Modeling Sediment and Nutrient Loads Input to Great Lakes and Effects of Agricultural Conservation Practices on Water Quality

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USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

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Texas A&M System

Presentation Overview

- CEAP National Assessment
  - CEAP/SWAT/APEX Modeling Approach

- Great Lakes Basin – Calibration and Validation

- Determine the Sediment and Nutrient Load Input to each of the Great Lakes

- Determine the Major Sources of Sediment and Nutrients discharged to local waters in Great Lake Basin

- Determine the Off-site Benefits of Agricultural Conservation Practice Scenarios on Water Quality in each of the Great Lakes

Conservation Effects Assessment Project (CEAP) - National Assessment

Conservation programs/practices implemented in the US since 1960's and earlier to increase agricultural production, control soil erosion and nutrient losses and sustain the environment

CEAP – Cropland National Assessment : Goal

- To measure the environmental benefits of conservation programs <u>currently on cropland</u> at regional/national level, and

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

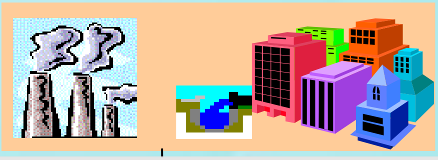
CEAP/SWAT/APEX National Modeling System

Watershed Configuration Details (Subbasins/Rivers/Routing/Reservoirs)

Landuse, Soils and Management Practices

Weather (Precipitation, Temperature and others)

Dry and Wet Atmospheric Nitrogen Deposition



SWAT Watershed Model (Calibrated)

APEX Farm Scale Model (Calibrated)

Point Sources: Flow, TSS and nutrient loadings from Municipal and Industrial Plants

Uncultivated Land: Flow, sediment, nutrient and pesticide loadings from HRUs

Cultivated Cropland &CRP: Edge of field flow, sediment, nutrient & pesticide loadings from subareas with practices

Effects on Edge of Field Water Quality

INTEGRATE APEX OUTPUT

Instream Processes: Routing through reach, ponds, reservoirs to 8-digit watershed outlet & through main river reaches to basin outlet

SCENARIOS

1. Current Conservation Baseline: SWAT simulation using APEX output with current conservation practices
2. No Practice: SWAT simulation using APEX output without conservation practices
3. Additional Treatment Need: SWAT simulation using APEX output with ENMC and ENMA
4. Background: SWAT simulation using APEX output with background grass-tree mix condition

Conservation Scenarios

1. Current Conservation Baseline: APEX inputs with current conservation practices from CEAP survey
2. No Practice: APEX inputs without conservation practices
3. Additional Treatment Need: APEX inputs with different combinations of practices & practice acres (ENMC and ENMA)
4. Background: APEX inputs with grass-tree mix condition on cropland

RESULTS

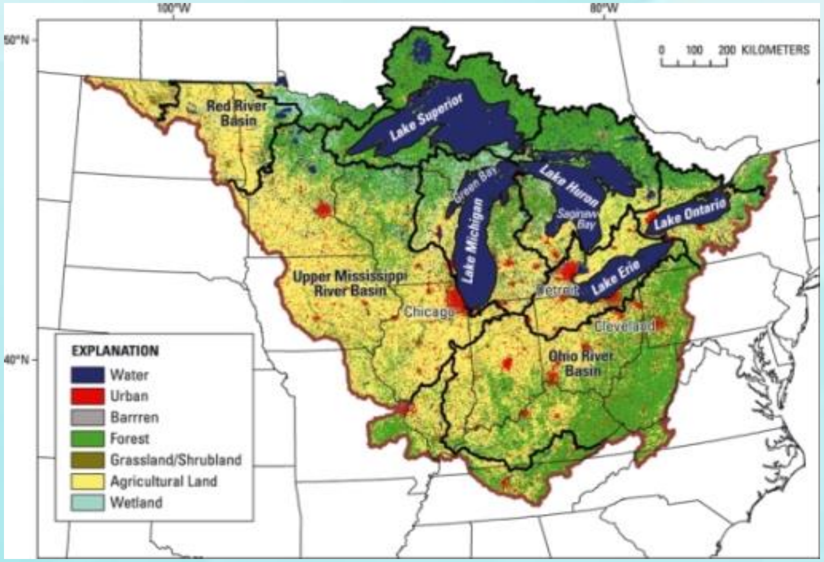
Effects on Local/Instream Water Quality

1. Reductions in sediment, nutrients and pesticide yields and loads at 8-digit watersheds due to current conservation practices and additional treatment practices on cropland
2. Reductions in instream loads at river points due to current conservation and additional treatment scenarios

NRI/Survey/Conservation Practice Details

- Structural Practices
- Cultural Management Practices
- Practice Acres
- Farming Activities/Survey Database
- NRI

Great Lakes Basin



Largest surface freshwater system in the world (21%). 84% of US Water Supply.

Population: 30 Million

Drainage Area: 521, 830 km^2 (US and Canada) (451,545 km^2)

