An Integrated Modeling Approach for Assessment of Impacts of Conservation Practices on Water Quality in the Ohio-Tennessee River Basins in USA

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Presentation Overview

- CEAP National Assessment –
  - Integrated Modeling Approach
  - HUMUS/SWAT/APEX Modeling Approach
  - Databases Used for Deriving Model Inputs

- Ohio-Tennessee River Basins
  - Calibration and Validation

- Benefits of Conservation Practice Scenarios Simulated in the River Basin
  - Off-site water quality impacts

- Future Direction

Conservation Effects Assessment Project (CEAP) - National Assessment

SWAT/APEX Modeling Approach

CEAP - National Assessment : Goal

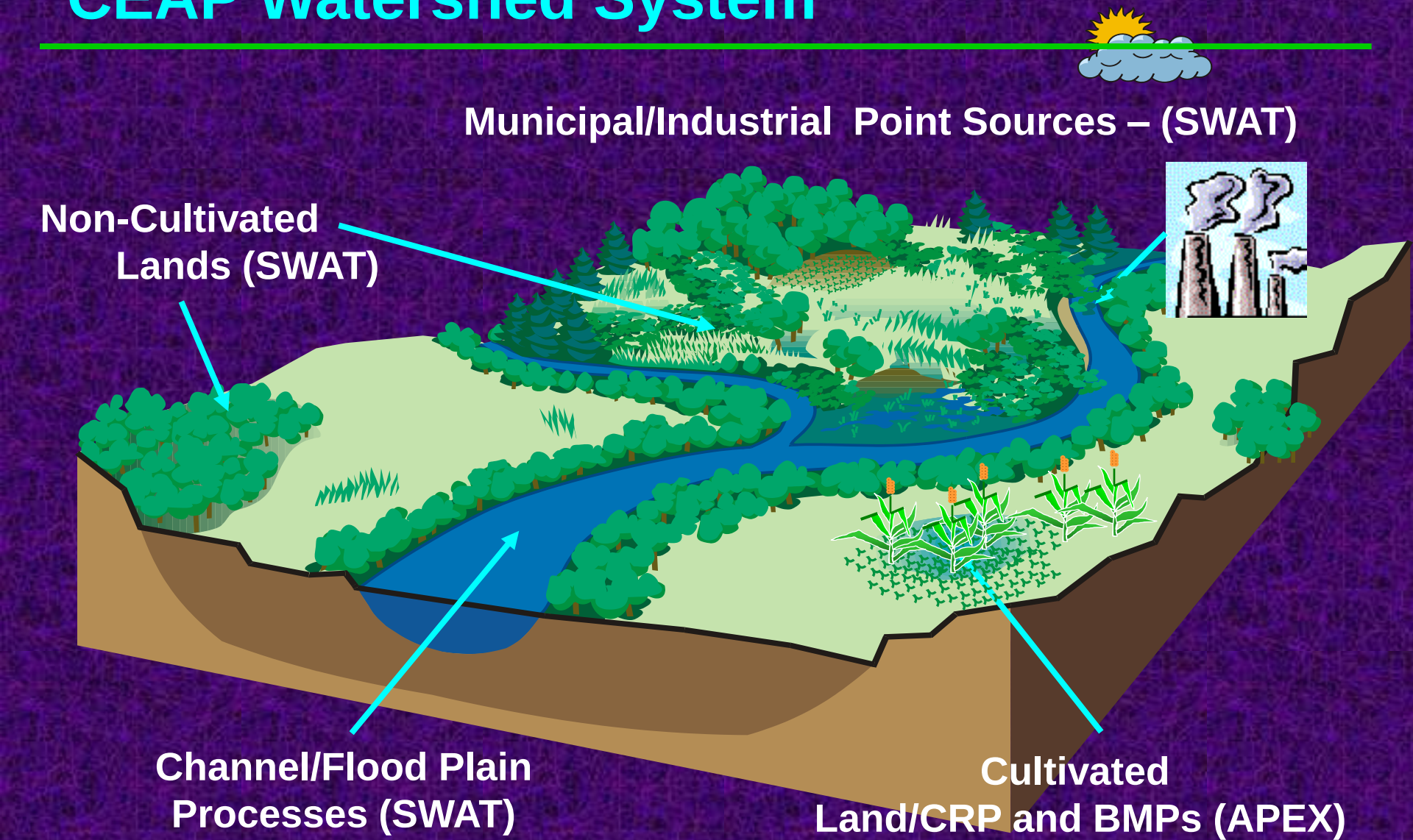
- To measure the environment benefits of conservation programs currently implemented on cropland at regional/ national level (on-site and off-site benefits) and

- To assess the potential additional environmental benefits with additional conservation treatment needs to meet the nation's natural resources needs

Presentation Focus

To assess how much the water quality conditions are improved currently in river basins in US due to conservation practices and programs and how far it can be improved in future

