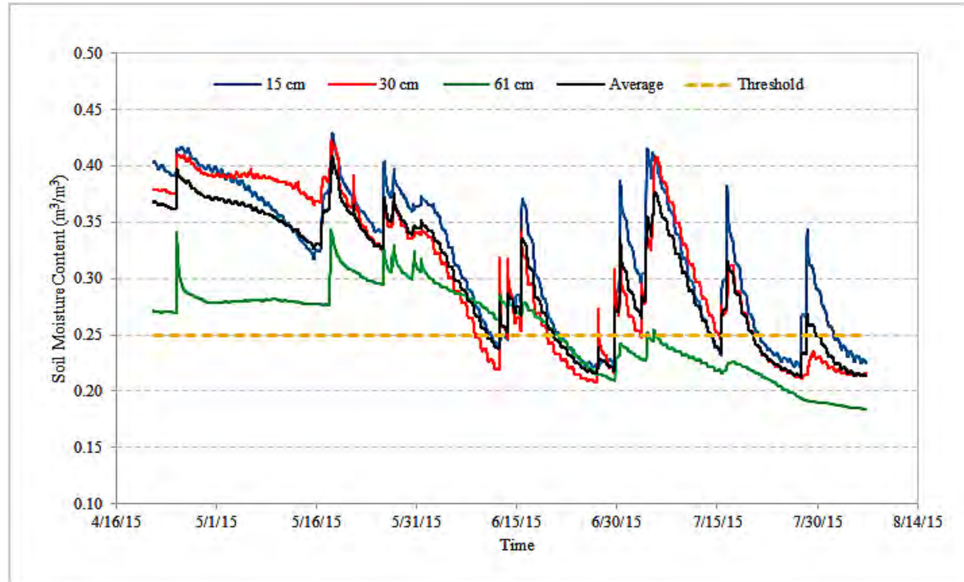
Wireless Sensor Network for Crop Water Management

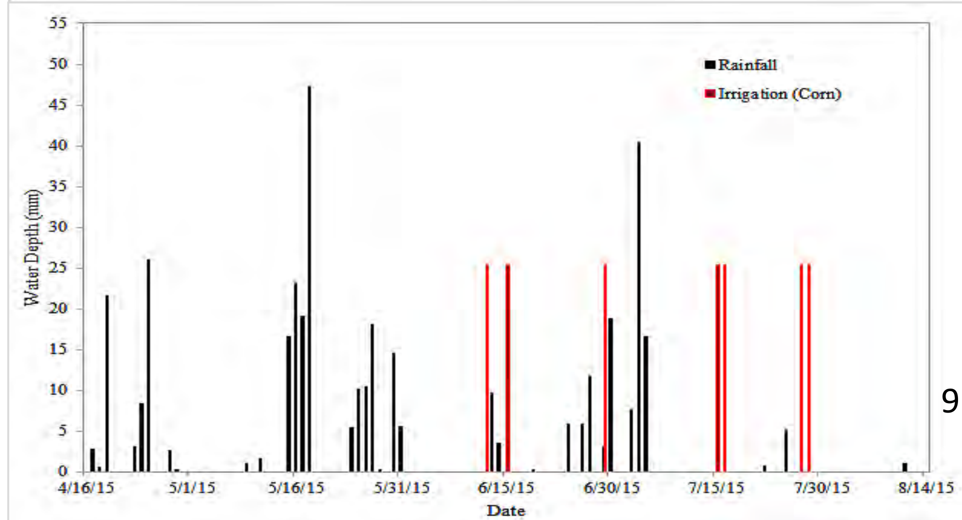
USDA-ARS, CPSRU, Stoneville, MS





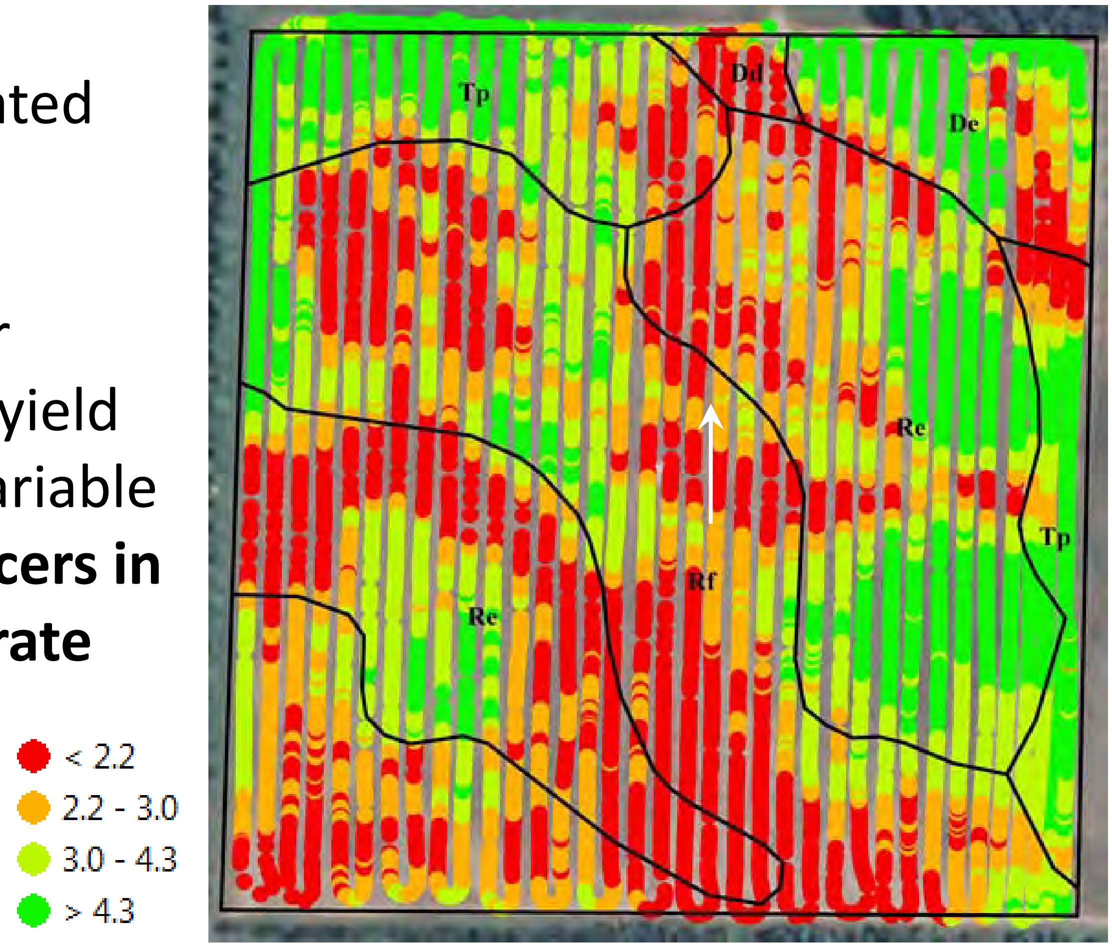
Soil Moisture & Rainfall Measured by Wireless Sensor Network and Used in Irrigation Scheduling





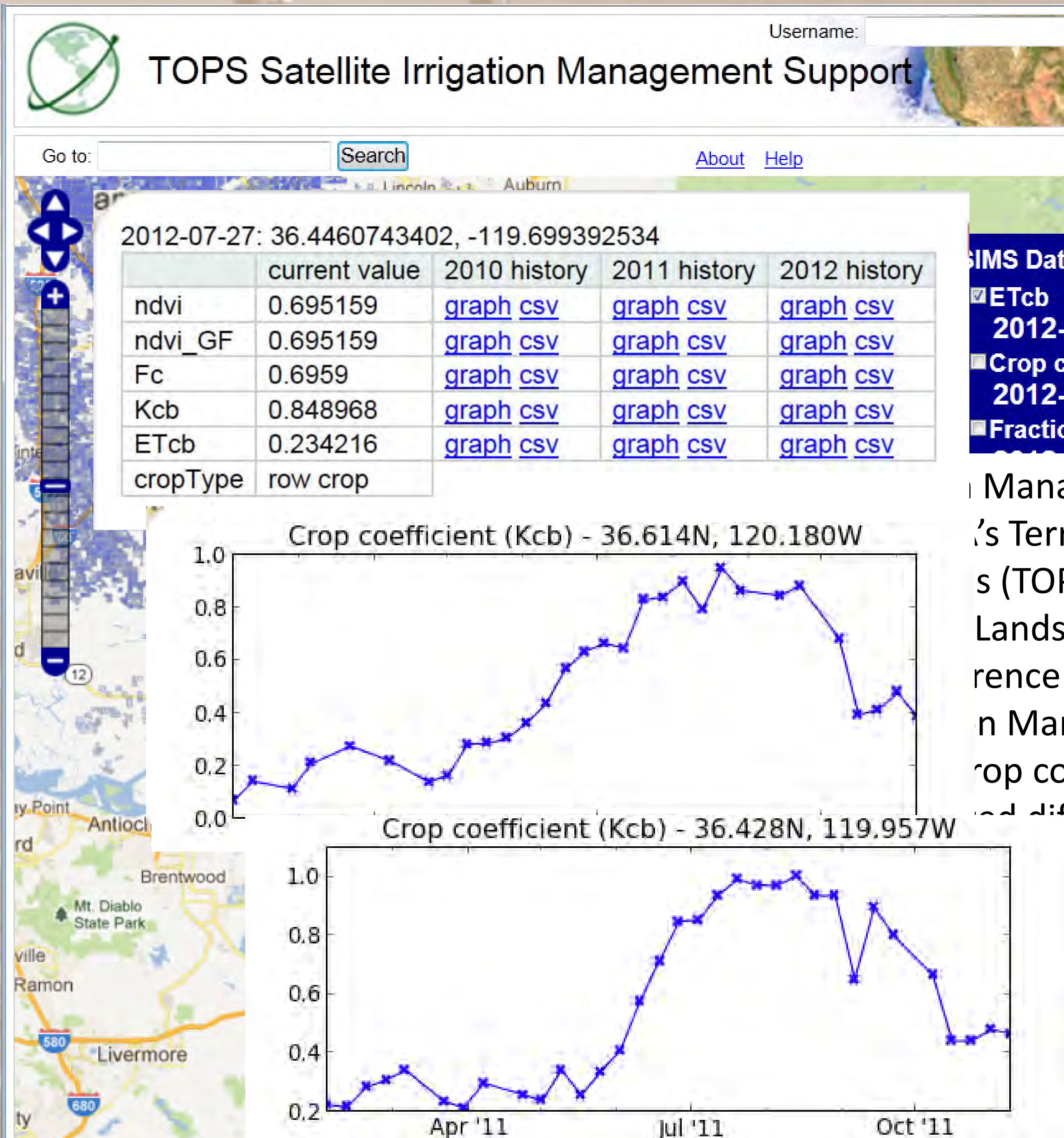
Demonstrated impact of soil spatial variability on irrigated cotton yield and water use efficiency

Portageville: ARS and university scientists related total irrigation and soil apparent electrical conductivity, a proxy for texture, to seed cotton yield for a field with highly variable soil. Findings **aid producers in proper use of variable rate irrigation systems.**



PS 1.1. Irrigation Scheduling Technologies for Water Use Efficiency

- Remote sensing based tools
  - **Parlier-Ft. Collins**: NASA-U.S. Navy collaboration predicting crop water requirements from satellite imagery – **10 million acres in CA**, TOPS (http://ecocast.arc.nasa.gov/dgw/sims/)
  - **Bushland, Maricopa:** Improved *E* and *T* partitioning and cotton WUE with TSEB.
- Modeling tools
  - **Maricopa-Ft. Collins**: Integration of dual Kc method into DSSAT models
  - **Lubbock**: Web app for cotton irrigation management balances dryland and irrigated acres
- Irrigation management guidance
  - **Florence:** Provided irrigation management guidance for hay and flax in the SE US.



Management Support (SIMS)
's Terrestrial Observation and
s (TOPS) to merge reflectance
Landsat and MODIS satellite
rence ET estimates from the
n Management Information
rop coefficients are estimated
ference vegetation index
ps crop fractional ground
ients, and basal ET of a
-m resolution over 6 million

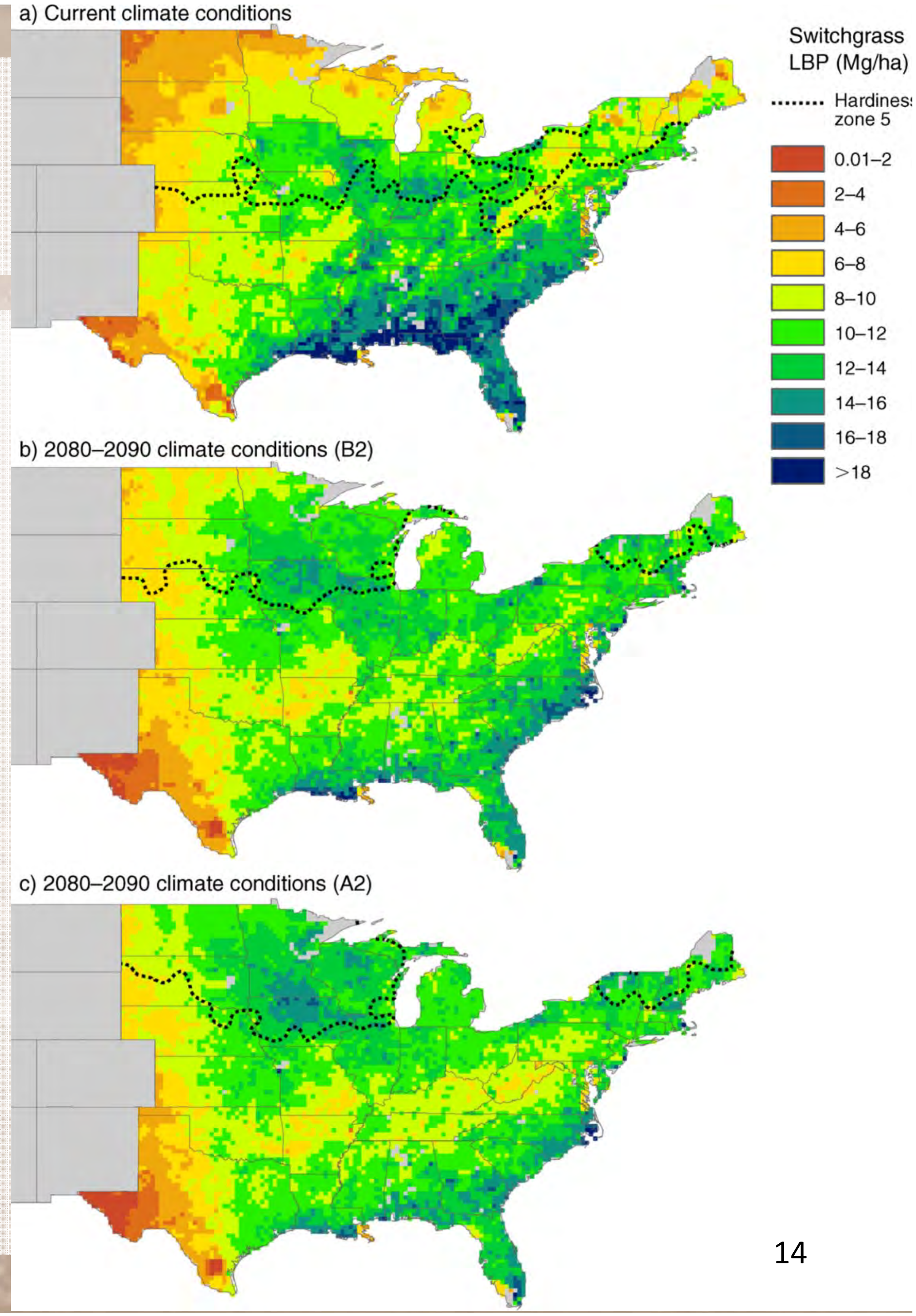
ast.arc.nasa.gov/dgw/sims/

PS 1.2. Water Productivity at Multiple Scales

- **Ft. Collins**: Regional simulation of Crop Water Production Functions (CWPF) by soil, irrigation type, and irrigation and N levels – **aids in crop choices**
- **Temple**: GeoAlmanac spatial forecasting of crop productivity (switchgrass, poplar, sugarcane, oilseed crops) – **U.S. Navy fuel security**
- **Ft. Collins-Maricopa**: DSSAT system model ET simulation improved, applied to deficit irrigation scenarios – **aids in deficit irrigation decisions**

GeoALMANAC

- **Temple**: Biomass potential of switchgrass
- A function of CO_2 concentration, soil type and water availability
- Climate change scenarios



Bioenergy crop evaluation across the Continental U.S. and Hawaii.

- Developed scientific basis for profitable biofuel crop production in cultivated and rangeland systems to support wise use of marginal and prime land.
- Conducted feasibility study to determine role that sugar-cane biofuel and Hawaiian agricultural base could play in fueling Pacific Fleet at request of US Navy and Hawaiian Commercial & Sugar Company.
- Developed modeling tools to determine optimal cropping systems (including oilseed crops, perennial grasses, energy sorghum, energy cane) for biofuel production on different soils with different management strategies.

MAUI HC&S HAWAIIAN COMMERCIAL & SUGAR COMPANY

Office of Naval Research ONR Science & Technology USN

Bioenergy crop evaluation across the Continental U.S. and Hawaii.

- Showed that the southern U.S. has the highest current biomass production potential but also predicted that the same region will have the largest productivity decrease due to increased temperature and decreased precipitation in the future.
- Management recommendations for effective water management to optimize biofuel crop production in the Pacific Rim were provided to Hawaiian Commercial & Sugar Company and to the Navy for consideration of alternative biofuel crops for the region.

Multi-sensor data fusion

Mapping Crop Phenology and Daily Water Use/Stress at Sub-Field Scales

TOOLS

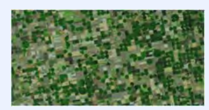
STARFM	Multi-sensor data fusion
DMS	Thermal image sharpening
ALEXI	Multi-scale ET modeling

SATELLITE ASSETS

		SW/TIR
GEO	Hourly	5km/5km
MODIS	Daily	250m/1km
Landsat	16 day	30m/100m
Lsat-like		~20-60m/ --

APPLICATIONS
(daily/30 m resolution)


Crop phenology metrics

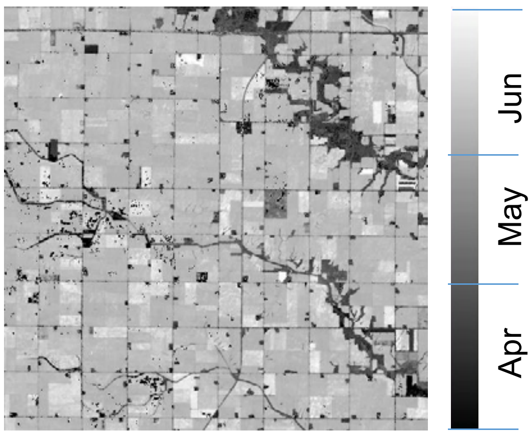

Crop water use (Evapotranspiration)


Crop stress (drought early warning)

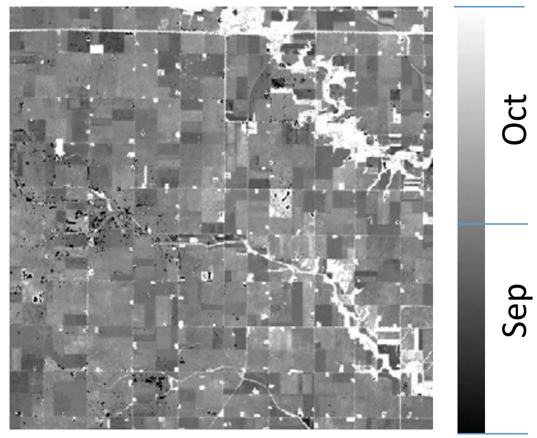
Multi-sensor data fusion

MAPPING CROP PHENOLOGY

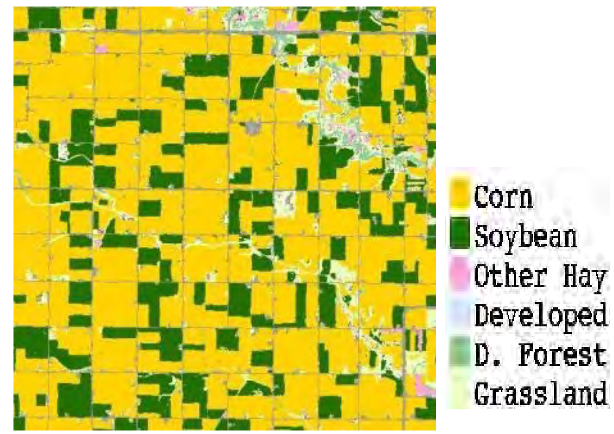
Crop progress and condition are reported weekly at state and district levels by the National Agricultural Statistics Service (NASS). The ground data collection supporting this effort is time consuming and subjective. HRSL scientists have developed remote sensing approaches for mapping crop phenology by fusing Landsat and MODIS satellite imagery. The remotely sensed crop phenology at field scale (30m) is clearly related to observed crop growth stages and crop types.



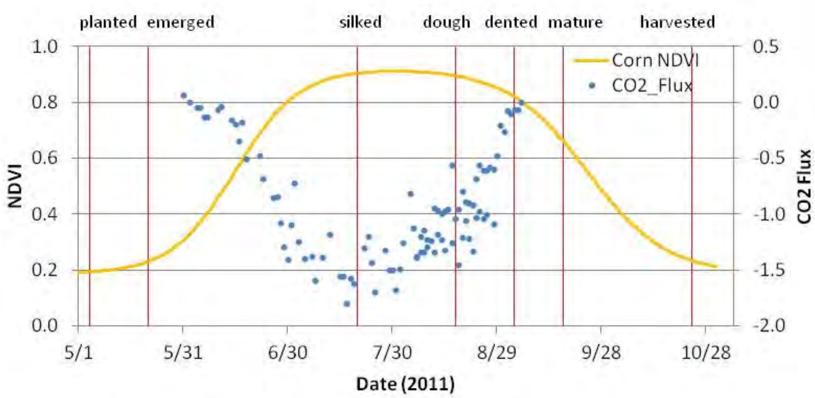
Greenup Dates in 2011

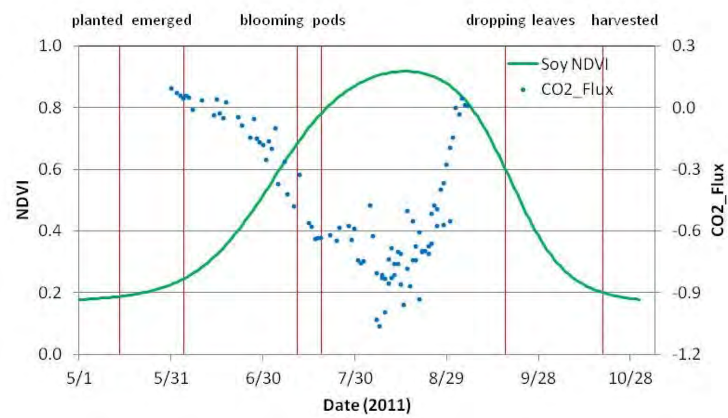


Dormancy Dates in 2011



Cropland Data Layer from NASS

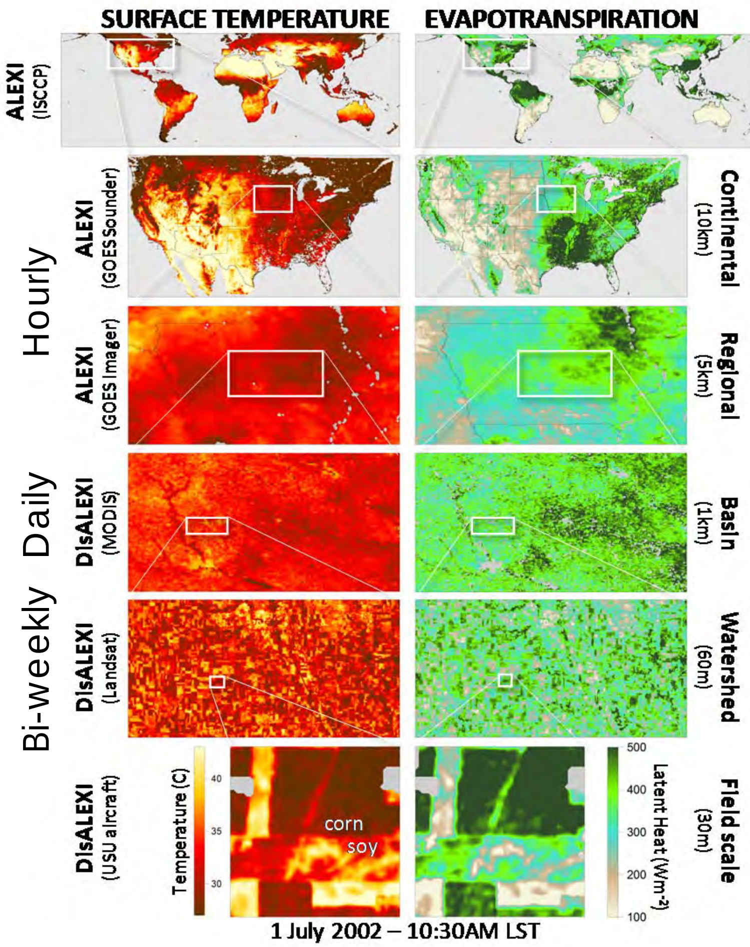


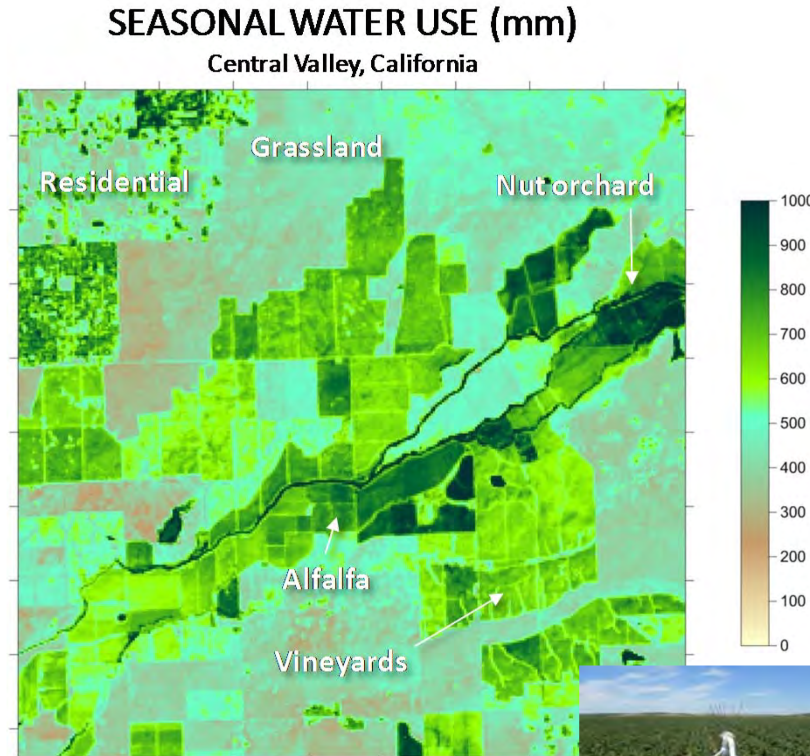


Multi-sensor data fusion

MAPPING DAILY/SEASONAL CROP WATER USE

The same data fusion techniques are being used to fuse evapotranspiration (ET) estimates from multiple satellites to map daily crop water use down to sub-field spatial scales.





GRAPEX: Grape Remote sensing Atmospheric Profiling Experiment

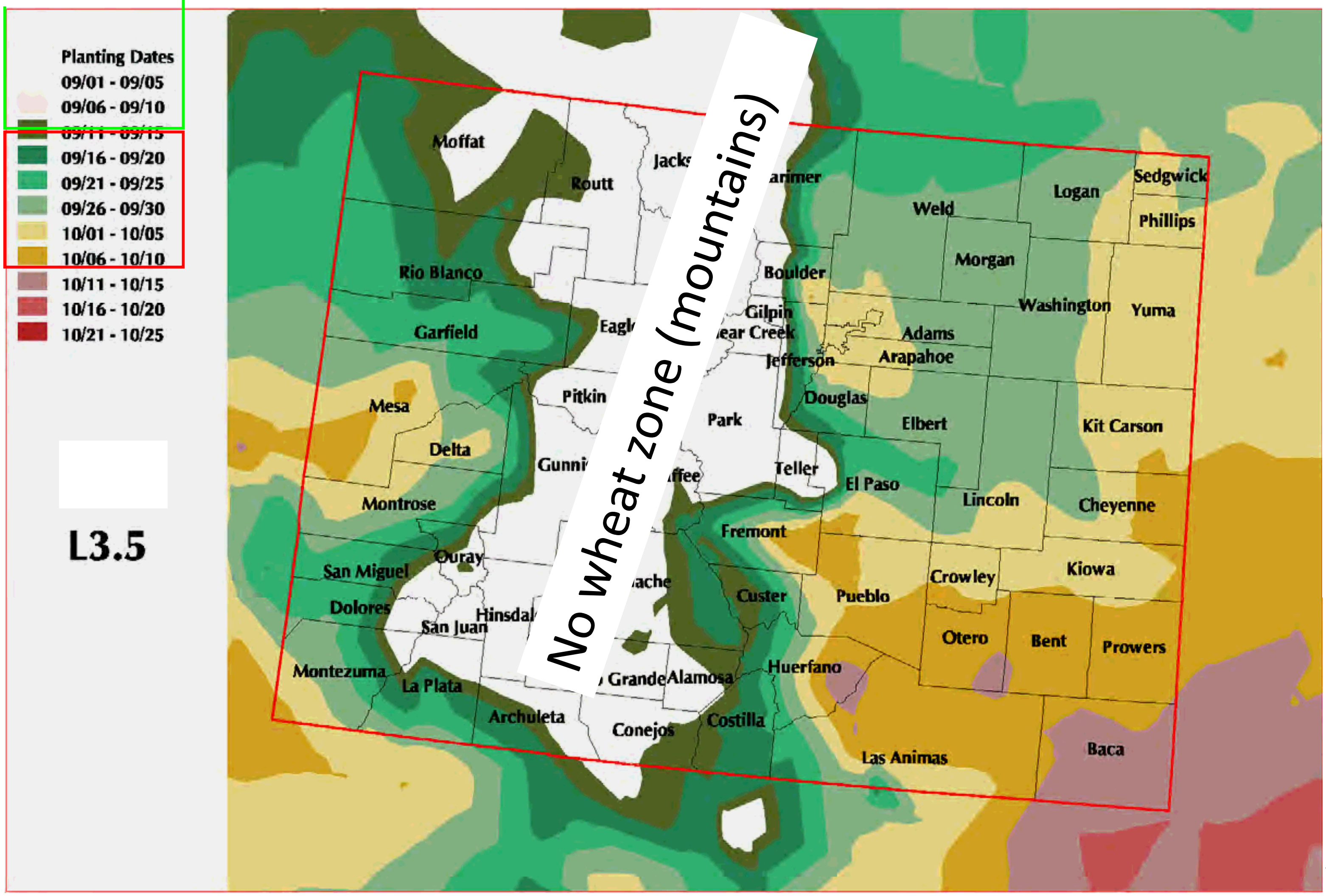
In collaboration with E&J Gallo, HRSL scientists are conducting field and remote sensing research to improve irrigation management and water use accounting in California vineyards.

Determining optimal planting dates in Colorado using *PhenologyMMS* for Risk Management Agency in assessing crop insurance penalties

Planting Dates

Sep.

Oct.



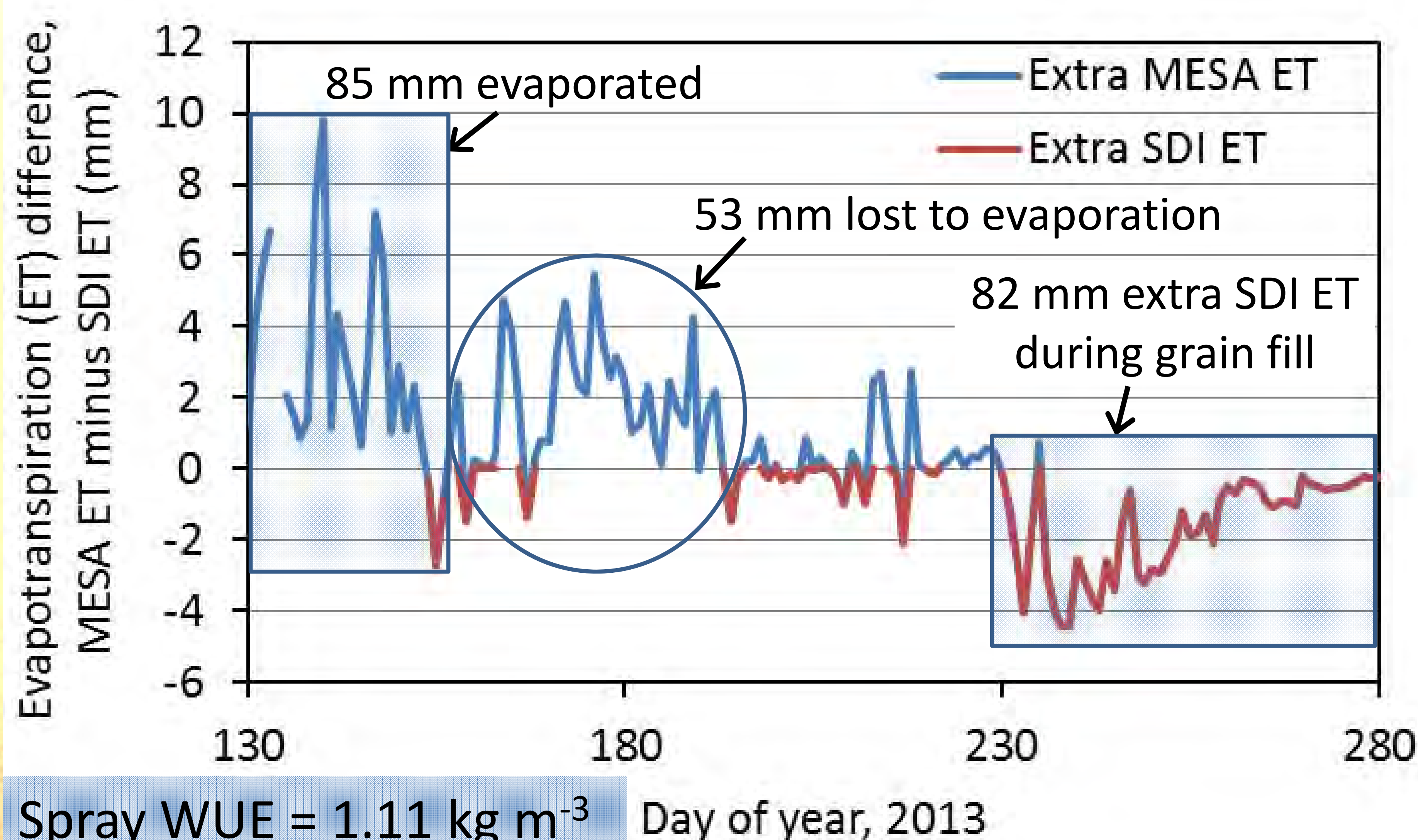
PS 1.3 Irrigation Application Methods

- **Portageville**: Showed that **center pivot irrigation of rice** on coarse-textured soil achieved yield and WUE comparable to flooded production. Affects producers in areas with soils not suitable for flood irrigation.
- **Bushland**: Subsurface drip irrigation **(SDI) increases yield and WUE** by reducing evaporation losses
- **Parlier**: Peach post-harvest water use decreased 50% by surface drip and micro-sprinklers
- 2014 Western Association of Agricultural Experiment Station Directors **Excellence in Multistate Research Award** to W-2128 Microirrigation for Sustainable Water Use project

Demonstrated feasibility of rice production using center pivot irrigation

ARS and university scientists in Missouri showed that **center pivot irrigated rice** on coarse-textured soil **achieved grain yields comparable to flooded production**. Research aids producers in areas throughout the world with soils not suitable for flood irrigation.

