MichiganTech Research Institute

Evaluating the Impact of NRCS Programs: New Measures and Improved Communication

Final Project Briefing

Michigan NRCS State Office, East Lansing, MI

May 21, 2008

USDA NRCS

Agenda for Today's Meeting

- Review project goals, approach & outcomes:
  - Overview of the Environmental Quality Index (EQI) approach to assessment of NRCS conservation program effectiveness – review of methods and project results
  - Information Visualization Tools – review of TATS activity and final results of the EQI viewer and Implementation and Benefits viewer
  - Air photo georeferencing – review of outcomes
  - Land cover mapping & water quality monitoring at the CEAP-Tiffin River Watershed Study site – data collection and results
- Recommended Next Steps

Goal of the MI-NRCS/MTRI Cooperative Agreement

GOAL: To assist the Michigan State NRCS office to improve conservation program evaluation and management. Includes:

- Helping to asses the outcomes of the NRCS conservation programs;
- Enabling improved communication and management of conservation-related information to facilitate improved conservation program management.
- Applying remote sensing and other advanced geospatial tools using the expertise of MTRI

Cooperative Agreement Timeline

Month	Award details
February 2002	Interest by Senators Stabenow and Levin
August 2003	FY'03 Award ($500K). Year end reports available on CD
August 2004	FY'04 Award ($500K). Year end reports available on CD
January 2005	FY'05 Award ($575K). Year end reports available on CD
February 2006	FY'06 Award ($600K).
May 2008	Conclusion of four-year cooperative agreement Year end reports available on CD May 2008

Project Structure and Process

Project Structure

- MTRI has worked directly with the MI-NRCS staff to identify goals and build products
- MTRI fills the role of innovator and enabler for MI-NRCS
  - By providing new management tools
  - By being responsive to the needs of the MI-NRCS staff to compliment and enhance their capabilities
- The tools and products directly help MI-NRCS, with the intention that products could be transferred to other states

Process

- Project update briefings every 6-8 weeks to highlight and discuss progress and next steps
- Technical level meetings as needed
- Comprehensive annual reports
- External presentations & publications

Project Team

MTRI

- Bob Shuchman
- Nancy French
- Tyler Erickson
- Colin Brooks
- Richard Wallace

And many more

Michigan NRCS

- Vicki Anderson
- Ruth Shaffer
- Monica Holley
- Brent Stinson
- Kevin Wickey
- Steve Davis

And many more

Reports & Briefings Generated (Yr 1-2)

Year 1 - Reports

- MI-NRCS Portal User Manual
- MI-NRCS Prototype Portal
- Program Data Summary and Evaluation, A review of NRCS conservation program, May 4, 2004
- Case Study of Erosion Control Practices in Michigan, August 2004
- Distribution of Endangered, Invasive, and Special Concern Species in Michigan, August 2004
- Framework for Evaluating NRCS Programs and Proposed Environmental Quality Metric, August 2004
- Remote Sensing for Assessment of Agricultural Resource Conservation Programs, August 2004
- Summary of Environmental Data Available for Michigan, August 2004
- Summary of Lessons Learned from Phase One of Evaluation of Environmental Effects of NRCS, August 2004
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication Project Dates: August 2003 – September 2004 (FY 2003 Funds), September 2004
- Summary of NRCS Program Implementation and Practices Data, August 2004

Year 1 – Briefings

- Statistical Case Study of the River Raisin Watershed, May 2004
- Communication and Collaboration - NRCS Portal Update, May 2004

Year 2 – Reports

- Revised Framework for Evaluating NRCS Programs and Proposed Modifications to Environmental Quality Index, September 2005
- Mapping Agricultural Land Cover with Satellite Imagery in the Tiffin River Study Area, September 2005
- Water Quality Measurements in the Tiffin River Watershed, Michigan, September 2005
- Technical Assistance Tracking System (TATS) , September 2005
- Analysis of Erosion Reduction Measures on Highly Erodible Land, September 2005
- Assessing Biodiversity with Remote Sensing., September 2005
- Internet Map Server Sites for Michigan NRCS Programs, September 2005

Year 2 – Briefings

- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Briefing to J. Bricker, Michigan NRCS State Conservationist, December 7, 2004
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Briefing to Michigan NRCS to Kickoff Year 2, November 2, 2004
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 2: First Interim Update, January 26, 2005
- Farm Bill Tracking Tool, Indianapolis Meeting, February 3, 2005
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 2: Second Interim Update, March 21, 2005
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, briefing to Jack Carlson, NRCS ITC, April 15, 2005
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 2: Third Interim Update, April 29, 2005
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 2: Fourth Interim Update, June 15, 20055
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 2: Fifth Interim Update, August 30, 2005
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication: Year 2 Executive Summary, September 2005

Reports & Briefings Generated (Yr 3)

Year 3 - Reports

- Technical Assistance Tracking System (TATS) Development, Lessons Learned, November 2006
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Evaluation Activities and EQI Development, Year 3, November 2006
- Geospatial Algorithms for Agricultural Applications: A Review of New Advanced Technologies, November 2006
- NRCS Technical Assistance Tracking System Database, Database Design, November 2006
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Synopsis of Year 3 Activities, November 2006

Year 3 – Briefings

- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 3: First Interim Update, November 10, 2005
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 3: Second Interim Update, January 12, 2006
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 3: Third Interim Update, March 28, 2006
- Environmental Quality Index (EQI) for Evaluation of NRCS Program Effects, May 2, 2006
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Briefing to Field Office Business Tools Coordinator, May 2, 2006
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 3: Fourth Interim Update, June 1, 2006
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 3: Fifth Interim Update, August 23, 2006
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 3: Sixth Interim Update, October 3, 2006
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 3: Seventh Interim Update, November 30, 2006

Year 3 – Publications/Conference Presentations

- Brooks, C., Schaub, D., Powell, R., French, N., Shuchman, R. (2006). Multi-temporal and multi-platform Agricultural Land Cover Classification in Southeastern Michigan. Presented at ASPRS 2006 Annual Conference, Reno, NV. May 1-5, 2006.
- French N., Wallace R., Shuchman, R., Wickey, K. (2006). Environmental Quality Index (EQI) for Evaluation of NRCS Program Effects. Presented at the Soil and Water Conservation Society Meeting: Managing Agricultural Landscapes for Environmental Quality, Kansas City, MO. October 11-13, 2006.