CEAP Watershed System



APEX : Agricultural Policy Environ. Extender

SWAT : Soil and Water Assessment Tool

APEX-SWAT model integration for CEAP national assessment

SWAT

APEX

Flow, TSS and nutrient loadings from Point Sources

Flow, sediment, nutrient and pesticide loadings from Non-Cultivated Land HRUs

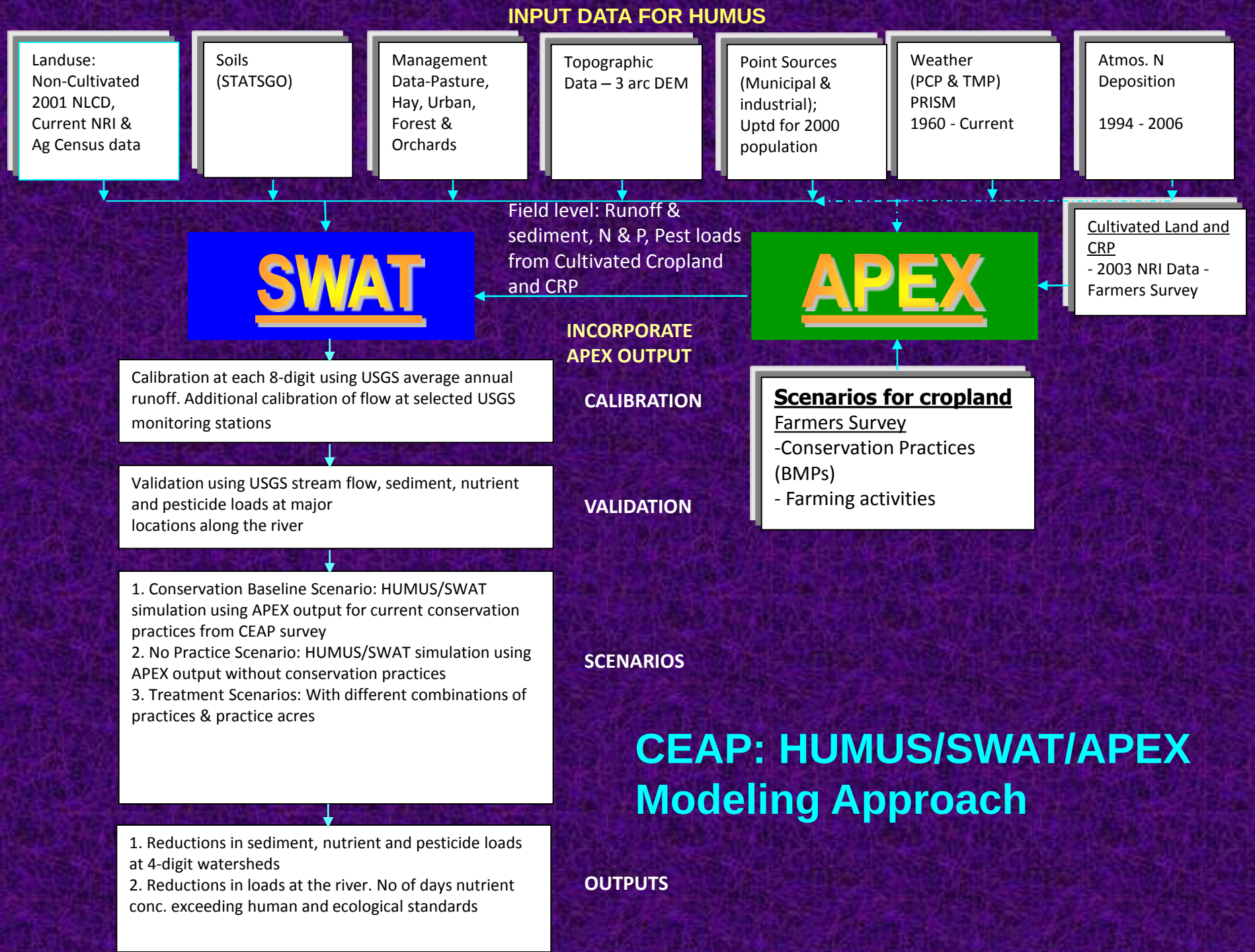
Flow, sediment, nutrient & pesticide loadings from Cultivated Cropland &CRP subareas with BMPs

Routing through reach, ponds, reservoirs to 8-digit watershed outlet

Continue routing and adding 8-digit watershed flows through main routing reaches along the river

Outputs: Simulated flow, sediment, nutrient and pesticide loadings for analysis

CEAP: HUMUS/SWAT/APEX Modeling Approach



Databases Used for CEAP/HUMUS

- ***Subbasin:*** **Each 8-digit watershed as a subbasin. Each river basin as a watershed in SWAT**

- ***Weather*** **: Daily precipitation and temperature data developed for 8-digit watersheds using National Climatic Data Center point measurements and monthly Parameter-elevation Regressions on Independent Slopes Model (PRISM) grids.**

- ***Point Source Data*** **: Effluent discharge from municipal and industrial treatment plants; USGS point source database adjusted for 2000 pop. conditions**

- ***Atmospheric Nitrogen Deposition*** **: Loads and concentrations developed for 8-digit watersheds using National Atmospheric Deposition Program/National Trends Network database - yearly deposition grids.**

Databases Used for CEAP/HUMUS/SWAT

- *Land use* : 2001 USGS-National Land Cover Data (NLCD) at 30-m res; 2003 National Resources Inventory (NRI) land use and 2003 Ag-Census data to derive model inputs (HRU, Apex and Swat land use)

- *Soils* : STATSGO database – soils for HRU

- *Management* : Management operations from planting, fertilizer, irrigation and harvesting; Heat units based operation scheduling for HRUs
  - ✓ Pasture and hay land: CAFO-manure application
  - ✓ Pasture and Range- Grazing and manure excretion application
  - ✓ Urban land – simulation of impervious area (parking lots) and pervious area (lawns)
  - ✓ Forest (Mixed, Deciduous and Evergreen)
  - ✓ Horticultural/Orchards
  - ✓ Forested and non-forested wetlands

Practices Simulated Within APEX

a) Structural Practices Simulated

In-field Practices for water erosion control

- Contour Farming
- Strip Cropping
- Contour Buffer Strips
- Terraces
- Grass Terraces
- Tile Drain

- Grade Stabilization Structures
- Grassed Waterways
- Diversion

Edge of field Practices for buffering

- Vegetative Barrier
- Filter Strips
- Riparian Forest Buffers
- Riparian Herb. Cover
- Field Borders

Wind Erosion Control Practices

- Windbreak / Shelterbelt
- Herbaceous Wind Barrier
- Hedgerow planting
- Cross Wind Practices

b) Annual Practices Simulated Within APEX

- Residue management practices and reduced tillage management practices
- Nutrient management practices – (Fertilizers, Manure: rate, time, method)
- Pesticide management practices
- Irrigation management practices
- Cover crops

c) Long-term conservation cover

- Conservation Reserve Program - Grass or trees grown on cropland

Calibration and Validation

- Spatial calibration of annual runoff in both SWAT and APEX models at 8-digit watersheds
- Monthly stream flow calibration and validation at Metropolis, IL & Paduka, IL and other gaging stations on the two rivers
- Calibration of annual and monthly sediment, nitrogen, phosphorus and pesticide loads at the gaging stations
- Verification of land use wise water balance, sediment & nutrient losses
- Automated calibration procedure

Conservation Practice Scenarios

- ***Current Conservation Condition Scenario*** **: HUMUS/SWAT simulation for the basin using APEX output for current conservation practices on cropland & CRP using CEAP farmer's survey**

- ***No Practice Scenario*** **: HUMUS/SWAT simulation using APEX output assuming no practices were implemented on cropland.** *To assess the worse status (Lower bound of benefits)*

- ***Background :*** **HUMUS/SWAT simulation using APEX output with grass-tree mix grown on cultivated cropland/CRP. Includes source loadings from non-cultivated land and point sources from SWAT.** *To assess the status with no cultivated cropland contribution (Upper bound of benefits)*

Conservation Practice Scenarios

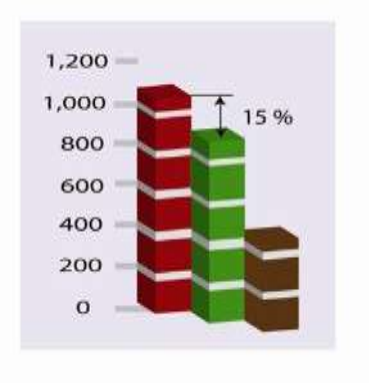
- **Evaluate the potential gains of environmental benefits from additional conservation treatment**

- ***Additional Treatment Need Scenarios*** **: HUMUS/SWAT simulation using APEX output with various combinations of erosion control and nut.mgt conservation practice treatment options and acres of additional treatment need**

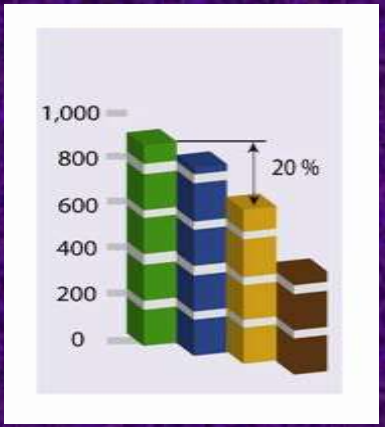
  - **Enhanced Nutrient Management Treatment of Critically Under Treated Acres:** *Critical under-treated acres have a high need for additional treatment.*
  - **Enhanced Nutrient Management Treatment of All Under-Treated Acres:** *Under-treated acres have either a high or moderate need for additional treatment.*