7% - U.S. Farm Production

25% - Canadian Ag. Production

Dominant source of sediment and nutrients to the Lakes

Eutrophication–Low DO-Fish Kill

Lake Erie: P enrichment; Algal bloom

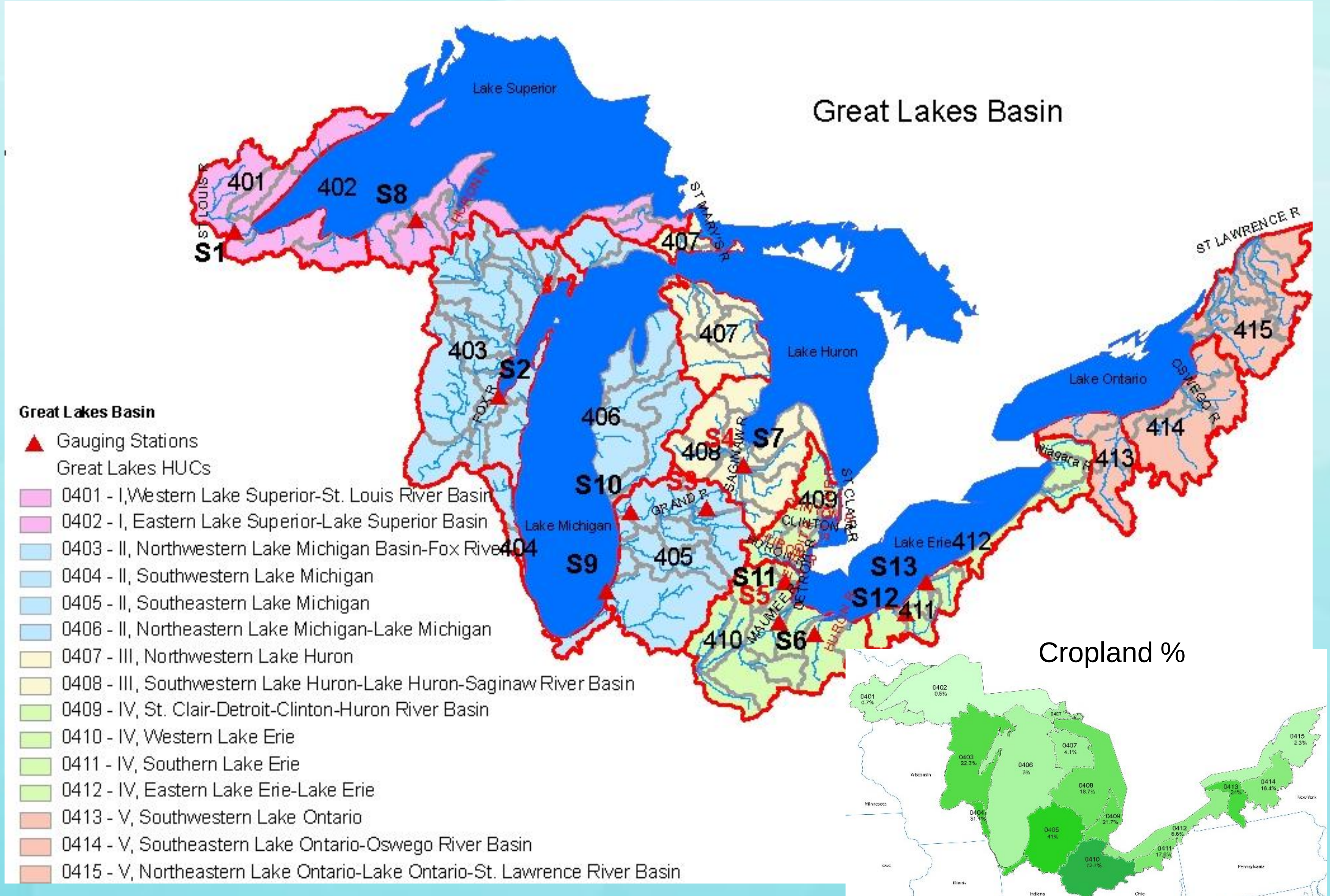
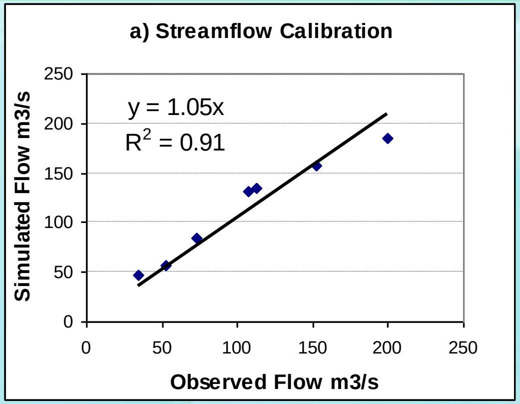


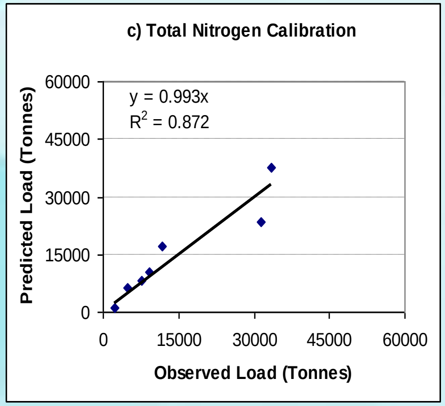
Figure. 1. Great Lakes Basin with gages and cropland area distribution

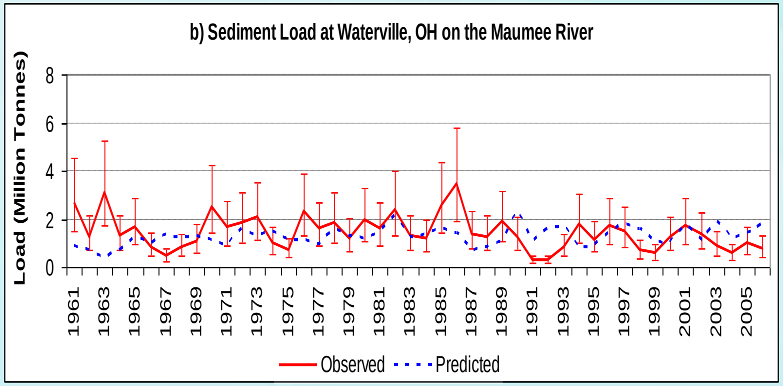
Calibration and Validation Gages

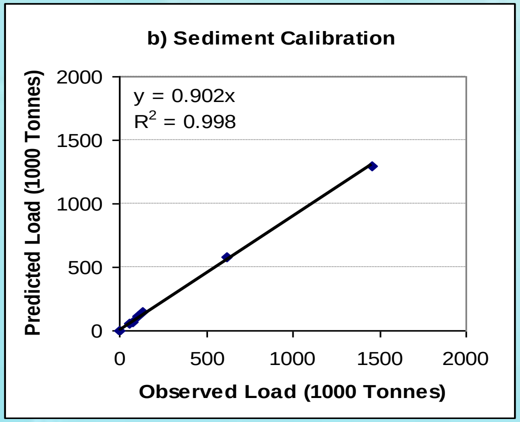
Gauging Station Name	Gage ID on Map	Hydrologic Unit Code	Lake	Drainage Area (km^2)
Calibration Gages				
St Louis River at Scanlon, MN	S1	04010201	Superior	8,884
Fox river at Appleton, WI	S2	04030204	Michigan	15,411
Grand River at Grand Rapids, MI	S3	04030204	Michigan	12,691
Saginaw River at Saginaw, MI	S4	04080206	Huron	15,695
Maumee River at Waterville, OH	S5	04100009	Erie	16,395
Sandusky River near Fremont OH	S6	04100011	Erie	3,240
Oswego River at Oswego, NY	S7	04140203	Ontario	13,209
Validation Gages				
Ontonagon River near Rockland, MI	S8	04020102	Superior	3,471
St. Joseph River at St. Joseph, MI	S9	04050001	Michigan	12,095
Grand River at Eastmanville, MI	S10	04050006	Michigan	13,701
River Raisin near Monroe, MI	S11	04100002	Erie	2,699
Cuyahoga River Independence, OH	S12	04110002	Erie	1,831
Grand River near Painesville OH	S13	04110004	Erie	1,774