Corn Water Use, SDI vs. MESA



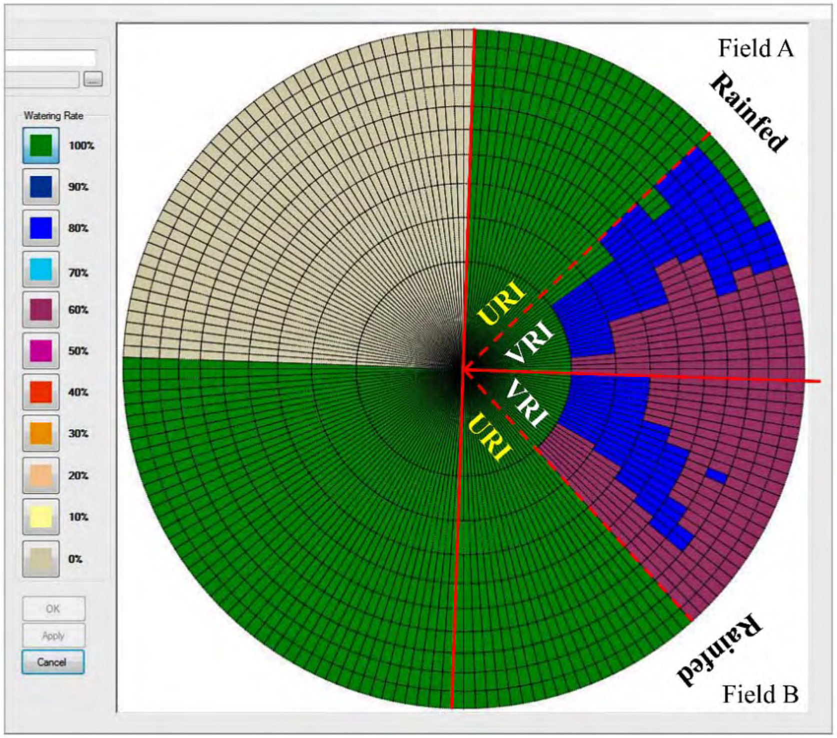
Spray WUE = 1.11 kg m^{-3}

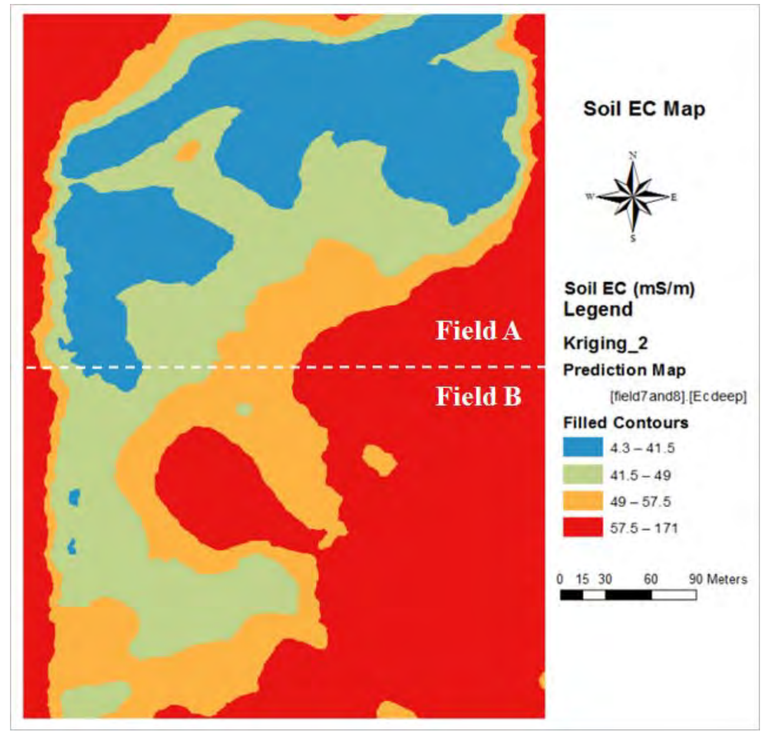
SDI WUE = 1.62 kg m^{-3}

PS 1.3 Irrigation Application Methods

- **Stoneville**: Using **variable rate irrigation (VRI)** based on EC_a mapping**,** water use efficiency was 31.2% greater in soybean and 27.1% greater in corn.
- **Bushland**: VRI system accuracy shown to be sufficient even in windy condition.
- **Florence:** Irrigator Pro shown useful for VRI management. New NDVI method for VRI management.

Variable Rate Irrigation Increases Water Use Efficiency





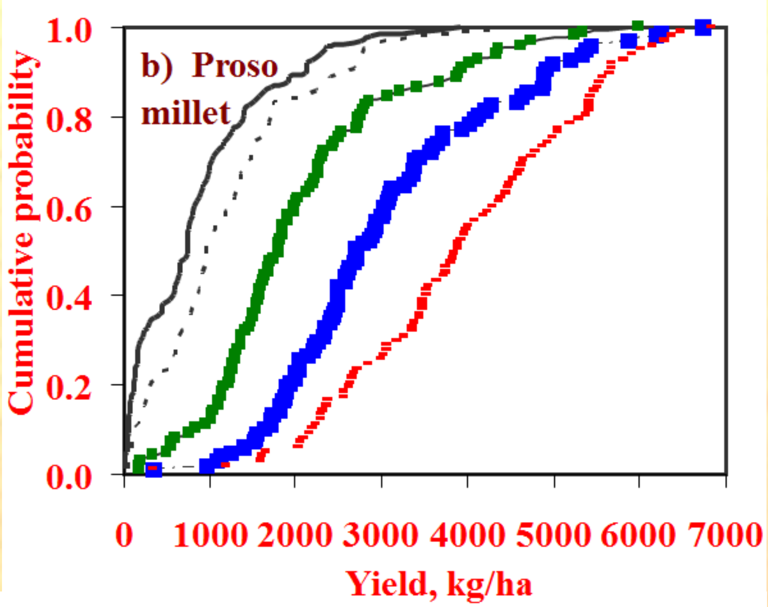
- Developed and evaluated variable rate irrigation (VRI) management in humid climates
- Field scale tests to compare VRI with uniform rate irrigation (URI) in corn and soybean; VRI prescription created using apparent soil electrical conductivity (EC)
- VRI treatment used 25% less irrigation water and produced 2.8% more yield in soybean and 0.8% more yield in corn than the URI treatment
- Irrigation water use efficiency of VRI was 31.2% higher in soybean and 27.1% higher in corn than URI

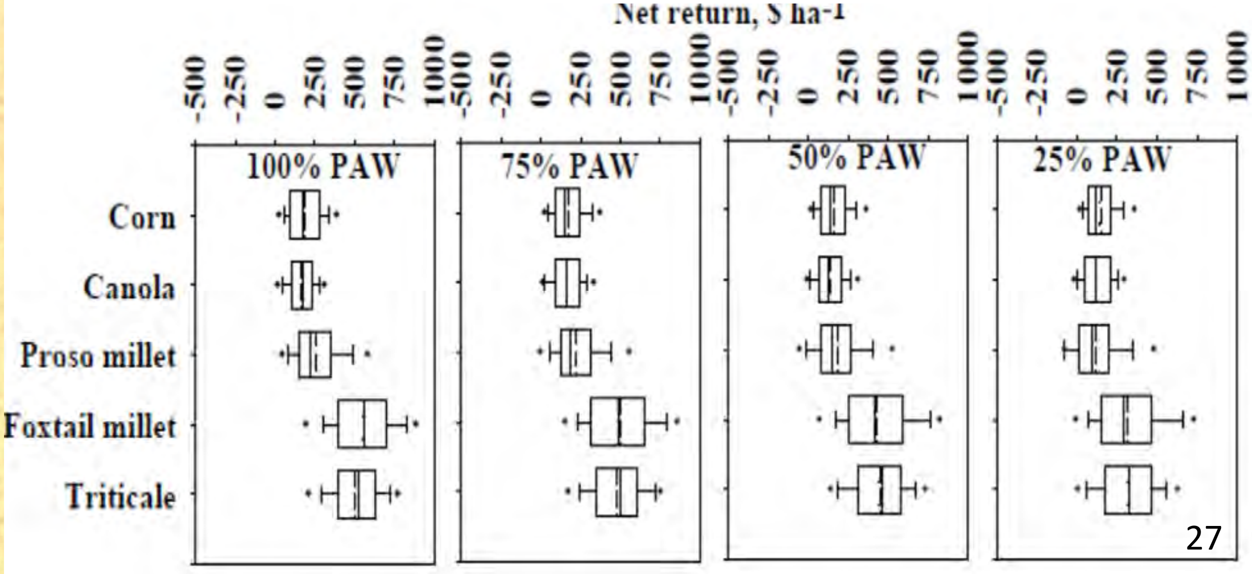
PS 1.4. Dryland Cover Crop Water Productivity

- **Akron**: **Multi-species cover crop mixtures** were not much more productive and water use efficient than single-species.
- **Water use efficiency of the mixture was directly related to the composition of the mixture**.
- Adding more grass grain crops will improve the water use efficiency, while adding more legumes or oilseeds will decrease the water use efficiency.
- Confirmed theory of Sinclair and de Wit (1975).

Dryland Decision Support Tool

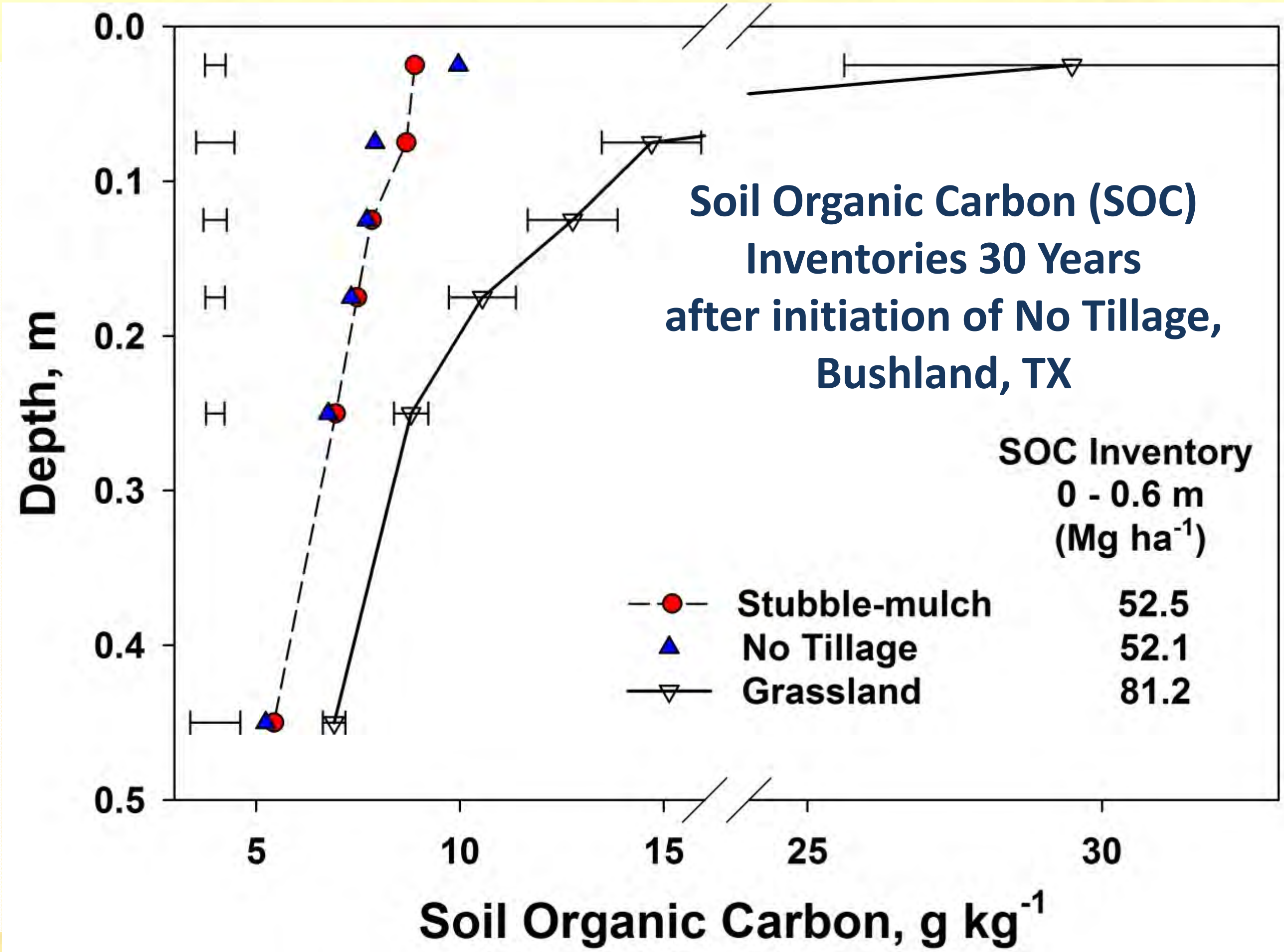
- **Ft. Collins**: **Select the right summer crop** in Wheat-Summer Crop- Fallow Rotation **based on soil water at planting**





Dryland/Rainfed Water Management

- **Bushland: 30 years of no tillage did not increase soil organic carbon**
- **Biomass production governed the long-term changes in SOC**



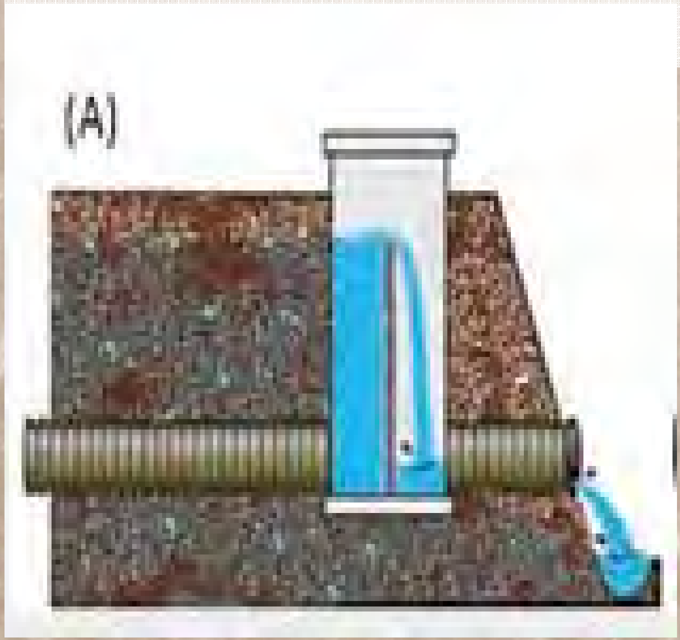
- **For this semi-arid location, increasing SOC requires improvement of WUE under dryland (or additional water via irrigation!)**

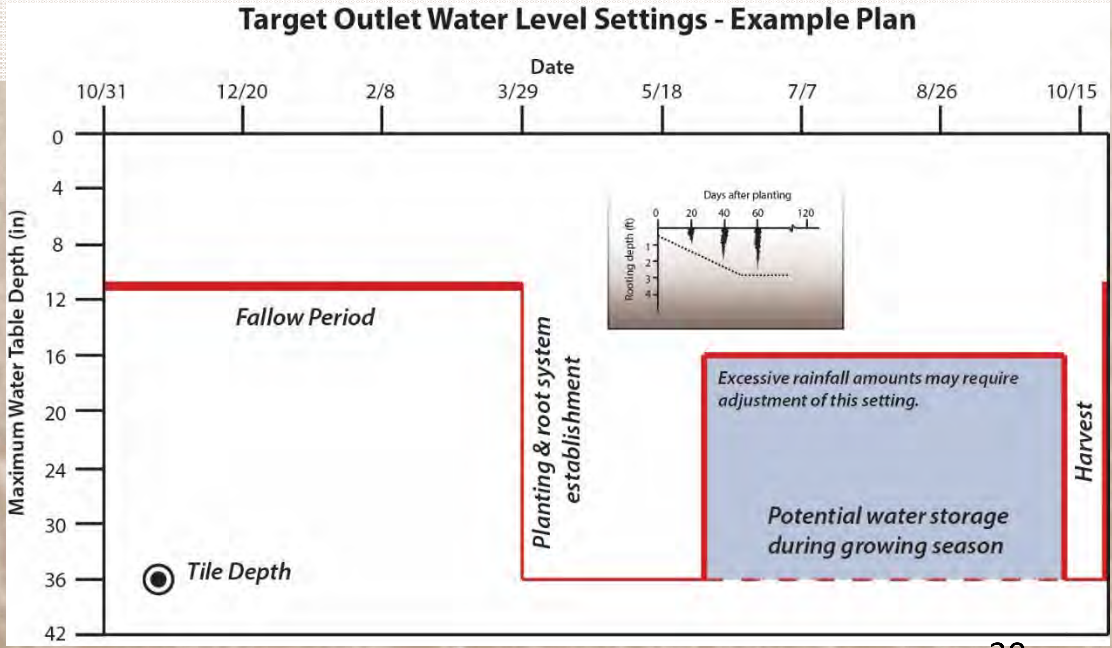
PS 1.5 Drainage Water Management/Control

- **St. Paul**: Paradox of **too much water** and **short-term drought** requires both drainage and supplemental irrigation – economic consequences drive technological solutions.
- **Columbus**: **active drainage water management** (DWM) maintains crop water availability while **reducing nutrient loads** in outflows. Provided **NRCS** with justification for development of **national DWM adoption program**.

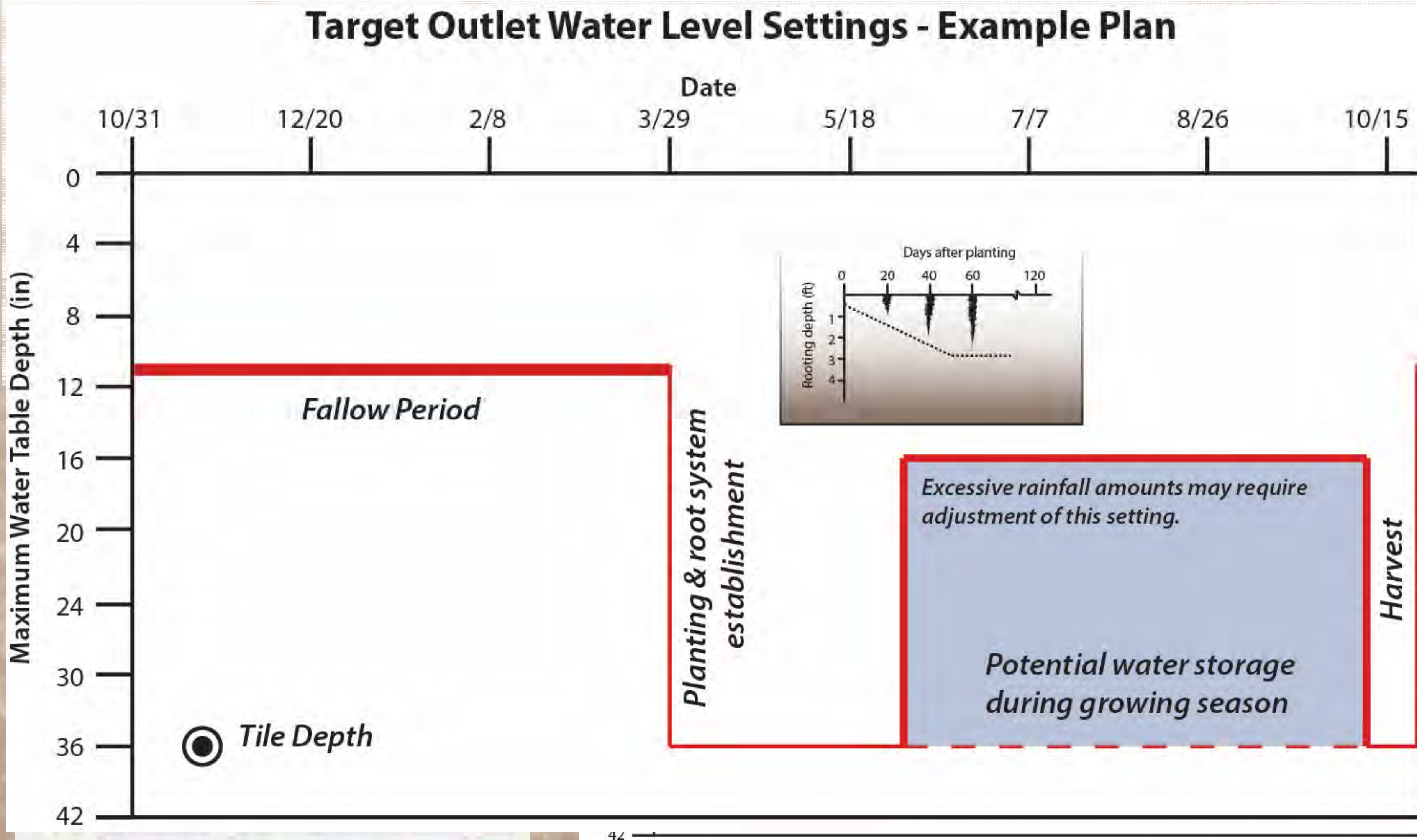
DWM Moves Forward – Cooperation with University, Industry and NRCS partners

Confirmed flow & nutrient load reduction when applying DWM.
NRCS now promotes and cost shares this practice nationally.
Most promising technology/practice available to reduce off-site delivery of agricultural nutrients.



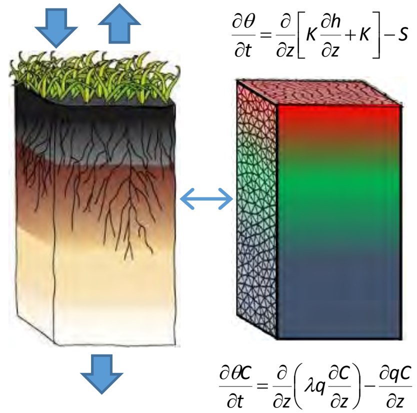


DWM Stores Water – Avoids Drought in Growing Season – Reduces Nutrient Loading



PS 1.6 Use of Degraded Waters – Alternative Irrigation Water Resources

- **Parlier**: Drainage waters high in Boron and Selenium successfully used to cultivate **mustard**, **opuntia** and **poplar**. Added-value, selenium enriched food products. Poplar lowers water tables.
- **Riverside**: **Regional scale salinity assessment tool** based on satellite imagery and ground truth – data assimilation
- **Riverside**: **Crop Water Production Function** simulated by water quality and irrigation rate, replaces FAO 29 and **shows use of saline water to be more productive than thought**



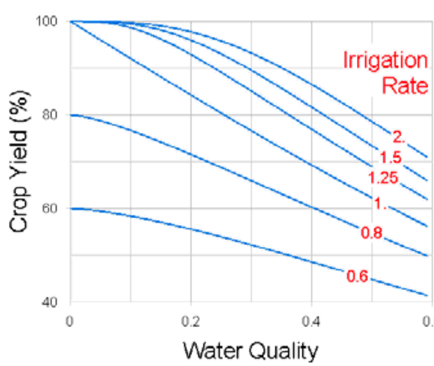
Mathematical Modeling & Decision-Support Systems

Sustaining Irrigated Agriculture in an Era of Diminished Water Quality and Availability

Drought, climate change, and competition for resources from non-agricultural sectors are forcing a greater reliance on marginal (saline) irrigation waters and lands.

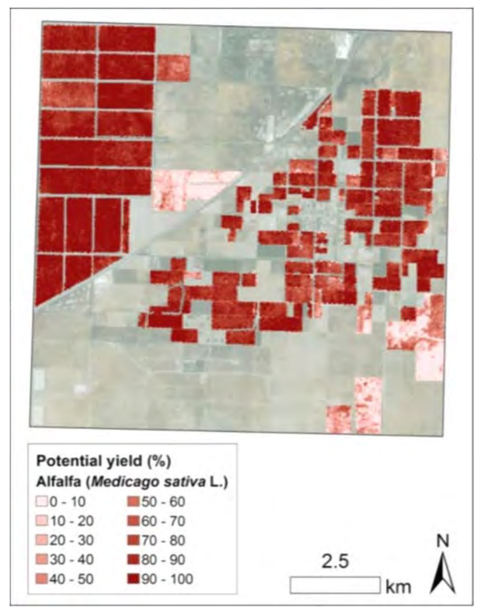
Salinity and water management are keys to sustaining productivity and minimizing environmental impacts.

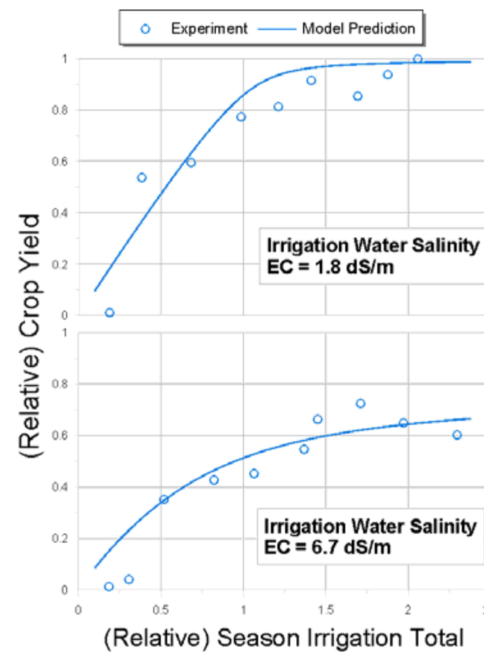
Irrigation Guidelines for Marginal Quality Waters



CSA News Magazine (2014)
doi:10.2134/csa2014-59-6-6

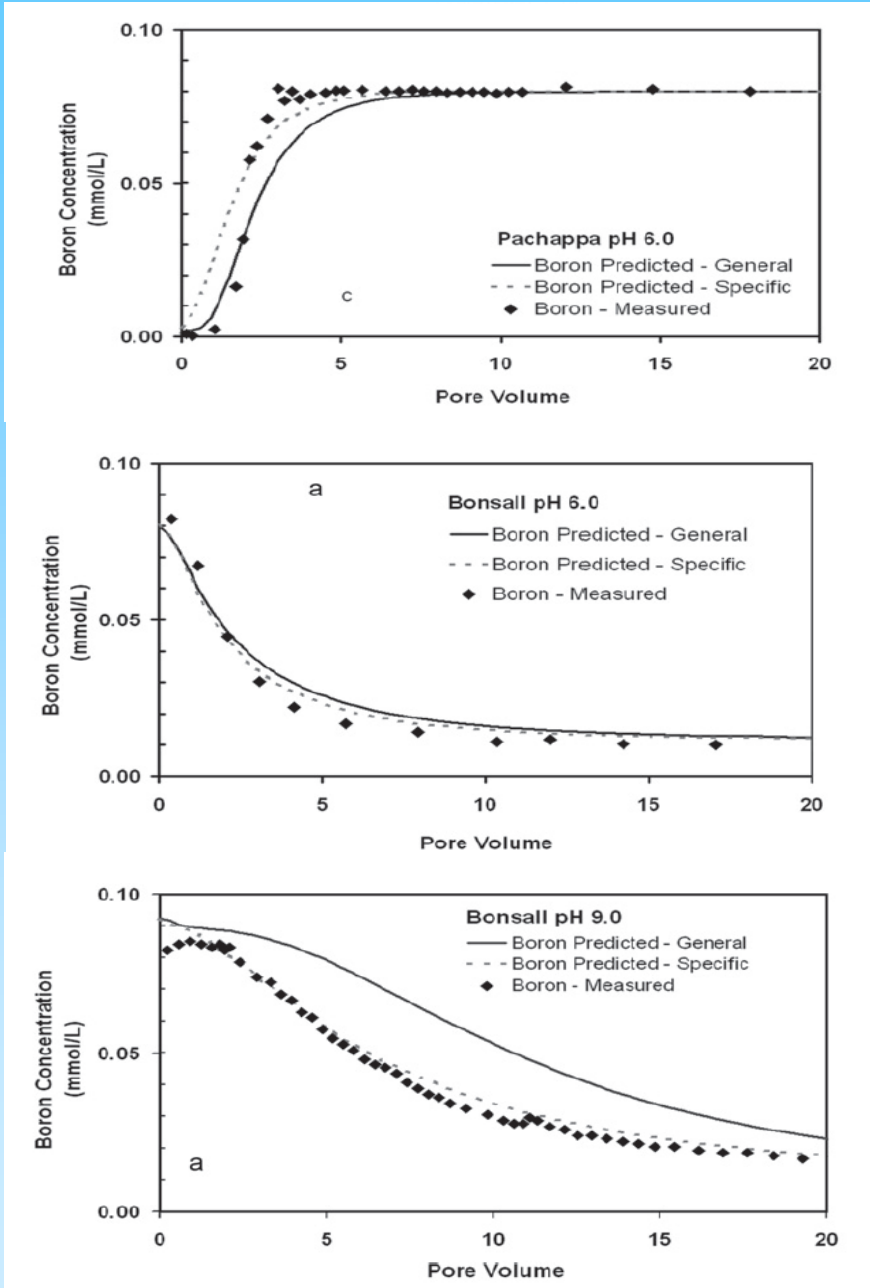
Crop Yield Projections





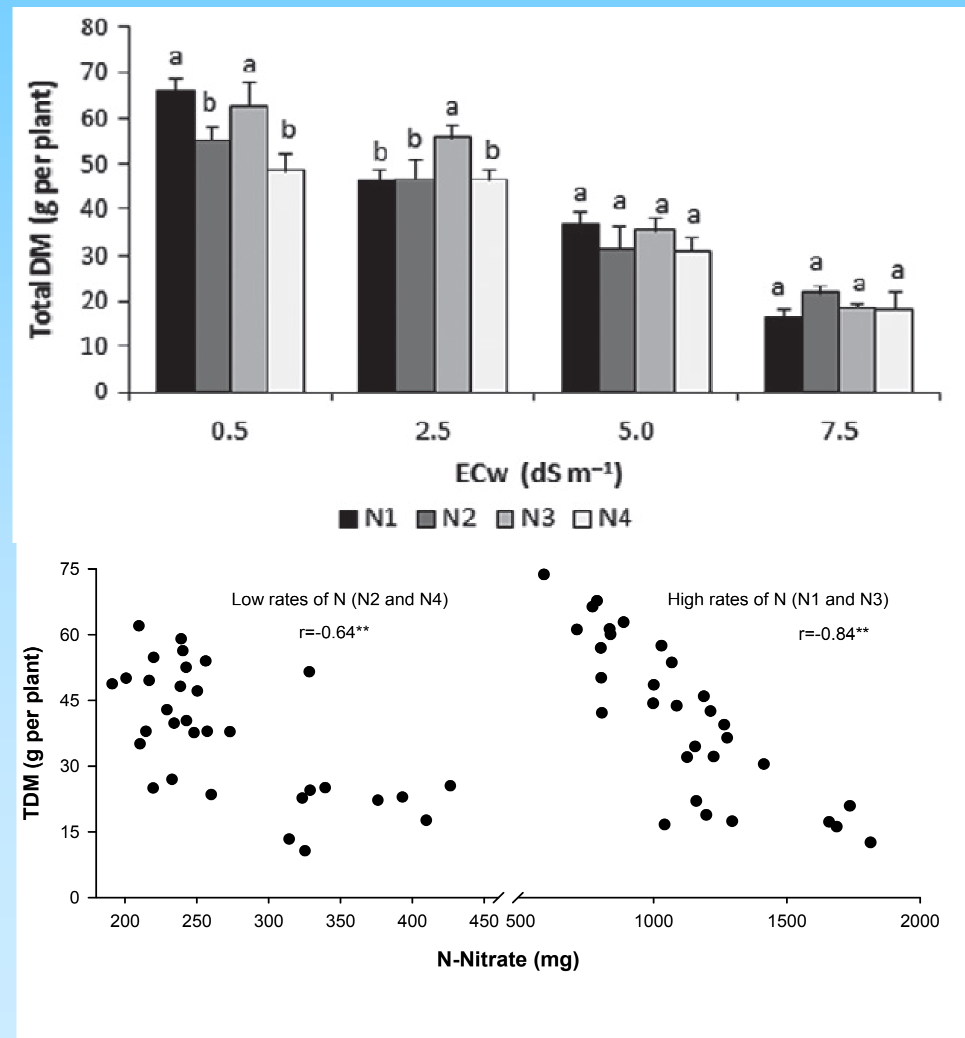
Efficient water use when using high B waters for irrigation

Using a water transport model (UNSATCHEM) with a coupled chemical absorption model (constant capacitance model) and a regression model to predict the model to predict the chemical parameters based on known soil properties, we can predict B accumulation and leaching without measuring B adsorption.