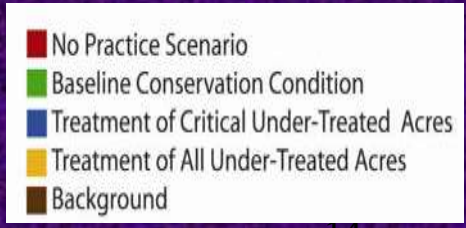
Offsite Water Quality Impacts

a) Determine limits (bounds): By comparing current conservation condition scenario with no practice and background



b) Treatment of under-treated areas: By comparing current conservation condition scenario with additional treatment need scenarios





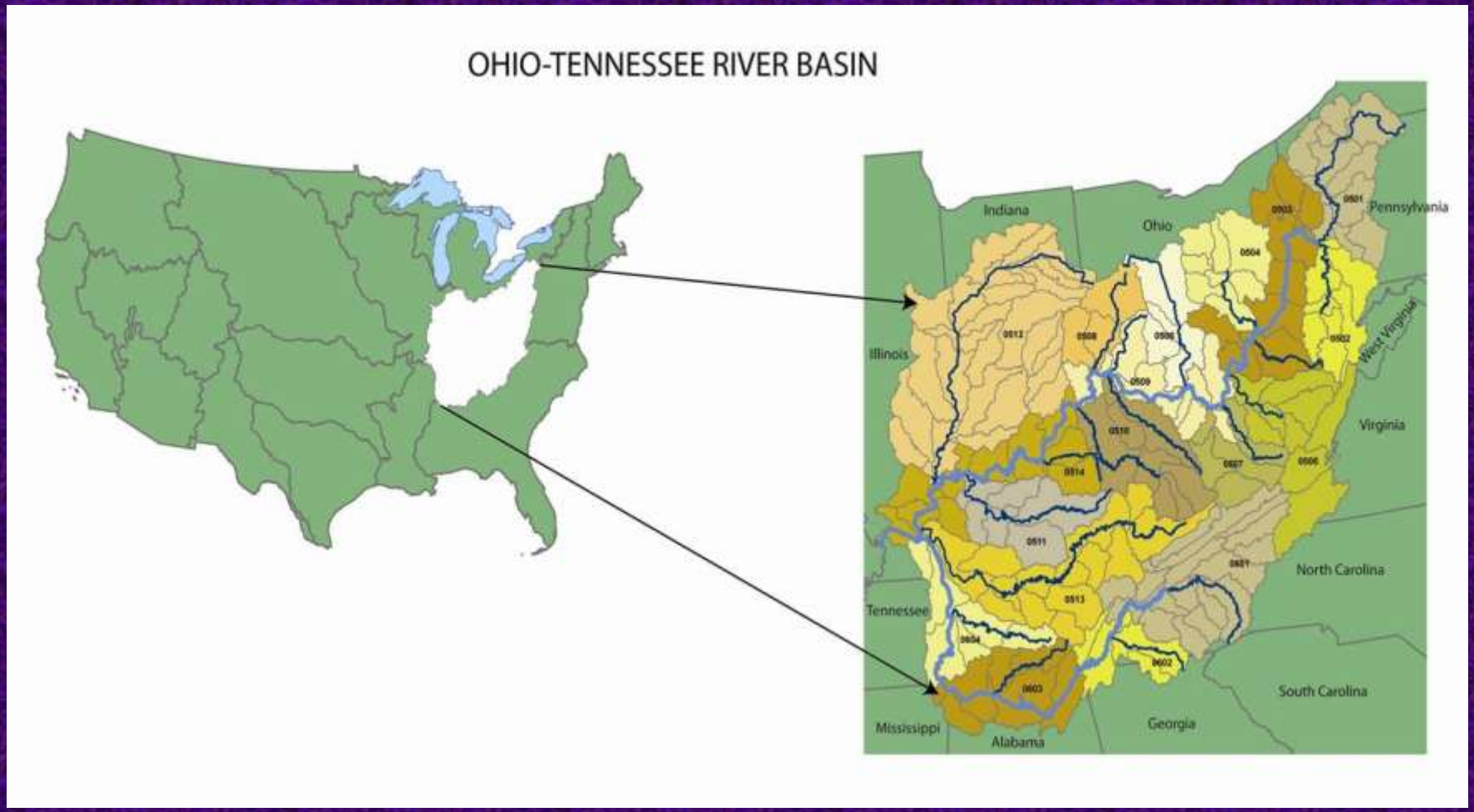
Offsite Water Quality Impacts

Systematic assessment of benefits from field to the watershed outlet in a basin

Reductions in source loads or instream loads

1. **Edge-of-Field from cultivated cropland and CRP**
2. **Delivery to the 8-digit watershed outlet from cultivated cropland and CRP**
3. **Delivery to the 8-watershed outlet from all sources including non-cultivated land and point sources**
4. **Instream loads – All sources aggregated and routed through rivers and reservoirs**
5. **Reductions in concentrations at key river locations**

Ohio-Tennessee River Basin



Ohio-Tennessee River Basin

Ohio River Basin

DA – 421,780 Sq.km (ohio)