Reports & Briefings Generated (Yr 4)

Year 4 - Reports

- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication: Summary of the Cooperative Agreement Project, May 2008
- Using C-CAP Land Cover Products for EQI Inputs: Analyzing Riparian Buffers, Habitat Improvement, and Fragmentation over Time with Satellite Imagery, May 2008
- The Environmental Quality Index Approach: Concepts, Methods, and Demonstration of the EQI Approach for NRCS Conservation Program Assessment, May 2008
- Inputs to the Environmental Quality Index: Report on datasets investigated and used for calculation of the EQI, May 2008
- Georeferencing of Scanned Historical FSA Aerial Photographs for Extraction of Wetlands Boundaries and Other Information for the Michigan NRCS, May 2008
- Remote Sensing of Lake Clarity, May 2008
- Land Use Land Cover Mapping in the Tiffin River Watershed: 2004-2006, May 2008
- NRCS Data Viewers Technical Documentation, Environmental Quality Index (EQI) Data Viewer ProTracts Data and Expected Benefit Viewer, May 2008
- Report on In-situ Water Quality Monitoring over Three Years in the Upper Tiffin River, MI, May 2008
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication: Report on the EQI Experts Meeting September 17, 2007, October 2007
- Michigan NRCS Technical Assistance Tracking System (TATS): Project Overview, May 2007

Year 4 – Briefings

- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 4: Ninth Interim Update, March 12, 2008
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 4: NRCS Web Tools Meeting, February 21, 2008
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 4: Eighth Interim Update, January 31, 2008
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 4: Seventh Interim Update, December 17, 2007
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 4: Sixth Interim Update, September 25, 2007
- The Environmental Quality Index (EQI): Experts Meeting & Workshop, USDA-NRCS Michigan State Office, East Lansing, MI, September 17, 2007
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 4: Fifth Interim Update, July 27, 2007
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 4: Fourth Interim Update, June 14, 2007
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 4: Third Interim Update, May 3, 2007
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 4: Second Interim Update, March 15, 2007
- Evaluating the Impact of NRCS Programs: New Measures and Improved Communication, Year 4: First Interim Update, January 18, 2007
- Demo: Using Geospatial Tools to Serve Temporal Monitoring Data to Multiple Clients, January 18, 2007

Year 4 – Publications/Conference Presentations

- Brooks, C., R. Powell, L. Spaete (2007). Integration of Thermal Remote-Sensing Data for Wetlands Mapping in Michigan: An Object Based Approach. Presented at the 2007 ASPRS Annual Conference, Tampa, FL. July 7-11, 2007.
- Schaub, D., N. French, C. Brooks, R. Powell (2007). Using ASTER data to detect crop residue and to improve crop classification. Presented at the ASPRS 2007 Annual Conference: Identifying Geospatial Solutions, Tampa, Florida. July 7-11, 2007.
- Brooks, C., Shuchman, R., Powell, R., Daining, C., Straub-Heidke, A., French, N., Liversedge, L., Schaub, D., Shaffer, R. (2007). Integrating geospatial algorithms for evaluating the effect of Michigan's agricultural land use on water quality. Presented at the Soil and Water Conservation Society (SWCS) Conference, Tampa, FL. July 21-25, 2007.
- Brooks, Colin, R. Shuchman, N. French, T. Erickson , R. Powell, B. Koziol, V. Anderson, R. Shaffer (2008). Integrating geospatial environmental data to assess the impacts of NRCS conservation programs in Michigan. To be presented at the Soil and Water Conservation Society (SWCS) 2008 Annual Conference, Tuscan, AZ. July 26-30, 2008 (Accepted Abstract).

Reports & Briefings Summary

- *Year 1:* 11 Reports, 2 briefings
  - Includes briefing to MI State Conservationist and senior staff
  - 1 interim update meeting
- *Year 2:* 7 reports, 10 briefings
  - Includes briefing to Michigan State Conservationist Jack Bricker
  - 5 interim update meetings
- *Year 3:* 5 reports, 9 briefings, 2 conference presentation
  - Includes briefing at USDA Headquarters to the Field Office Business Tools Coordinating Council
  - Includes presentation at the SWCS 2006 technical conference & ASPRS 2006
  - 7 interim update meetings
- *Year 4:* 9 reports, 16 briefings, 5 conference presentations
  - Includes presentations at the SWCS 2007 & 2008 annual meetings & ASPRS 2007
  - 9 interim update meetings

Major Tasks

- Refinement of program evaluation approaches and the EQI
- Development and Deployment of Technical Assistance Tracking System (TATS)
- Development of MI-NRCS Web-based mapping and visualization tools
- Georeferencing of FSA scanned aerial photos
- Support of Conservation Effects Assessment Program (CEAP) project in the Upper Tiffin River Watershed

Summary of Important Outcomes

- Completed development of methodology and demonstration products for implementing an EQI-based assessment of NRCS
- Developed web-accessible geospatial data systems for gathering, managing, and communicating NRCS data and analyses.
- Georeferenced 11,403 FSA aerial photos for NRCS (87% of state total)
- Described relationship between water quality and land use in agricultural Tiffin River watershed; Defined efficient water quality sampling methodology