Corn N requirements under salt stress can be reduced and be predicted by the expected reduction in ET caused by salt stress

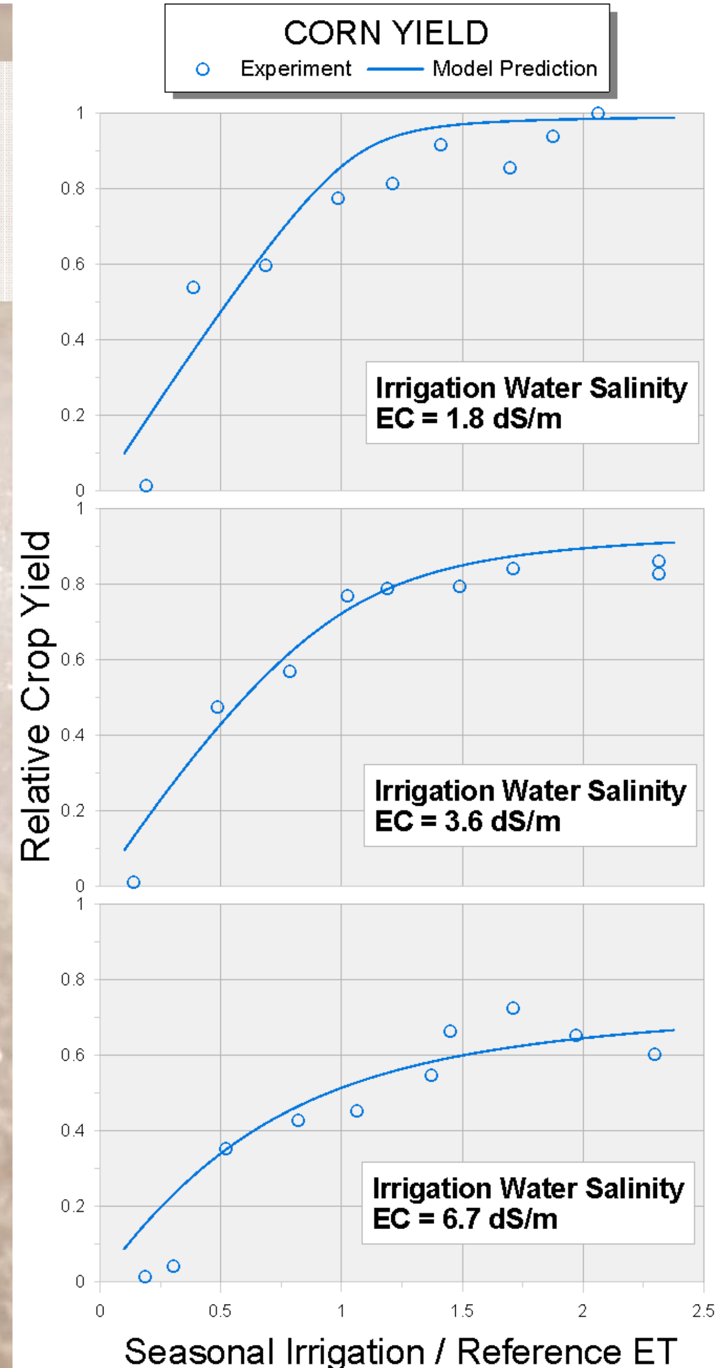
Reduced application of N under salt stress maintained yield and reduced N leaching. N requirements can be reduced according to the predicted reduction in yield and ET related to salt stress



Using Alternative Waters

Mustard – Boron & Selenium rich drainage water
Selenium enriched food products

Poplar – lowers water table.
Grows in saline water

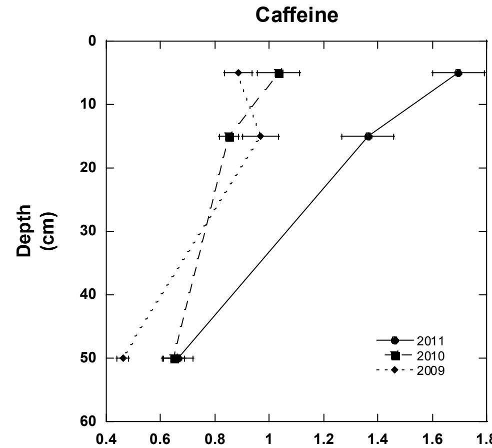


Problem Area 1 - Effective Water Management in Agriculture (Parlier, CA)

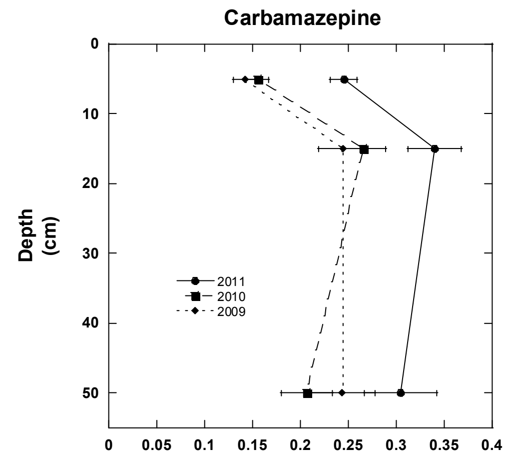
Salt and Boron tolerant Brassica production using poor quality water in poor quality soils

Fate of Pharmaceuticals in Wastewater Recharge Basin Gilbert, Arizona

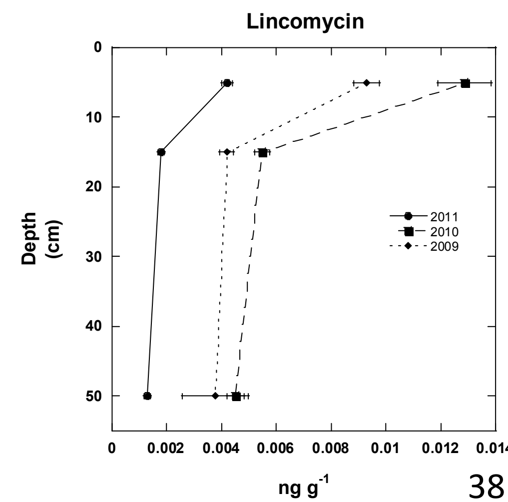
Increasing



Lower surface concentration

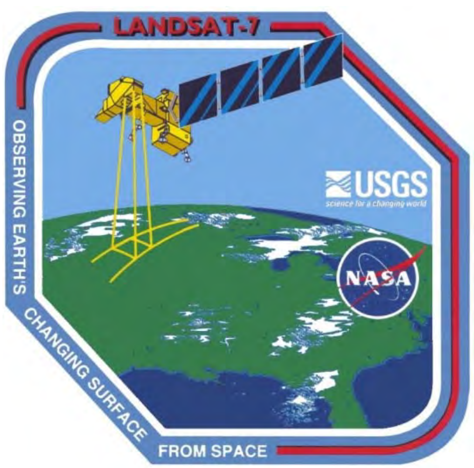


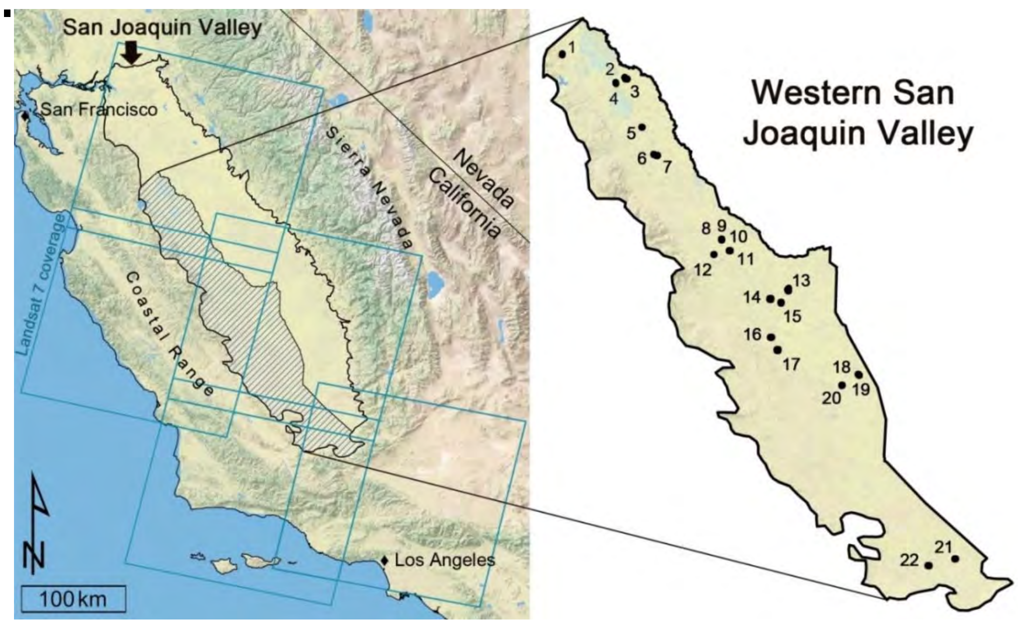
No trend



Regional-scale Soil Salinity Mapping Using Landsat 7 and EC_a-directed Soil Sampling

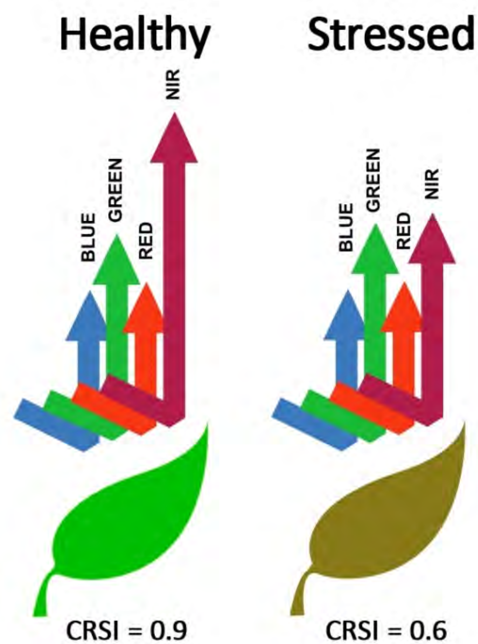
- Study area: west side of California's San Joaquin Valley (WSJV)
- Data used:
  - 7 years of Landsat 7 canopy response (2007-2013): imagery collected every 16 days with 30x30 m resolution.
  - Ground-truth salinity of 22 fields (about 600 ha) using EC_a-directed soil sampling.



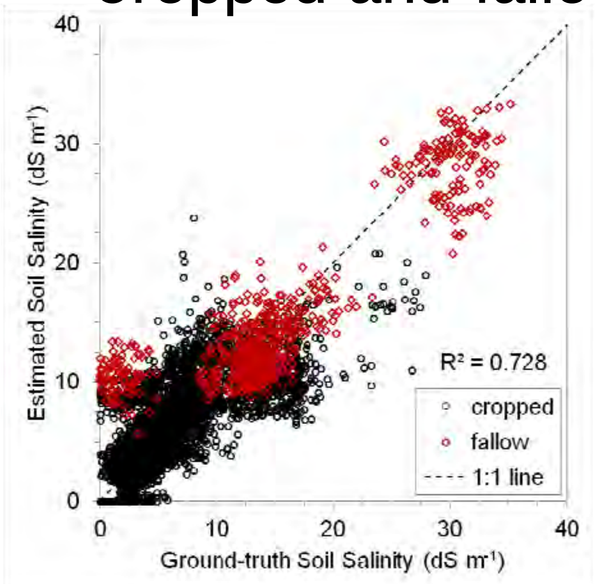


Soil Salinity Model

- The canopy response salinity index (**CRSI**) is a vegetative index indicating crop health.
- Multi-year CRSI highlights the effect of soil salinity by masking the effects of other more transient stresses.
- Rainfall and temperature influence the salinity – CRSI relationship.
- Cropped and fallow fields behave differently.



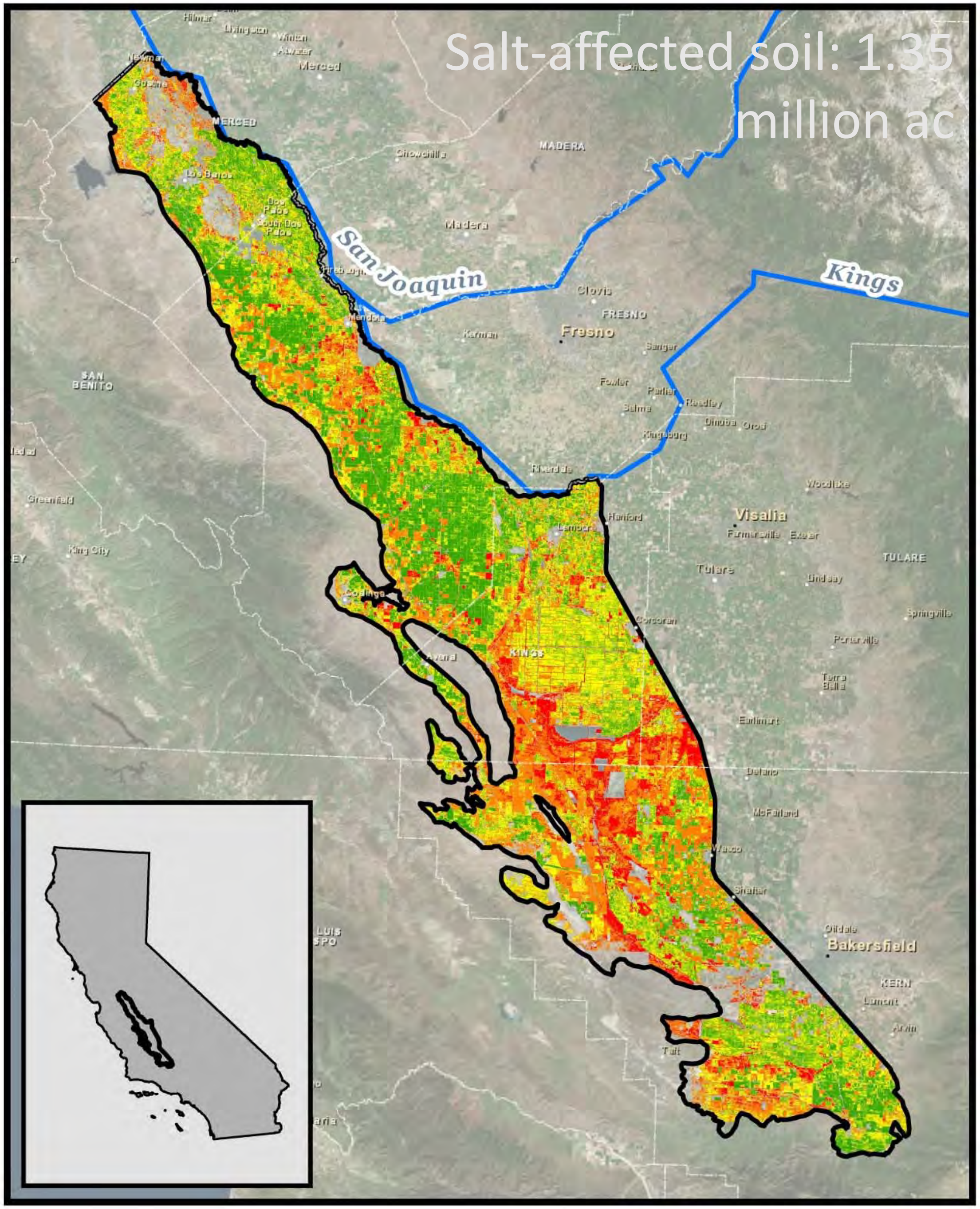
$$CRSI=\sqrt{\frac{(NIR\times R)-(G\times B)}{(NIR\times R)+(G\times B)}}$$



<u>Salinity Model</u>:

$$\text{Soil Salinity} = \alpha_0 + \alpha_1 \times CRSI_{Max} + \alpha_2 \times \text{Rainfall} + \alpha_3 \times \text{Temperature}$$

where α_1 differs for cropped and fallow soils.



Soil Salinity Map of the Farmlands in the Western San Joaquin Valley, CA

Remote Sensing of Soil Salinity*

Depth 0-1.2m

- Non-Saline 0-2 dS m^{-1}
- Slightly Saline 2-4 dS m^{-1}
- Moderately Saline 4-8 dS m^{-1}
- Strongly Saline 8-16 dS m^{-1}
- Extremely Saline >16 dS m^{-1}

Soil Salinity	Area ha	Area Acres
0-2 dS m^{-1}	192,776	476,361
2-4 dS m^{-1}	158,478	391,608
4-8 dS m^{-1}	230,139	568,685
8-16 dS m^{-1}	243,768	602,364
>16 dS m^{-1}	72,024	177,976

0 25 50 100 Kilometers
0 12.5 25 50 Miles
N

* Scudiero, Elia, Dennis L. Corwin, and Todd H Skaggs. Regional-Scale Soil Salinity Assessment Using Landsat ETM+ canopy reflectance. *Remote Sensing of Eniroment*, doi: 10.1016/j.rse.2015.08.026
Prepared By: Kevin Yemoto, USDA-ARS
Service Layer Credits: Copyright:© 2014 Esri, DeLorme, HERE, TomTom
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Questions on Problem Area 1?

Effective Water Management in Agriculture

Problem Area 2

Erosion, Sedimentation, and Water Quality Protection

Eddy Langendoen

Problem Area 2: Erosion, Sedimentation, and Water Quality Protection

- PS 2.1: Field scale processes controlling contaminant fate and transport
- PS 2.2: Quantify and predict in-stream processes
- PS 2.3: Ecological response to improved water quality
- PS 2.4: Development and testing of cost-effective control measures for agriculture, urban, and turf systems

Problem Area 2: Erosion, Sedimentation, and Water Quality Protection

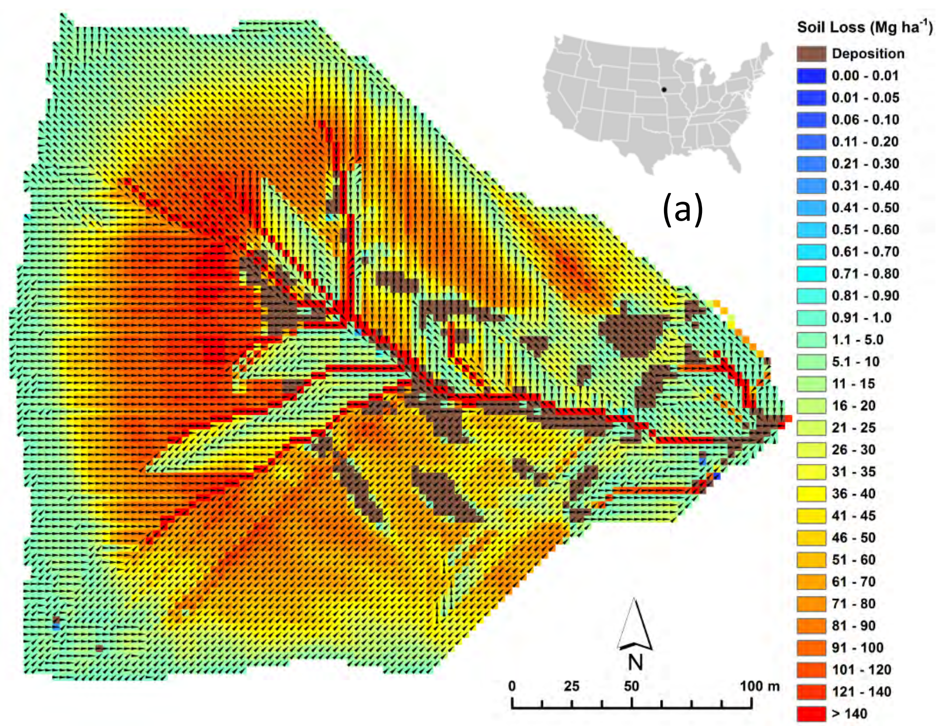
- PS 2.1: Field scale processes controlling contaminant fate and transport
  - Cropland erosion and transport processes
  - Rangeland erosion and transport processes
  - Soil erodibility
  - Contaminant transport (nutrients, pesticides, pathogens, pharmaceuticals and other emerging contaminants)

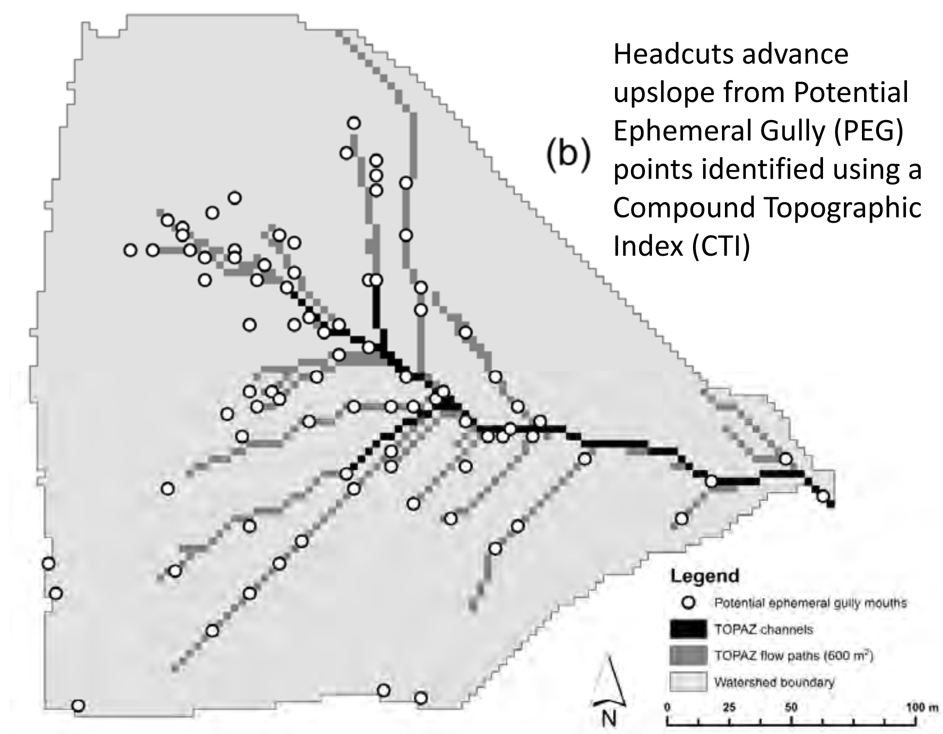
Tools to quantify the benefits of conservation practices in reducing ephemeral gully erosion (PS2.1)

Targeting the placement of integrated practices at field and watershed scales for ephemeral gully and sheet & rill erosion control ensures efficient use of conservation resources.

Ephemeral Gully Modeling Technology (PS2.1)

Scientists from the National Sedimentation Laboratory, Oxford, MS, developed and implemented complementary ephemeral gully modeling systems. At the field scale, a new ephemeral gully model, the Ephemeral Gully Erosion Estimator (EphGEE) has been linked a distributed version of the Revised Universal Soil Loss Equation version 2 (RUSLE2). At the watershed scale, the Annualized Agricultural Non-Point Source pollution model (AnnAGNPS), was released with enhanced ephemeral gully capability. Both these technologies, explicitly calculate ephemeral gully flow paths defined using topographic analysis and quantify ephemeral gully and sheet & rill soil losses.

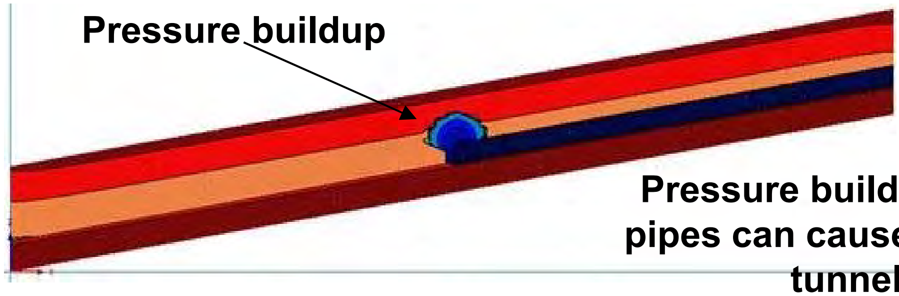




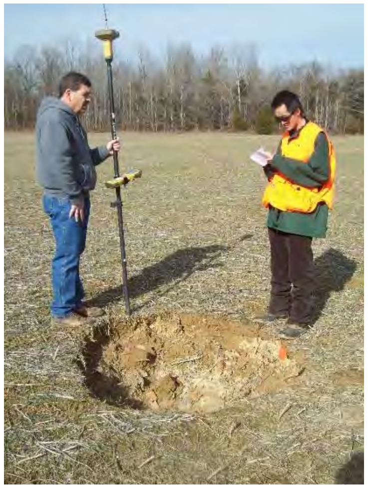
Headcuts advance upslope from Potential Ephemeral Gully (PEG) points identified using a Compound Topographic Index (CTI)

Subsurface flow through large pores, called soil pipes, can cause internal erosion of pipe walls that produce ephemeral gullies (PS2.1)

Soil pipes can intercept runoff, or generate runoff depending upon soil, landscape, and hydrograph conditions



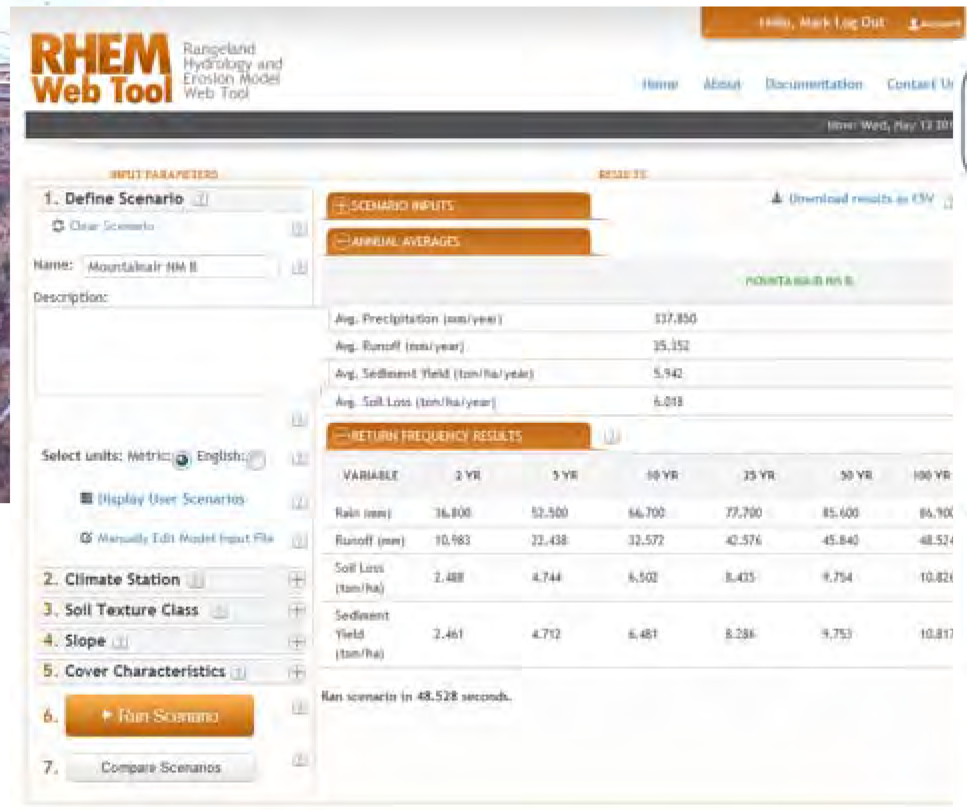
Pressure buildups from clogged pipes can cause bank failures and tunnel collapse

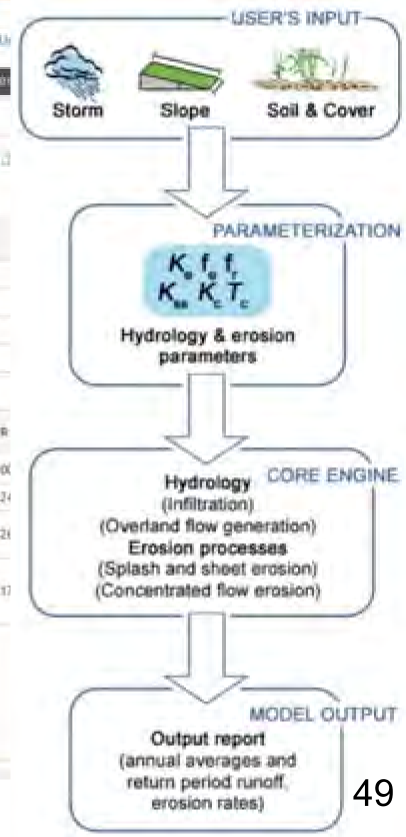


Flow through soil pipes causes internal erosion of the pipes that leads to sinkholes and gullies

RHEM

The Rangeland Hydrology and Erosion Model (PS2.1)



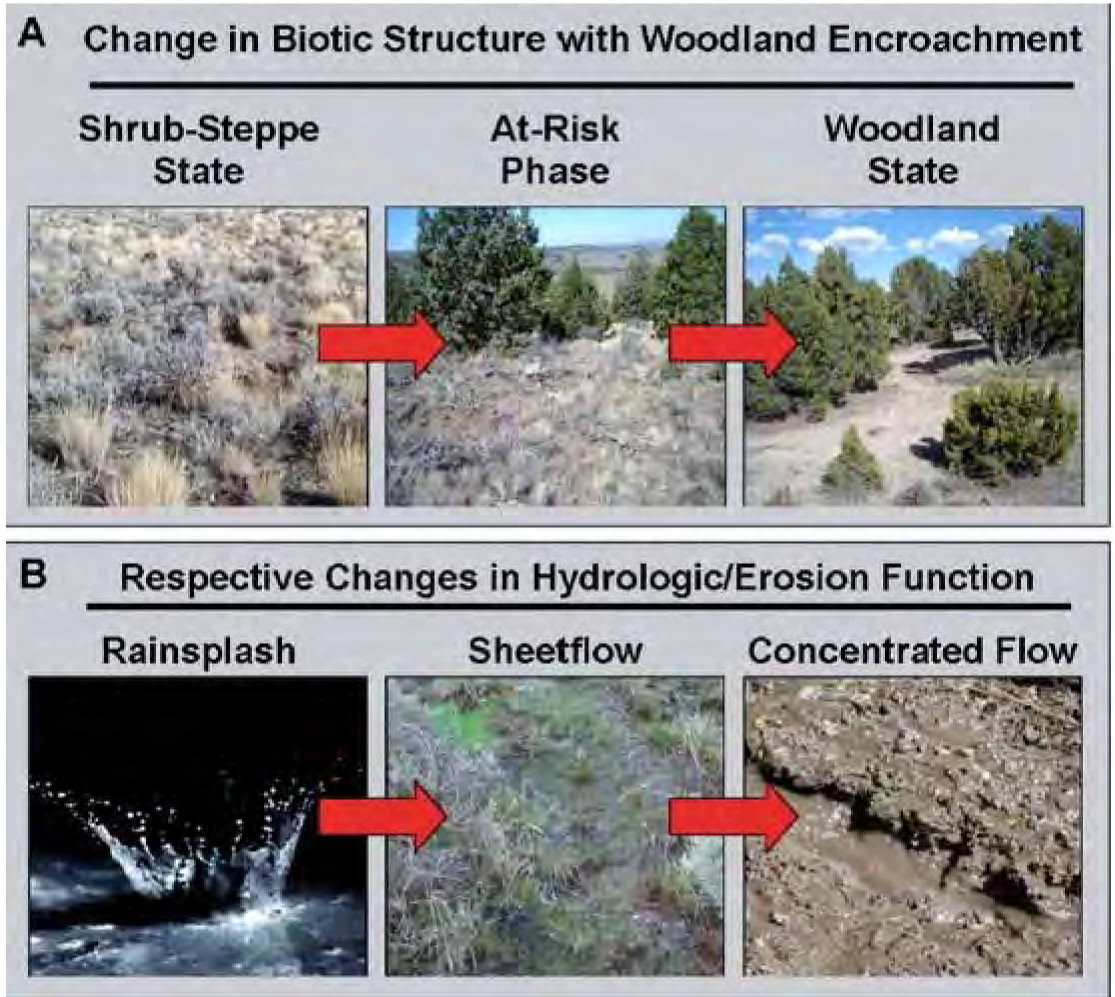


RHEM

Ecological Site Descriptions

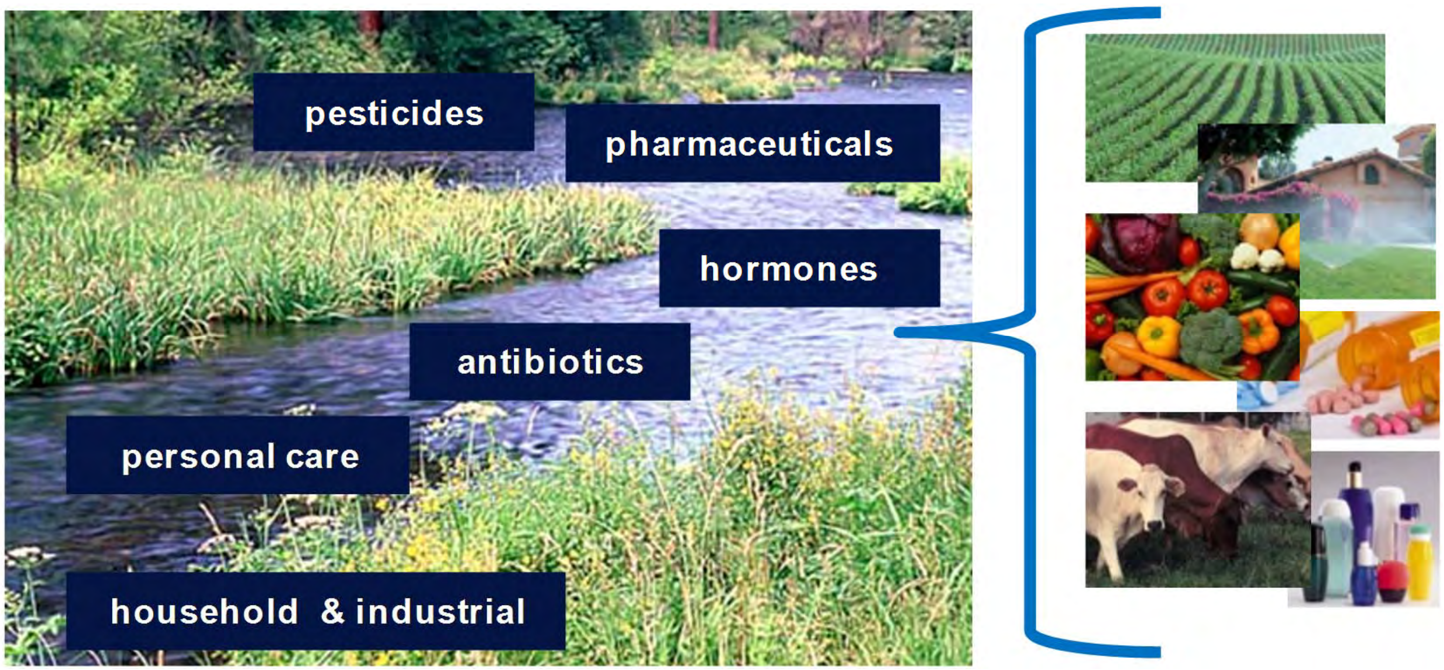
Are being developed by NRCS, BLM, and FS across the western US.

Credit: Jason Williams, Fred Pierson, Boise, ID: South Slopes 12-16 PZ" Ecological Site Malheur High Plateau Mountain Land Resource Area (MLRA 23, USDA 2006)



Identifying Sources of Contaminants of Emerging Concern (CEC) in Surface Waters of a Mixed Use Watershed: Why the Interest? (PS2.1)

Contaminants have been detected in surface waters world-wide

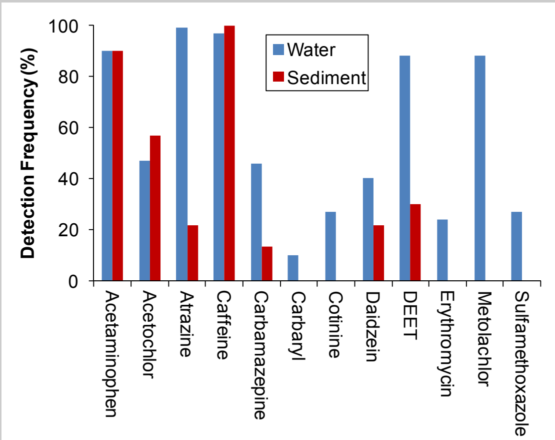


Concerns:

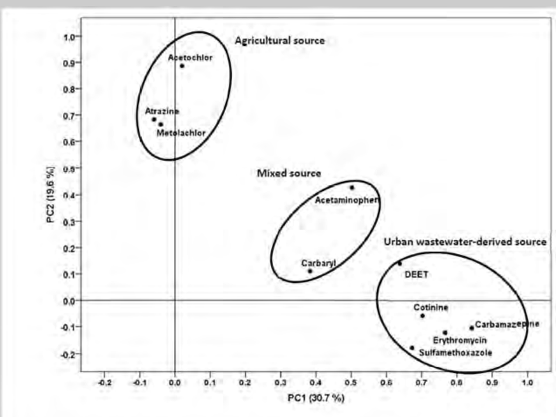
- Bioactive compounds, endocrine disrupting compounds
- Potential ecological or human health risks

Objective: Compare sub-watershed land uses with contaminant profiles in surface waters, at the agriculture-urban interface, to identify markers of pollution sources.

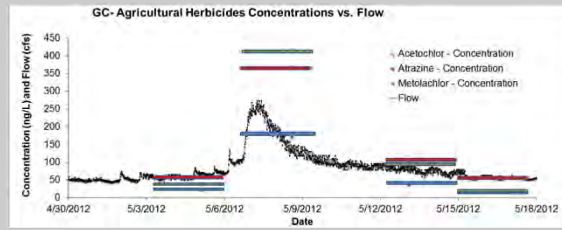
Identifying Sources of Contaminants of Emerging Concern (CEC) in Surface Waters of a Mixed Use Watershed: Findings (PS2.1)



CECs were detected in both water and sediment samples.



Principal Components Analysis differentiate CECs from agricultural and urban wastewater sources.



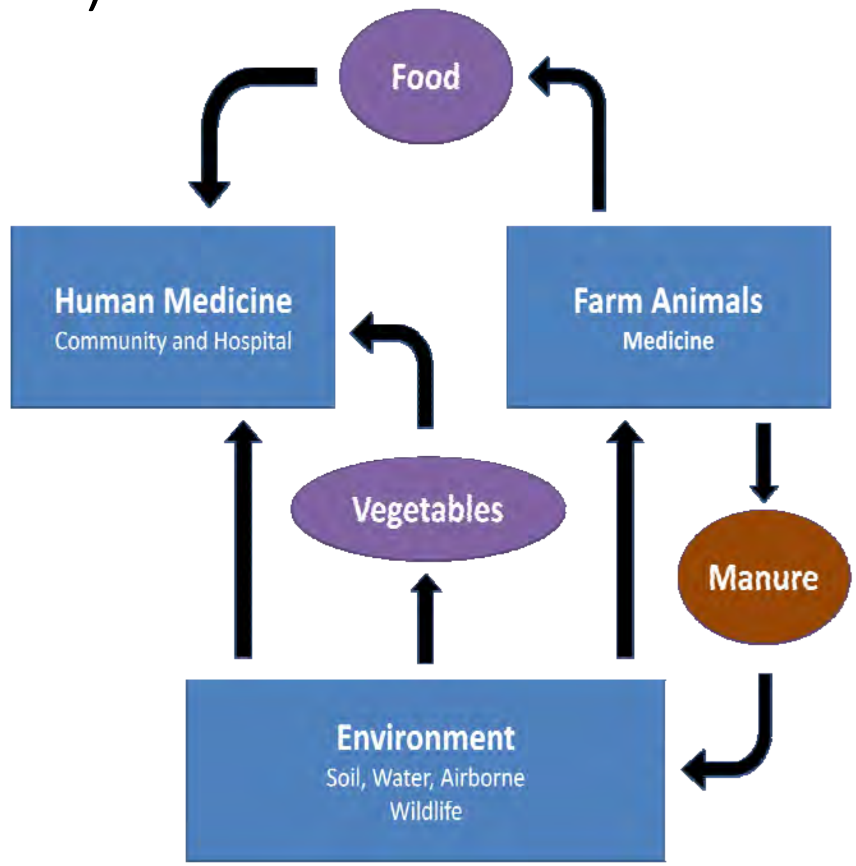
- Changes in CECs concentrations relative to river hydrographs discerned overland flow contributions of row crop herbicides while consistent concentrations of pharmaceuticals and personal care products indicate other primary sources
- Row crop herbicides and a phytoestrogen showed greatest concentrations during the spring and summer
- Human antibiotics were detected during all seasons only downstream from the WWTP

"Contaminant signatures" serve as tools to:

- Differentiate agricultural sources from urban sources
- Assist identification of origins of pollution
- Aid identification of mitigation and remediation strategies that focus resources and efforts to reduce contaminants and sources of greatest risk; improving water quality.