Cropland and CRP - 24%

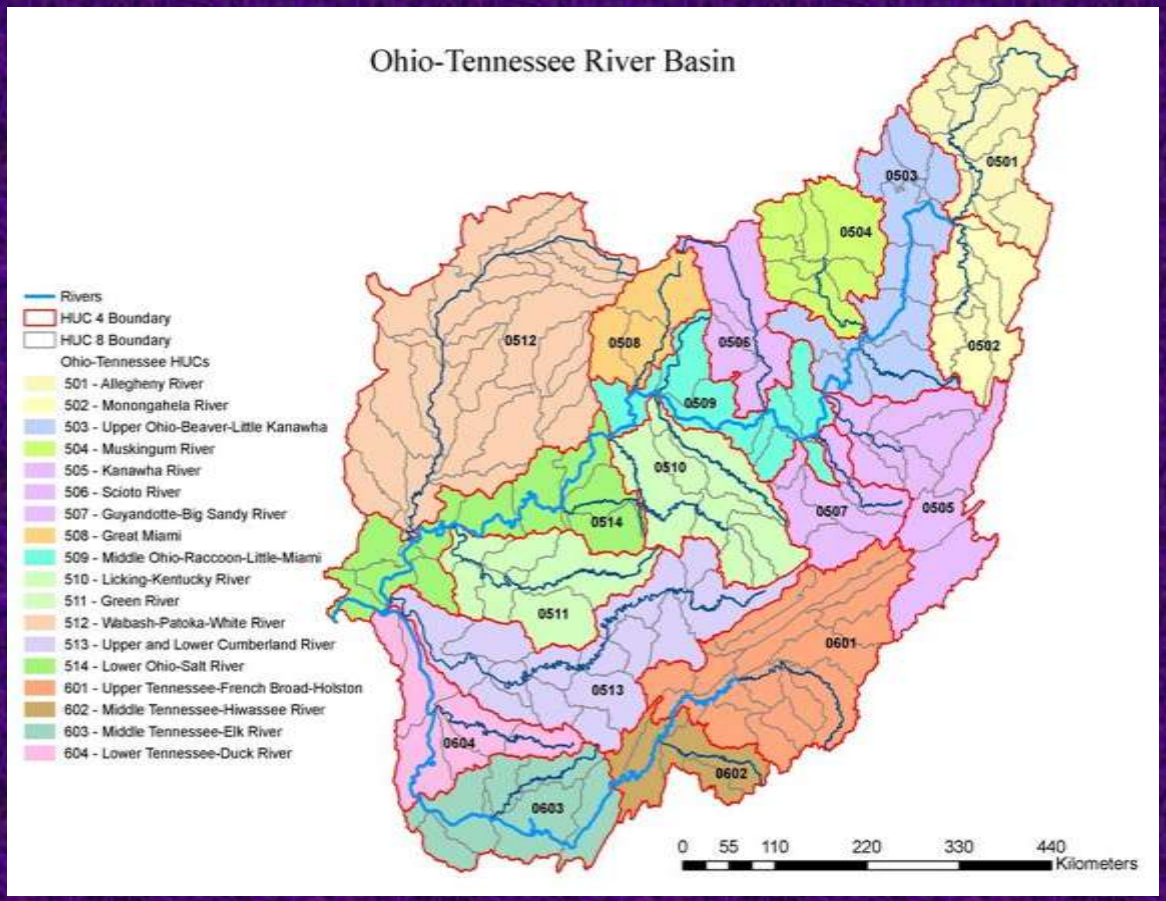
Non-cultivated Land - 76%

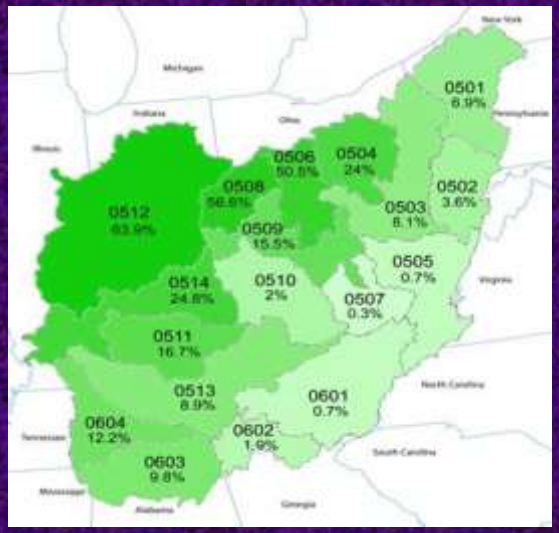
Tennessee River Basin

DA – 105,750 Sq.km.