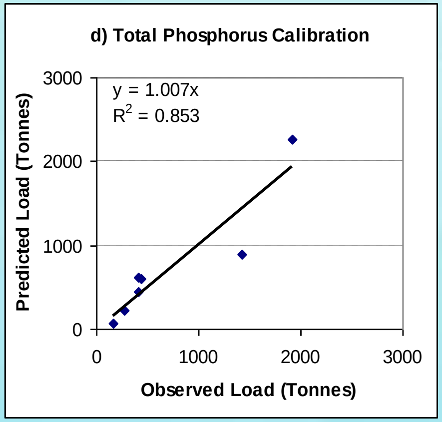
Calibration Results at the Gages

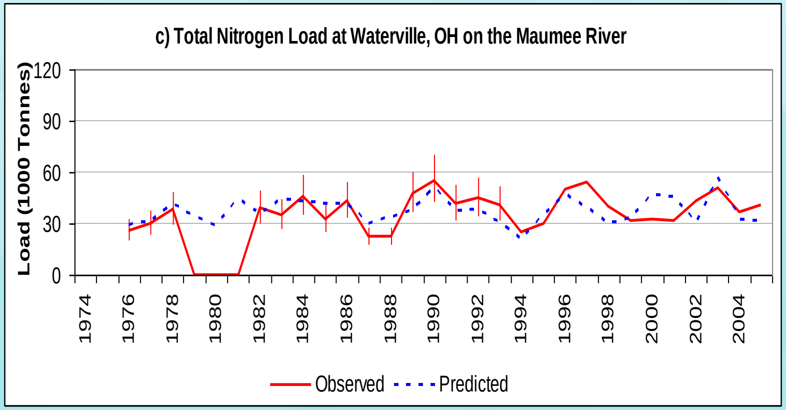


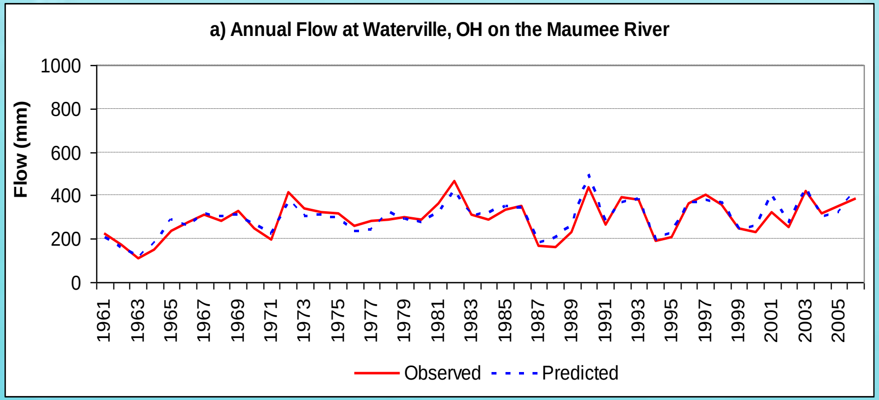


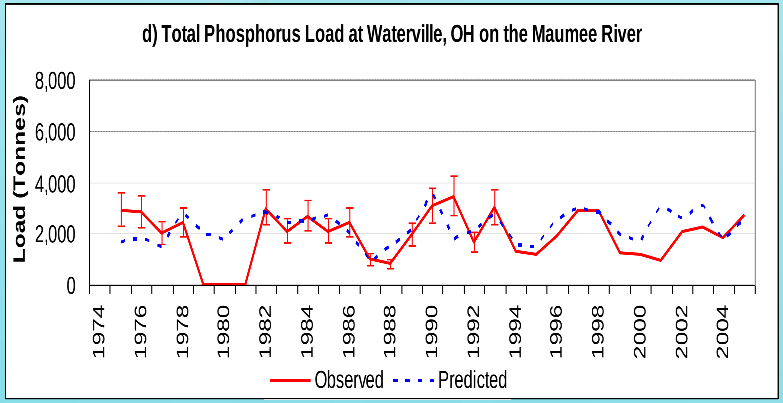




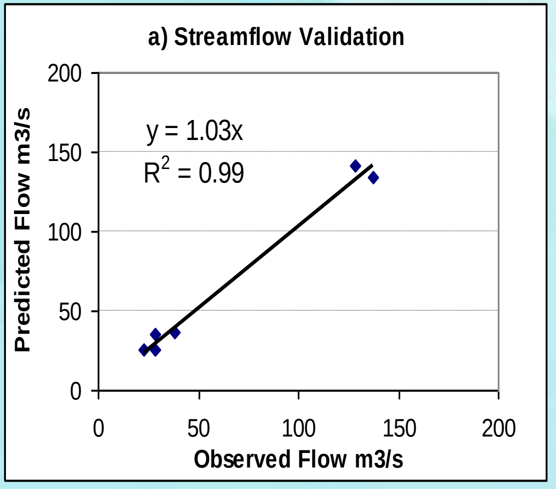


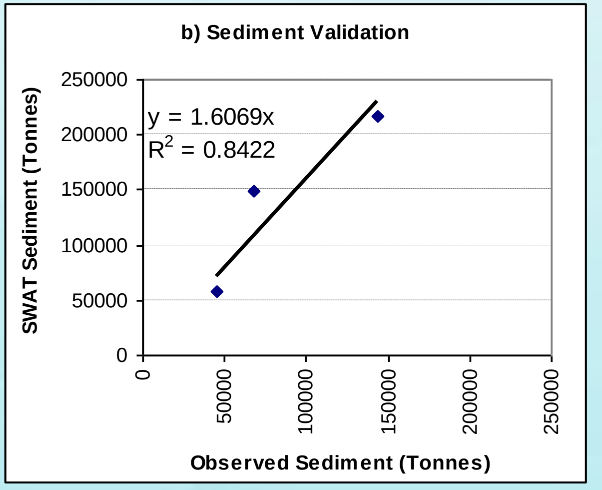


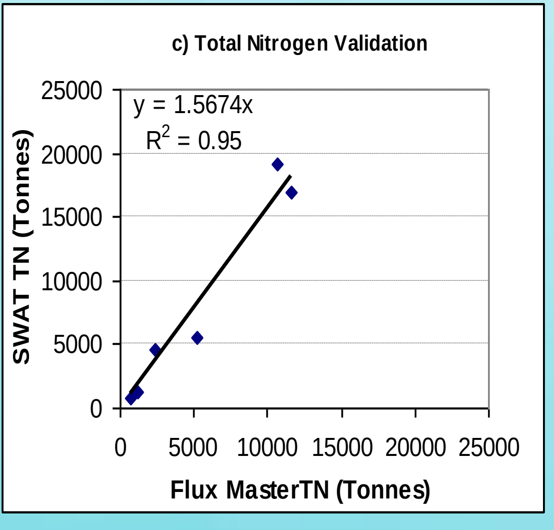