Antibiotics and Resistance Genes: Why the Interest? (PS2.1)

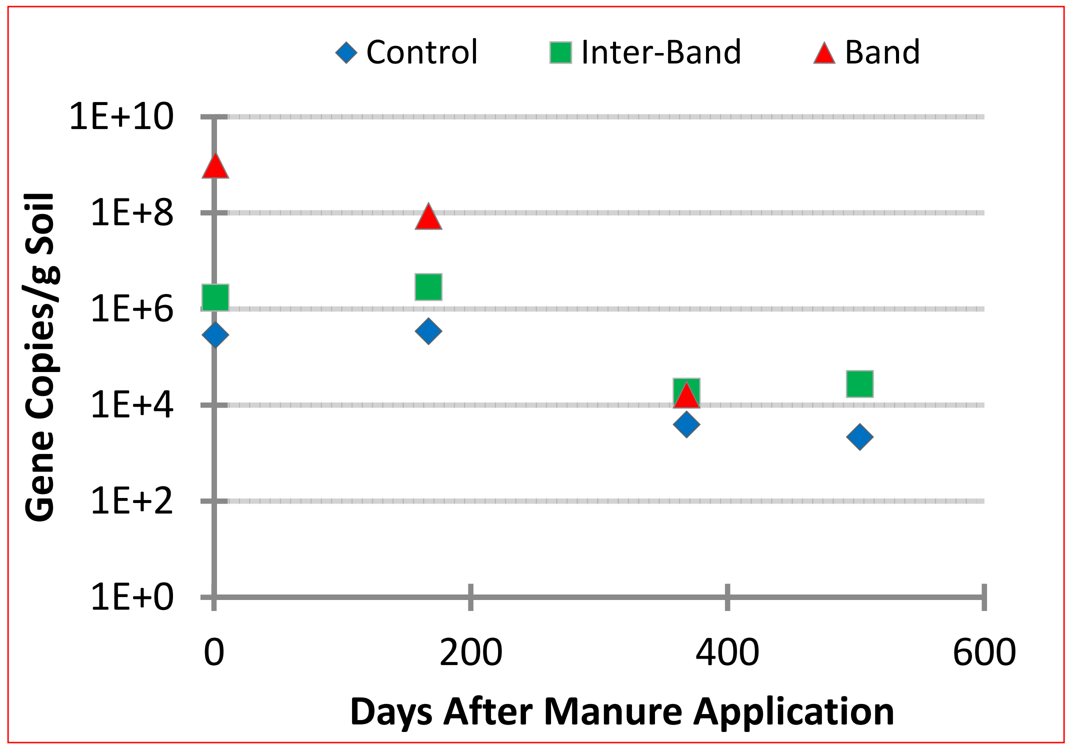
- Does antibiotic use in animal agriculture affect resistance in clinical settings?
- *Erm* genes confer resistance to macrolide antibiotics (tylosin, erythromycin)
- Measured persistence of *erm* genes in soil and off-site transport in tile drainage water at Nashua, Iowa



Movement of Antibiotics, Antibiotic-Resistant Bacteria, and Resistance Genes

Antibiotics and Resistance Genes: Findings (PS2.1)

- Swine manure temporarily increased *erm* genes in soil.
- *Erm* genes were found in drainage water, but manure use caused an increase (over control) in gene abundance one of three years.
- The antibiotic tylosin was detected infrequently in drainage water.



Problem Area 2: Erosion, Sedimentation, and Water Quality Protection

- PS 2.2: Quantify and predict in-stream processes
  - Transport and fate of sediments
  - Transport and fate of contaminant (nutrients, pesticides, pathogens, pharmaceuticals and other emerging contaminants)

Dams & Sediment (PS2.2)

- Since the Declaration of Independence about 1 dam/day has been built in the US
- >11,000 dams financially supported by USDA for flood and erosion control
- Concerns:
  - Aging dams, embankment physical integrity
  - Sediment retained in reservoirs reducing their capacity
  - Release of finer sediment over coarser beds from dam removal

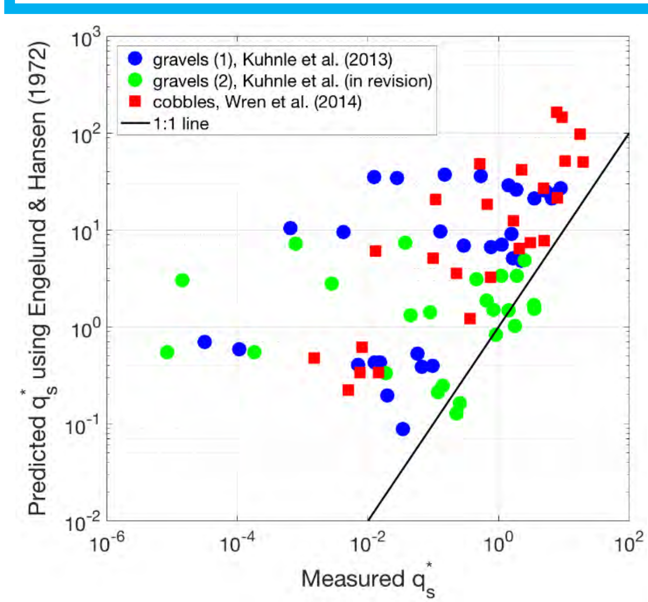
Ventura River

Elwha River

New tool for predicting sand transport downstream of dams (PS2.2)

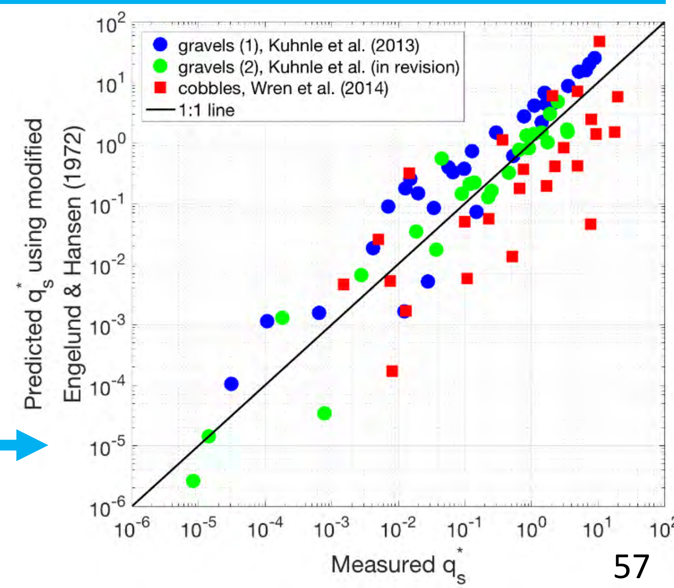
Detailed sediment transport measurements

High resolution topography measurements



New theory of supply-limited sand transport over coarse bed material

Improved sand transport prediction

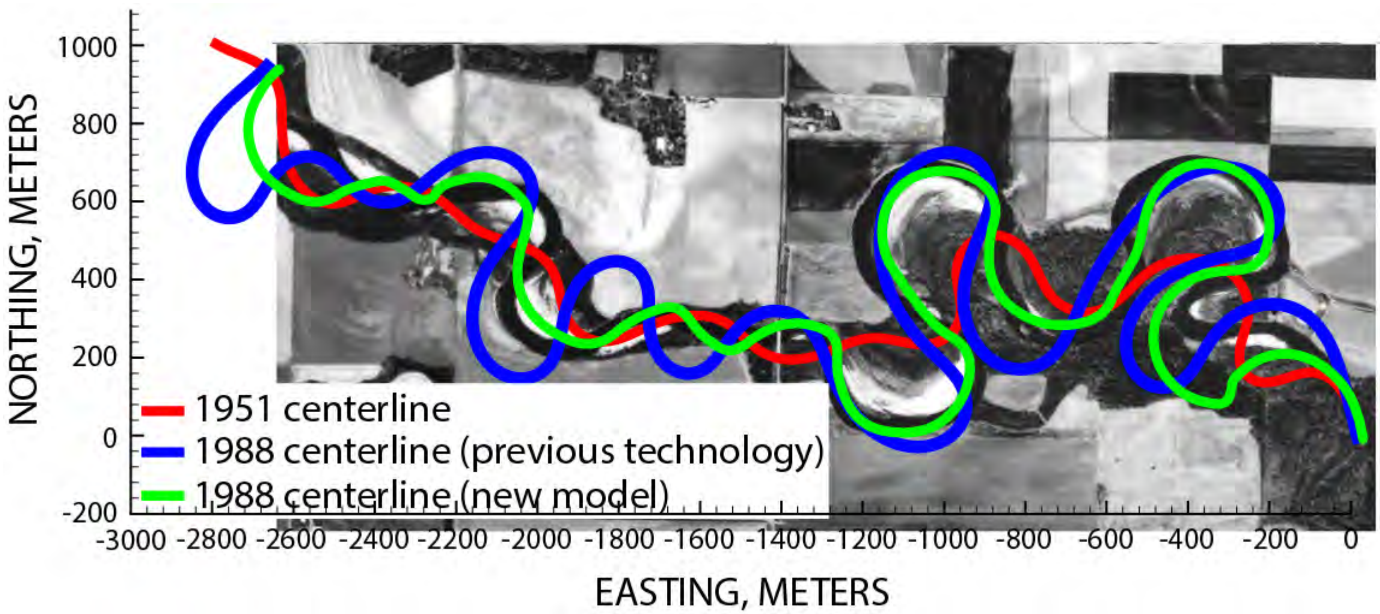


Lateral Channel Migration Assessment Tools: Why? (PS2.2)

- Meandering rivers are the most common type of alluvial rivers
- Meander planform adjustment erodes large portions of farmland and damages irrigation infrastructure
- Assessment tools are empirical
- Need to reduce uncertainty in determining future migration patterns and rates

Lateral Channel Migration Assessment Tools: Outcome (PS2.2)

- New model uses measurable erosion-resistance properties of bank and floodplain soils
- Rapid analysis of long-term benefits of instream BMPs in a GIS framework
- Greater range in meander bend and planform shape is simulated
- Reduction in prediction error by 46%



Mackinaw River, Illinois

Identification of new relationships between N_2O emissions and stream order

- Nitrogen fertilizer applied to cropping systems can reach surface waters through runoff and leaching of nitrate and other forms of reactive nitrogen.

- The amount of nitrous oxide (N_2O) emitted from streams and rivers is one of the least understood and most uncertain sources in the global N_2O budget.

- This study used a novel chamber system to measure N_2O emissions from streams and rivers in southern Minnesota.

Nitrogen Fertilizer

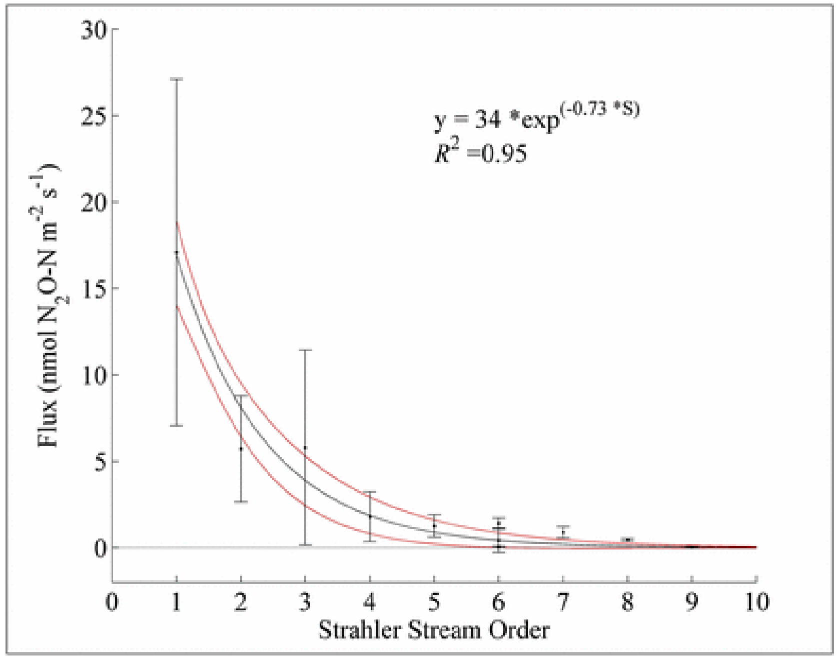
Nitrous Oxide (N_2O)

Reactive Nitrogen (e.g. Nitrate)

Identification of new relationships between N_2O emissions and stream order

• The results revealed a strong relationship between N_2O efflux from the water column and the 'Strahler stream order'. N_2O fluxes were greatest in smaller streams and decreased as stream size and order increased:

Turner, P., T.J. Griffis, X. Lee, J.M. Baker, R.T. Venterea and J.D. Wood. 2015. Proceedings of the National Academy of Sciences. 112 (32): 9839-9843.



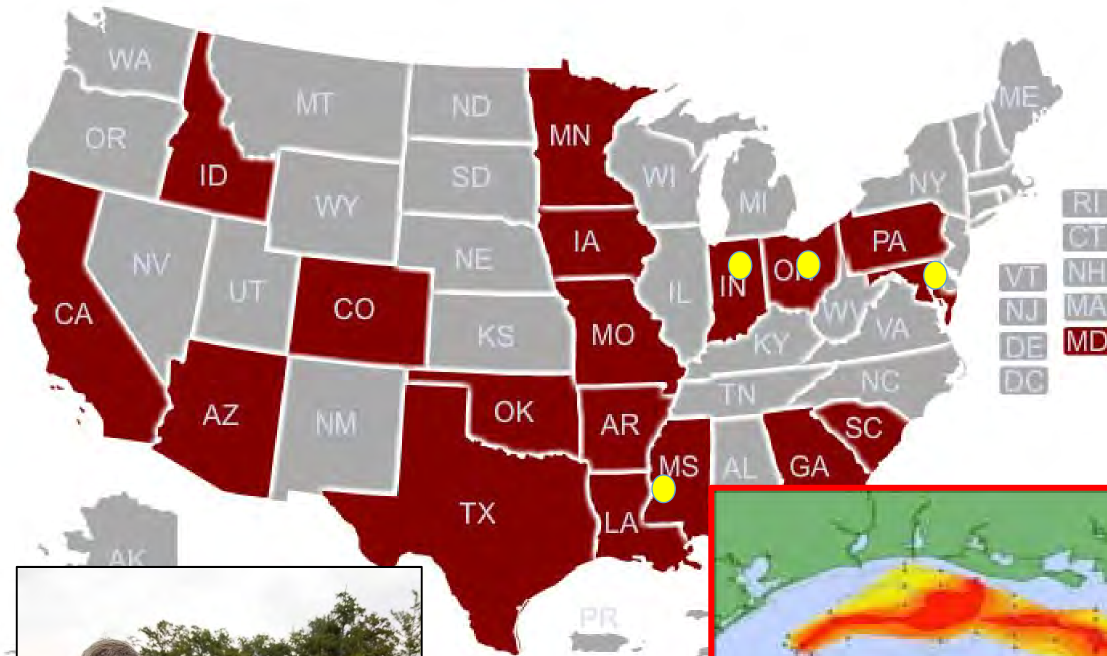
• The relationship was used for regional-scale modeling which showed the Intergovernmental Panel on Climate Change (IPCC) indirect emission factor (EF_5) for rivers is underestimated up to ninefold in southern Minnesota.

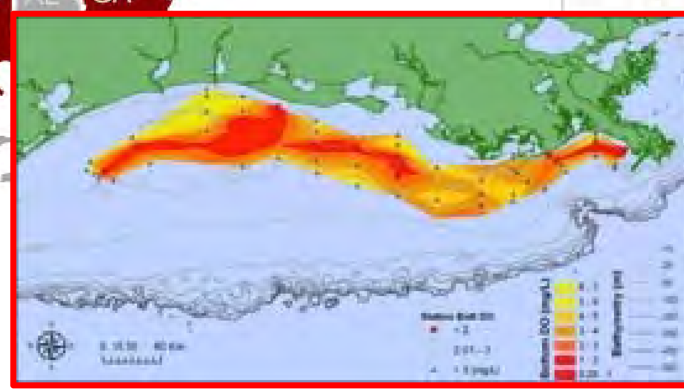
• The same analysis applied to the US Corn Belt showed that the IPCC-EF_5 underestimation explains the large differences observed between top-down and bottom-up emission estimates.

Problem Area 2: Erosion, Sedimentation, and Water Quality Protection

- PS 2.3: Ecological response to improved water quality

ECOLOGICAL RESPONSE TO CHANGES IN WATER QUALITY



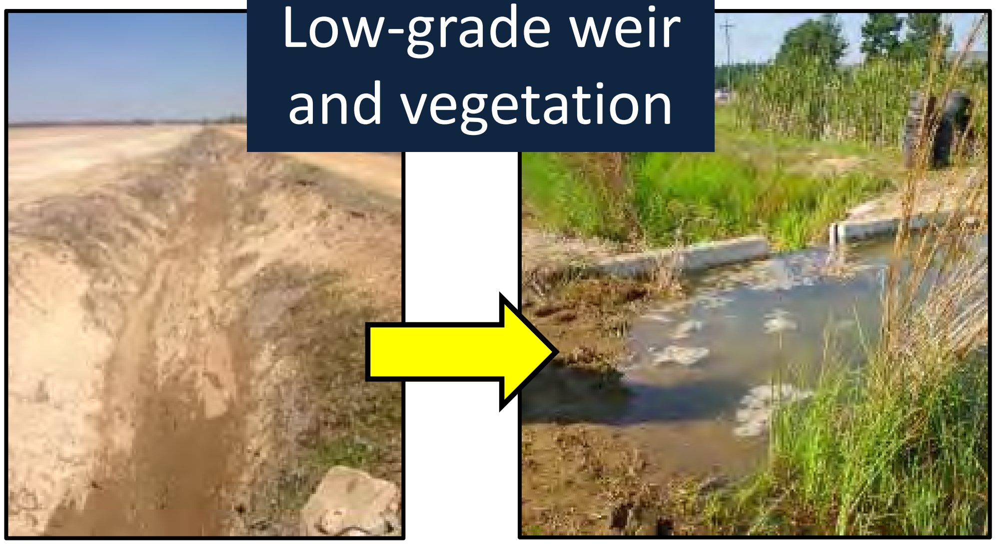


How can agriculture enhance ecosystem services and help maintain healthy aquatic ecosystems?

Enhanced Ecosystem services in vegetated drainage (PS2.3)

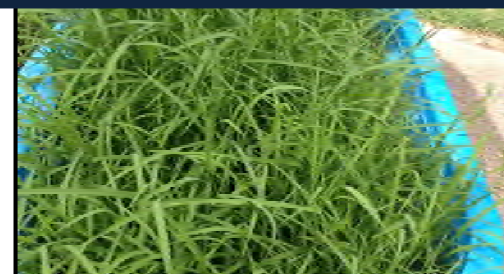
Drainage control structures **increased residence time and chemical transformation**

Low-grade weir and vegetation

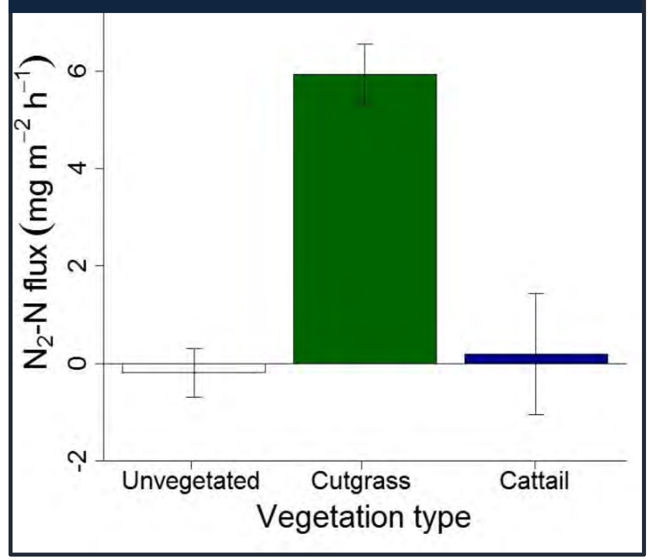


Vegetation **improved biotic interactions, chemical transfer and sediment retention**

Cutgrass improved nutrient trapping & allocation



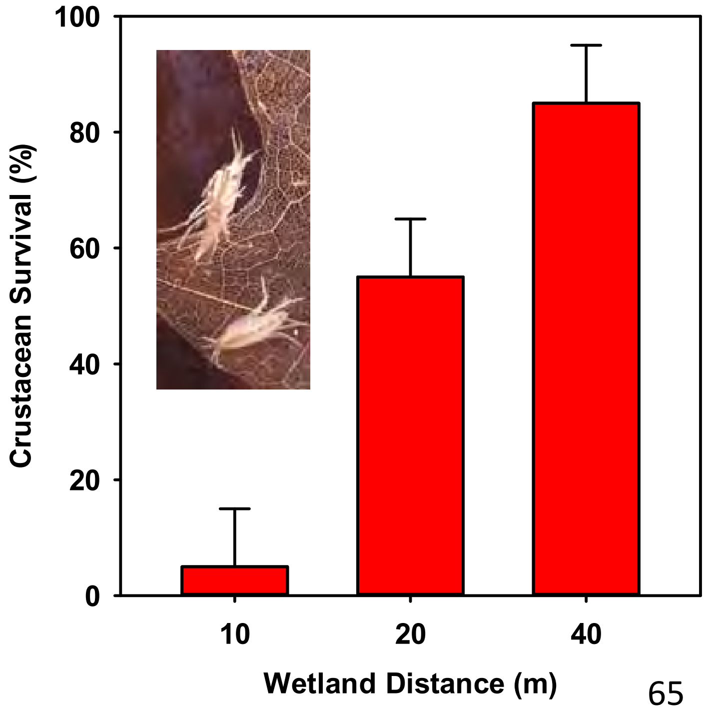
Cutgrass enhanced denitrification



Constructed wetland habitats enhance ecosystem services (PS2.3)

Identified wetland vegetation species and size that enhanced contaminant removal and reduced toxicity in wetlands

Wetland travel distance increased invertebrate survival



Quantifying the relationships of the biota with habitat and water chemistry leads to improved conservation strategies (PS2.3)

Fishes in agricultural streams in Ohio and Indiana are more strongly influenced by physical habitat than water chemistry

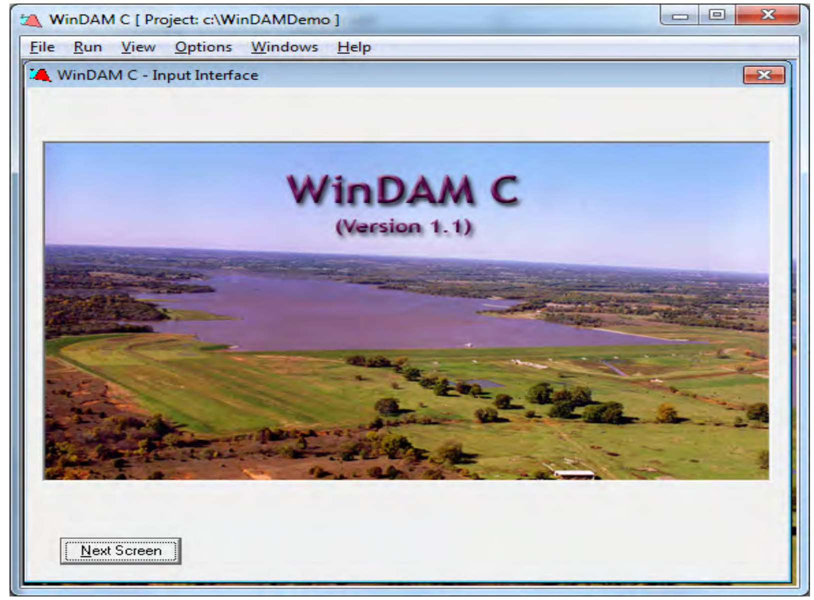
Frogs within agricultural streams in Ohio and Indiana more strongly influenced by water chemistry than physical habitat

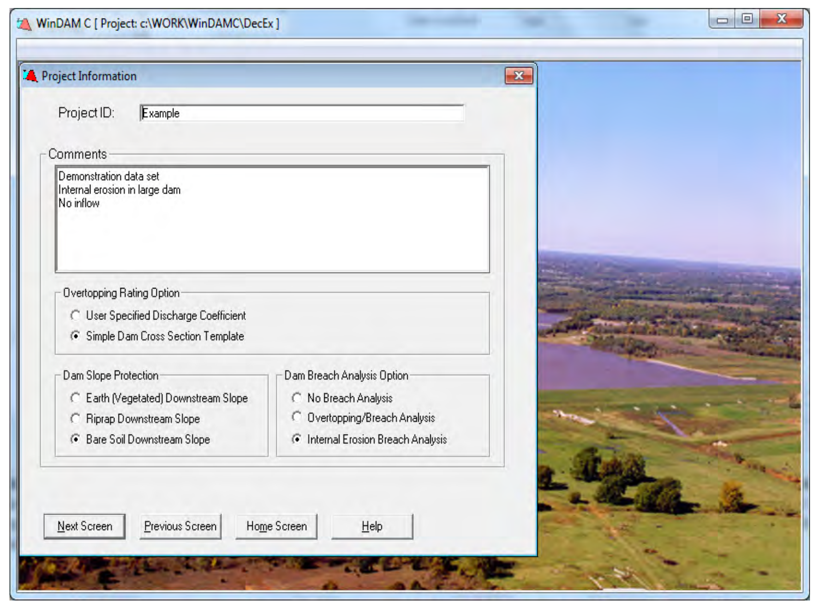
Conservation strategies that improve both habitat and water quality in agricultural streams in the Midwest will benefit fishes and amphibians

Problem Area 2: Erosion, Sedimentation, and Water Quality Protection

- PS 2.4: Development and testing of cost-effective control measures for agriculture, urban, and turf systems
  - Embankment erosion
  - New & innovative BMPs to control contaminants

WinDAM C: Application Software to Evaluate Embankment Overtopping and/or Internal Erosion (PS2.4)





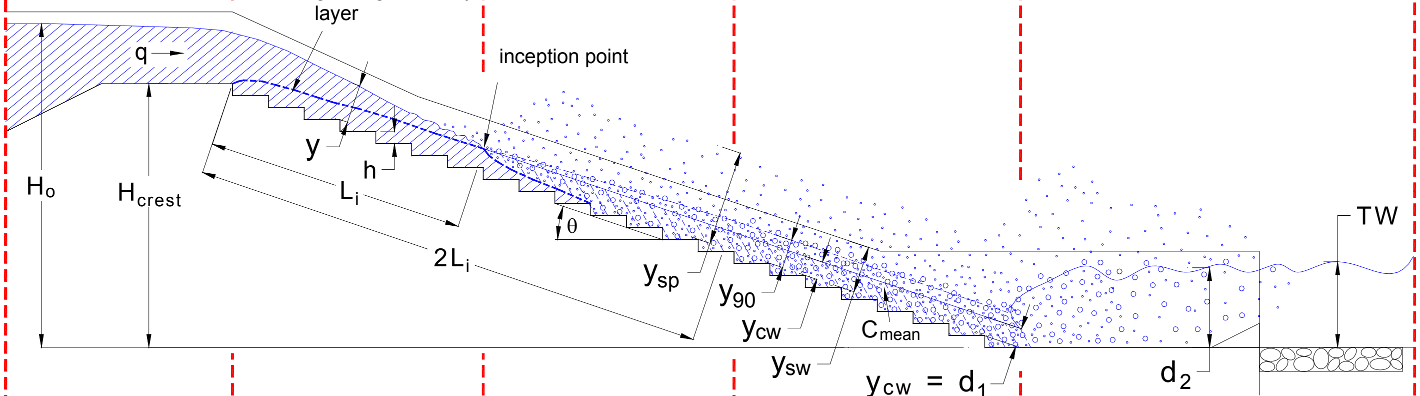
Step by Step: Design Procedures for Stepped Chutes (2.4)

Stepped Chute Design Parameters for Skimming Flow: $h/d_c < 1/(1.2 - 0.325\tan\theta)$

Given:
- Unit discharge, q
- Chute slope, θ
- Step height, h
- Total drop, H_{crest}

Calculate:
- Critical depth, $d_c = (q/g^{0.5})^{0.67}$
- Normalized step height, h/d_c
- Roughness Froude number, F^* = eq.1
- Length to inception point, L_i = eq. 2 or 3

entrance conditions	non-aerated flow region, $L/L_i < 1.0$	developing aerated flow region, $1.0 \le L/L_i \le 2.0$	fully developed aerated flow region, $L/L_i > 2.0$	stilling basin and exit conditions
H_o = eq. 4	y = eq. 5 α = eq. 7	y_{cw} = eq. 6 α = eq. 8 C_{mean} = eq. 9 y_{90} = eq. 11 y_{sw} = eq.12	y_{cw} = eq. 6 α = eq. 8 C_{mean} = eq. 10 y_{90} = eq. 11 y_{sw} = eq.12	F_r = eq. 13 $d_1 = y_{cw}$ d_2 = eq. 14 H = eq. 15 $\Delta H/H_o = 1 - H/H_o$



Equations:

- eq. 1: $F^* = q/[g(\sin\theta)(h\cos\theta)^3]^{0.5}$
- eq. 2: $L_i = 5.19(F^*)^{0.89}(h\cos\theta)$ for $0.1 < F^* \le 28$
- eq. 3: $L_i = 7.48(F^*)^{0.78}(h\cos\theta)$ for $28 < F^* < 10^5$
- eq. 4: $H_o = H_{crest} + 1.5d_c$
- eq. 5: $y = d_c(L/L_i)^{-0.22}[0.34(h/d_c)^{0.063}(\cos\theta)^{0.063}(\sin\theta)^{-0.18}]$ for $0.1 \le L/L_i \le 1.0$
- eq. 6: $y_{cw} = d_c[0.34(h/d_c)^{0.063}(\cos\theta)^{0.063}(\sin\theta)^{-0.18}]$ for $L/L_i \ge 1.0$
- eq. 7: $\alpha = 1.0+[1.025(h/d_c)^{-0.128\sin\theta}-1.0](L/L_i)^{0.632}$ for $0.1 \le L/L_i \le 1.0$
- eq. 8: $\alpha = 1.0+[1.025(h/d_c)^{-0.128\sin\theta}-1.0][(L/L_i+0.718)^{-2.37}+0.723]$ for $L/L_i > 1.0$
- eq. 9: $C_{mean} = 0.11-[0.22/(L/L_i)]+0.0645+0.216(h/d_c)+0.453(\sin\theta)$ for $1.0 \le L/L_i \le 2.0$
- eq. 10: $C_{mean} = 0.0645+0.216(h/d_c)+0.453(\sin\theta)$ for $L/L_i > 2.0$
- eq. 11: $y_{90} = y_{cw}/(1- C_{mean})$
- eq. 12: $y_{sw} = F.S. \times y_{90}$ F.S. ranges from 1.2 to 2.0
- eq. 13: $F_r = (y/d_c)^{-1.5}$ or $(y_{cw}/d_c)^{-1.5}$
- eq. 14: $d_2 = 1/2[(1+8F_r^2)^{0.5}-1]d_1$
- eq. 15: $H = y_{cw}\cos\theta + \alpha(q/y_{cw})^2/2g$

Minimizing Sediment & Nutrient Transport in Runoff from Tile-Drained Croplands: Why the Interest? (PS2.4)

- Topography of the Midwest U.S. Corn Belt includes closed depressions that are drained into the subsurface tile system to prevent waterlogging of crops after heavy rains.
- Often the entrances to these drains are open, leaving a direct connection from surface water, laden with dissolved nutrients and sediments and sediment-associated phosphorus and agrochemicals to the tile drains and ultimately surface waters.
  - Farmed, closed depressions in MN: 1 to 11 per km^2 [1]

[1]Mueller, M., and G. Wehrenberg. 1994. SWCD methodology of land use assessment. Minnesota Pollution Control Agency, St. Paul, MN.

Problem:

Open Inlets

- Direct connection to subsurface tile system and natural surface waters
- Are an exceptional liability for fields fertilized with manure

Tile Standpipes (orange pipe in lower picture)

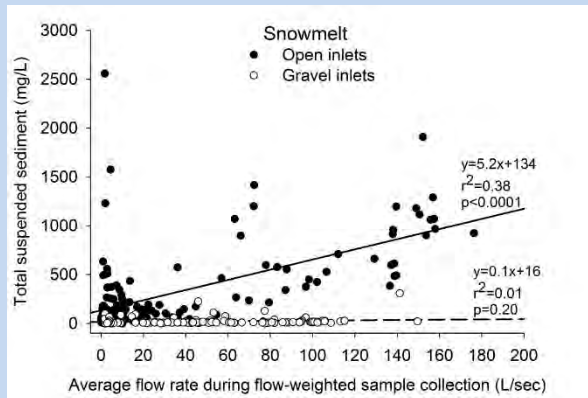
- Increase ponding time and therefore trap additional sediments
- Are a nuisance to avoid during field operations

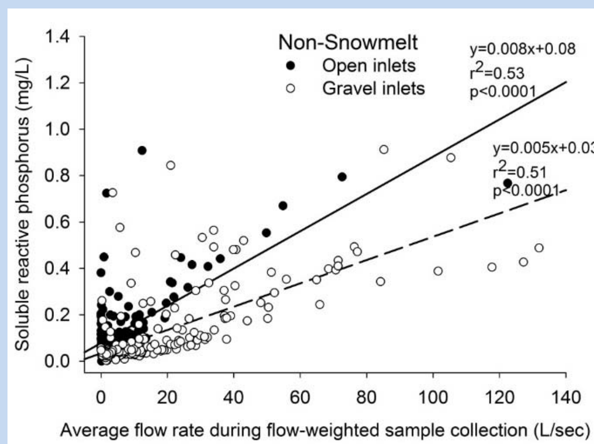
Objective: to determine whether blind or gravel inlets could reduce suspended sediment and P concentrations and loads in drainage effluent relative to tile risers or open inlets.

Minimizing Sediment & Nutrient Transport in Runoff from Tile-Drained Croplands : Findings (PS2.4)

Design: Inlet buried in a trench filled with very coarse sand / very fine gravel

- Study compared 3y with open inlets vs. 3y with fine gravel inlets for total suspended sediment (TSS) and soluble reactive phosphorus (SRP) concentrations.