Cropland and CRP - 5%

Non-cultivated Land - 95%

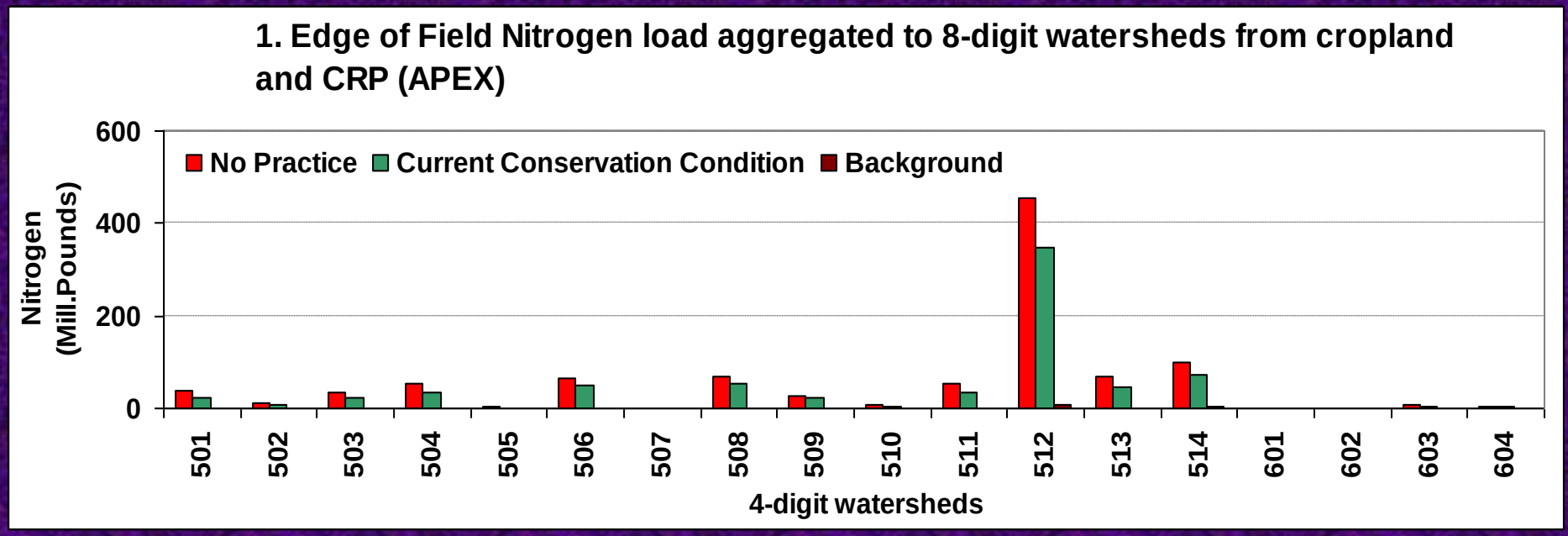


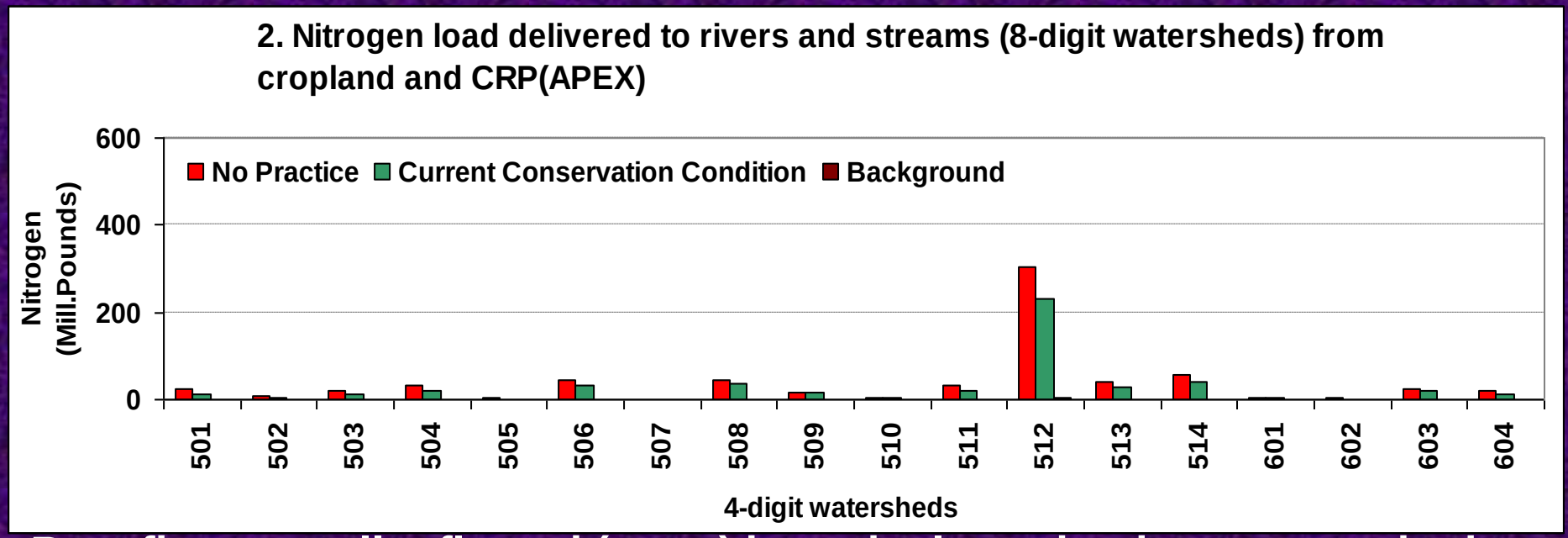


Cultivated cropland & CRP (%)

18, 4-digit watersheds &
152, 8-digit watersheds

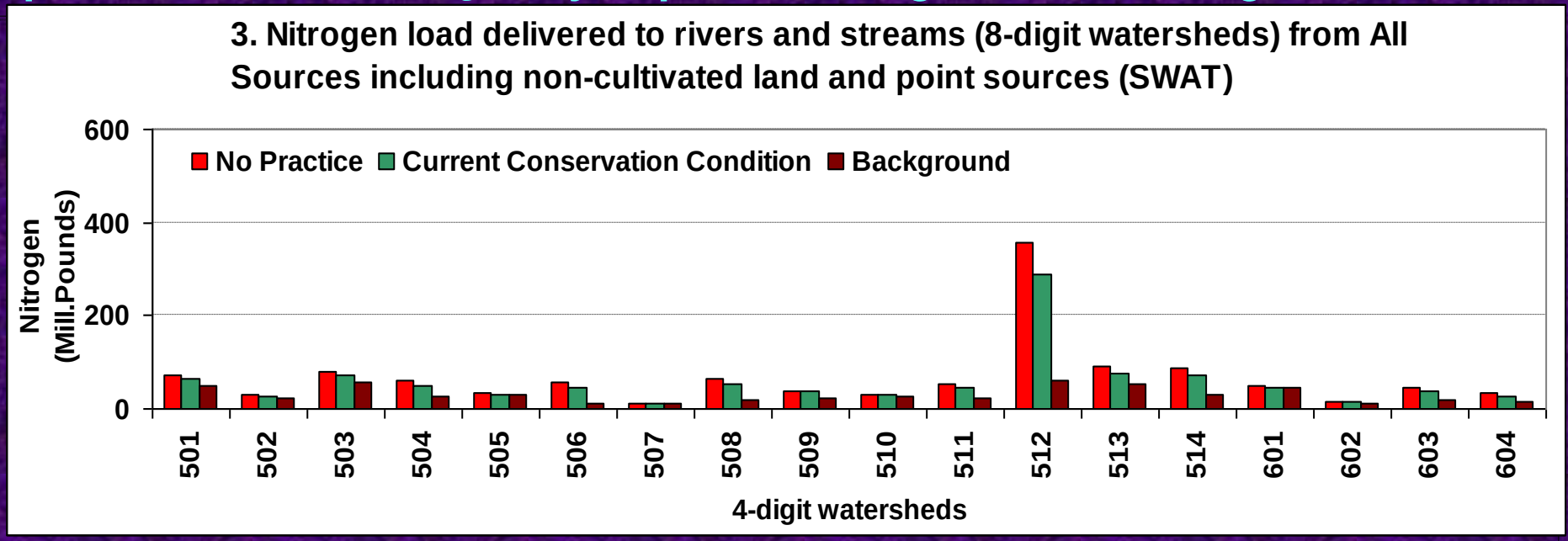
Spatial offsite Water Quality Impacts: Nitrogen load at 4-digit watersheds