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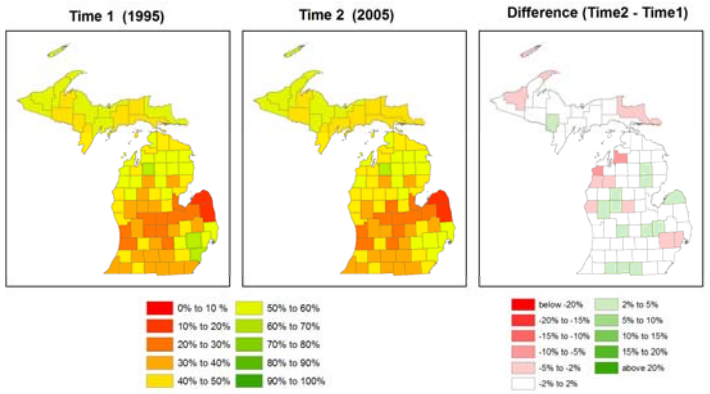
Assessment of Conservation Program Effectiveness Using the Environmental Quality Index (EQI)



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USDA NRCS

Process for Development of EQI

NRCS Conservation Program Goals
- maintain water quality
- reduce soil erosion

Observable outcome
- water quality improvement
- soil saved

Source of inputs
- remote sensing
- models (RUSLE)
- in-situ measures of water quality, biodiversity, etc.

Spatial/ temporal analysis

GIS

Combine inputs into an index (EQI) to compare outcomes (over time, between regions)

Development of the Environmental Quality Index (EQI)

Establish an index baseline for measuring change over time and across geographic units of interest (counties/districts, watersheds)

- Develop scaling system that accounts for good program outcomes (achieving program goals)
  - Based on measures of environmental quality over time
- Obtain data from inside and outside NRCS – based on program goals
  - ProTracts, PRS, etc.
  - Analysis of remote sensing (satellite imagery) & GIS data
  - EPA, USDA, other federal agencies
  - State agencies: MI-DNR, MI-DEQ, MDA
  - Correlations from literature or in-situ measurements
  - NGO's: Duck Unlimited, MNFI
- Use MTRI expertise in application of in-situ sampling data and remote sensing

Inputs to the EQI

- A comprehensive and thorough assessment of available and soon to be available environmental quality data was completed:
  - 10 inputs were found practical at this time
  - New data products that are repeatable and are available as geospatially-defined products (maps) can be easily used in the EQI.
  - Historical EQI data are challenging to find that work well at the scale of counties
  - Assessments for c.2000 onward are feasible for EQI data

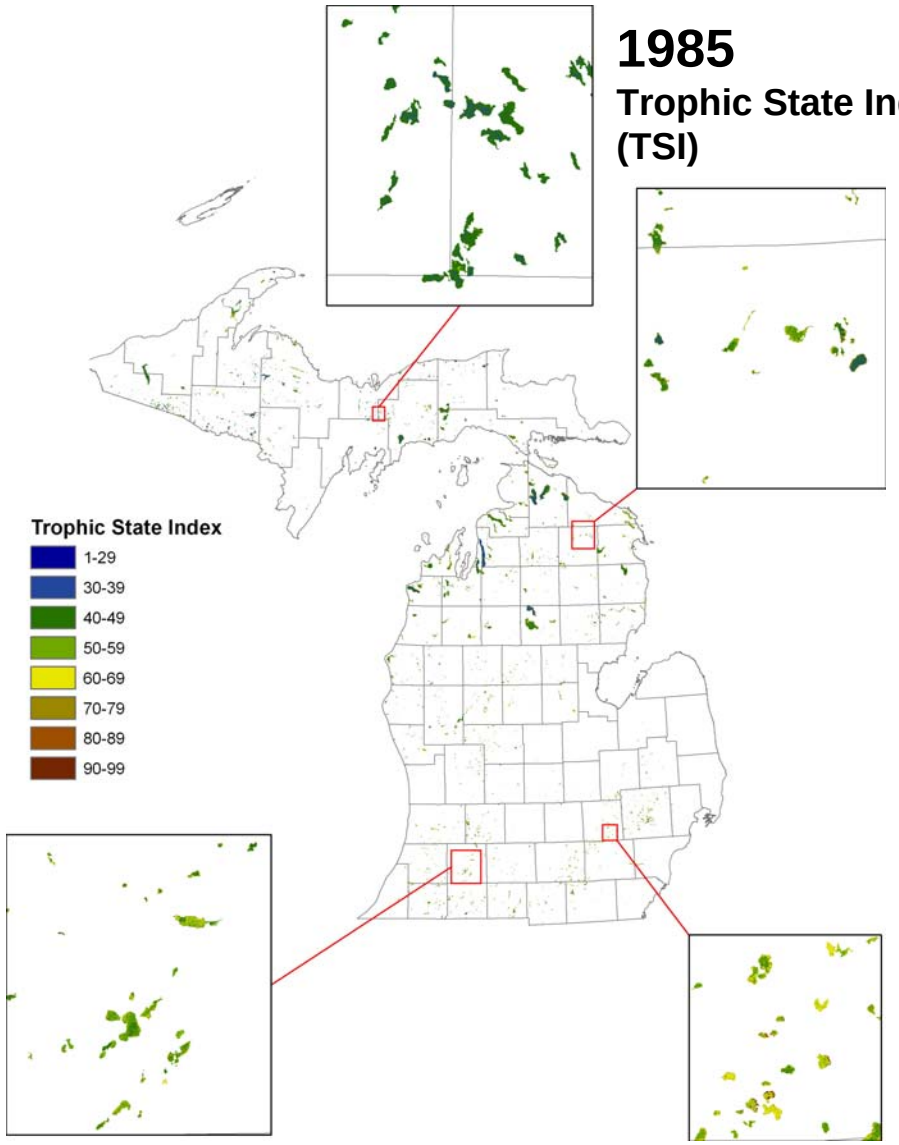
EQI =	**Soil condition index** +	**Water health index** +	**Land habitat index** +	**Air quality index**
	Soil erosion	*Lake Clarity*	*Habitat improvement*	*Ammonia emissions*
	Residue cover/tillage practice	*Riparian buffers*	*T&E plants & wildlife*	*Particulates*
	Crop rotation		*Fragmentation*	