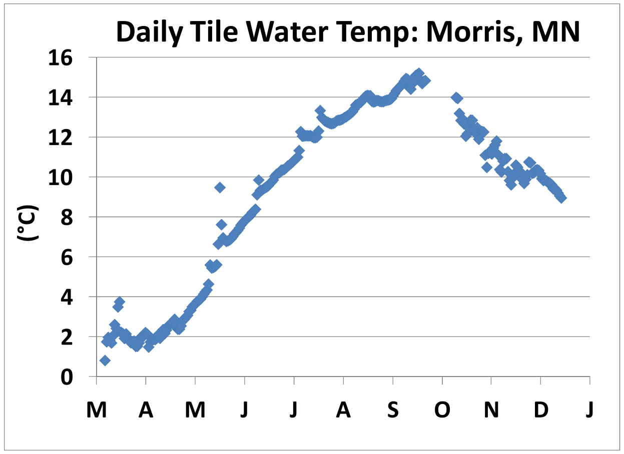


- Replacing open inlets with fine gravel inlets reduced median concentrations of :
  - TSS – from 97 to 8.3 ppm
  - SRP – from 0.099 to 0.064 ppm.
- TSS concentrations were reduced in snow melt and non-snowmelt periods.
- SRP concentrations were also lower in snow melt and non-snowmelt periods.

Reducing Nitrate-N Losses from Tile-Drained Croplands: Why the Interest? (PS2.4)

- Nitrate-N loads originating from tile-drained croplands in the Upper Mississippi River Basin contribute to hypoxia in the Gulf of Mexico
- States in the UMRB have established goals to reduce nitrate-N loads by 45% over the coming years.[1]
- Wood chip denitrifying bioreactors are one edge-of-field conservation practice that is being promoted to remove nitrate-N from tile drainage. Field estimates in Iowa show ≈32% load reduction.[2]

[1] Minnesota Pollution Control Agency. 2014. The Minnesota Nutrient Reduction Strategy. Minnesota Pollution Control Agency, St. Paul, MN.
[2] Christianson, L., M. Helmers, A. Bhandari, K. Kult, T. Sutphin, and R. Wolf. 2012. Performance evaluation of four field-scale agricultural drainage denitrification bioreactors in Iowa. Trans. ASABE 55:2163-2174.



Challenge:

- Biological activity is reduced as temperature decreases. A more labile C source than wood chips may enable improved removal at the colder temperatures of spring snowmelt runoff.

Approach:

- Test agricultural residues for nitrate-N removal at cold temps
  - C is more available than for wood chips
  - Ag residues (below) are readily accessible to croplands

Corn Stover

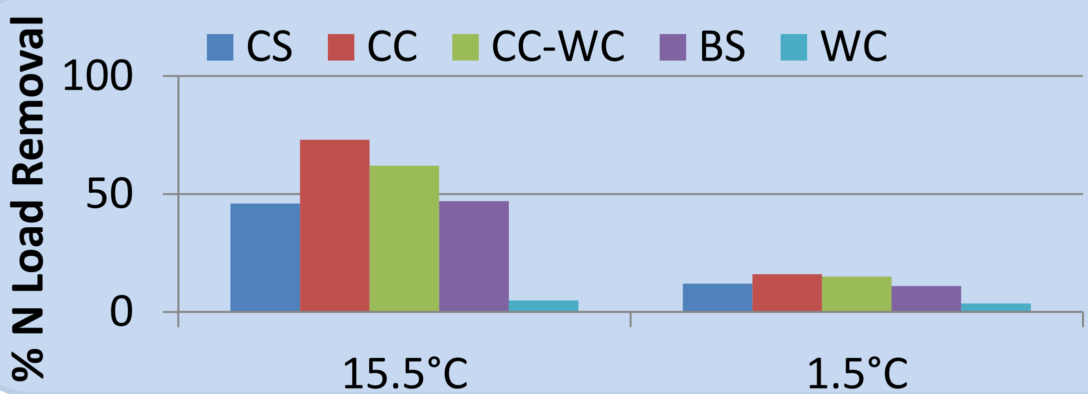
Corn Cobs

Barley Straw

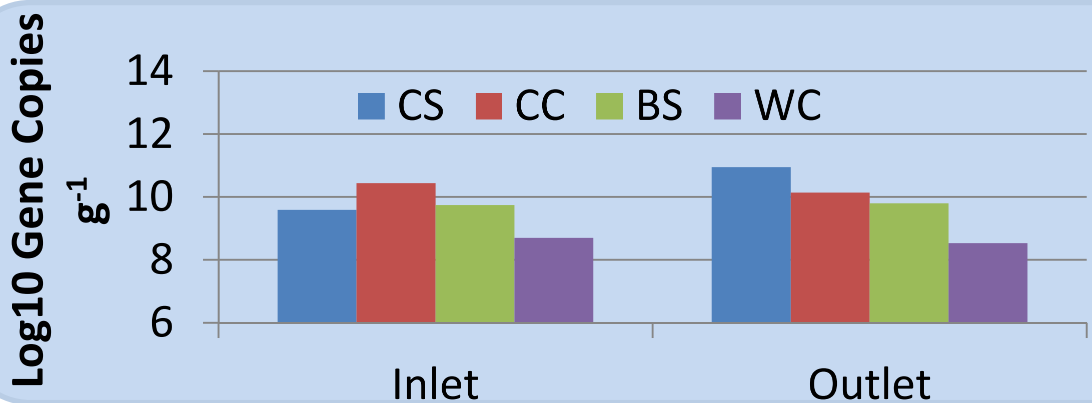
Wood Chips

Objectives: (i) to test three agricultural residues, and a combination of a residue in series before wood chips, for nitrate-N removal performance, (ii) to quantify denitrifier populations, and (iii) to measure nitrous oxide production of these treatments.

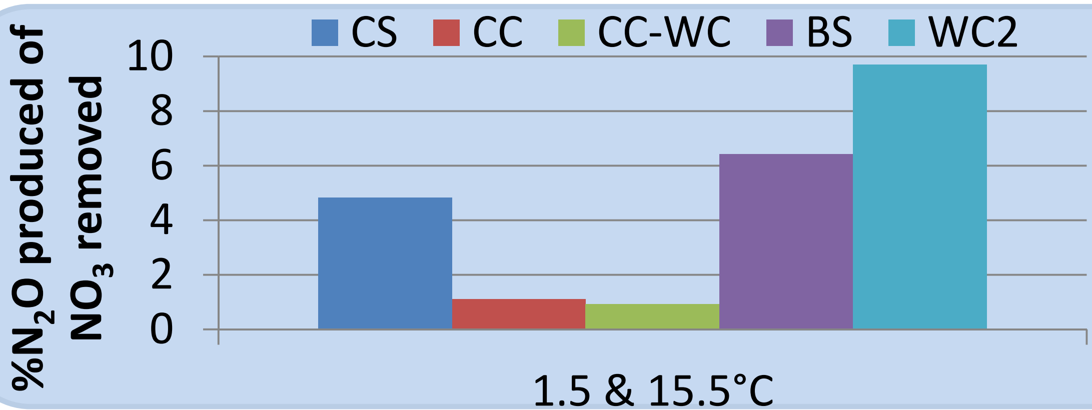
Reducing Nitrate-N Losses from Tile-Drained Croplands: Findings (PS2.4)



- Cumulative nitrate-N load removal was greatest for corn cobs, followed by corn cobs in series with wood chips, then corn stover and barley straw were equivalent.
- The biological temperature affect, Q_{10}, was about 3 for ag residues.

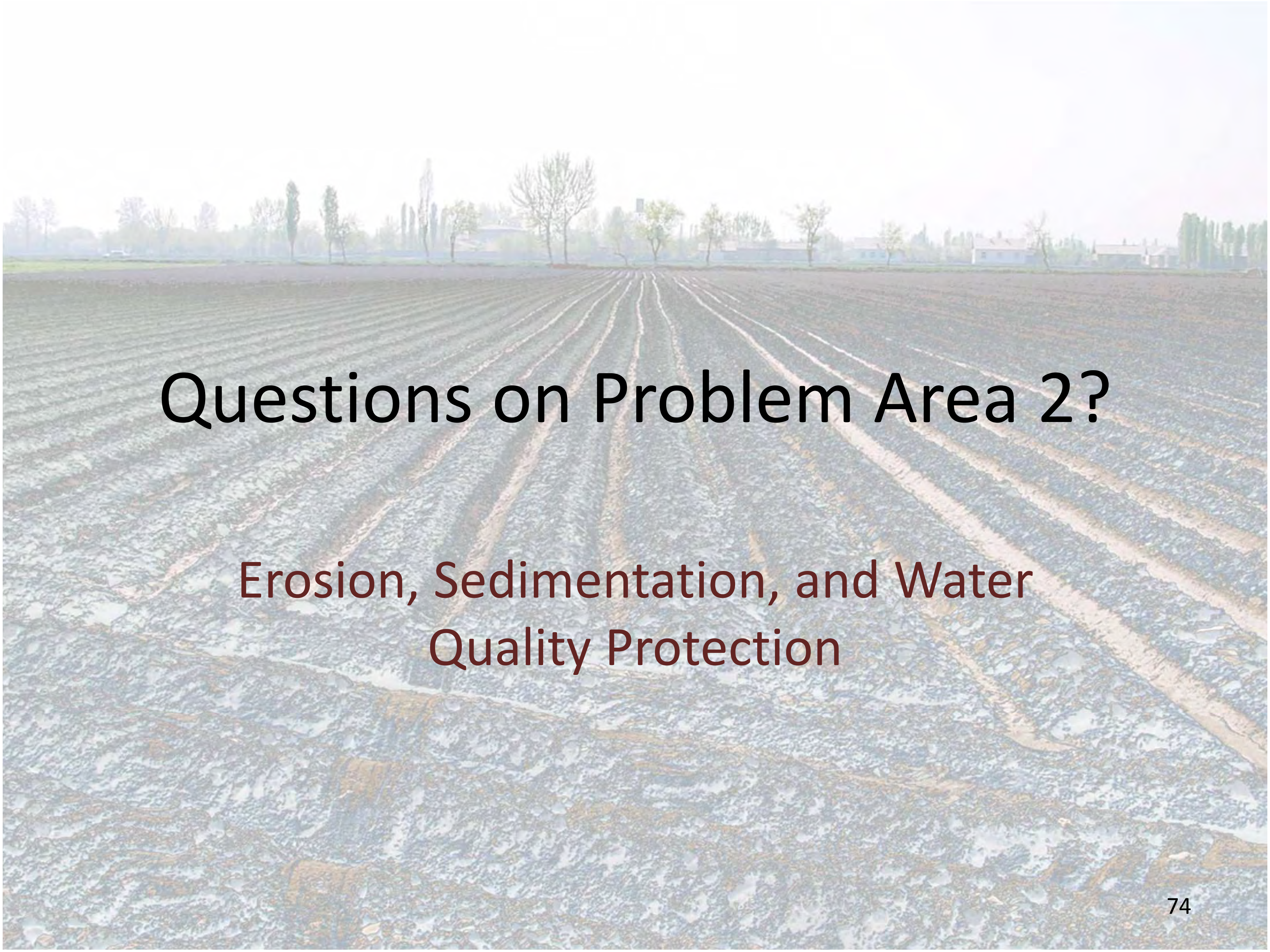


- Denitrifier populations (*nosZ* clade 1) were similar for the ag residues and higher than for wood chips. The higher N removal of corn cobs was therefore attributed to C bioavailability.



- Across both temps, cumulative production of N_2O was greater for barley straw and corn stover.
- % N_2O produced per NO_3 removed was least for corn cobs and corn cob – wood chips. (graph to left)
- % N_2O produced per NO_3 removed was 4X higher at 1.5 than 15.5°C

Feyereisen, G.W., TB.. Moorman, L.E. Christianson, R.T. Venterea, J.A. Coulter, and U.W. Tschirner. 2016. Performance of agricultural residue media in laboratory denitrifying bioreactors at low temperatures. J. Environ. Qual. doi:10.2134/jeq2015.07.0407


Questions on Problem Area 2?
Erosion, Sedimentation, and Water Quality Protection
74

Problem Area 3

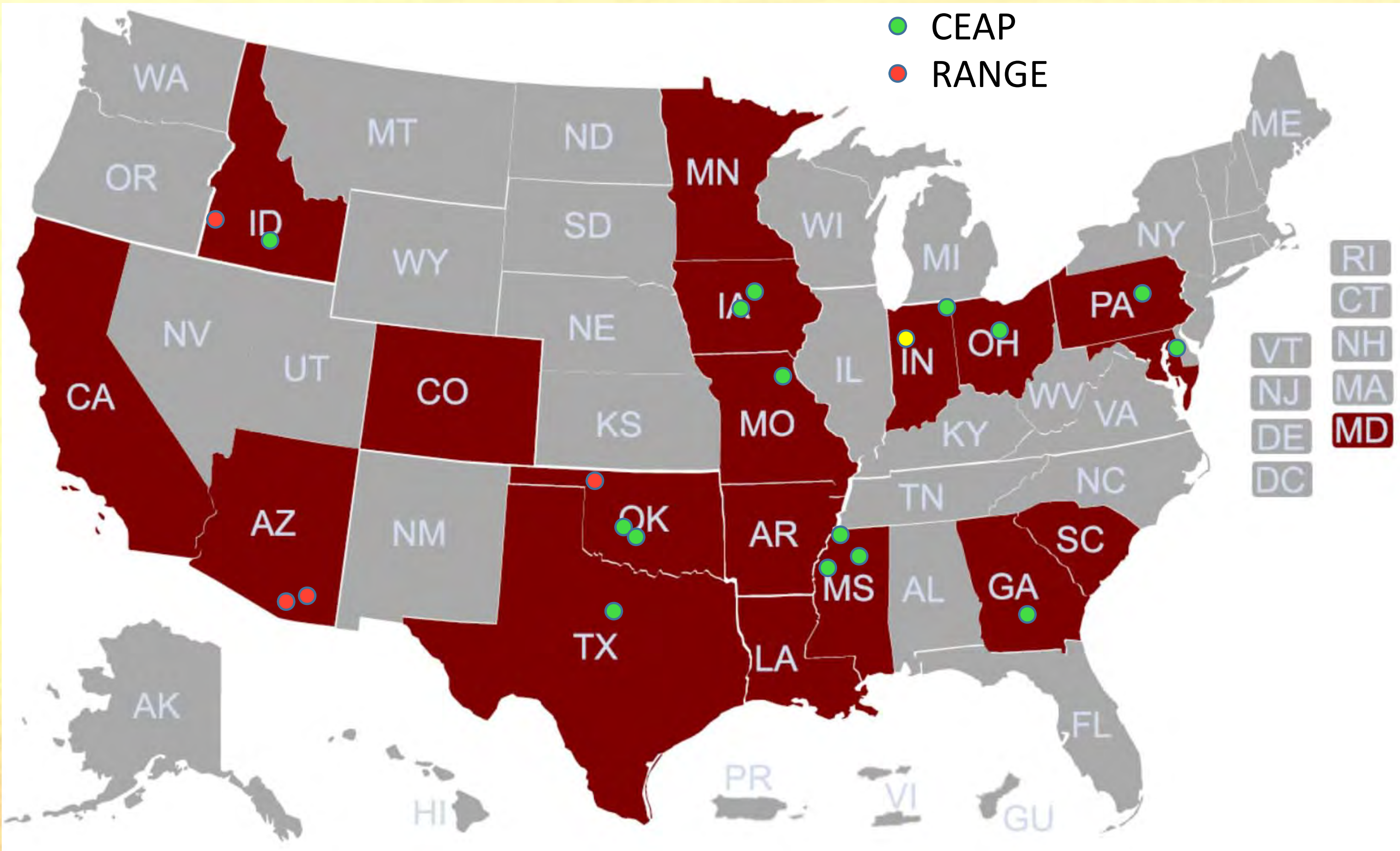
Improving Conservation Effectiveness

Mark Tomer

Problem Area 3: Improving Conservation Effectiveness

- PS 3.1: Improving our understanding of the aggregate effects of conservation practices at the watershed scale
- PS 3.2: Improving our ability to select and place conservation practices on the landscape for maximum effectiveness
- PS 3.3: Improving conservation practices to better protect water resources
- PS 3.4: Maintaining the effectiveness of conservation practices under changing climate and land use
- PS 3.5: Understanding how conservation practices affect ecosystem services
- PS 3.6: Developing a better understanding of the economic impacts and social drivers of conservation practice adoption in agricultural watersheds

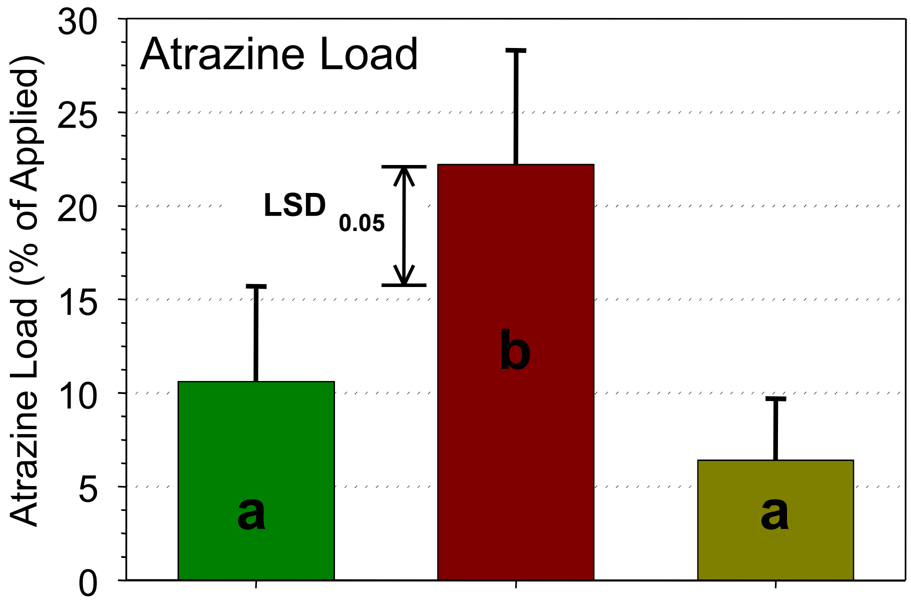
Problem Area 3
CEAP Locations

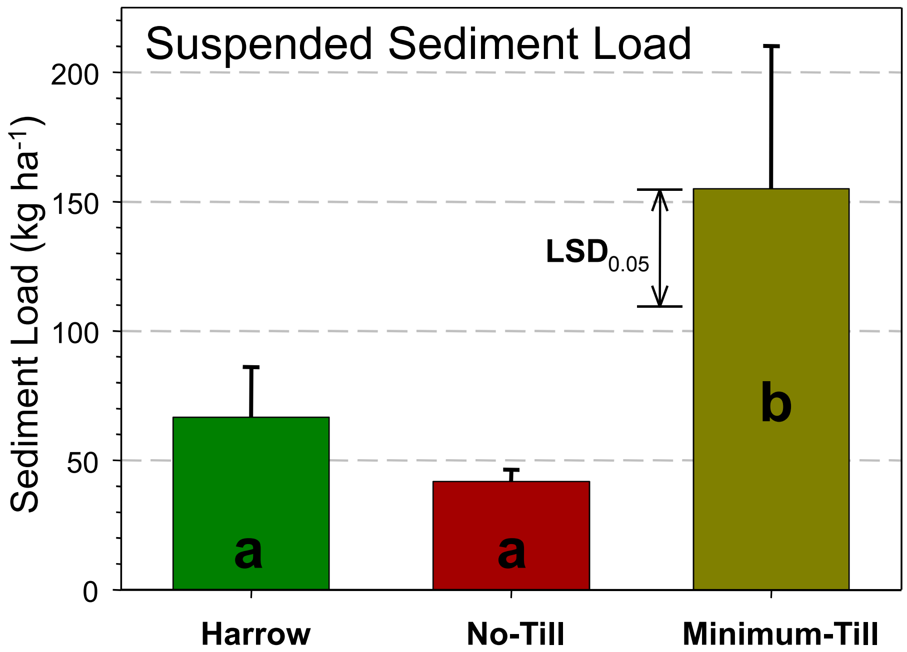


Problem Area 3: Conservation Effects Assessment

Need	Approach
Knowledge to identify viable management options and their water quality and ecological impacts	Assessments of conservation effectiveness: Edge-of-field, 4R, and rotational practices, watershed and ecological assessments, and establishment of monitoring networks PS 3.1, 3.3, 3.4, 3.5, 3.6
Better tools to define management options	Tools to select and place conservation practices on the landscape for greater effectiveness; Standards for new conservation practices PS 3.2, 3.3, 3.6
Better capacity to predict impact of management change	Improved utility of watershed models PS 3.1, 3.2, 3.4
Better public access to ARS research information	Databases and special issue contributions PS 3.1 – 3.6

Minimizing impacts of environmental tradeoffs with minimum disturbance methods





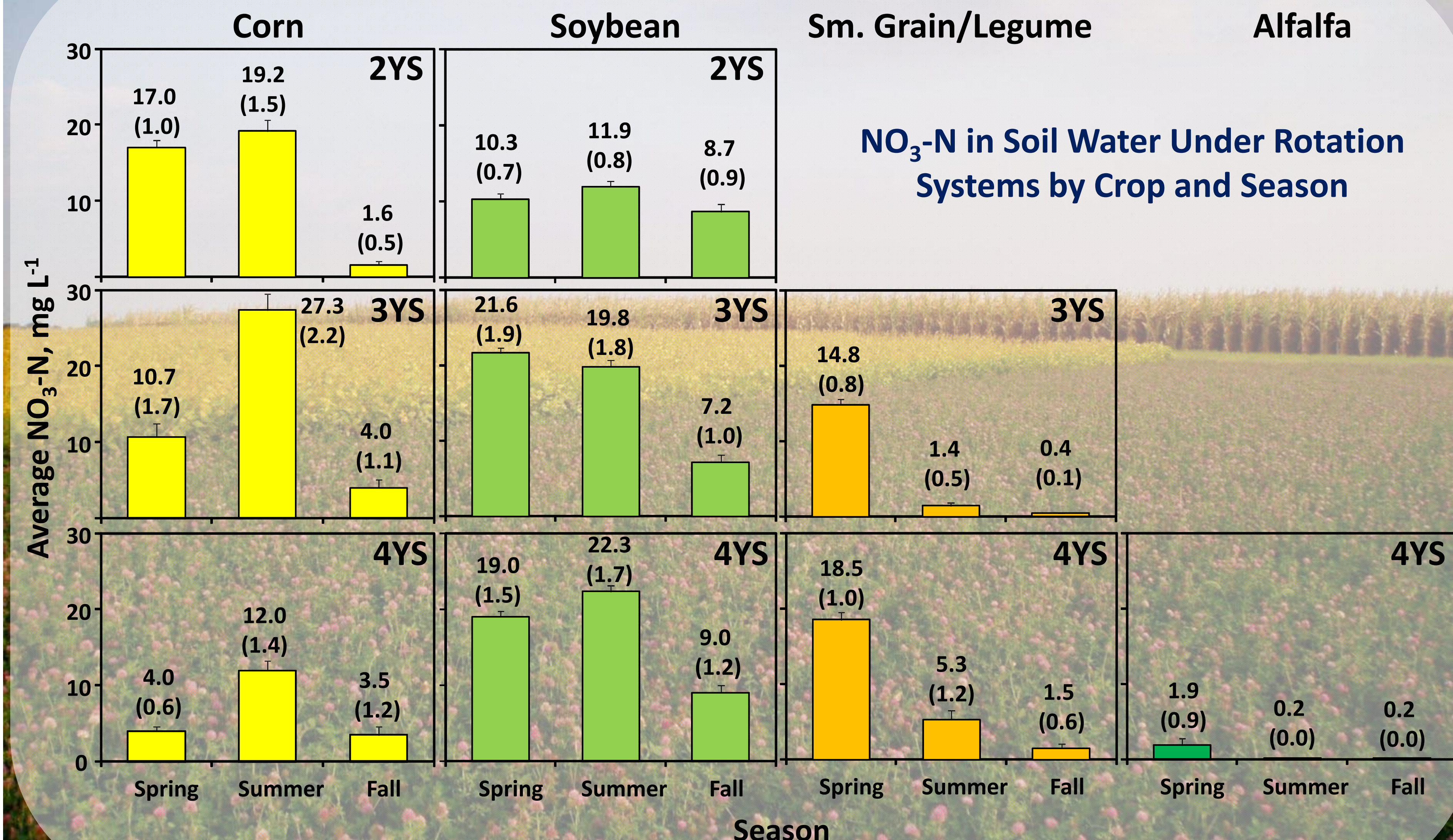
Gulf Atlantic Coastal Plain LTAR in Tifton, GA

Strip tillage & winter cover crops enhance soil and water quality

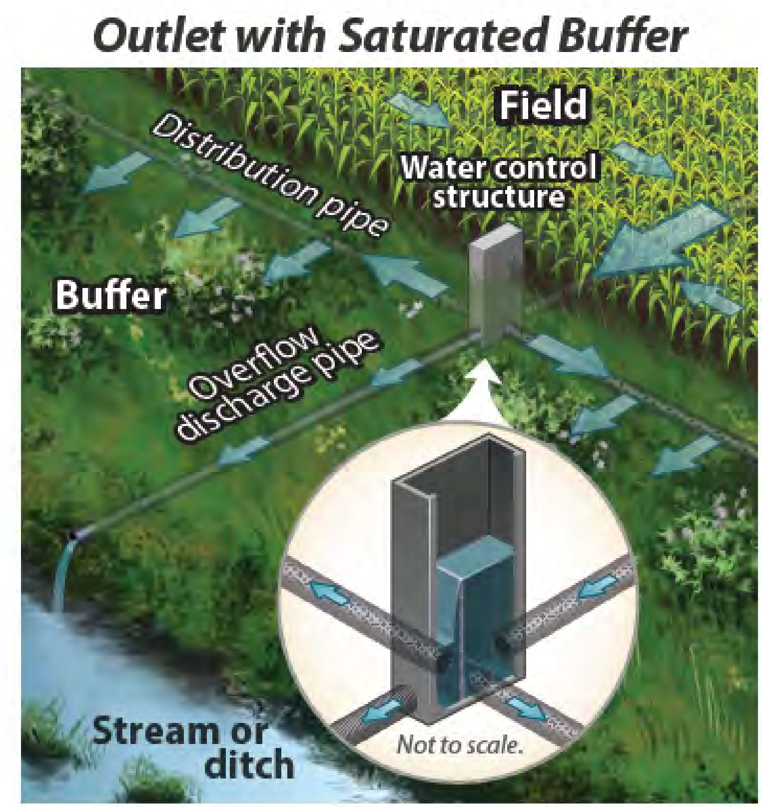
During ten years of rotational cotton and peanut production:

- 20% of rainfall on conventionally tilled plots became surface runoff, compared with only 12% from strip-tilled plots, and
- Sediment in runoff from strip-tilled plots was 87 % lower than that from conventionally tilled plots.
- Trade-offs do occur: strip-tilled fields lost about 20% of N applied as NO_3-N in subsurface flow versus 10% from the conventionally tilled fields.

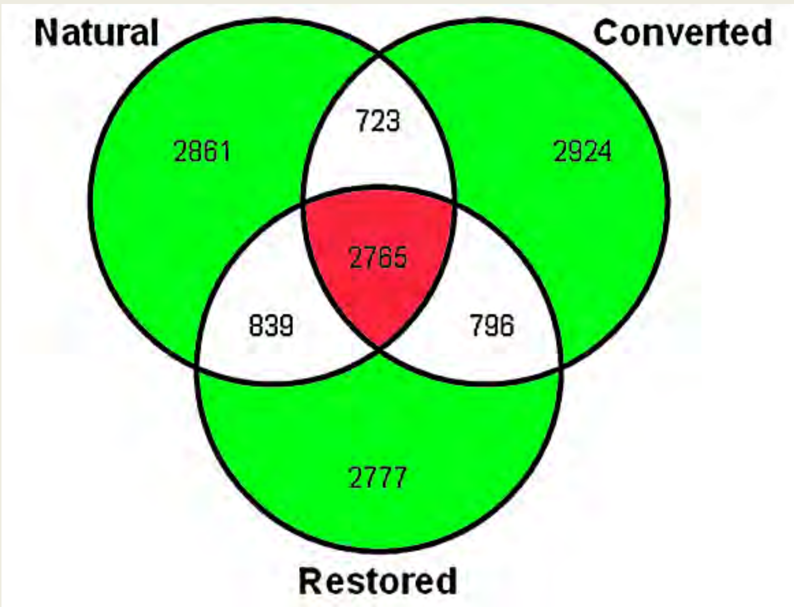
NO_3-N in Soil Water Under Rotation Systems by Crop and Season



Edge of field practices: Saturated buffer



Conservation Effects Assessment Project, Mid-Atlantic Region – Wetland Restoration effects on Biological Properties (Florence SC)

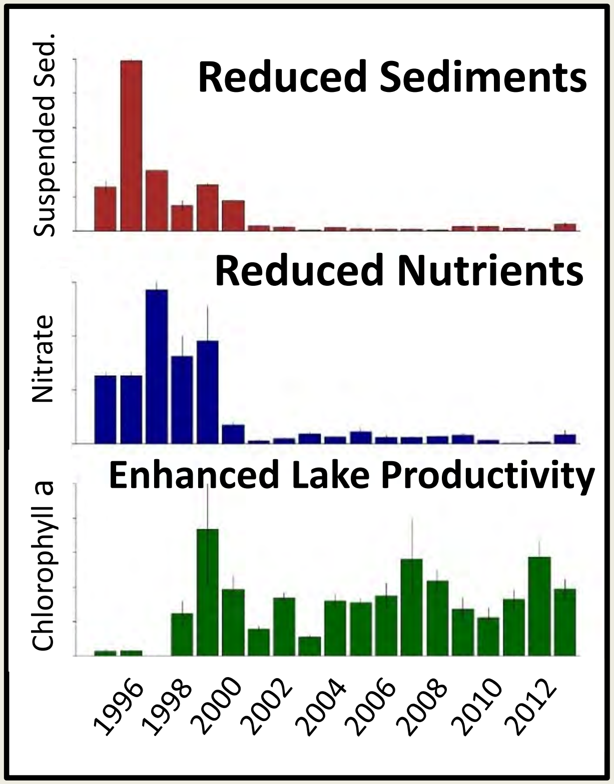


•Identified about 14,000 bacterial taxonomic units; 62% were land-use specific, 20% were shared among all land uses.

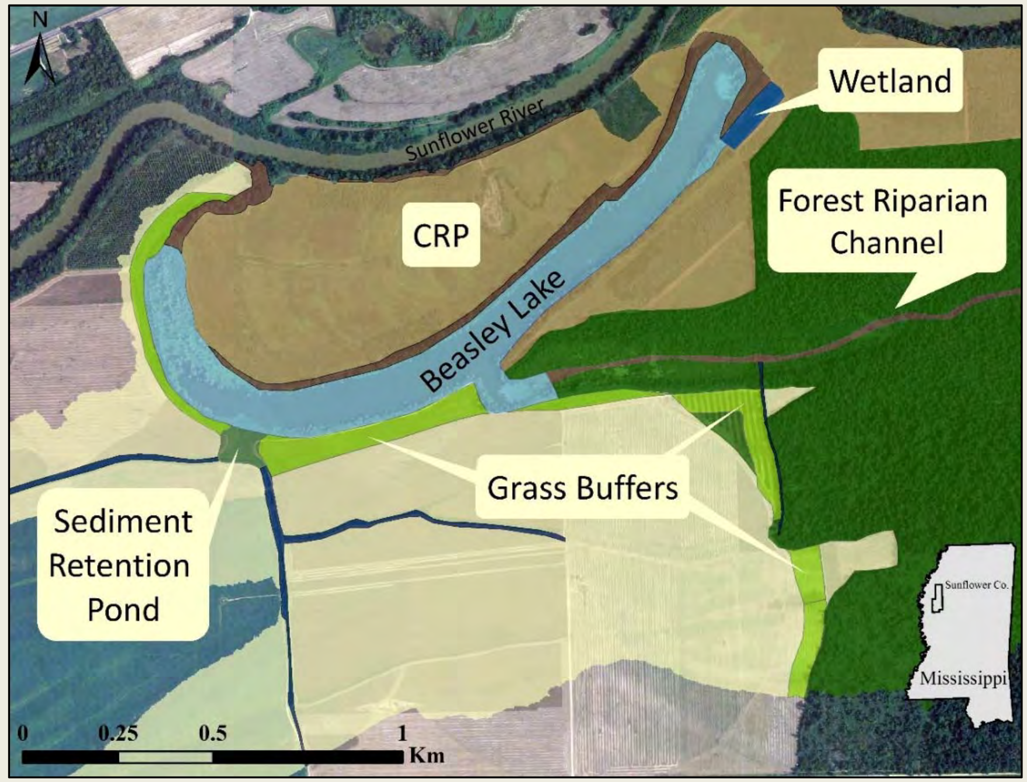
• *Biological characteristics* (denitrification enzyme activity, denitrification enzyme abundances, bacterial species) responded to wetland restoration.

• No unintended consequences (e.g., increased greenhouse gas emissions) were found post restoration.