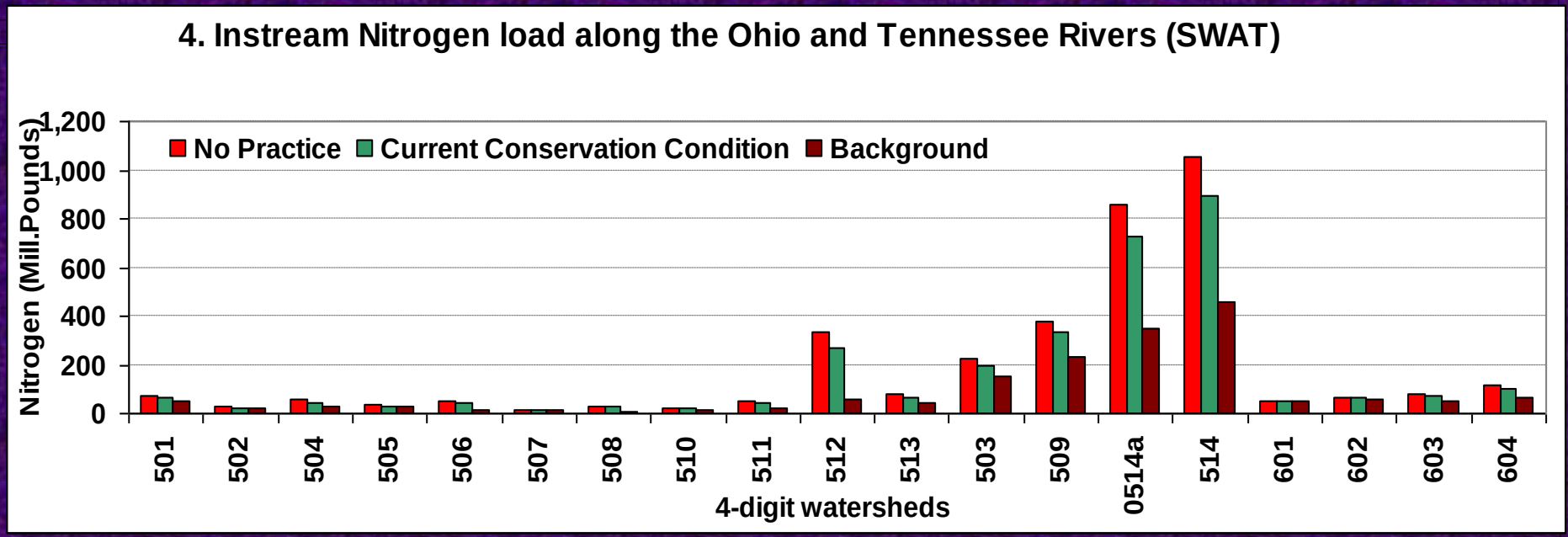




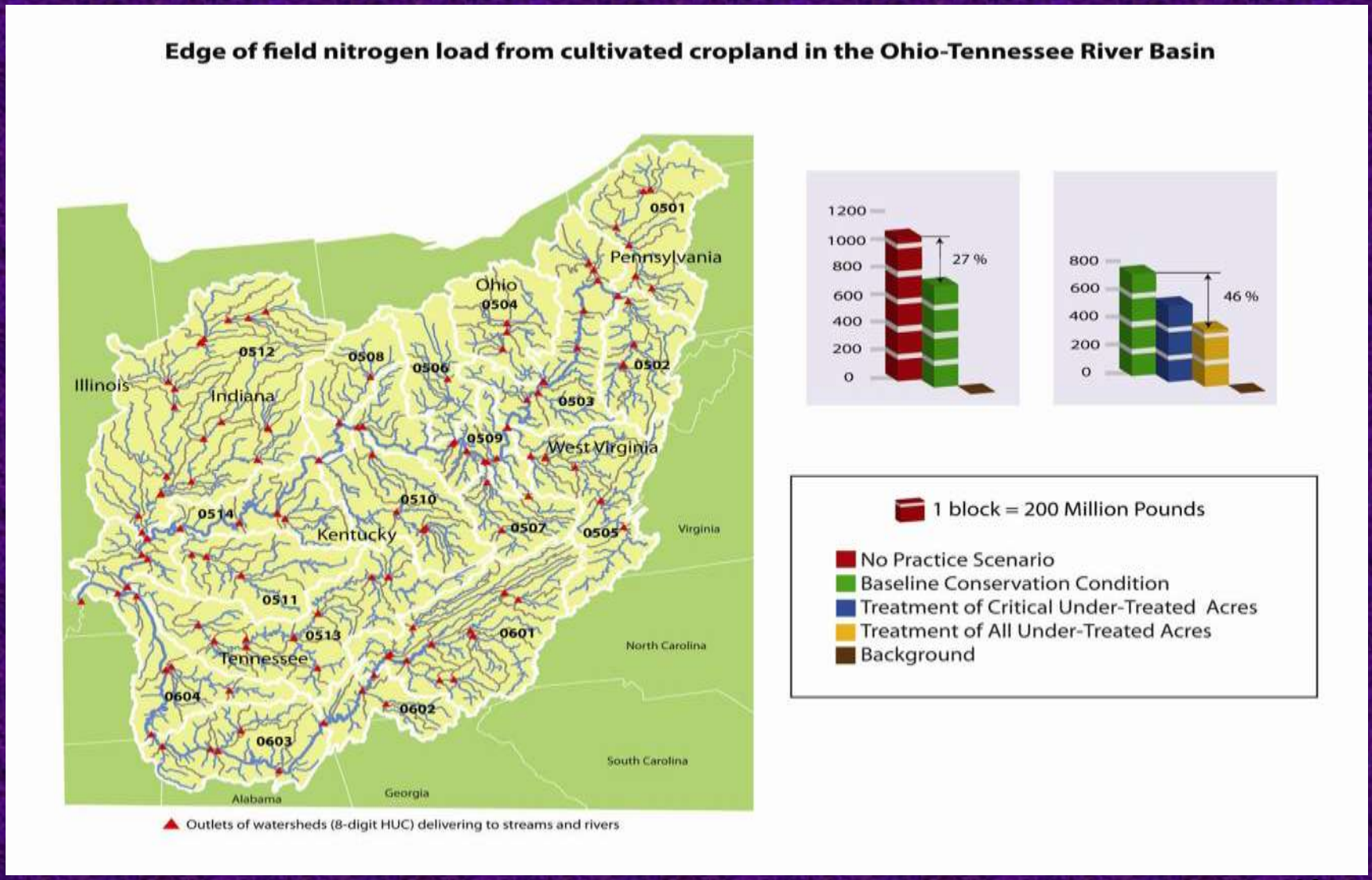
Benefits are well reflected (more) in agriculture dominant watersheds

Spatial Offsite Water Quality Impacts: Nitrogen load at 4-digit watersheds





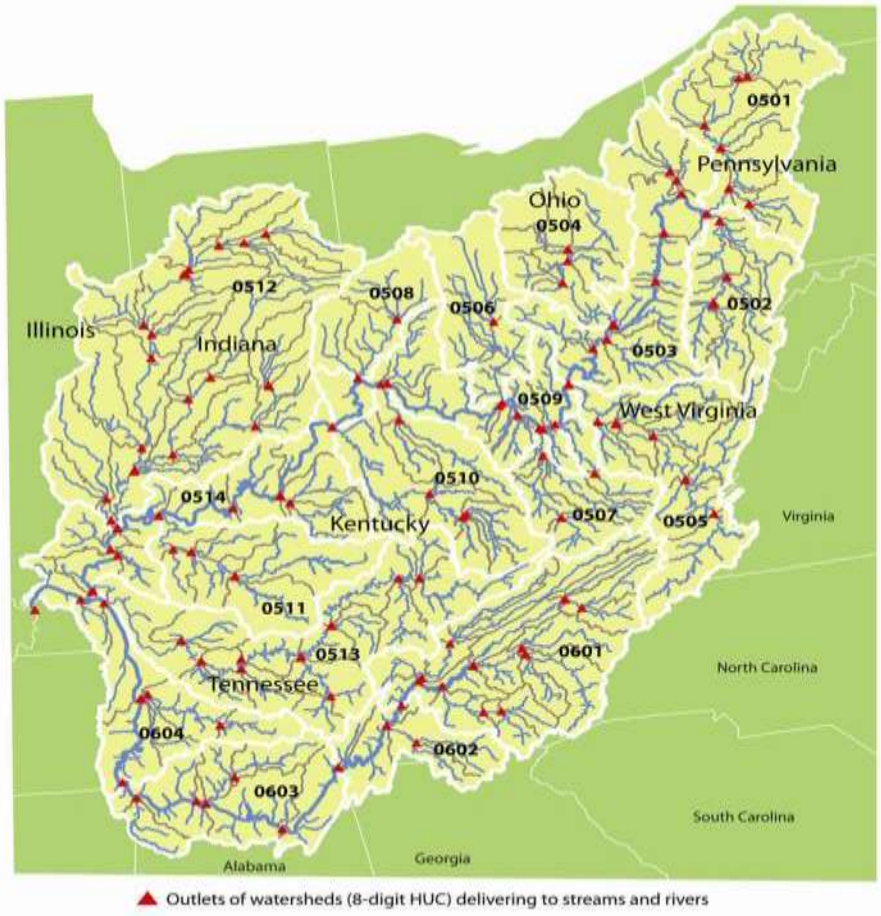
Reductions in Edge of Field Nitrogen Load from cultivated cropland and CRP for the Basin