Inputs to the EQI

Input	Units	Source	Resource Concern or Practice	Weight for EQI Calculation
Soil condition Index				**30**
Soil erosion	tons of sediment	EPA STEPL model (RUSLE-based)	Sheet & rill erosion	40
Tillage practice	% conservation	CTIC (Purdue)	conservation tillage practices (329, 344,345,346)	35
Crop rotation history	number of rotations	MTRI developed	Organic matter depletion	25
Surface water health Index				**30**
Lake clarity	index	USGS & MTRI developed	Turbid surface water	45
Riparian buffers	% vegetated	MTRI developed	Riparian buffer practice (391)	55
Land habitat index				**25**
Habitat improvement	acres	MTRI developed	Inadequate cove/shelter/space	10
T&E species	count	Mich. Natural Features Inventory (MNFI)	T&E species	20
Habitat fragmentation	index	MTRI developed	Habitat fragmentation	5
Air quality index				**15**
NH3 emissions	kg	EPA- National Emissions Inventory	Ammonia	25
Particulate levels	density	MTRI developed	PM 10 level	75

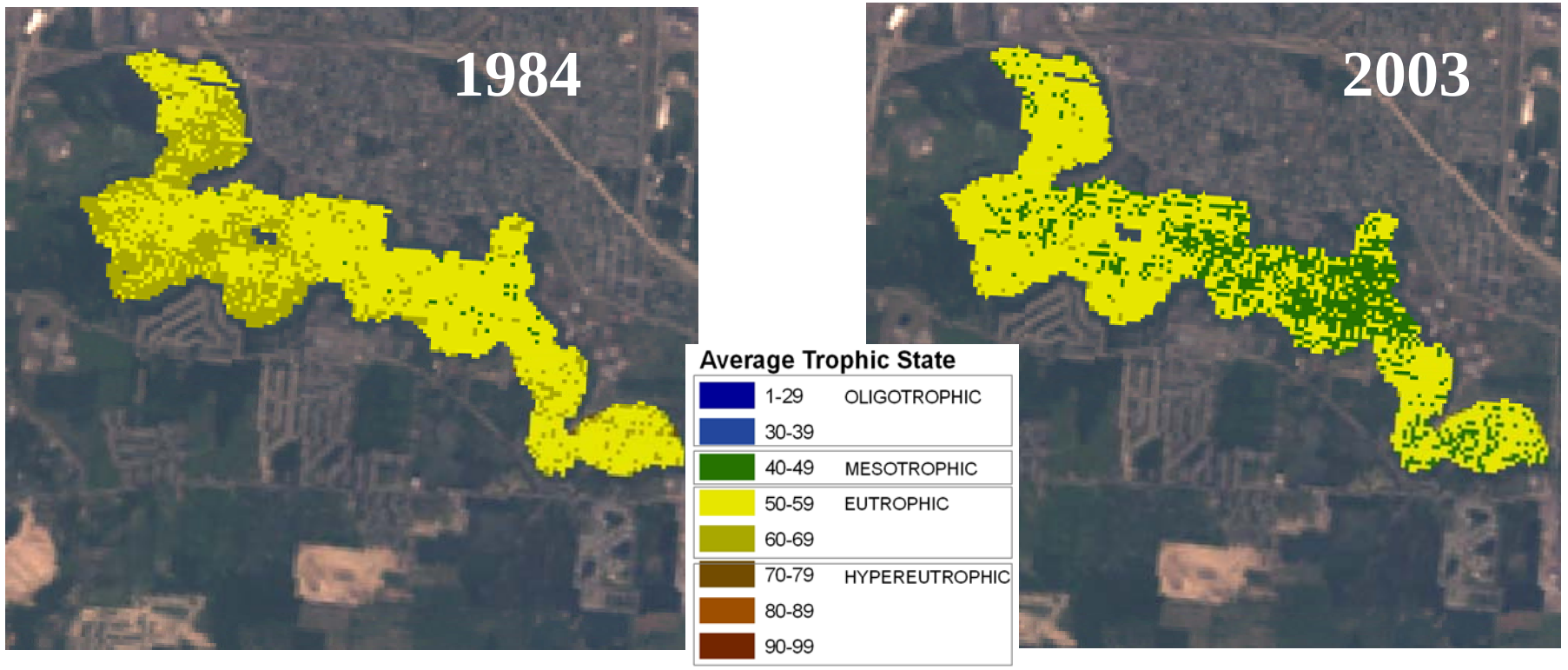
Example: Lake Clarity Products

- USGS created c.2003 lake clarity map for Michigan
  - Secchi-disc based Trophic State Index: TSI(SD)
- MTRI used 2003 as base to create c.1985 lake clarity (TSI) map for Michigan
- Maps were aggregated to county level to create EQI input