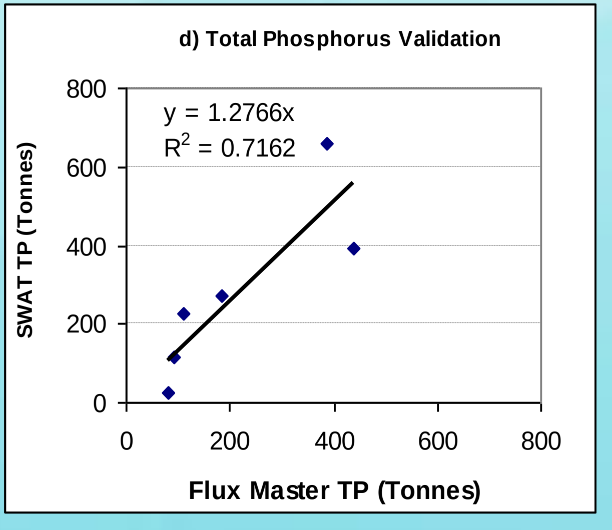


Validation Results at the Gages

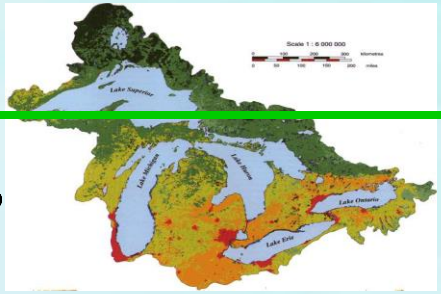








Specific Objectives

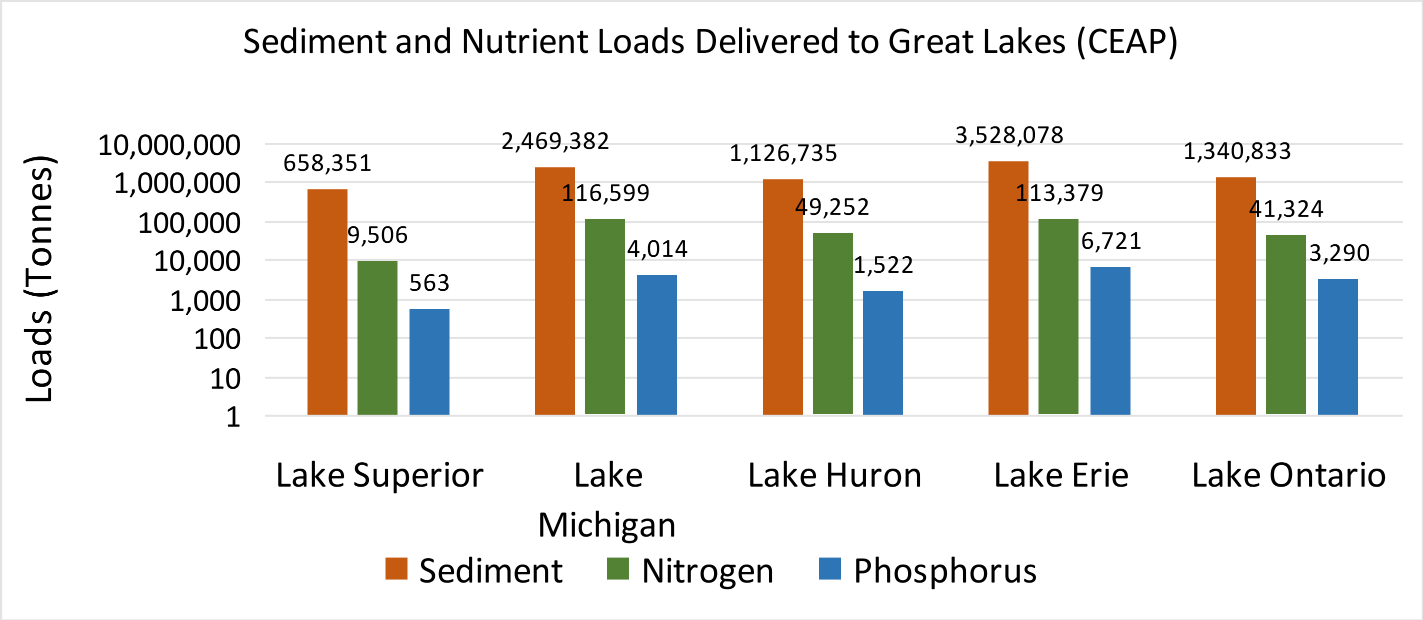


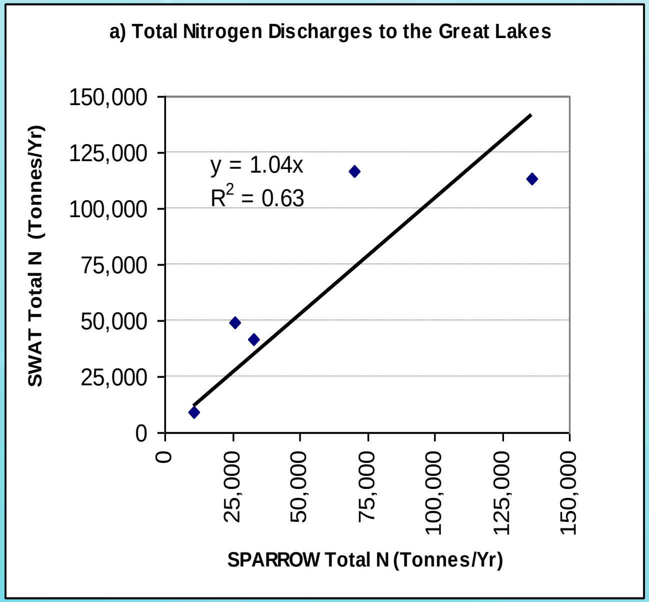
1) Estimate the sediment and nutrient loads discharged to each Great Lake,