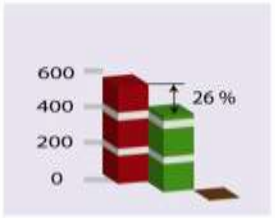


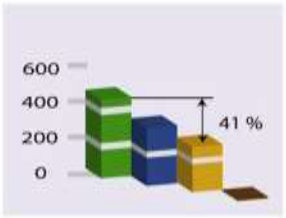
Targeting critical acres improves conservation effectiveness significantly

Reductions in Nitrogen Load delivered to 8-digit watersheds from cultivated cropland for the Basin

Nitrogen delivered from cultivated cropland to rivers and streams in the Ohio-Tennessee River Basin







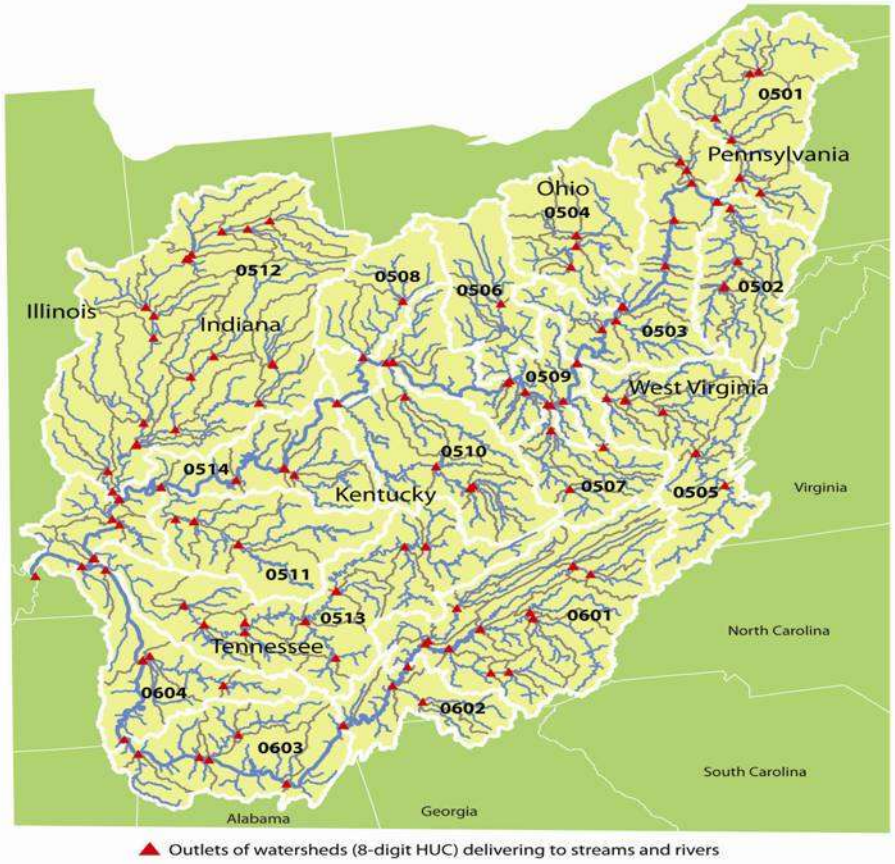
1 block = 200 Million Pounds

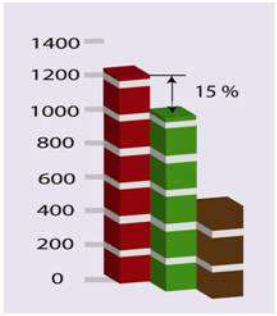
- No Practice Scenario
- Baseline Conservation Condition
- Treatment of Critical Under-Treated Acres
- Treatment of All Under-Treated Acres
- Background

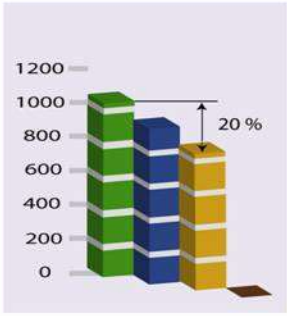
Reductions in Nitrogen Load delivered to 8-digit watersheds from all sources for the Basin

All Sources: Cultivated cropland, non-cultivated land & point sources

Nitrogen delivered from all sources to rivers and streams in the Ohio-Tennessee River Basin



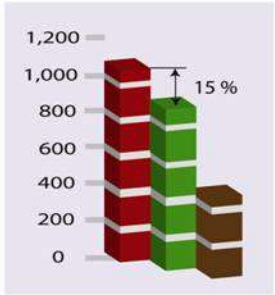


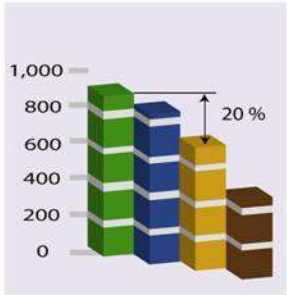


Reductions in Instream Nitrogen Load for the Basin

Nitrogen delivered to the Mississippi River from the Ohio-Tennessee River Basin (all sources - instream loads)

- Outlets of Ohio-Tennessee Rivers delivering to the Mississippi River
- Outlets of watersheds (4-digit HUCs) on the main stem of the Ohio-Tennessee Rivers
- Outlets of tributary/minor river watersheds (4-digit HUCs) delivering to the Ohio-Tennessee Rivers