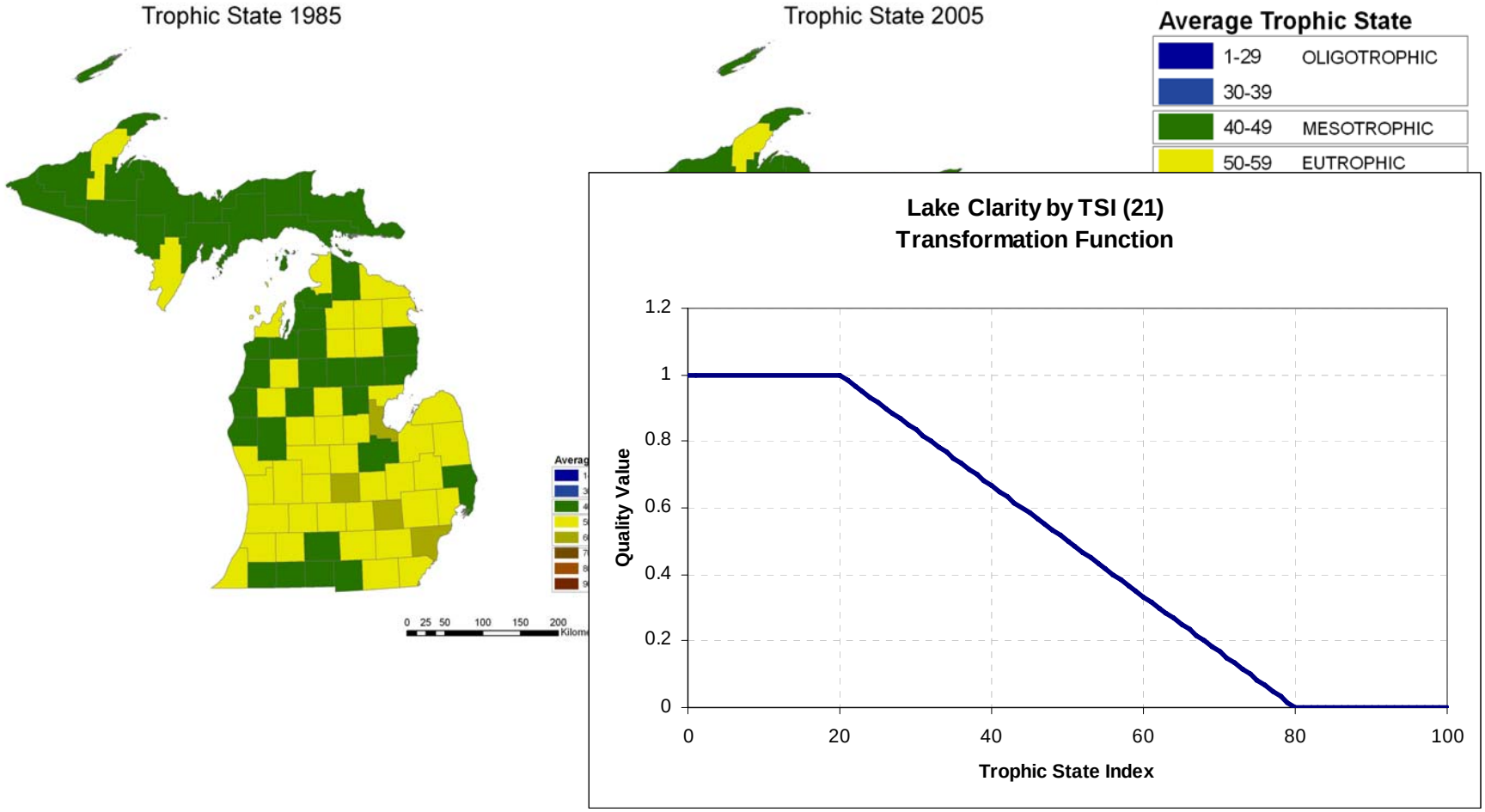
Example: Lake Clarity Products

- **Example of local scale TSI values for Ford Lake during the two study periods.**
  - *Note the improvement from Eutrophic to Mesotrophic in the central and eastern basin*