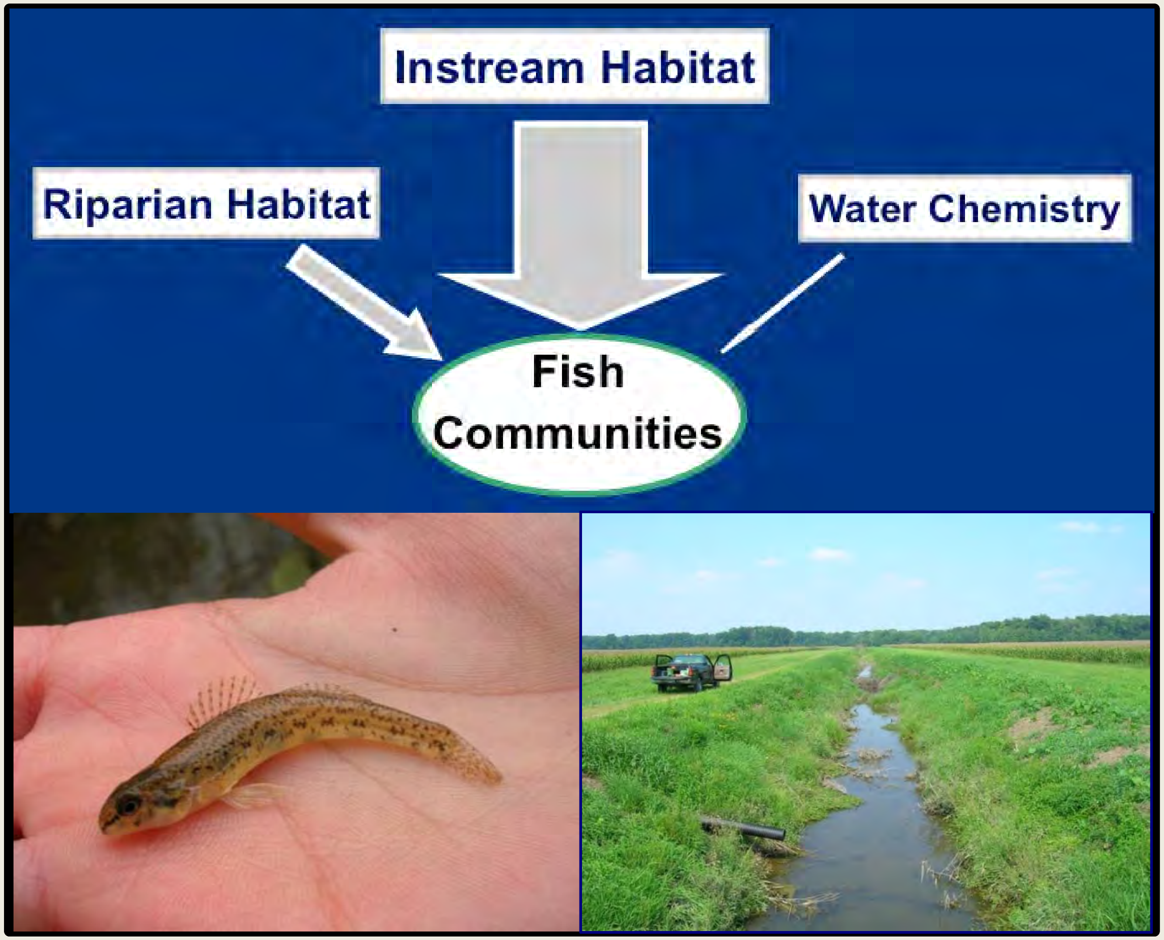
Long-term research on conservation practices demonstrated enhanced watershed sustainability



CEAP Watershed: Beasley Lake, MS



Integrated conservation practices improved lake water quality resulting in the recovery of viable fishery production

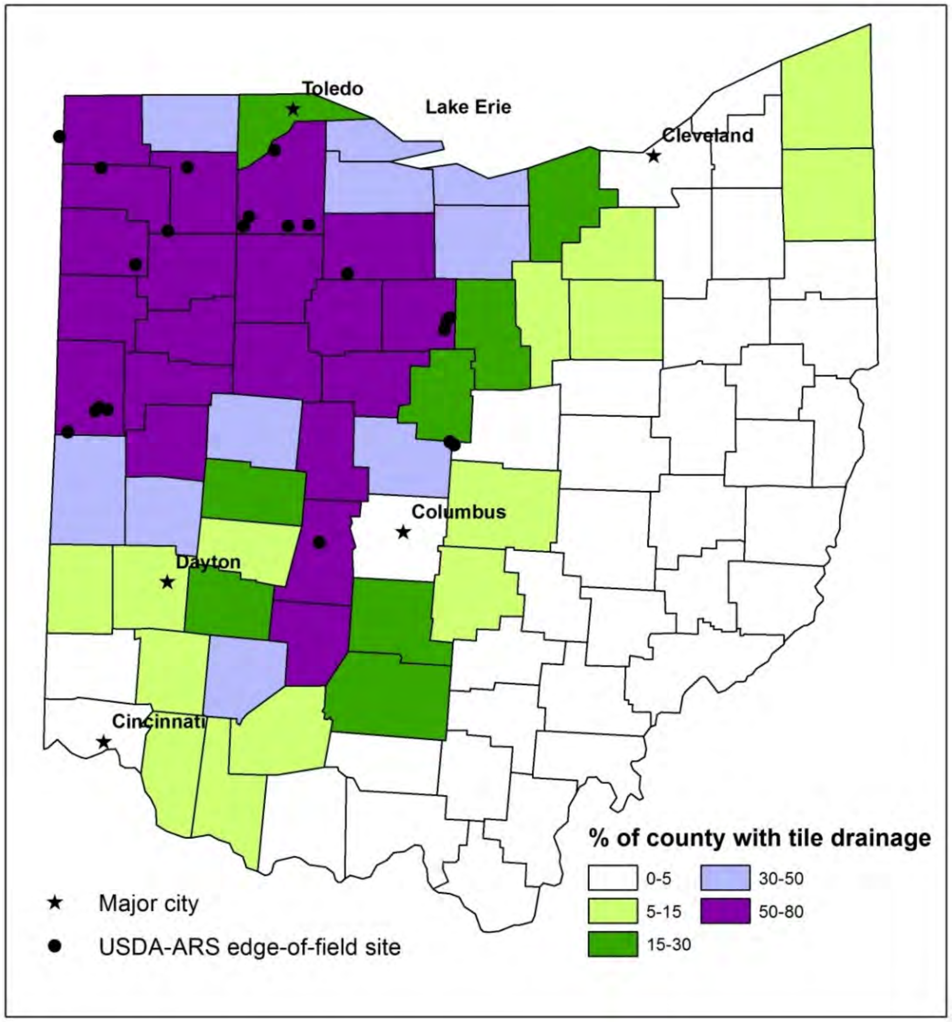


Ecological Assessments within CEAP Watersheds in Ohio and Indiana indicated that the use of conservation practices intended to improve water quality within small agricultural watersheds will not benefit fish biota

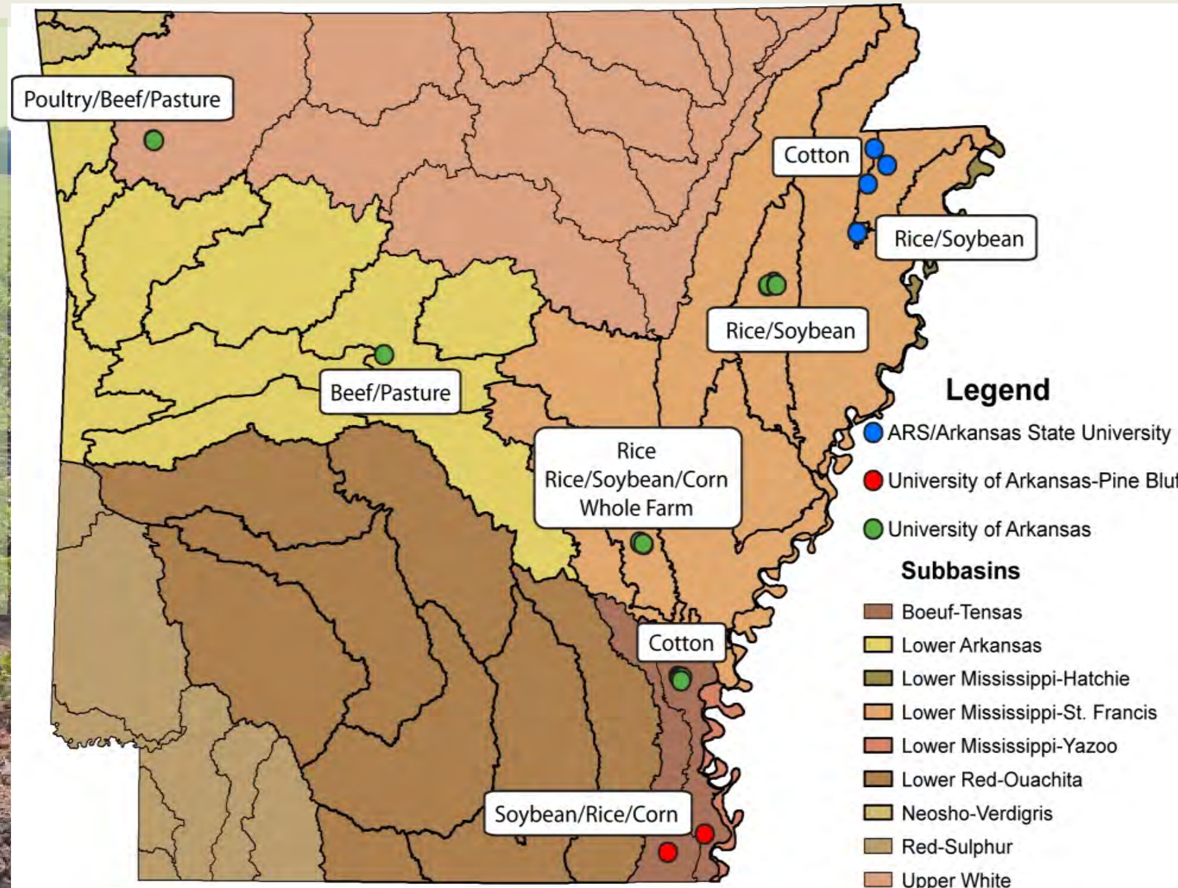
Agricultural conservation programs need to adopt a greater focus on improving physical habitat quality within small agricultural watersheds streams to develop conservation strategies capable of mitigating the increasing impacts of agriculture anticipated as a result of climate change.

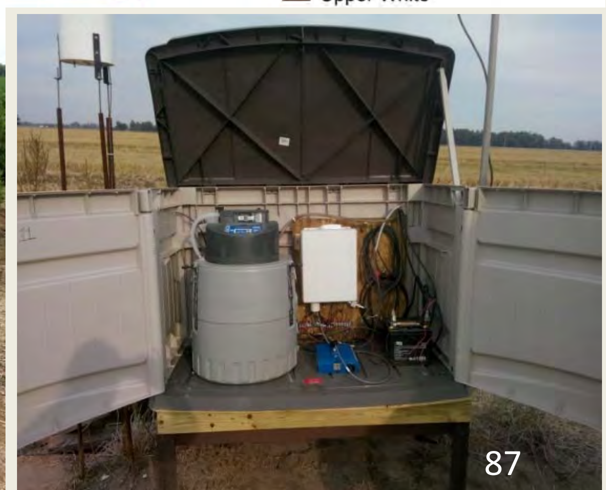
Regional networks for edge-of-field research: Ohio

- 20 paired field sites representative of Ohio crop production systems
- Surface runoff and tile discharge measurements
- Automated samplers and flumes
- Using a before-after control-impact study design



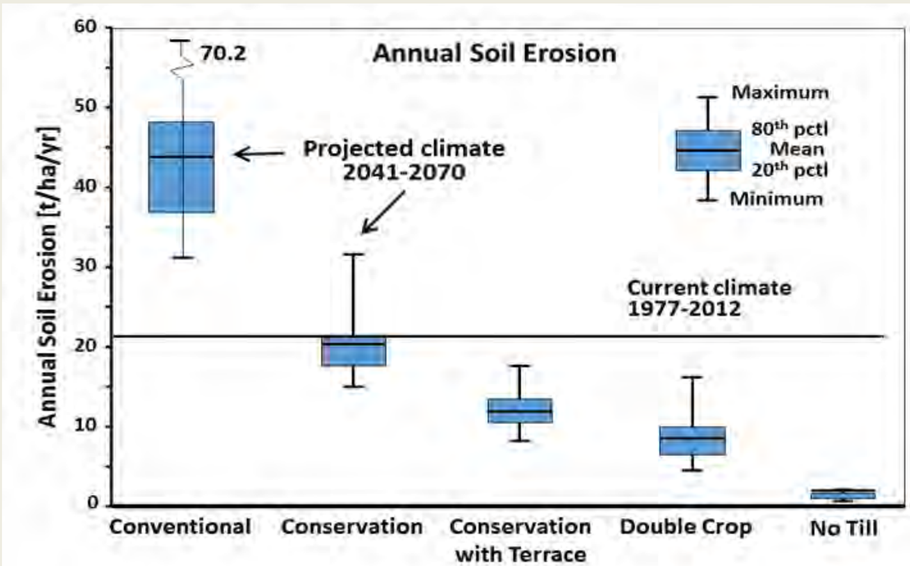
Regional networks for edge-of-field research: Arkansas



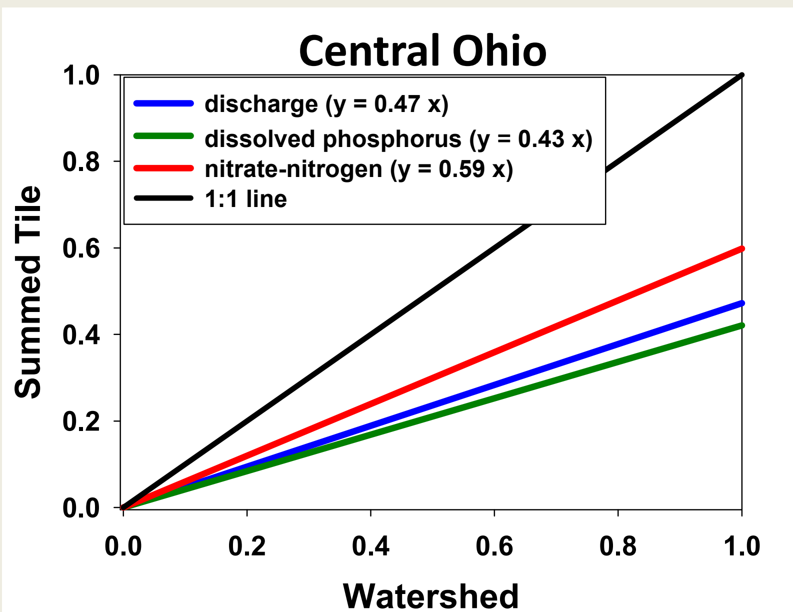


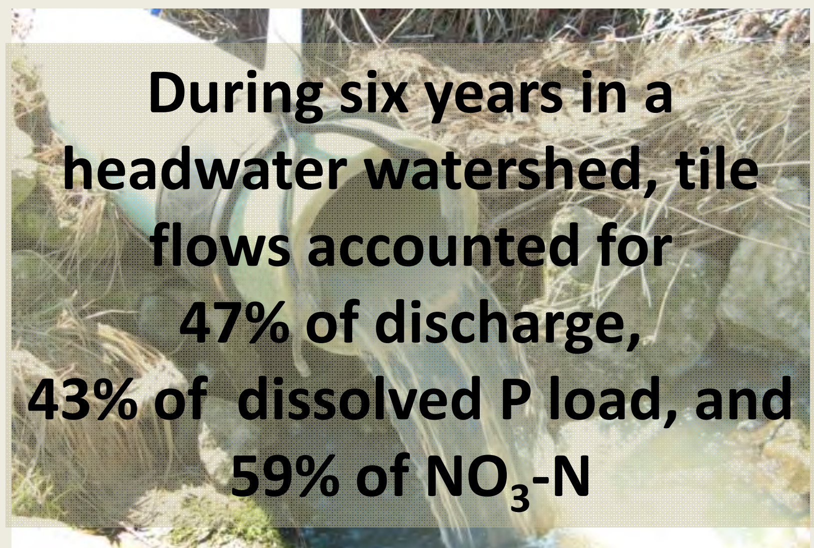
Watershed Assessments Identify Opportunities and Challenges for Conservation

Central Oklahoma



With soil conservation practices, Expected increases in soil erosion from climate change can be held at today's rates, thereby maintaining soil and crop productivity.





Problem Area 3: Conservation Effects Assessment

Need	Approach
Knowledge to identify viable management options and their water quality and ecological impacts	Assessments of conservation effectiveness: Edge-of-field, 4R, and rotational practices, watershed and ecological assessments, and establishment of monitoring networks PS 3.1, 3.3, 3.4, 3.5, 3.6

Impact

Minimum disturbance technologies could be more widely used in a number of diverse agricultural systems. PS 3.3

Combinations of practices including cover crops and diverse rotations being shown effective in different settings. PS 3.3

Ecological and watershed assessments making scientific impact and informing on options to improve ecosystem responses. PS 3.1, 3.5

Monitoring networks established to engage producers and provide long term data. PS 3.3, 3.6

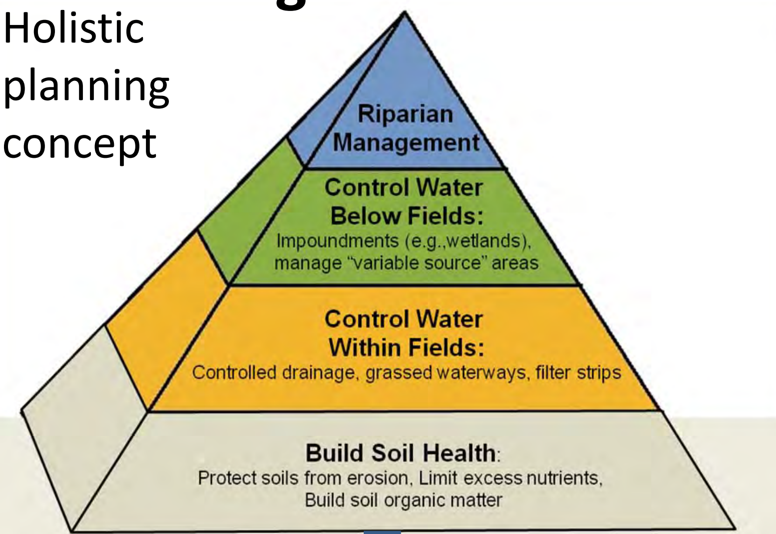
Findings on remaining challenges to help focus future efforts. 3.1, 3.4, 3.5

Problem Area 3: Conservation Effects Assessment

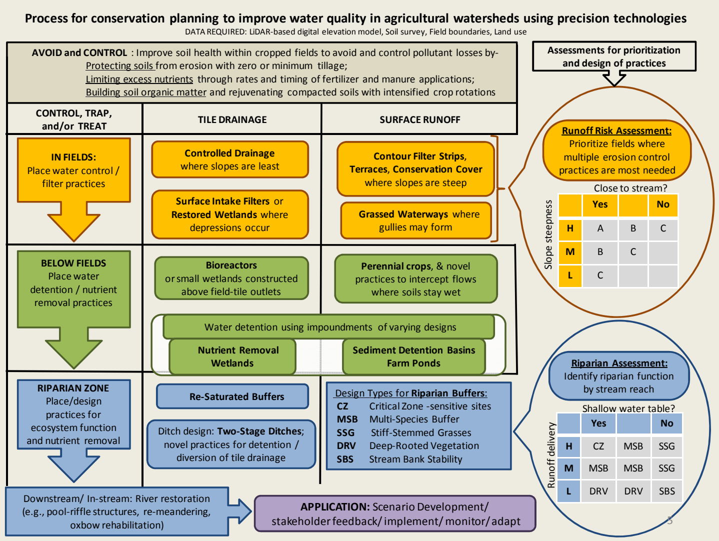
Need	Approach
Better tools to define management options	Tools to select and place conservation practices on the landscape for greater effectiveness Standards for new conservation practices PS 3.2, 3.3, 3.6

Decision Support Tools for Selection and Placement of Practices: Agricultural Conservation Planning Framework

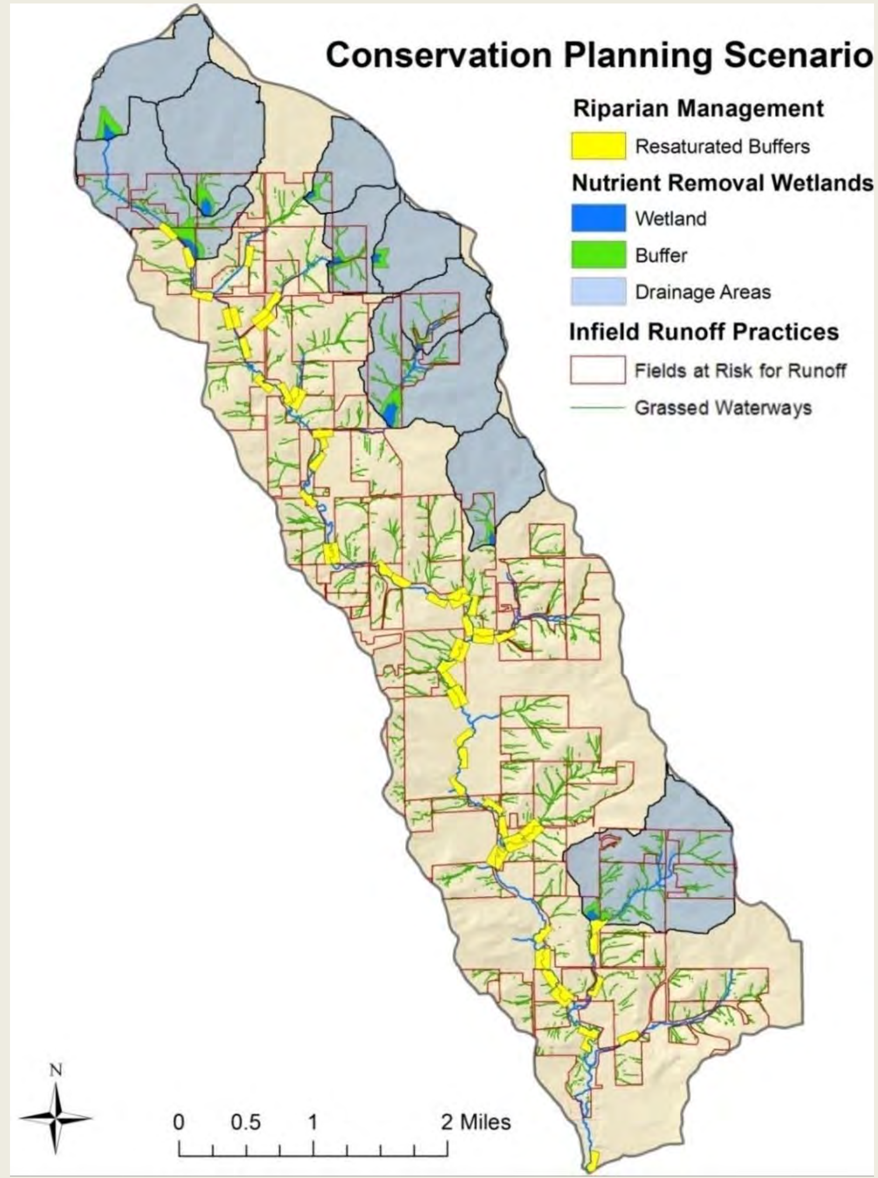
Holistic planning concept



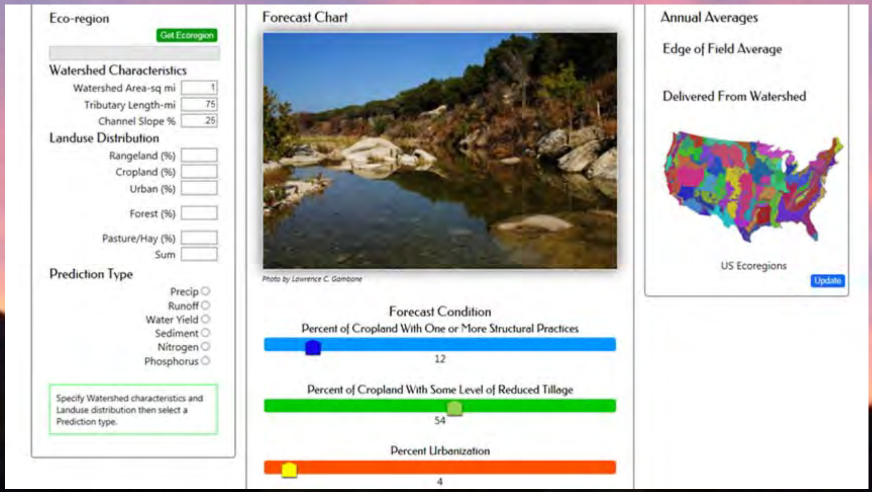
Database for regional consistency



GIS-based practice siting toolbox



- **Developed science-based, easy-to-use decision support tools, Temple, Texas.**
  - **NCAT (QuickLET) - its unique capability predicts pollutant loads at national level with more than 600,000 export coefficient values.**
  - **TBET (Texas BMP Evaluation Tool) - developed for Texas State Soil and Water Conservation Board to use in every Management Plan to demonstrate public benefits and report that critical information to the Texas Legislature.**
  - **SNAP (Soil Nutrient Assessment Program) - utilized by farmers to select appropriate yield goals and fertilizer application rates.**
  - **SWIFT (Small Watershed nutrient Forecast Tool) - frequently utilized by NRCS and ARS to predict small watershed nutrient and sediment loss.**



Conservation Practice Standard Code 333: Amending Soil Properties with Gypsum Products

PURPOSE

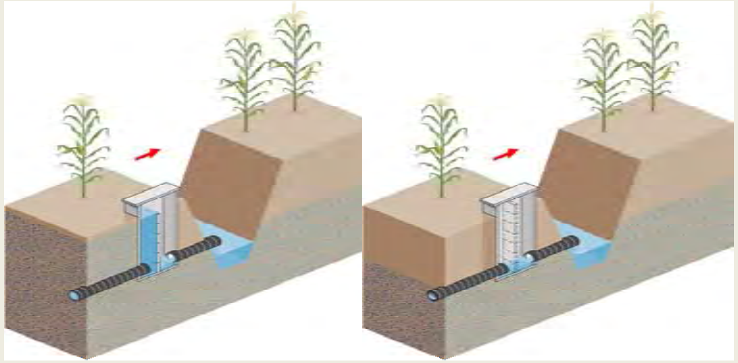
- **Reduce dissolved phosphorus in runoff and drainage**
- **Mitigate subsoil aluminum toxicity**
- **Reduce potential for pathogen transport**
- **Increase infiltration and reduce soil erosion**

USDA

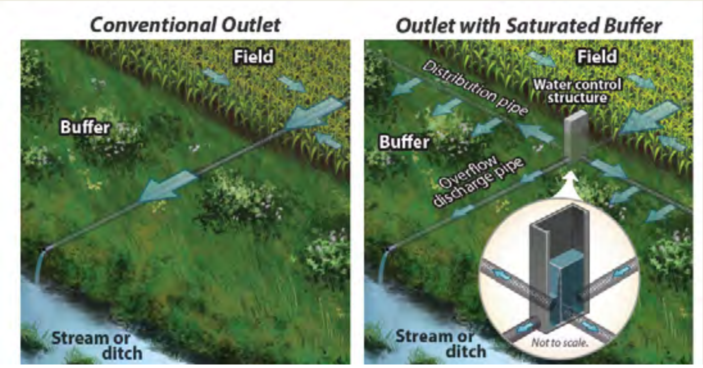
Conservation practice standards to improve quality of tile drainage water

- Denitrifying bioreactors (CP 605)

- Drainage water management (CP 554)



- Saturated buffers (CP 739 - interim)

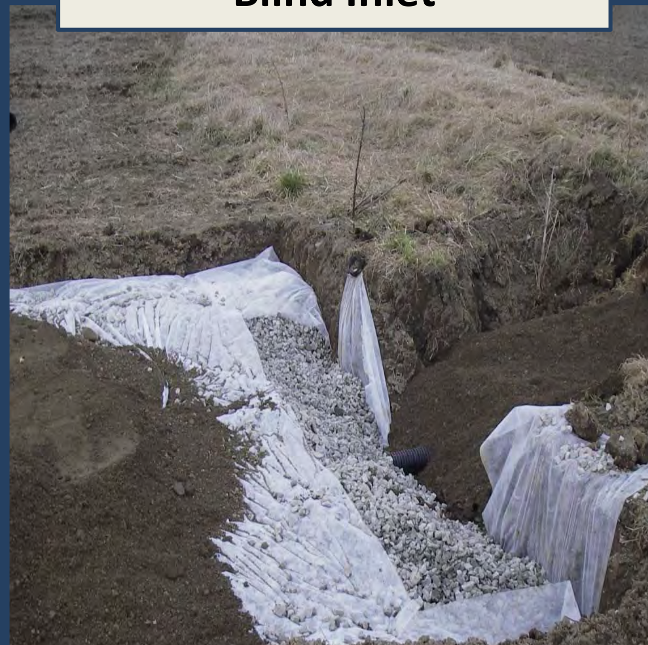


Assessing edge-of-field conservation practices

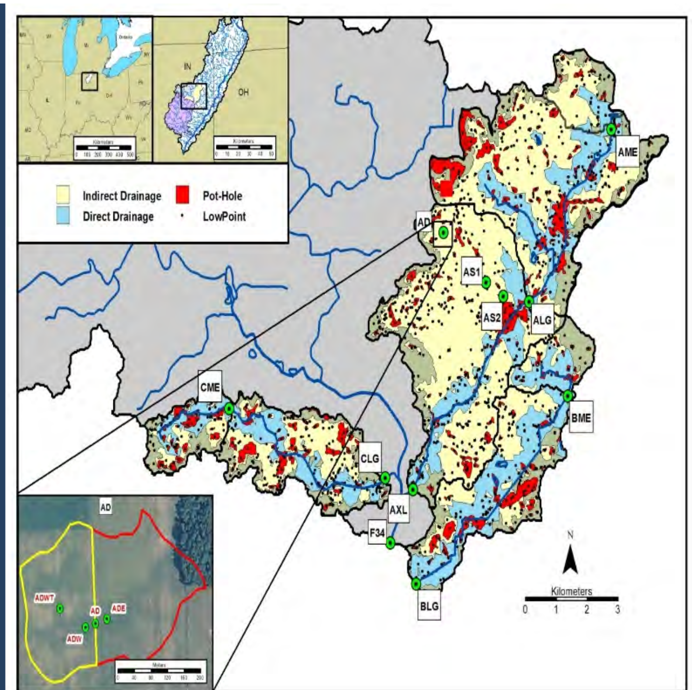
Tile Riser

There are 10-15 closed depressions per mi^2 in much of the Midwest.

Blind Inlet



Replacing tile riser with blind inlet improves water quality while keeping land in production.



Load reductions: Blind inlet vs tile riser

Pollutant	Reduction
Sediment	79%
Ammonium-N	59%
Nitrate-N	24%
Total Kjehldahl N	48%
Soluble P	72%
Total P	78%

Problem Area 3: Conservation Effects Assessment

Need	Approach
Better tools to define management options	**Tools to select and place conservation practices on the landscape for greater effectiveness** **Standards for new conservation practices** **PS 3.2, 3.3**

Impact
Providing NRCS, state and local planning partners with technology based decision support tools to identify options for future management and conservation implementation. PS 3.2 **Watershed planning tools being applied in seven states PS 3.2** **Five *examples* of contributions to new NRCS conservation practice standards. PS 3.3**

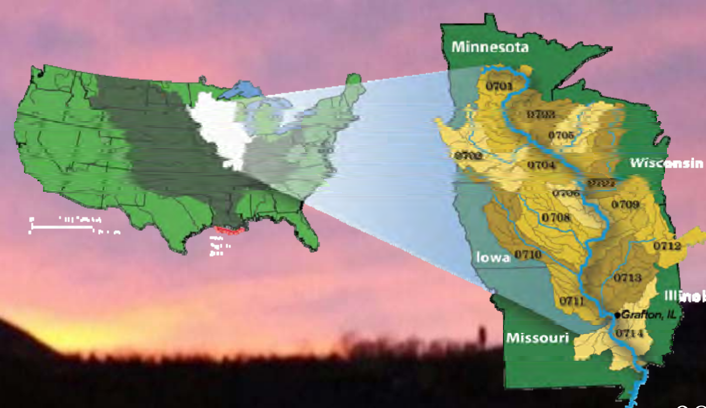
Problem Area 3: Conservation Effects Assessment

Need	Approach
Better capacity to predict impact of management change	Improved utility of watershed models PS 3.1, 3.2, 3.4

• Enhanced Soil and Water Assessment Tool (SWAT)

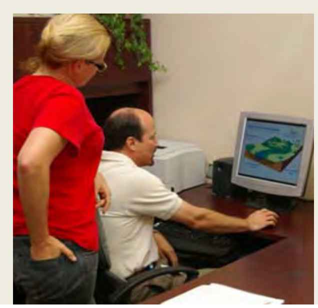
- State-of-the art scientific tool relied upon world-wide to support natural resource management and conservation.
- Critical component of CEAP through which Congress and OMB mandated that USDA evaluate regional/national conservation practice effects.
- Empowered NRCS/ARS national CEAP modeling team to better address Cabinet-level and Congressional requests.
  - provide scientific information on regional/national conservation effects
  - support agricultural policy formulation and implementation through Farm Bill and other regional and national programs.

NRCS Natural Resources Conservation Service

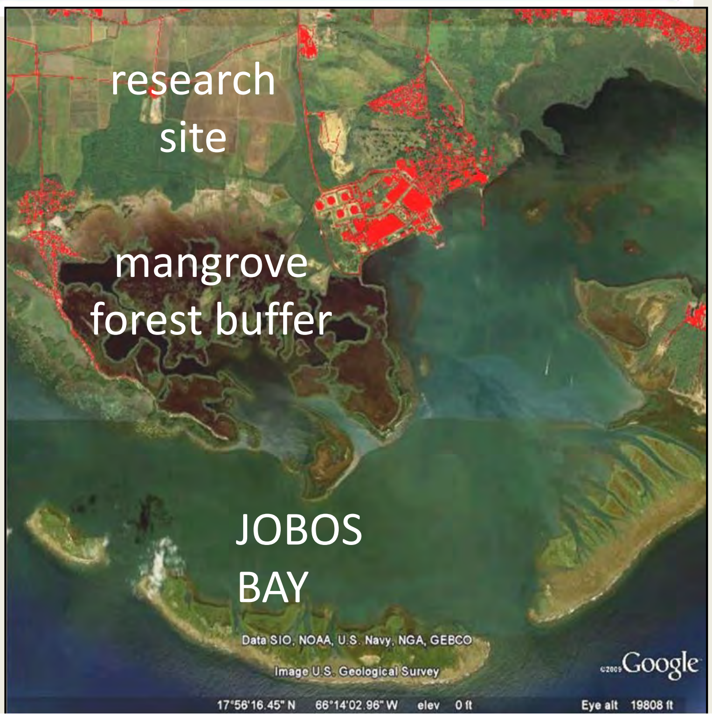


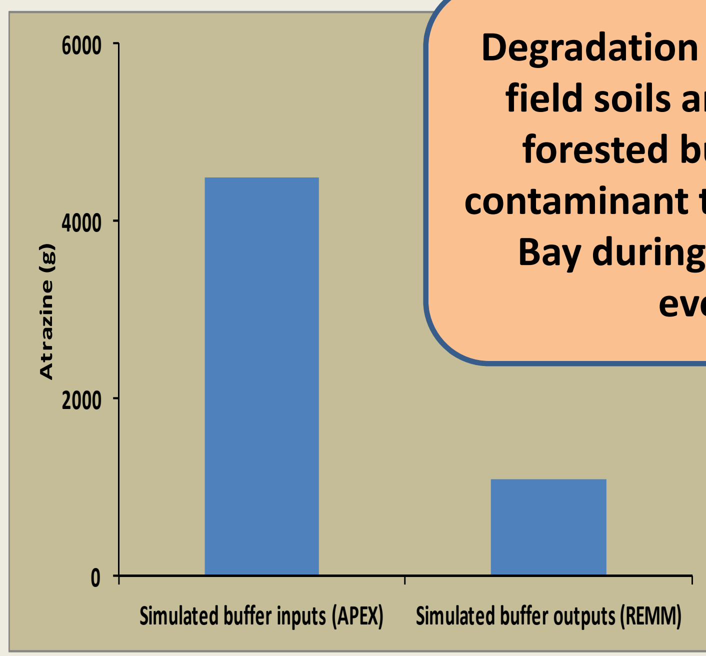
Development of the SWAT Model to better assess environmental effects of management practices at watershed scale.

- CEAP National Assessment: Major regional reports assessing impacts and effectiveness of agricultural conservation policies.
- Modernized input data structures and modules to manage output data.
- Developed web-based interface to analyze results and what-if scenarios.
- Improved capacities to address critical questions:
  - Landscape routing, flood plain, riparian, and gully erosion routines.
  - Tile drainage routines for flow volumes and nutrient transport
  - Integrated SWAT with a key groundwater flow model (MODFLOW)



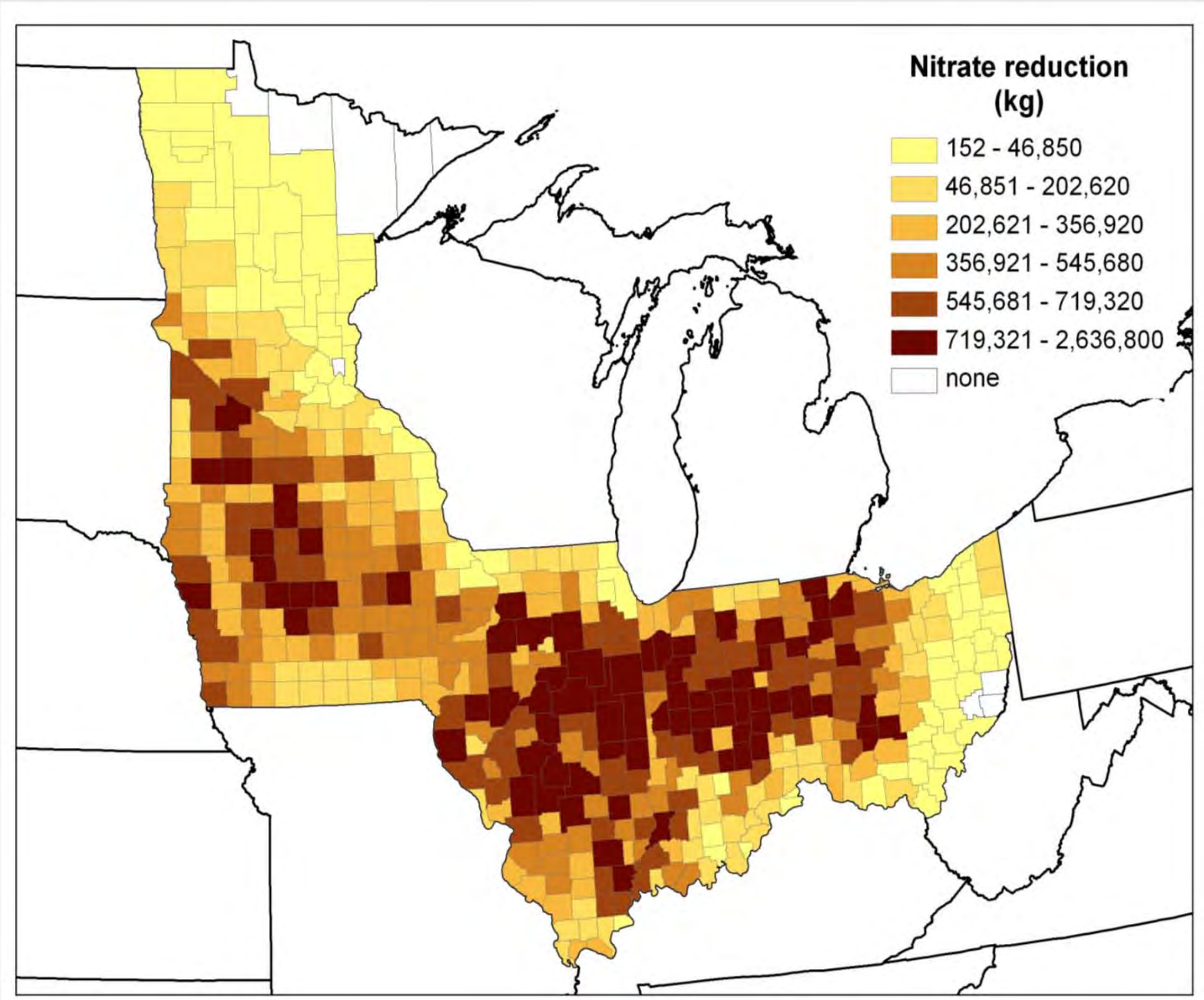
Farm runoff has potential to carry herbicide residues to Jobos Bay, a National Estuarine Research Reserve. During three years, nearly all herbicide transport to the Bay occurred during a tropical storm that soon followed field spraying.