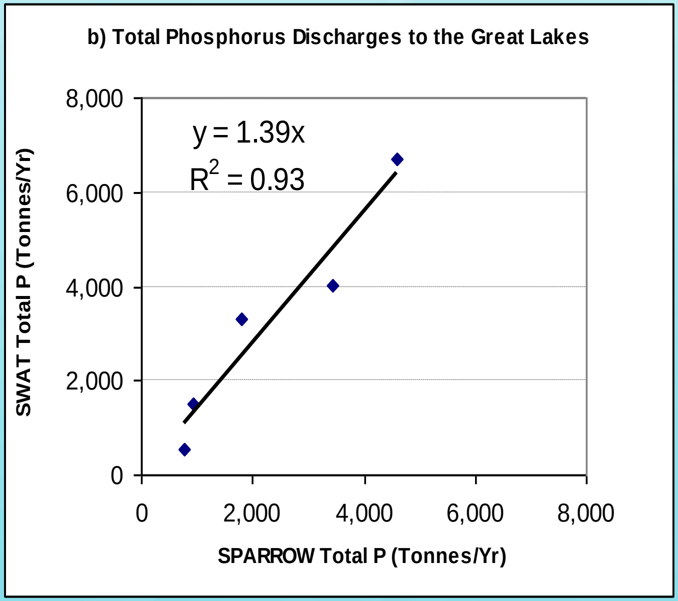
2) Determine the major sources of sediment and nutrients delivered to local waters in each Great Lakes Basin, and

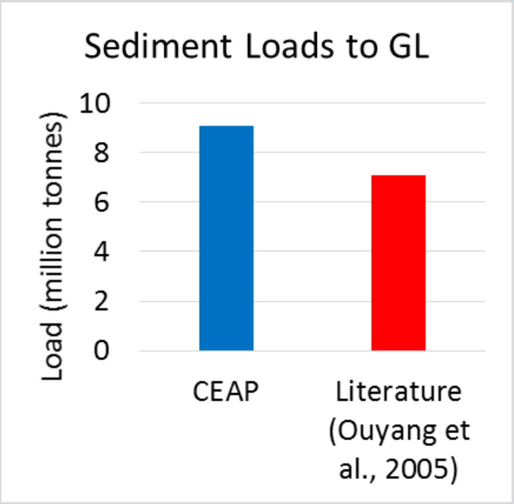
3) Evaluate the effects of current agricultural conservation practices and future conservation needs on water quality in the Great Lakes Basin