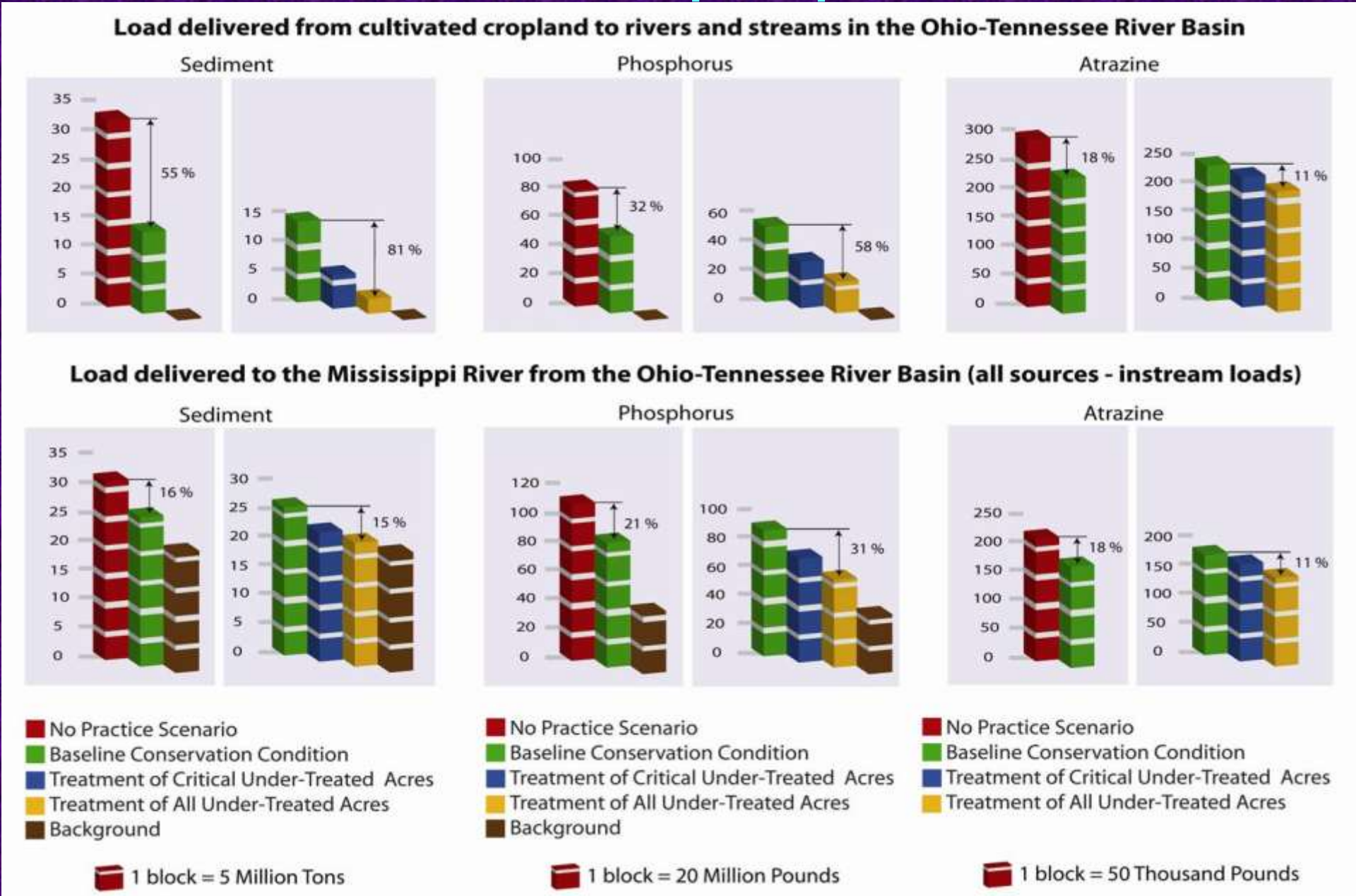


1 block = 200 Million Pounds

- No Practice Scenario
- Baseline Conservation Condition
- Treatment of Critical Under-Treated Acres
- Treatment of All Under-Treated Acres
- Background

Targeting Conservation Increases its Impact

Reductions in sediment, phosphorus and atrazine



Application of the National Modeling Framework

Modeling is a potential tool for generating science based information for improving the efficacy of conservation practices/programs and policy planning

"Quantitative and science based information" are useful for policy makers and planners

- **To assess the impacts of existing conservation practices on water quality**
- **To assess future conservation treatment needs and develop new programs more effectively and efficiently**
- **To make comprehensive planning, better resource management and regional and national policy planning**

Future Direction

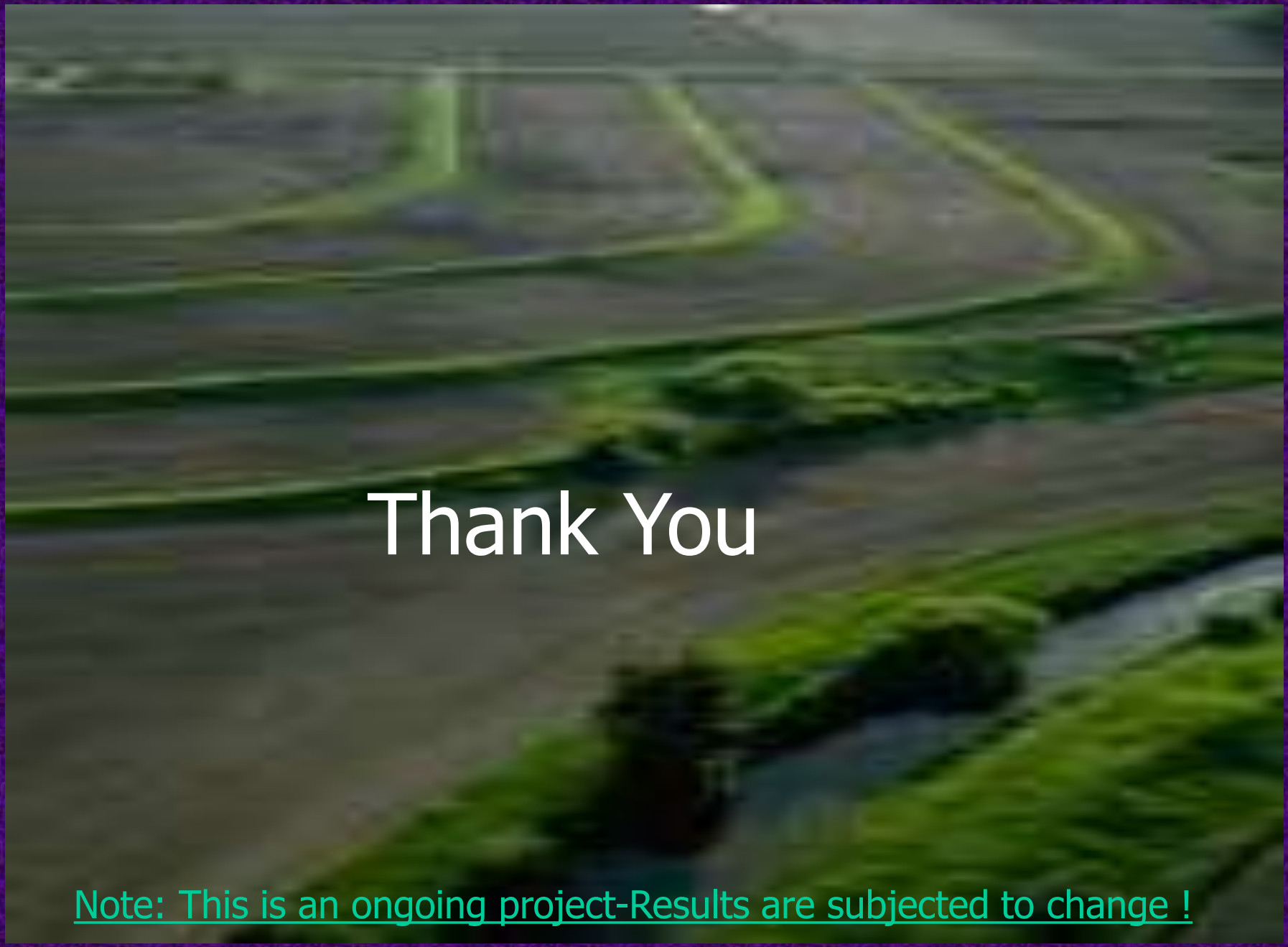
- Continuous Improvement of Model Routines and Databases

- Calibration & Validation with additional gages & data

- River Basin Analysis – Mississippi Basin and Other Basins

- Future Scenarios –
  Evaluate and Identify Natural Resource Problems & Find Solutions

  - Bio-Fuel Production
  - Climate Change Scenarios
  - Carbon Credit Analysis
  - Source Contribution and Targeting on Priority Areas


Thank You
Note: This is an ongoing project-Results are subjected to change !