Example Lake Clarity as an EQI Input

County-level lake clarity for 1985 and 2005



Transformation function for lake clarity in to Q-value

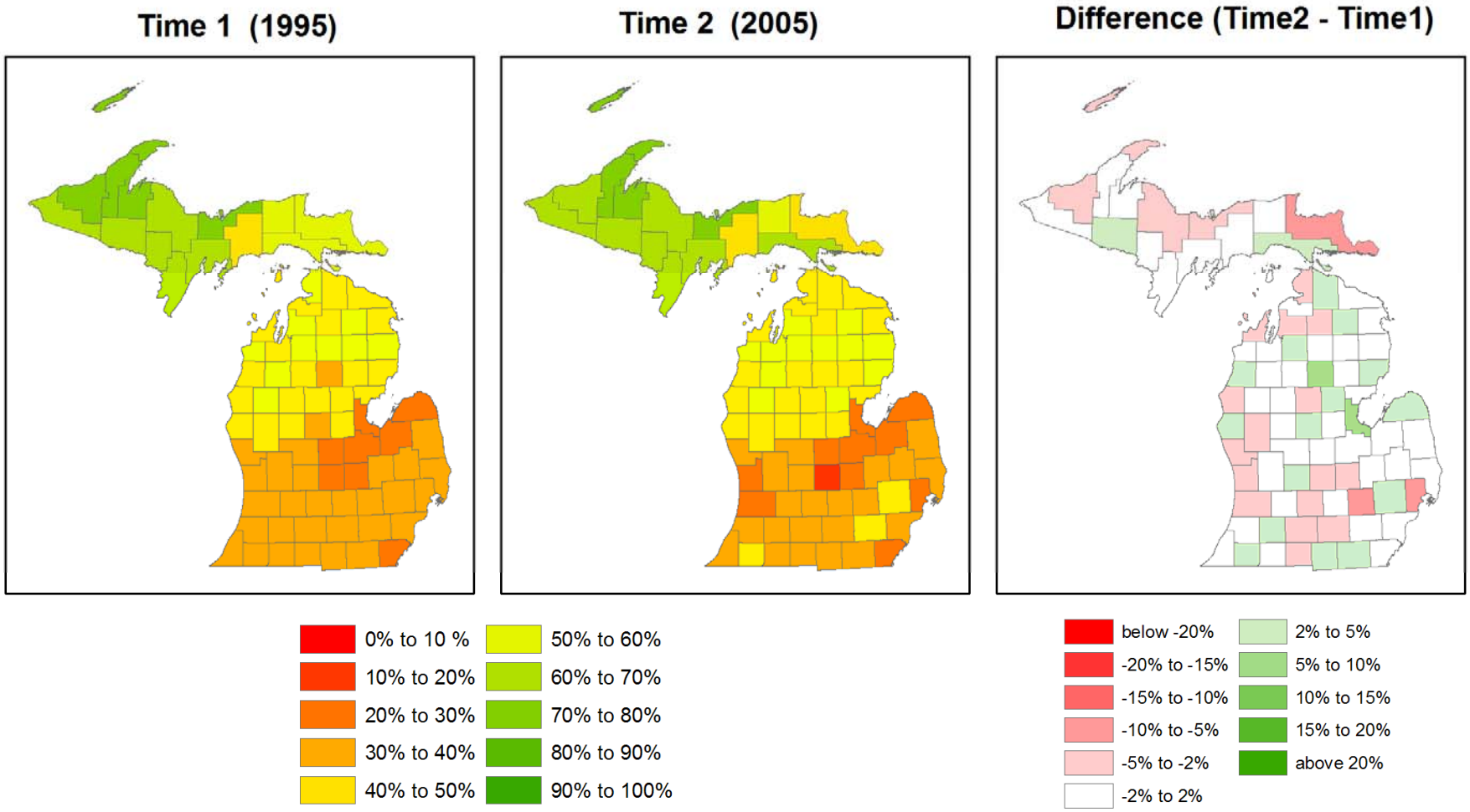
Calculating the EQI

EQI =	Soil condition index	+	Water health index	+	Land habitat index	+	Air quality index
	Soil erosion		*Lake Clarity*		*Habitat improvement*		*Ammonia emissions*
	Residue cover/tillage practice		*Riparian buffers*		*T&E plants & wildlife*		*Particulates*
	Crop rotation				*Fragmentation*		

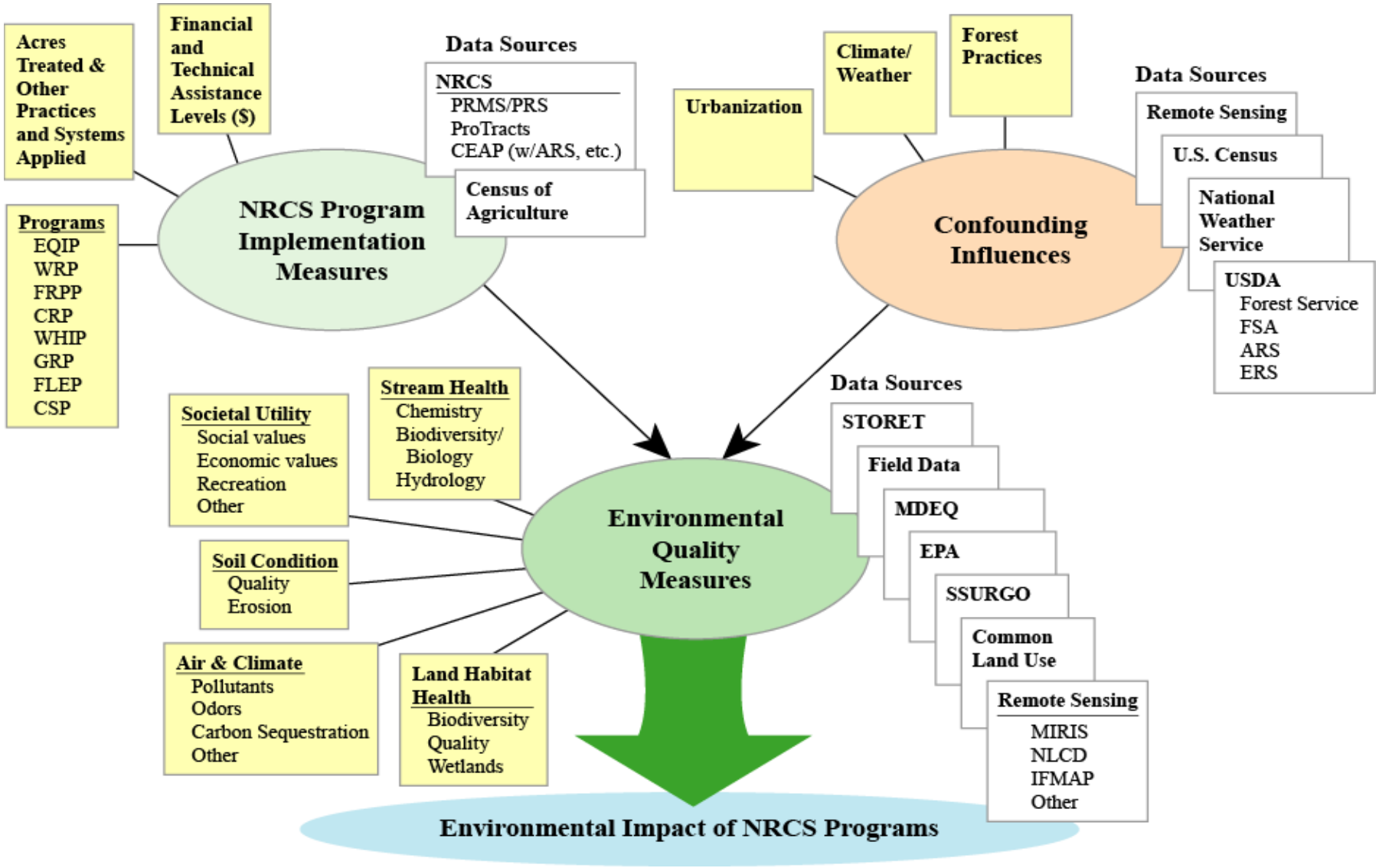
- Q-values for EQI inputs are combined through a weighting method
- Weights were determined from NRCS expert opinion (Sept workshop)
- Individual EQI components can be assessed independantly or combined into one EQI score