Degradation of herbicide in field soils and within the forested buffer limited contaminant transport to the Bay during other storm events.

Models can assess regional impacts resulting from broad adoption of a single practice



RZWQM predicts winter rye cover crops can reduce nitrate-N loss from Midwest tile drains to the Mississippi River by more than 300 million pounds of N, or about 20%.

Thus, state-wide adoption of winter rye cover crops on tile drained croplands in five states could provide a substantial portion of the reduction in nitrate loading needed to reduce the size of the hypoxic zone in the Gulf of Mexico.

Highlights: Watershed modeling research (SWAT, AnnAGNPS, RZWQM)

- **Quantify nutrient load reductions from combinations of conservation practices compared to single practice (IN)**
- **Quantify threshold adoption rates necessary to achieve measureable reduction in herbicide losses (OH)**
- **Identify 4R practices and vulnerabilities affecting movement of herbicide to sensitive coastal waters (Puerto Rico)**
- **Assess site-specific wetland benefits for N reduction at watershed scale to inform nutrient trading schemes (AnnAGNPS; MS/IA)**
- **Highlight the importance of considering both tile drainage and surface runoff for reducing P loadings in the western Lake Erie basin (IN)**

Problem Area 3: Conservation Effects Assessment

Need	Approach
Better capacity to predict impact of management change	Improved utility of watershed models PS 3.1, 3.2, 3.4

Impact

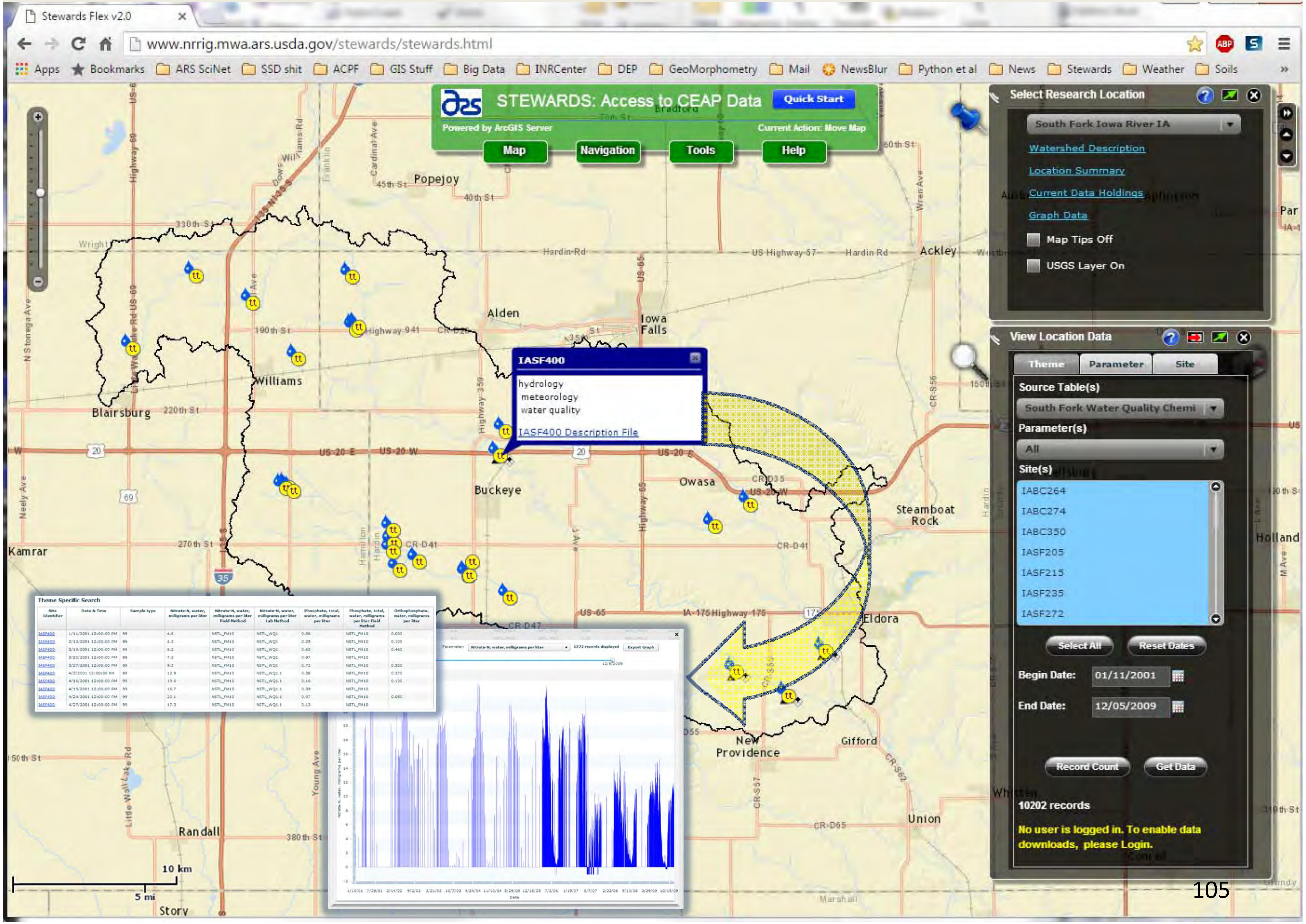
Understanding impact of USDA conservation programs on environmental outcomes documented program benefits and future challenges. National assessment supported by ARS watershed assessment studies under CEAP. PS 3.1, 3.2, 3.4

Capacity to extend research from plot scale towards improved watershed management – distinct examples that respect regional differences in soil, climate, and cropping systems. PS 3.2, 3.4

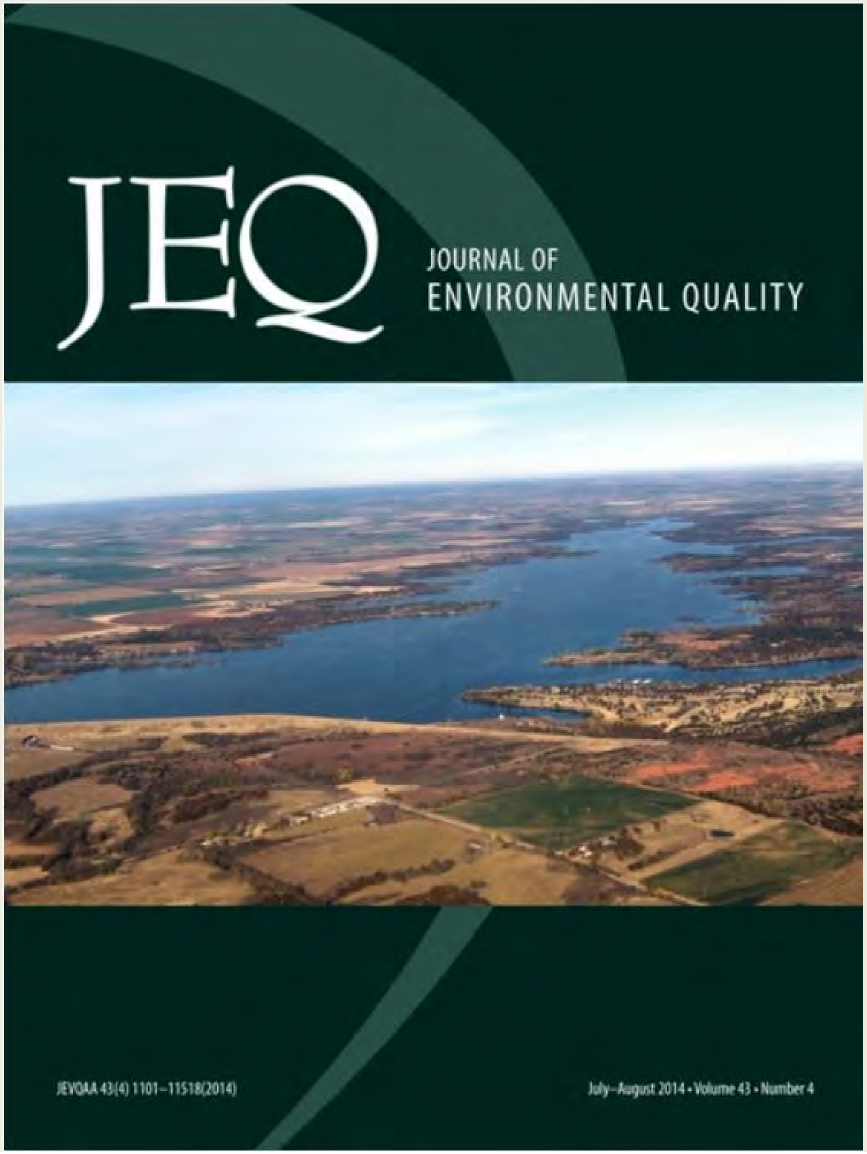
Problem Area 3: Conservation Effects Assessment

Need	Approach
Better public access to ARS research information	Databases and special issue contributions PS 3.1 – 3.6

USDA/ARS CEAP STEWARDS: search, visualize, and download agricultural research data



Long-Term Environmental Research: The Upper Washita River Experimental Watersheds, Oklahoma, USA



- The USDA–ARS conducts long-term watershed research in the Upper Washita River Basin of southwestern Oklahoma to improve understanding of climate drivers, hydrologic processes, and sources, fate and transport, and options for mitigation of sediment and nutrients that impair water quality in agricultural watersheds.

- A 2014 special collection in Volume 43: Issue 4 of Journal of Environmental Quality included a review paper, 6 data papers (weather, hydrology, physiography, land cover, and sediment and nutrient water quality) and 4 research papers.

- This "living history" of research was presented to engage collaborative scientists across institutions and disciplines to further explore complex, interactive processes and systems.

Special Section Publications – Multi-watershed overview and single location compendium

Problem Area 3: Conservation Effects Assessment

Need	Approach
Better public access to ARS research information	Databases and special issue contributions PS 3.1 – 3.6

Impact
Future progress towards improved conservation effects assessments and decision support/ modeling tools depends on improvements in data availability and public access to water data. ARS has turned a corner towards provision and sharing of research data about water with the public.

Questions on Problem Area 3?

Improving Conservation Effectiveness

Problem Area 4

Improving Watershed Management and Ecosystem Services in Agricultural Landscapes

Tim Strickland

Problem Area 4: Improving Watershed Management and Ecosystem Services in Agricultural Landscapes

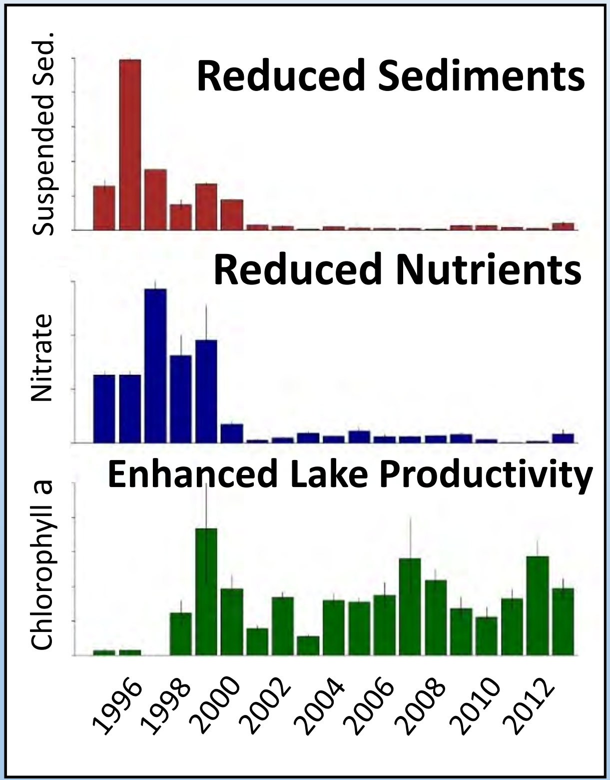
- PS 4.1: Developing tools to improve hydrologic assessment and watershed management
- PS 4.2: Improving watershed management and ecosystem services through long-term observation and characterization of agricultural watersheds and landscapes
- PS 4.3: Maintaining water availability in a changing global environment
- PS 4.4: Developing tools to improve the quantification of hydrologic processes and water budget parameters in varying landscapes and under varying conditions
- PS 4.5: Understanding the water implications of biofuel production
- PS 4.6: Downscaling climate change impacts to improve water availability and watershed management

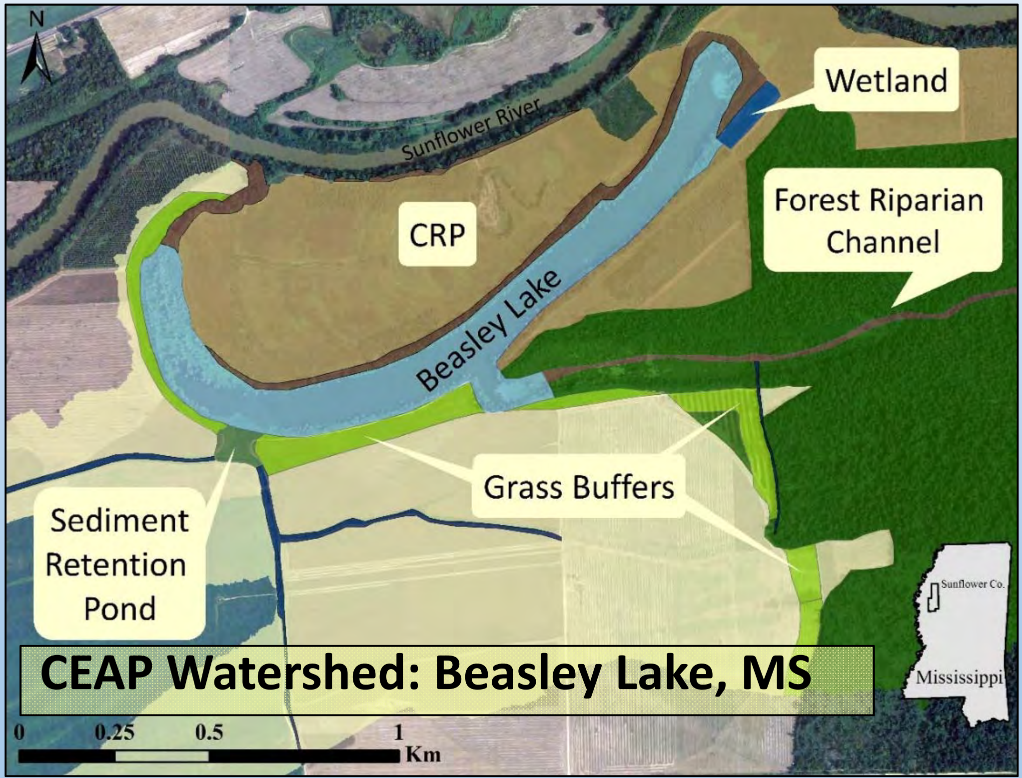
Problem Area 4

Improving Watershed Management and Ecosystem Services in Agricultural Landscapes


Landscape Assessment and
Strategic Design Improve
Delivery of Ecosystem Services

Long-term research on conservation practices demonstrated enhanced watershed sustainability Oxford, MS





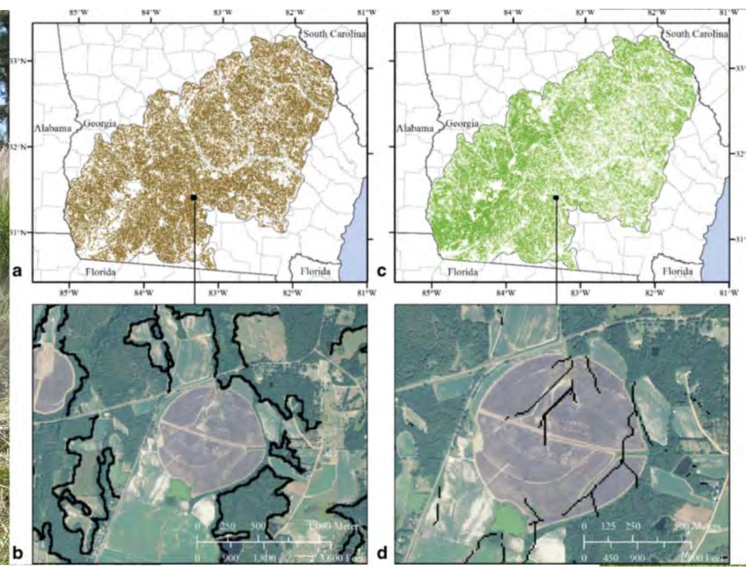
Integrated conservation practices improved lake water quality resulting in the recovery of viable fishery production

Sediment Measurement and Transport Modeling: Impact of Riparian and Filter Strip Buffers El Reno, OK

- **Developed cost-effective methods to collect stream channel parameterization and evaluation data for modeling in watersheds with sparse data.**
- **Results of a case study project within the Fort Cobb Reservoir Experimental Watershed in Oklahoma indicated promise for using the rapid geomorphic assessment and acoustic profiling system methods to obtain data to improve water quality simulations in ungauged watersheds.**
- **Using the calibrated Soil and Water Assessment Too (SWAT) model showed that effect riparian and filter strip buffers can reduce suspended sediment concentration at the outlet 73%, which has potential to increase reservoir life.**

Perennial Biofuel Feedstock Production from Conservation Buffers Tifton, GA

Precision management of landscapes that incorporates perennial grasses as conservation buffers on marginal lands may supply from 1.6 to 6.7% of the increased advanced biofuel production called for by the Energy Independence Security Act of 2007. Strategic scenarios targeting landscape positions susceptible to soil erosion and nitrogen loss has the potential to produce from 2.2 to 9.4 Tg yr^{-1} of biomass, provide 778 to 3,296 Ml yr^{-1} of ethanol, and remove 8,100 to 51,000 Mg yr^{-1} of nitrogen from surface waters.



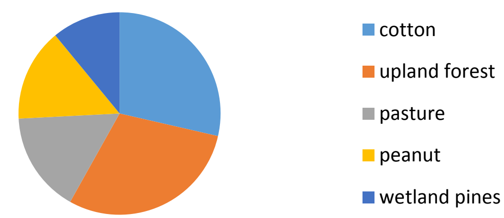

Non-Agricultural Land Use
Effect on Water Demand

Riparian Forests Dominate Water Use in Coastal Plain Watershed, Tifton, GA

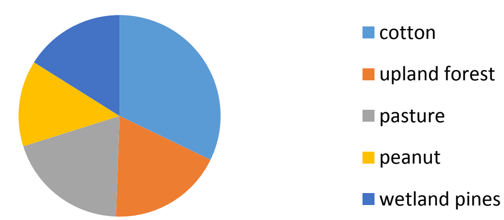
A 70 m wide riparian forest buffer along a first order stream in South-central Georgia averaged 88% of total watershed potential evapotranspiration and accounted for 86% of annual precipitation on the watershed. The data indicate that transpiration within regional buffers is 19 to 144% higher than the other land uses in the watershed. The relatively lower contribution cropped areas to watershed ET can be attributed to the 150 day growing season versus 365 days for wetland pine, pasture and upland forests and is an important consideration when examining overall water consumption in regional watersheds.

Land cover	% of area	% of ET
Cotton	24	28
Upland forest	25	16
Pasture	13	17
Peanut	12	12
Wetland pines	9	14

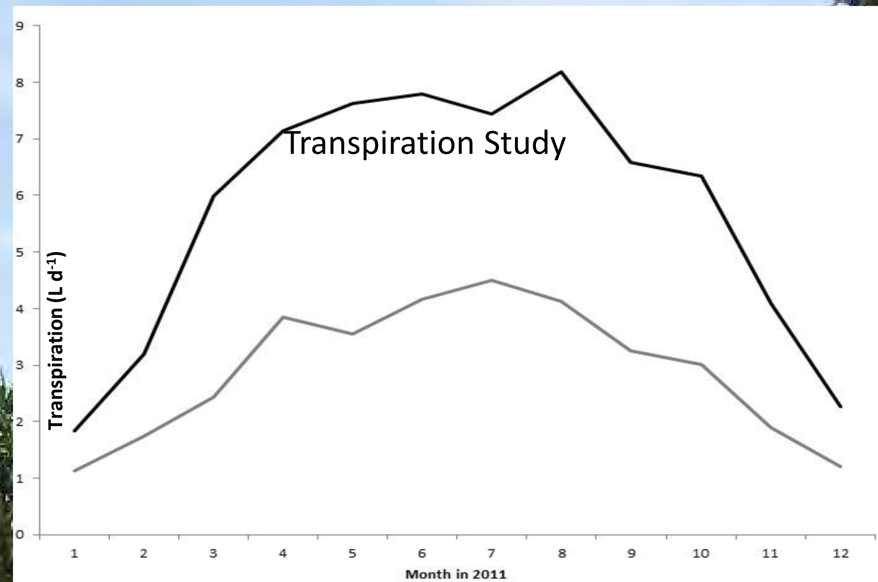
Land use as a fraction of total watershed area (%)



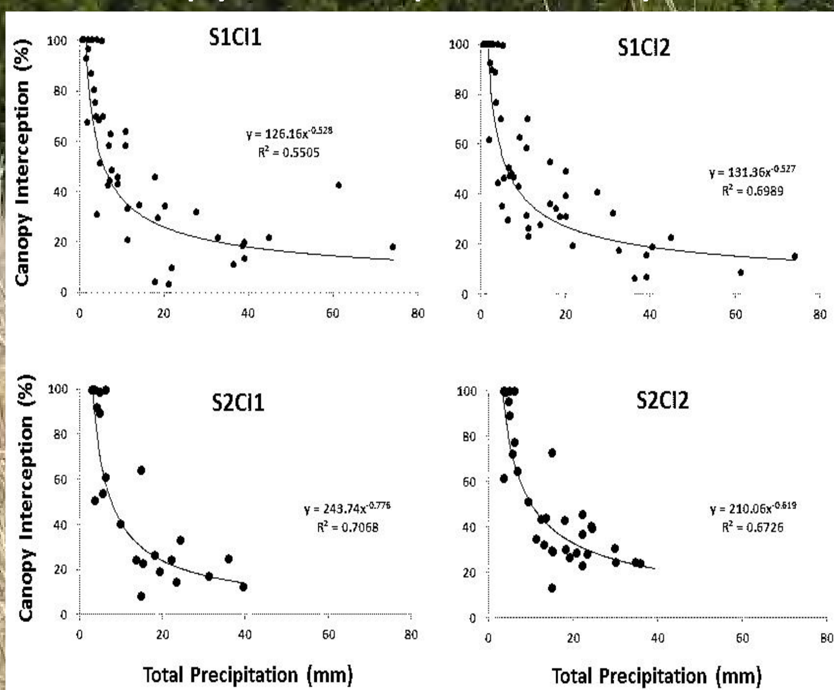
Land use as a fraction of % of total ET

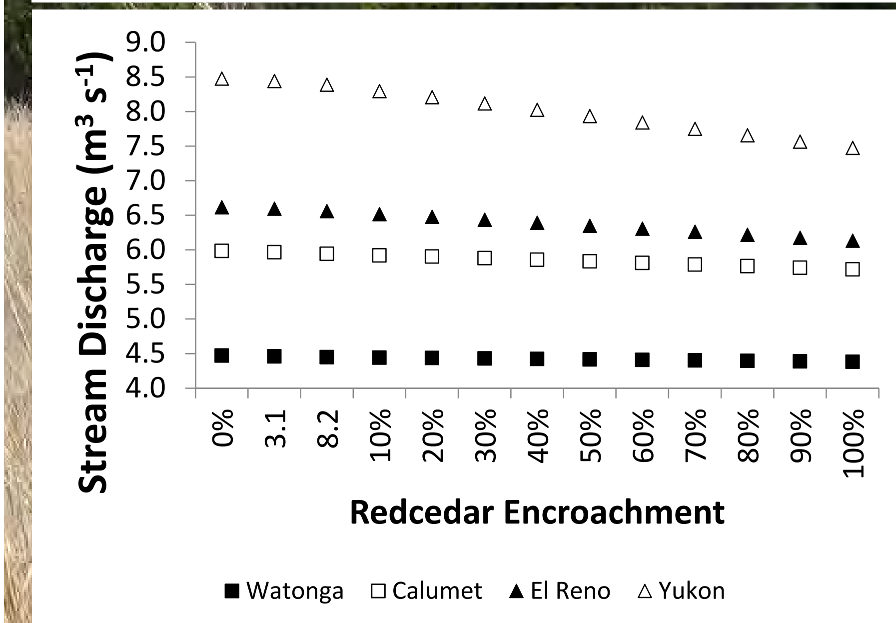


Impact of Eastern Redcedar Encroachment On Stream Discharge El Reno, OK



Canopy Interception Study

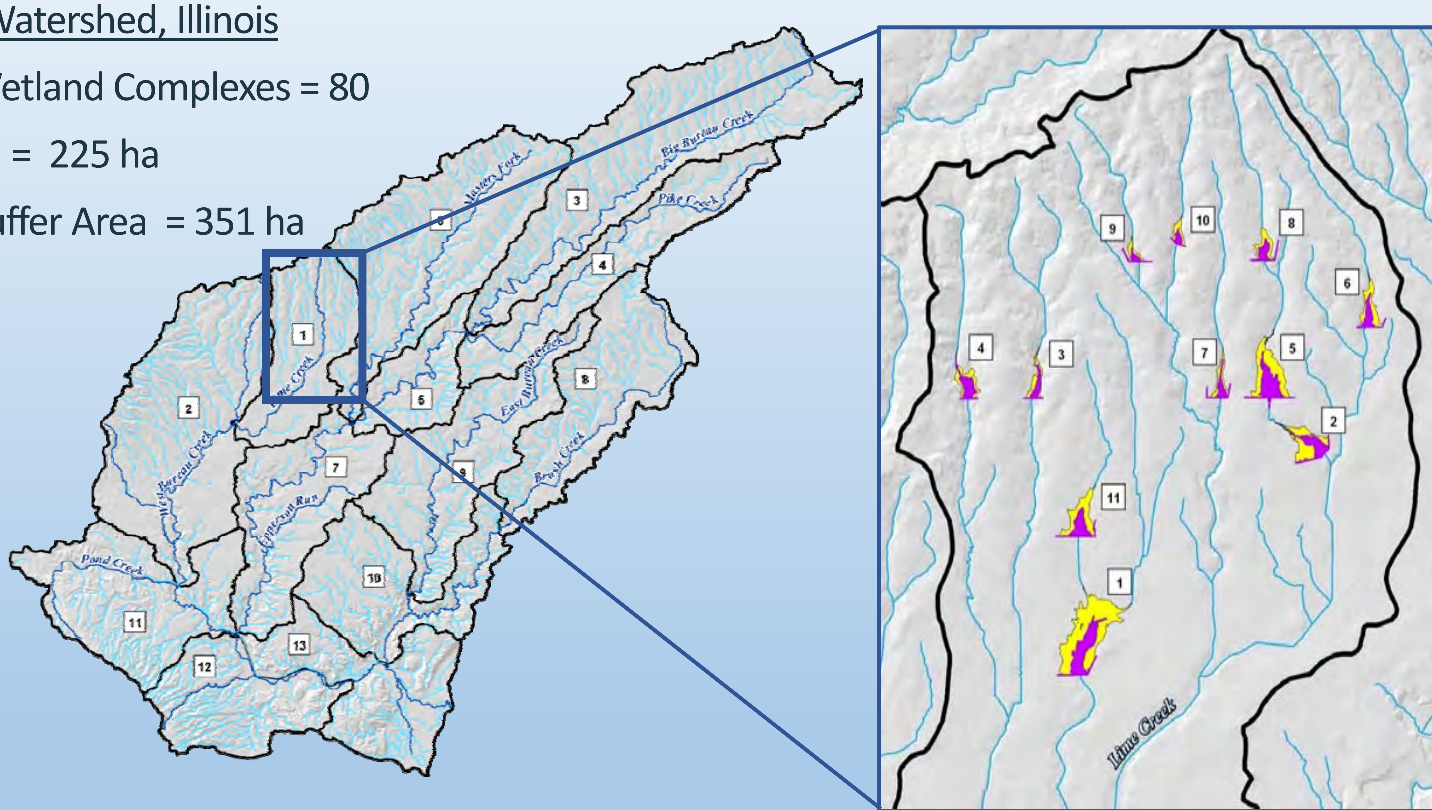




Improved Modeling Tools Enhance Ecosystem Services Provided by Agricultural Landscapes

Placement of conservation practices can now be evaluated using a new AnnAGNPS wetland module, Oxford, MS

- Big Bureau Creek Watershed, Illinois
- Total Number of Wetland Complexes = 80
- Total Wetland Area = 225 ha
- Total Wetland & Buffer Area = 351 ha

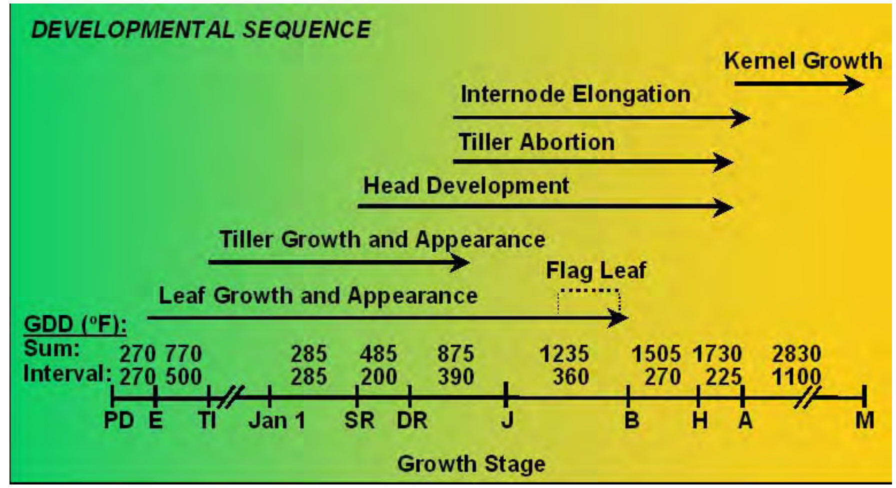


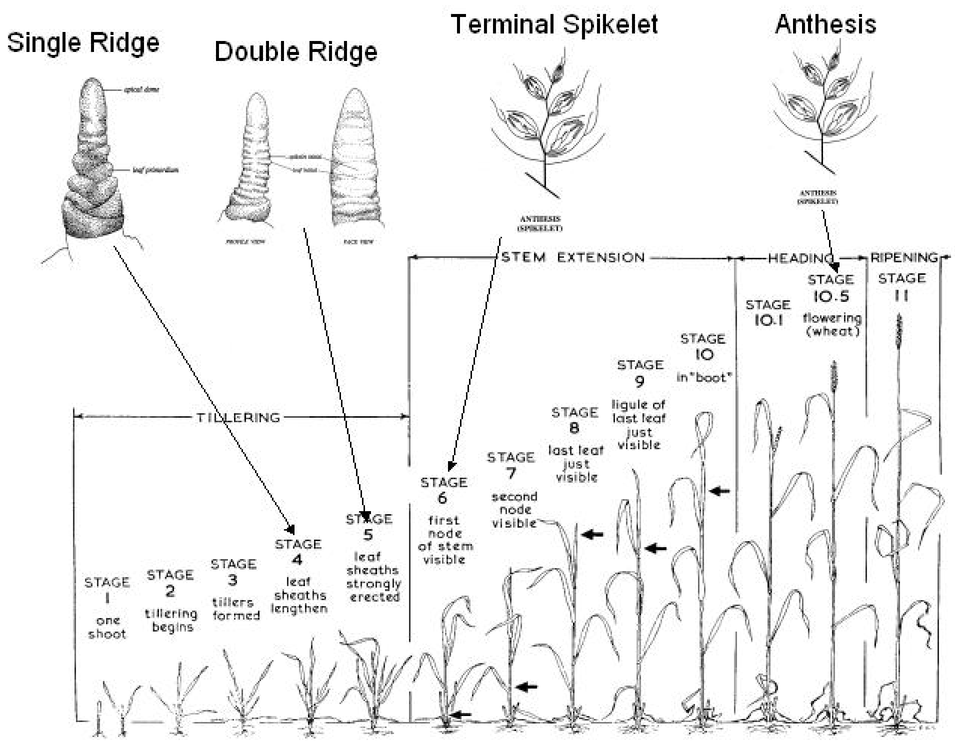
Strategic placement of wetlands/buffers (0.3% of total watershed area) is predicted to reduce N and P loads by 14 and 11%

PhenologyMMS

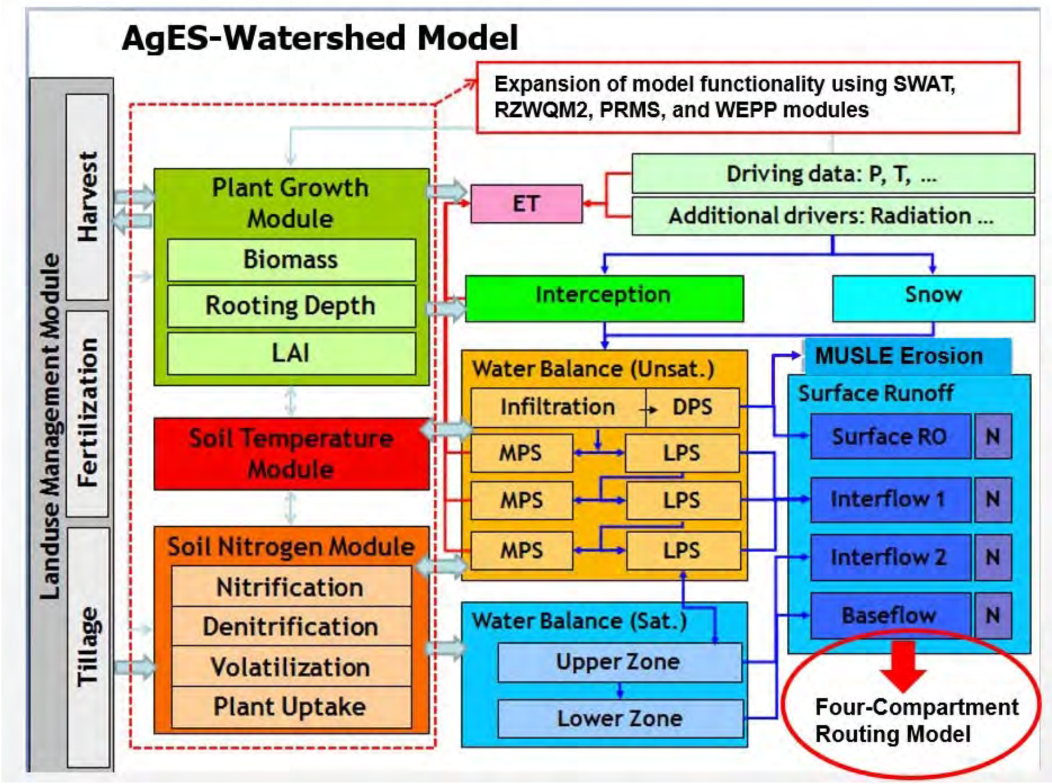
Ft. Collins, CO

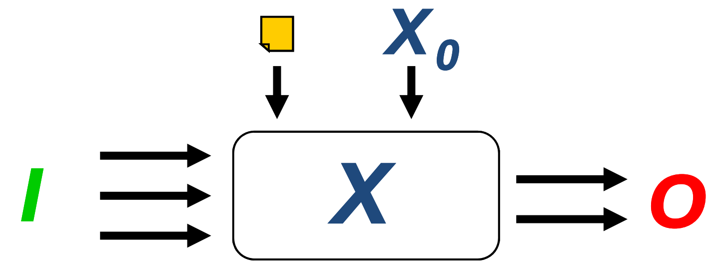
Decision support technology and educational tool to predict crop growth stages as influenced by temperature and water availability.