Loads Discharged to Great Lakes: Prediction and Validation



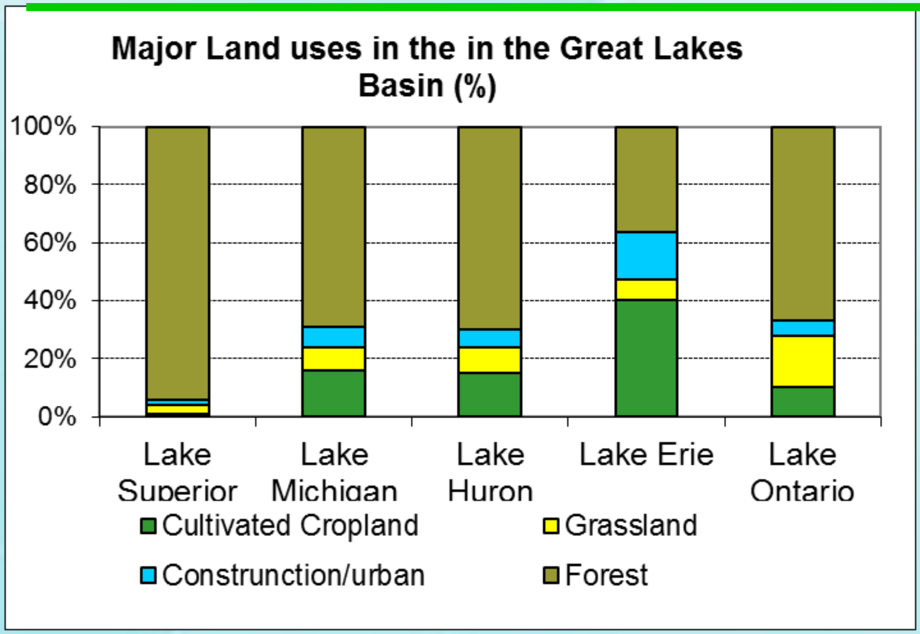


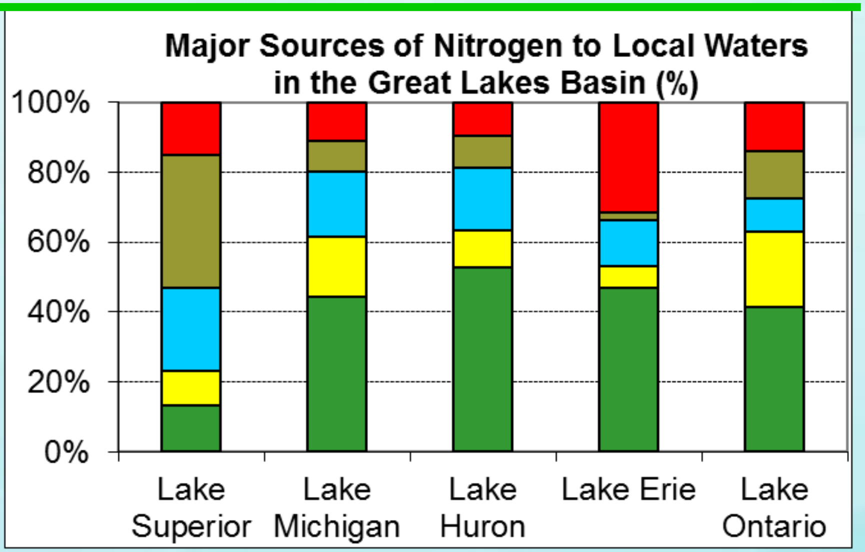


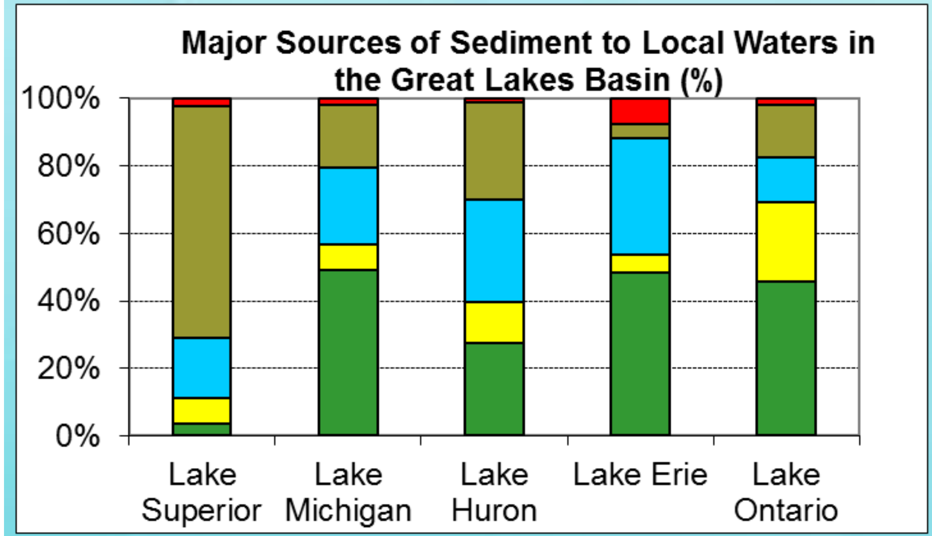


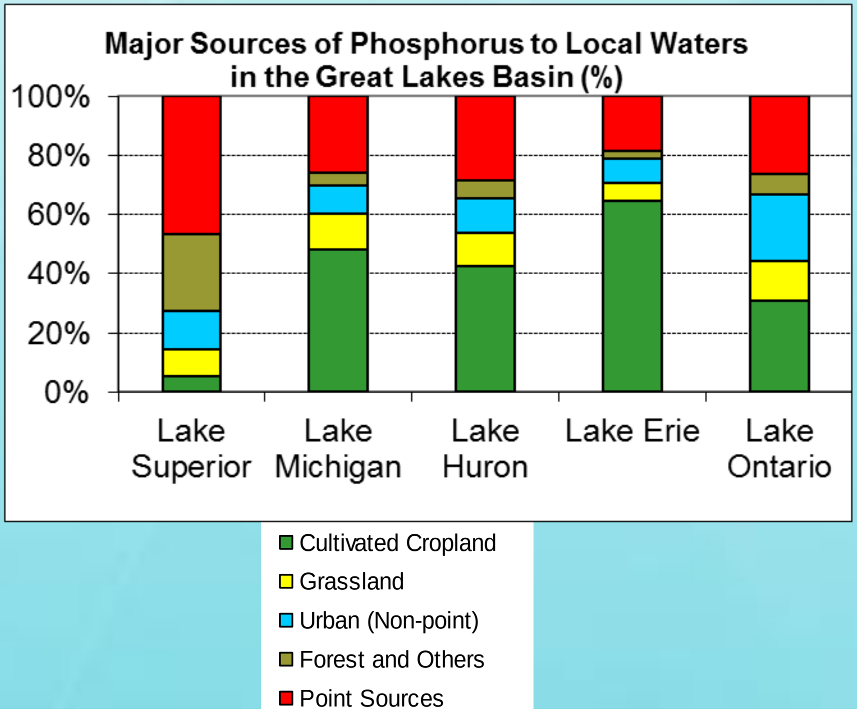
(without wind, gully and bank erosion)

Sources of Sediment and Nutrients









Practices Simulated Within APEX

a) Structural Practices

In-field Practices for 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

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

Wind Erosion Control Practices

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

b) Cultural/Agronomical Management Practices

Residue, tillage, nutrient, pesticide and irrigation management practices and cover crops

c) Long-term conservation cover:

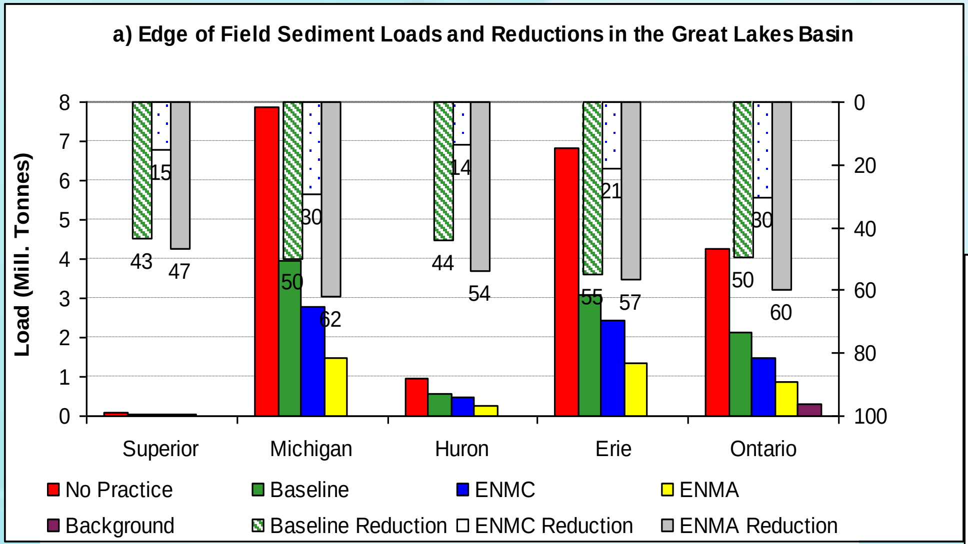
Grass/trees planted on cropland

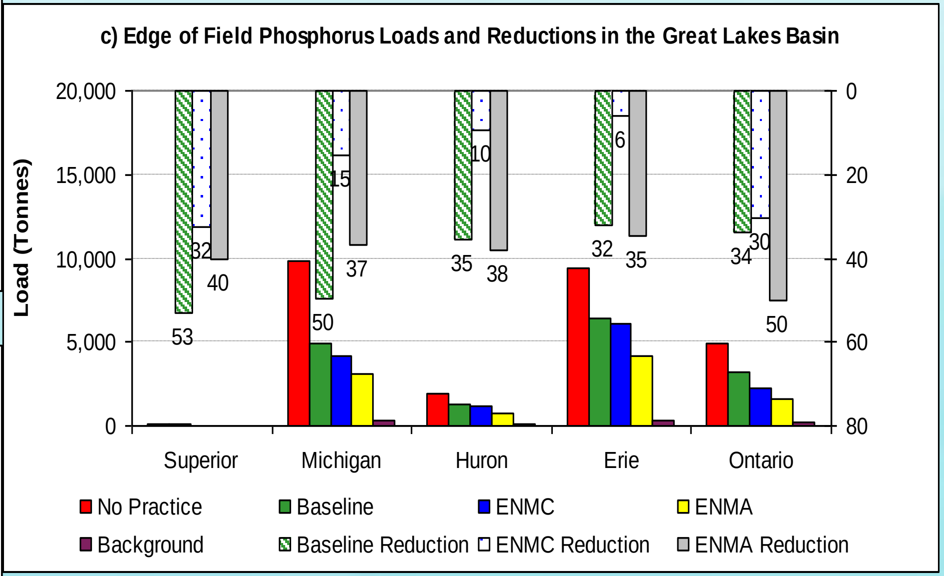
Conservation Practice Scenarios

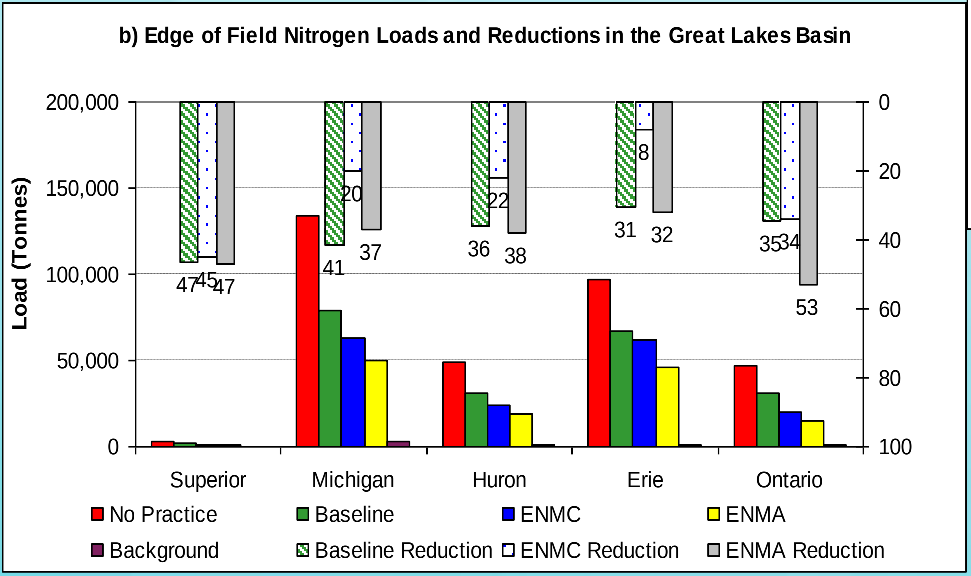
Scenarios	Practice Details	Cropland & CRP (%)
No Practice	No practices on cropland	100
Current Conservation Condition (Baseline)	Current conservation practices on cropland	100
Enhanced Nutrient Management on Critically under-treated cropland (ENMC)	Practices on critically-under treated area have a high treatment need	16
Enhanced Nutrient Management on all under-treated cropland (ENMA)	Practices on under treated area have either a high or moderate treatment need	44
Background	Grass-Tree mix grown on cropland. No cultivated land contribution	100

US Basin Area (km^2)	451,545
Cropland & CRP (km^2)	72,250

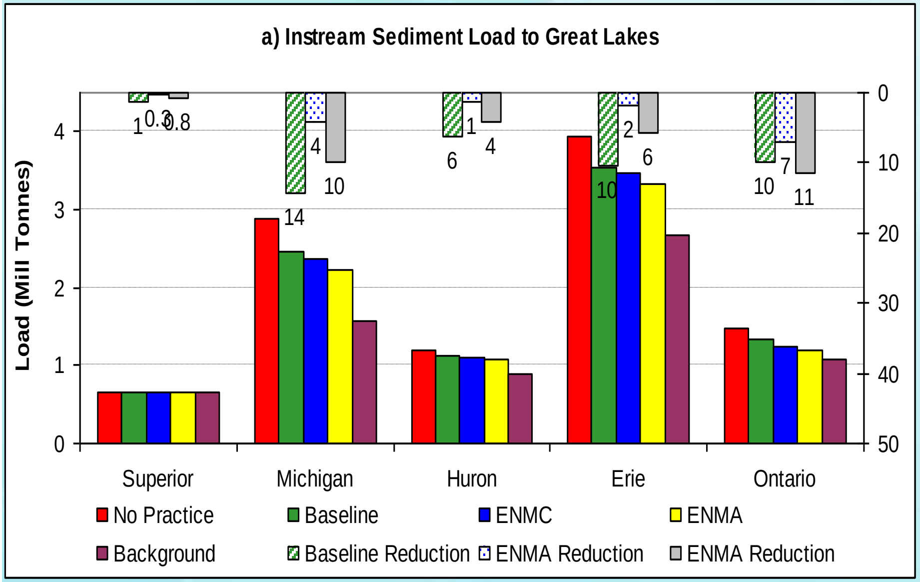
Edge of Field Water Quality Benefits: Conservation Scenarios
Reductions in Edge of Field Loads from Cropland