EQI Component: Surface Water Health (2)

Example of the type of output for component 2 of the EQI



Program Evaluation Framework

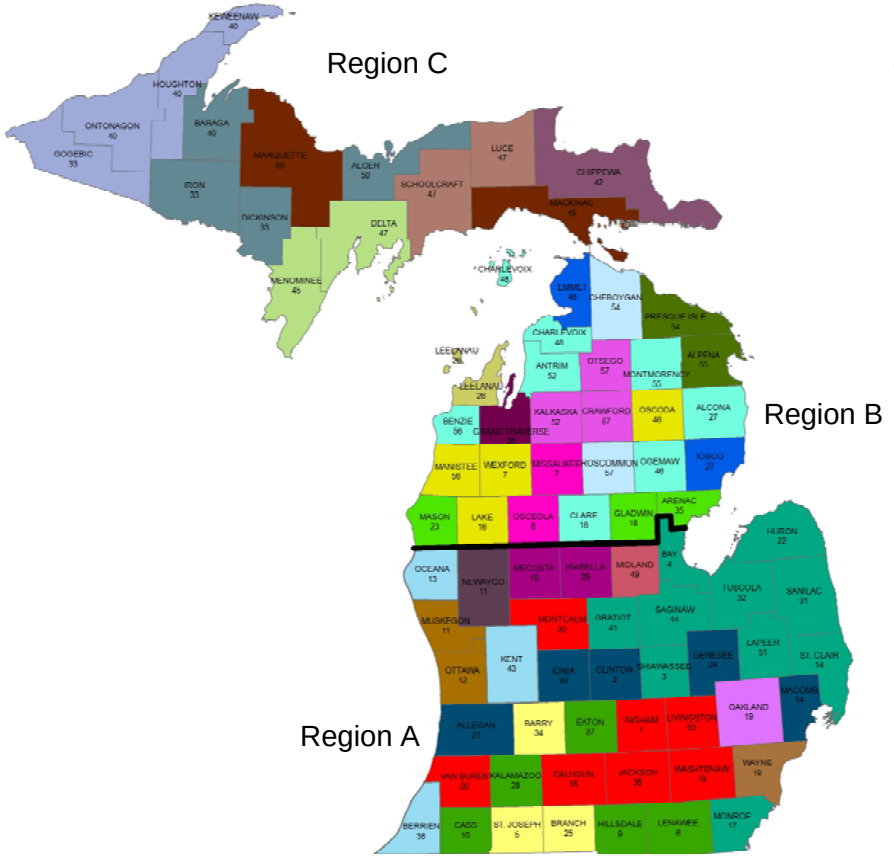


Program Implementation Measures

- ProTracts and Performance Results System (PRS) provides consistent recordkeeping and is useful as a program implementation measure for 2004 to present.
  - Past program implementation information is difficult to use because of non-standardized recordkeeping.
- MTRI developed a method using Conservation Practice Physical Effects (CPPE) scores with ProTracts-based practice implementation data for assessing level of effort by county.
  - Combines raw implementation data with a measure of expected benefit using the CPPE scoring system.
  - Will benefit from more complete and accurate implementation data now available via ProTracts.

Accounting for Confounding Influences

- MTRI has demonstrated a method to control for variations in land by identifying similar counties using a statistical analysis of county-level land use and hydrology.
- Methodology is appropriate for retrospective or future effectiveness assessments
- Additional statistically-basec methods to control for variability outside of the problem set (NRCS program influence on EQI) are being explored under our current USDA-CSREES grant.



Analysis regions, based on NRCS Admin Areas

Future of the EQI

- The USDA Conservation Effects Assessment Program (CEAP) is underway to answer a specific question about the effectiveness of conservation programs. Two study sets are underway:
  - Watershed studies – needed to directly connect conservation activity to outcomes for building models;
  - National assessment – needed to look at the broad-scale implications of conservation programs.
- State or regional scale assessments, as has been developed in this project, should be continued to fill the gap in CEAP
  - To provide a direct connection of assessment results to State Office needs

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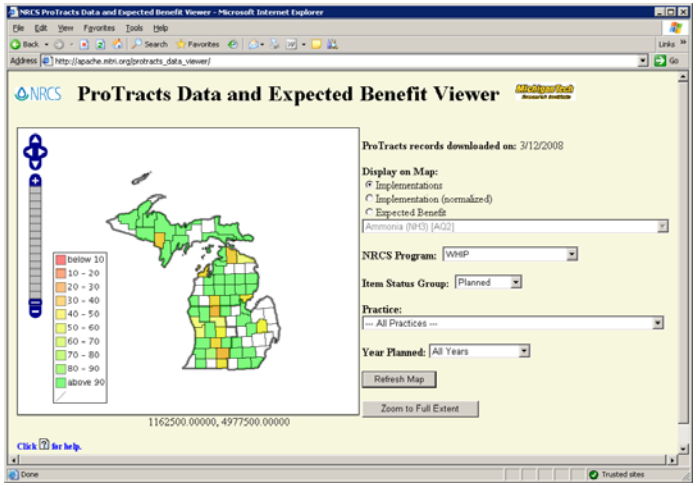
Web-based Information Visualization Systems