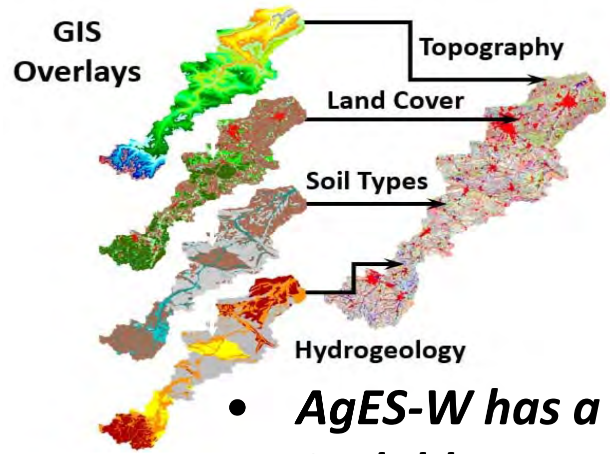


AgroEcoSystem-Watershed (AgES-W) Model Development and Evaluation





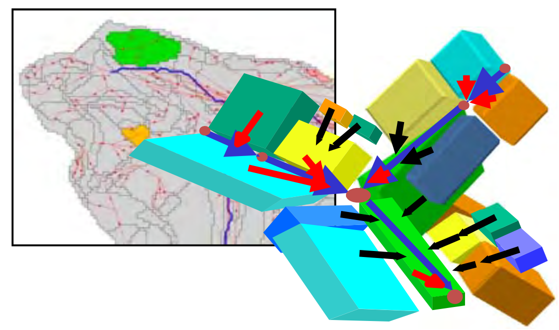
- *AgES-W is Component-Based*



- *AgES-W has a Scalable HRU Concept*

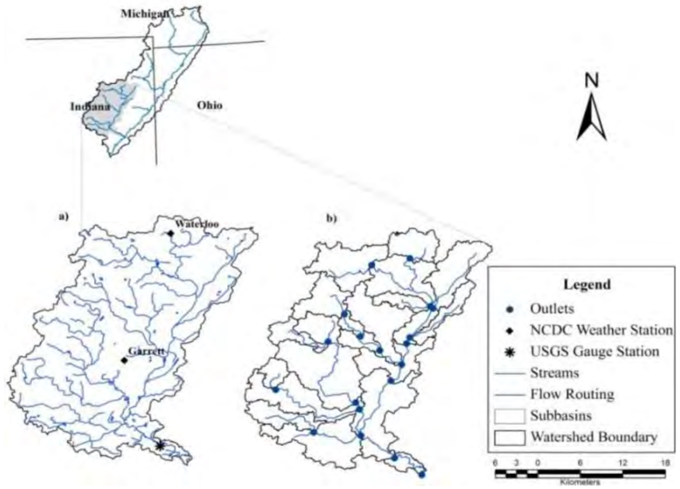
AgES-W) Primary Modeling Applications:

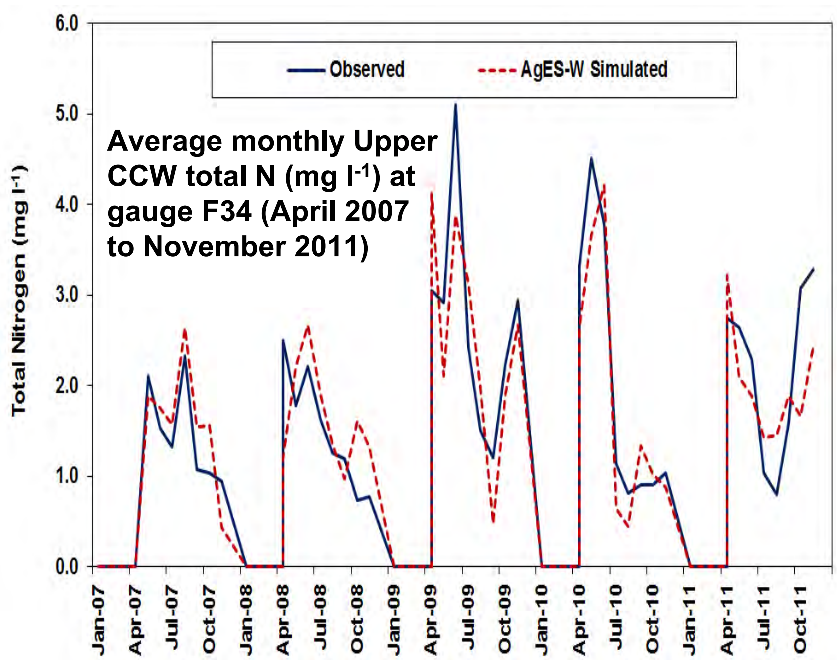
- Micro-environment at HRU scales affecting conservation practices on surface runoff, chemical, and sediment transport to streams
- Dominant surface-subsurface hydrologic and chemical interactions between HRUs and streams/water bodies
- Effects of soil and crop conservation management practices in space and time



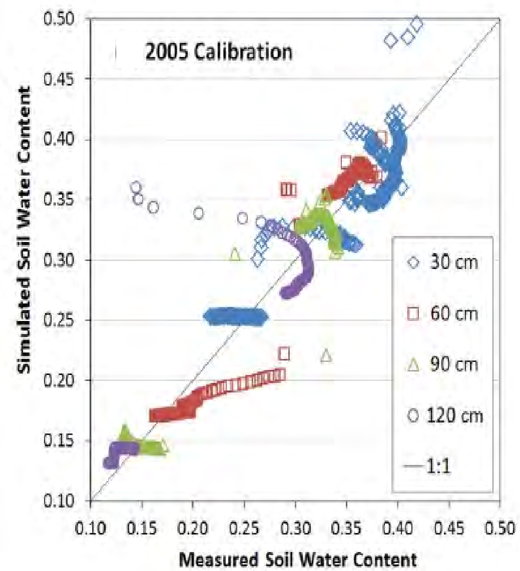
- *AgES-W is Fully Spatially Distributed*

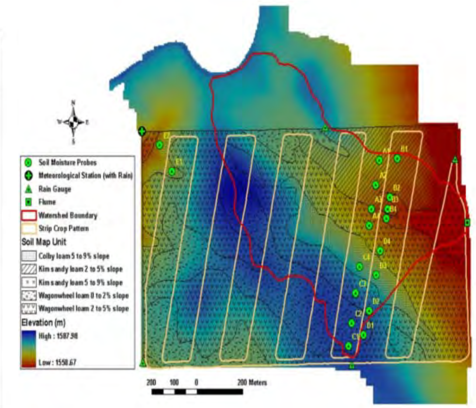
AgES-W Hydrological and Water Quality Modeling - Cedar Creek Watershed, IN

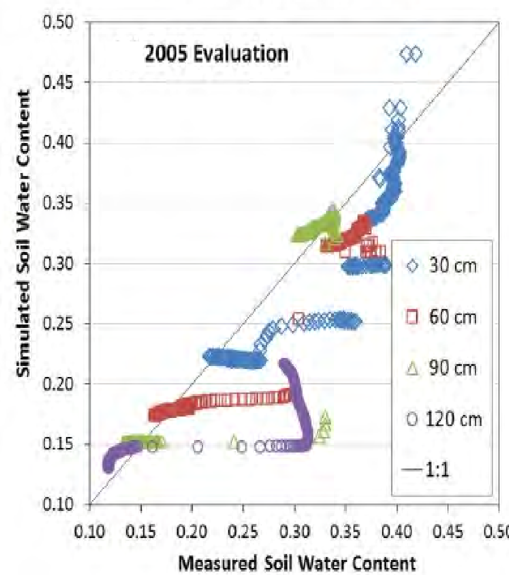




AgES-W Soil Water Modeling – Drake Farm, Ault CO

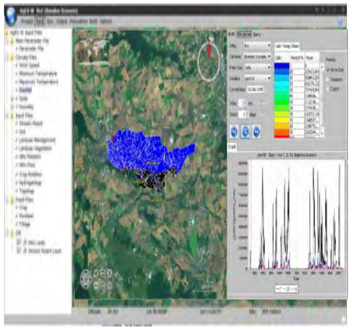




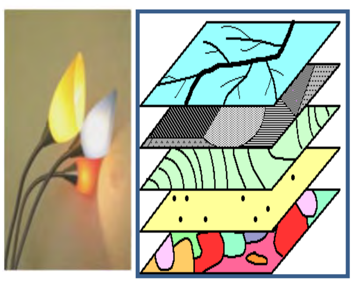


Scatterplots of AgES-simulated vs. measured soil water content (SWC, $m^3 m^{-3}$) at four sensor depths for independent layer shuffling calibration and evaluation

Models and Services run in the Cloud Services Innovation Platform (CSIP)

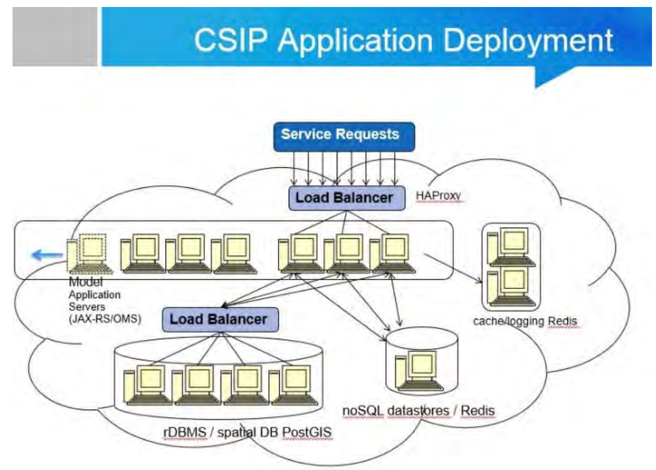


- AgroEcoSystem-Watershed (**Ages-W**) spatial process model is deployed using CSIP for complex model parameter calibration.



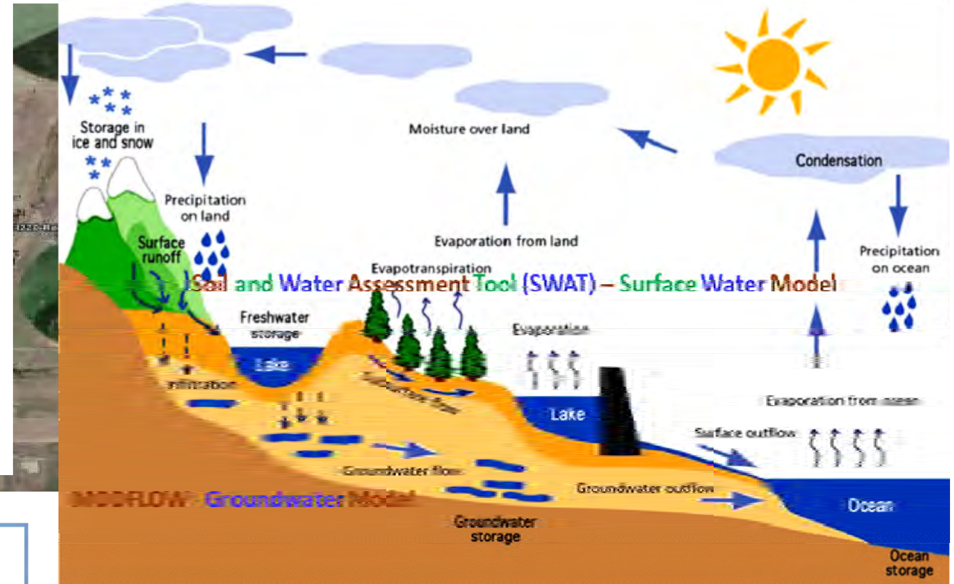
- Landuse and Agricultural Management Practices web-Service (**LAMPS**) automatically generates crop rotation and management information in space and time for conservation planning and modeling.

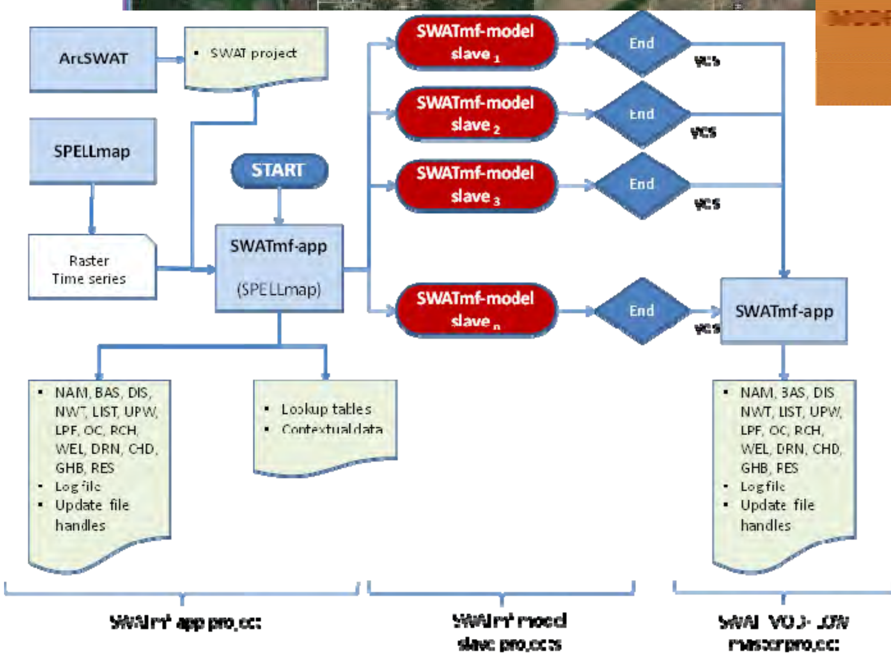
- NRCS Runoff Curve Number model (WinTR-20 **Hydrology Tool**) is deployed as a web service.



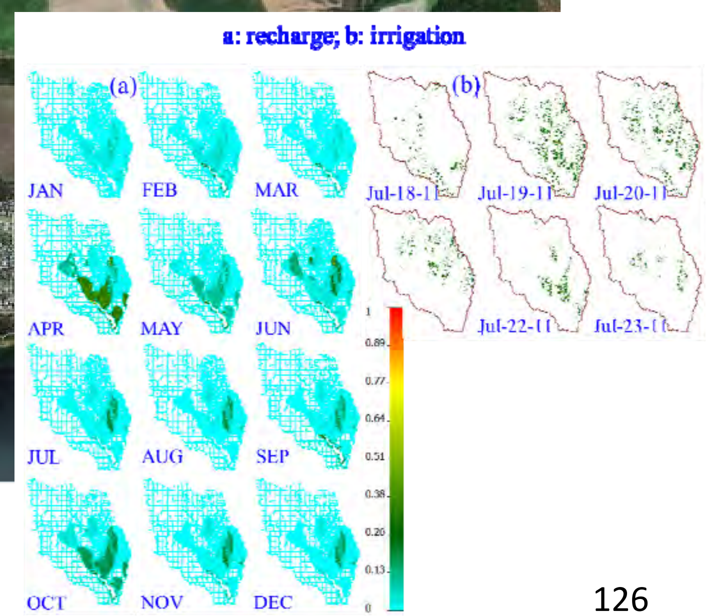
SWAT$_{mf}$: Integrated Surface-Groundwater Model El Reno, OK

- **Coupled SWAT and MODFLOW models**
- **The integrated model is expected to improve simulation of impacts of climate variability and change, land use change, and irrigation technology and management on transport of nutrients to aquifers in agricultural production systems and water resources.**

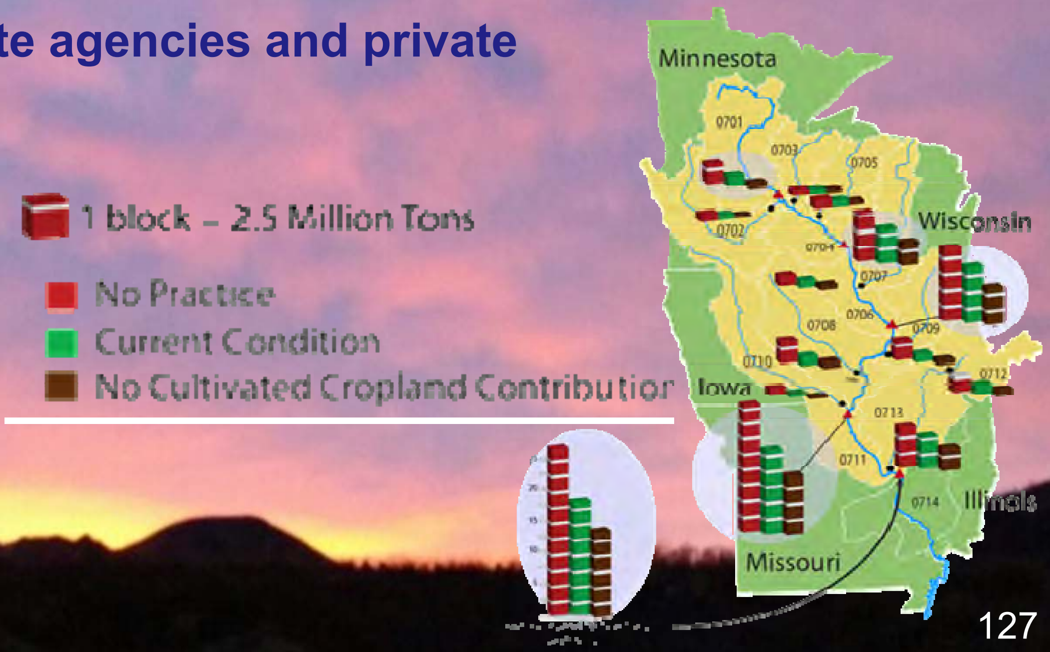




SWAT$_{mf}$: Integrated Surface-Groundwater Model



- **Enhanced Soil and Water Assessment Tool (SWAT) to better assess watershed-scale environmental effects of crop, forest, and rangeland management.**
  - **Modernized data structures and modules.**
  - **Developed web-based interface with an output analyzer and scenario analysis tools.**
  - **Improved flood plain, riparian zone, and gully erosion routines.**
  - **Better represented critical agricultural production regions.**
  - **Used by USGS for Hypoxia Task Force Assessments**
  - **DLL available and used by state agencies and private companies**



AGWA / KINEROS2 (K2)

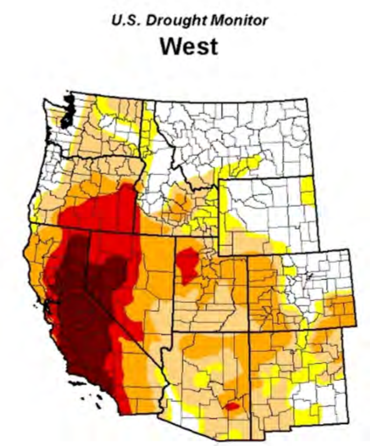
- **AGWA was developed by ARS, Tucson AZ in cooperation with EPA, U. of Arizona & Wyoming to predict the impacts of land cover change**
- **An <u>automated GIS interface</u> for watershed modeling designed for resource managers for applying three well-established ARS models using nationally available datasets in gauged / ungauged watersheds**
  - **KINEROS2 (K2)**
  - **SWAT**
  - **RHEM / WEPP (hillslope runoff and erosion within K2)**

<u>IMPACT:</u>

- **Adopted by Dept. of Interior National Burn Area Emergency Response (BAER) teams for rapid post-fire watershed assessments**
  - **Rapidly predicts "at-risk" areas to target fire mitigation – for the 130,000 ac 2013 Elk Fire in ID alone, it resulted in savings of ~$7.8M**
- **AGWA/K2 analysis on Cienega Creek as part of Agency Perf. Goal (APG) resulted in new Nat. strategy for USDA's Strategic Plan (FY'14 –'18, p 17)**
- **AGWA has 4000+ registers users; 10,500+ downloads in 170 countries; >250 citations; K2 has 700+ citations; training sessions, tutorials**


New Remote Sensing Tools to Track Water Stress and Improve Water Management

Improving Water Management in the Western US
Boise, ID and NASA JPL Partnership



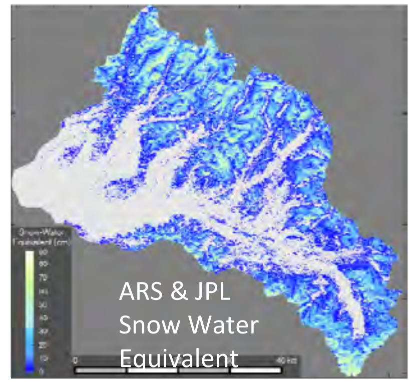
Increased demand combined with reduced water supply requires careful water management, but *operational forecasting models are unreliable during droughts*. The ARS-Boise worked with JPL-NASA to improve matters. The result is an improved operational water supply application.

Widespread, multi-year drought
Economic Impacts:

- Estimated loss of $2.2 billion to agriculture (2015)
- Energy production
- Natural habitat
- Land subsidence
- Increased wildfire activity
- Thousands of jobs lost

NASA-JPL provides

Basin-scale airborne measurements of snow depth and albedo using Lidar and spectrometer data from weekly acquisitions during spring (2013, 2014, 2015).



ARS provides

Simulated snow water storage using the *iSnobal* model developed by the ARS at the Reynolds Creek Experimental Watershed in Idaho. Research supported by several recent publications.

Highly successful outcomes

Product shared with Hetch Hetchy (San Francisco) water managers for operations

Due to improved water supply forecasting the program is expanding to cover the entire Sierra Nevada Range.

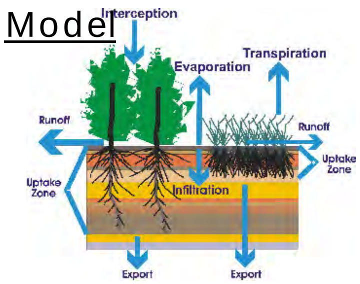
Airborne LiDAR and Snow Model

iSnobal: the ARS snow model
Providing densities to determine SWE

Global root-zone monitoring

Global Root-Zone Soil Moisture Monitoring for USDA FAS Beltsville, MD

Soil Water Balance Model

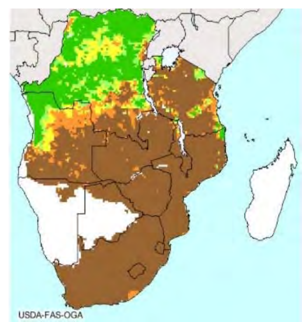


ESA SMOS

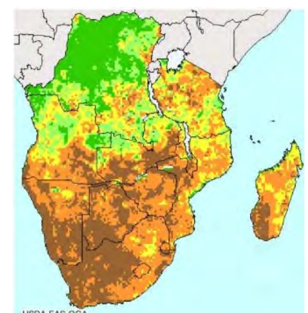
Data Assimilation

USDA FAS

Model



Model + SMOS



3-day, global, 0.25° root-zone soil moisture products posted at: http://www.pecad.fas.usda.gov/cropexplorer/

Routine operational delivery to USDA FAS crop production analysts.

Mapping Crop Phenology and Daily Water Use/Stress at Sub-Field Scales Beltsville, MD

Multi-sensor data fusion

TOOLS

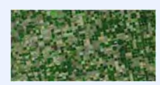
STARFM	Multi-sensor data fusion
DMS	Thermal image sharpening
ALEXI	Multi-scale ET modeling

SATELLITE ASSETS

		SW/TIR
GEO	Hourly	5km/5km
MODIS	Daily	250m/1km
Landsat	16 day	30m/100m
Lsat-like		~20-60m/ --

APPLICATIONS
(daily/30 m resolution)


Crop phenology metrics

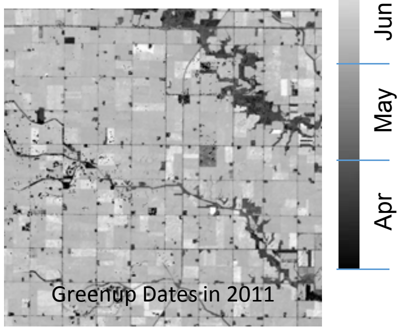

Crop water use (Evapotranspiration)

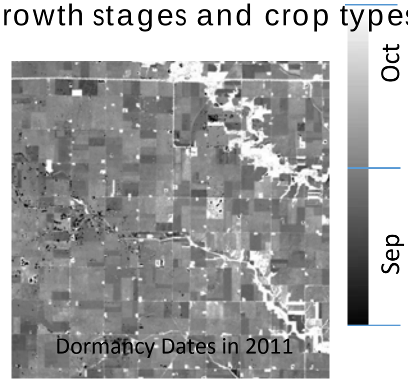

Crop stress (drought early warning)

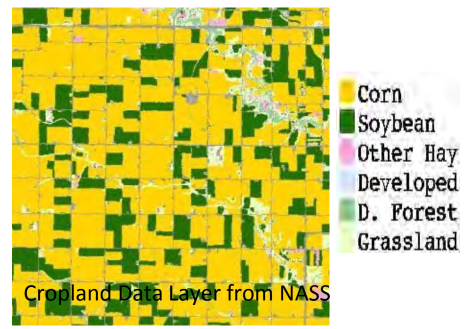
Multi-sensor data fusion

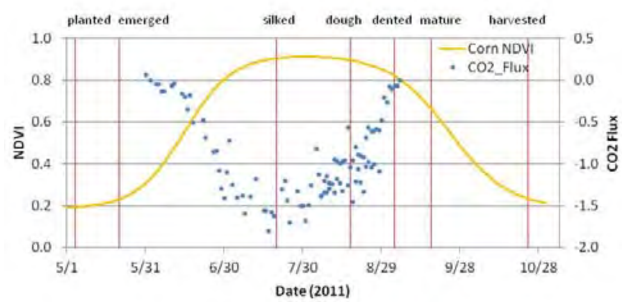
MAPPING CROP PHENOLOGY Beltsville, MD

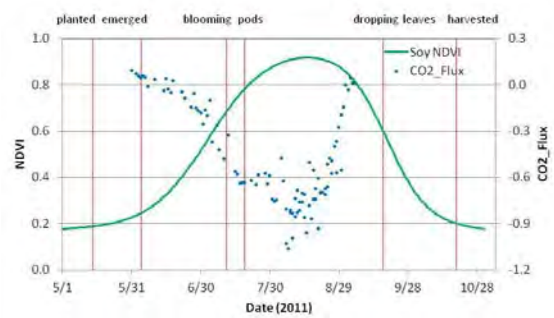
Crop progress and condition are reported weekly at state and district levels by the National Agricultural Statistics Service (NASS). The ground data collection supporting this effort is time consuming and subjective. HRSL scientists have developed remote sensing approaches for mapping crop phenology by fusing Landsat and MODIS satellite imagery. The remotely sensed crop phenology at field scale (30m) is clearly related to observed crop growth stages and crop types.











Why LTAR?

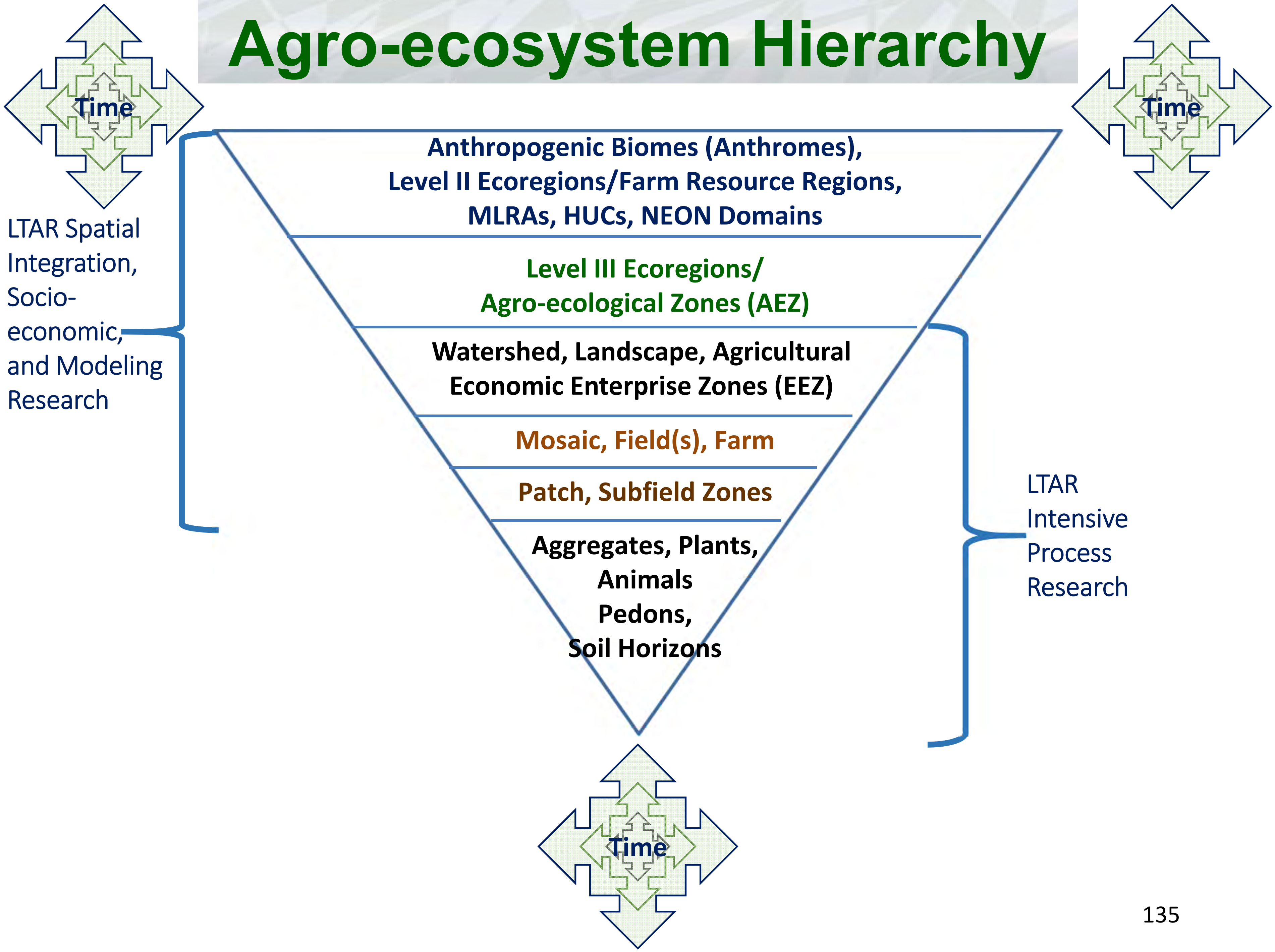
Agriculture must transform itself.....

- **INTENSIFY RAPIDLY**
- **BECOME CLIMATE SMART**
- **BE SUSTAINABLE***

- ***Satisfy human needs for food, feed, and fiber, & contribute to biofuel**
- **Enhance environmental quality & the resources base**
- **Sustain economic viability of producers**
- **Enhance the quality of life for farmers, farm workers, & society as a whole**

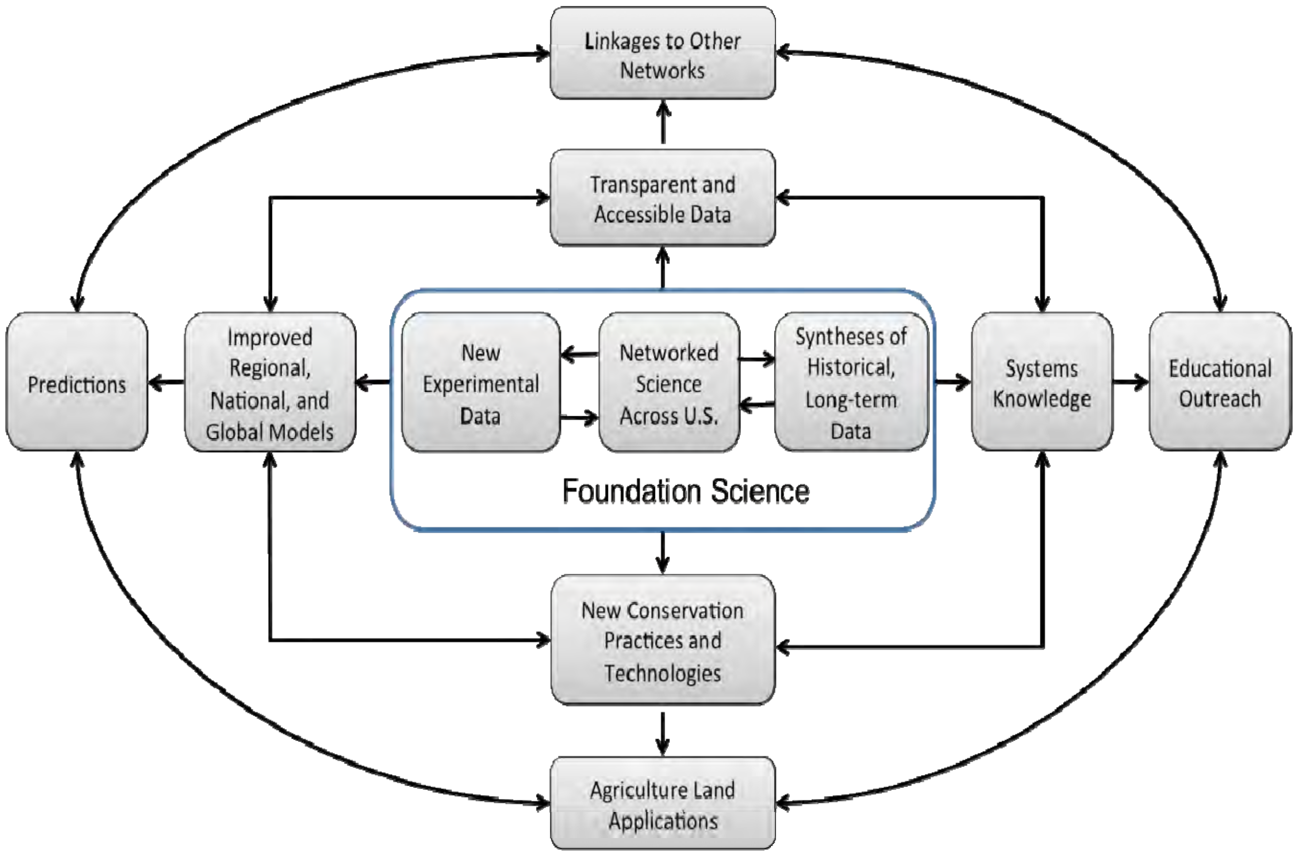
-Agricultural Sustainability defined by its goals (NAS, 2010)

Agro-ecosystem Hierarchy



LTAR

Understanding the ability of agricultural production systems to adapt to changing conditions (adverse and beneficial) while sustaining societal and ecosystem services.



The foundation science activities of the LTAR network (figure center) result in key products (middle rectangle) that lead to an array of outcomes (outer ring).

Questions on Problem Area 4?

Improving Watershed Management
and Ecosystem Services in
Agricultural Landscapes

Wrap Up

NP211 – Water Availability and Watershed Management

Steve Evett, Acting NPL

Thank You

Time for Panel Discussion

William Hargrove and Panel