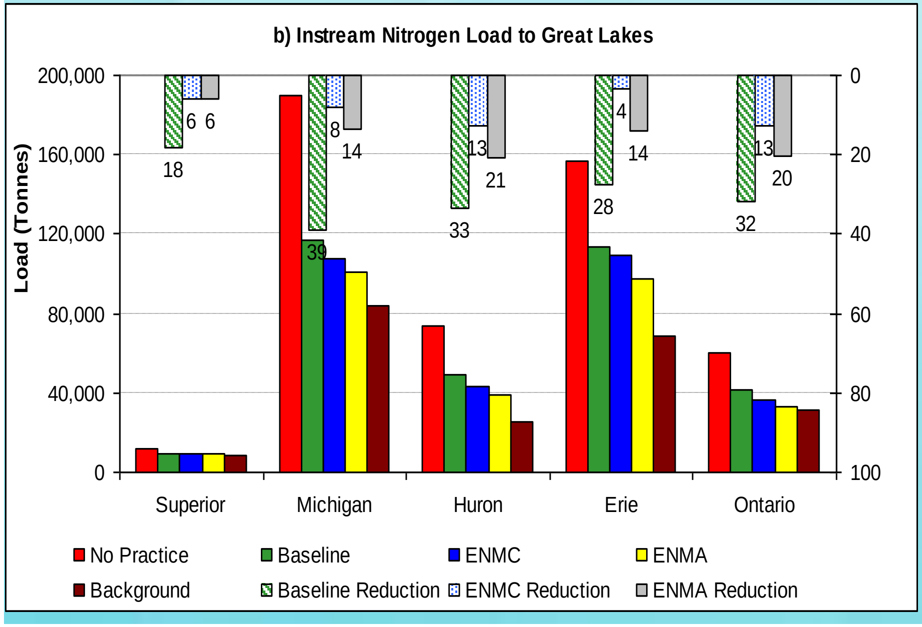


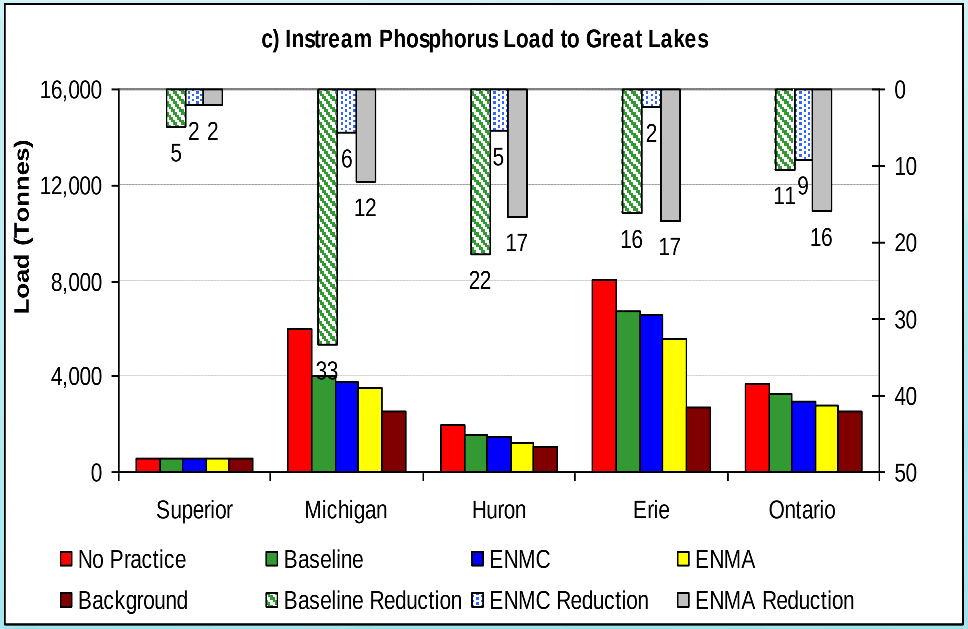




Instream Water Quality Benefits: Conservation Scenarios Reductions in Loads Discharged to the Lakes







Conclusions from Assessment on Great Lakes

- Conservation practices reduces field level losses of sediment, nutrients and pesticides. Benefits of the practices are better reflected and greater at field level.

- Conservation practices improves water quality of streams and rivers, lakes and other water bodies in the river basin.

- Targeting critical acres improves effectiveness of conservation practices significantly.

- Modeling can aid in all of the above processes.

- Modeling system is available to study other emerging issues on future conservation programs, eutrophication, algae blooms, climate change, and restoration efforts.


Thank you !!!
Grazie !!!

Conservation Practices in Great Lakes

Structural Practices	% of Cropland
In field overland flow control practices such as contour farming, strip cropping, contour buffer strips, terraces, grass terraces and tile drain	9
In field concentrated flow control practices such as grade stabilization structures, grassed waterways and diversion	12
Edge-of-field buffering and filtering practices such as filter strips, riparian forest buffers, riparian herbaceous cover and field borders	12
One or more structural practices for water erosion control	26
Wind erosion control practices	4
Cultural Management Practices and CRP	
Crop rotation meeting the criteria for no-till or mulch	82
Reduced tillage on some crops in rotation but average annual tillage intensity greater than criteria for mulch till	9
Continuous conventional tillage in every year of crop rotation	9
†All crops in rotations in meeting appropriate rate, timing and method of nitrogen application	18
Crops in rotations in meeting the appropriate rate, timing and method of phosphorus application	29
Cover crops	<1
Long-term cover establishment/CRP as % of cropland	<1