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System List

1. Technical Assistance Tracking System (TATS)
2. Implementations and Benefit Viewer
3. Environmental Quality Index (EQI) Viewer
4. Tiffin River Study Area Viewer

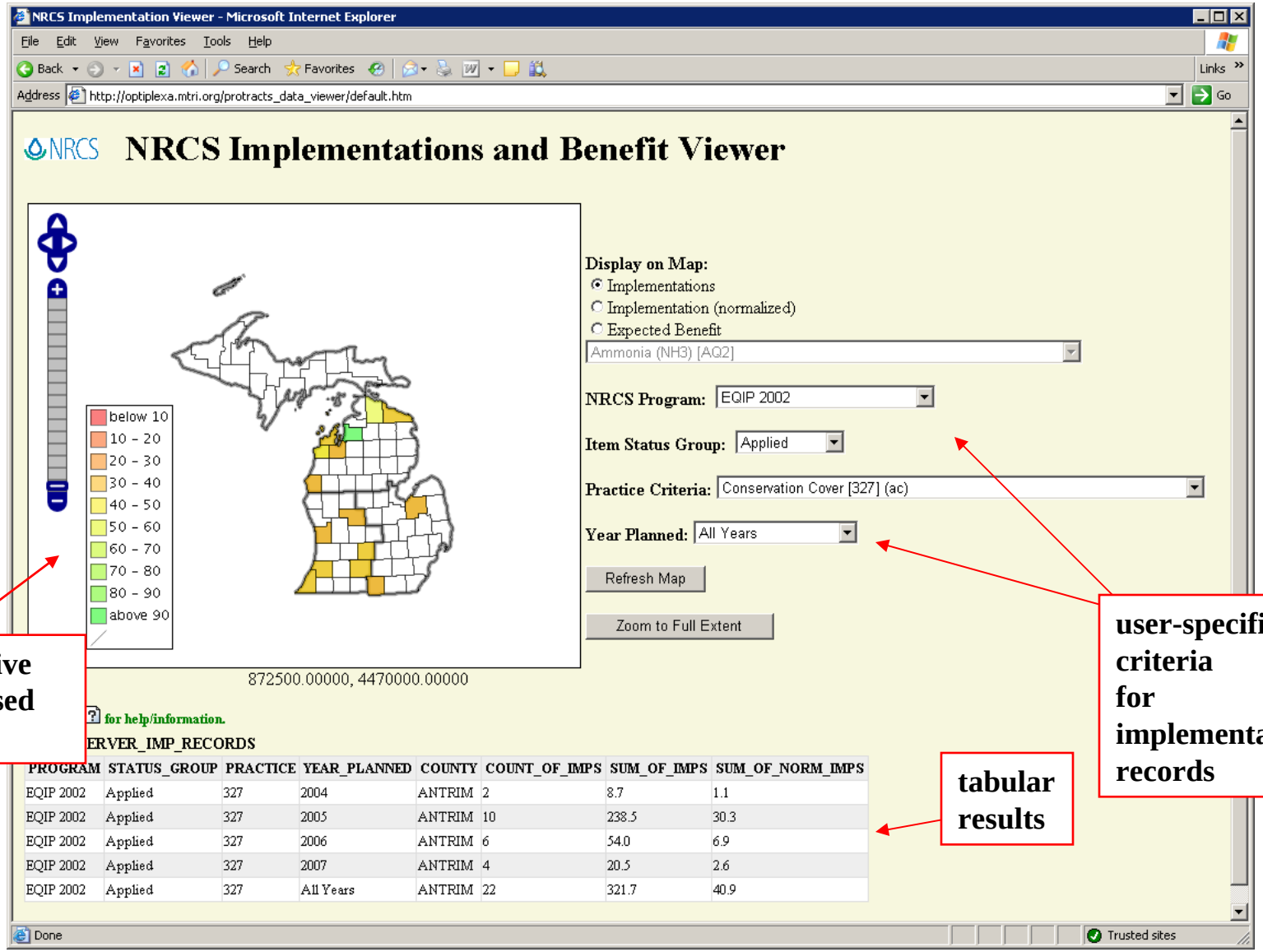
1. Technical Assistance Tracking System (TATS) Overview

- Activity Goals:
  - create a system to track and prioritize technical assistance activities for the Michigan NRCS
  - provide summary tools for monitoring workload levels
  - create a web-accessible system to enable real-time data sharing (replacement for current Excel-file and email-based system)
  - to avoid duplicate data entry, create a system that augments the national NRCS data systems (i.e. ProTracts, Toolkit, NCPDB) with TA-related data that is not contained within those national systems
- Activity Summary:
  - developed prototype system on USDA ITS Web Farm
    - system was integrated with the SCIMS web service
    - system was not integrated with NCPDB (no web service was developed)
  - TATS development stopped in early 2007, as the USDA Customer Relationship Management (CRM) project started
    - 5/2007 - MTRI presented TATS development work (including requirements, use cases, and data model documentation) to CRM project planning group

2. Implementations and Benefit Viewer Features

- Provides quick access to county tabular and mapped summaries of ProTracts Implementation data for a variety of user-specified criteria:
  - By NRCS Program (EQIP 2002, EQIP 1996, CSP, WHIP)
  - For either planned or already applied implementations
  - By a specific NRCS Practice (or all NRCS Practices)
  - By a specific year (or all years)
- Determines the total expected benefit of planned or applied implementations using the Conservation Practice Physical Effects (CPPE) scores
- System is implemented using free, open-source server software
  - i.e. no software costs for duplicating this system

2. Implementations and Benefit Viewer Overview Screenshot

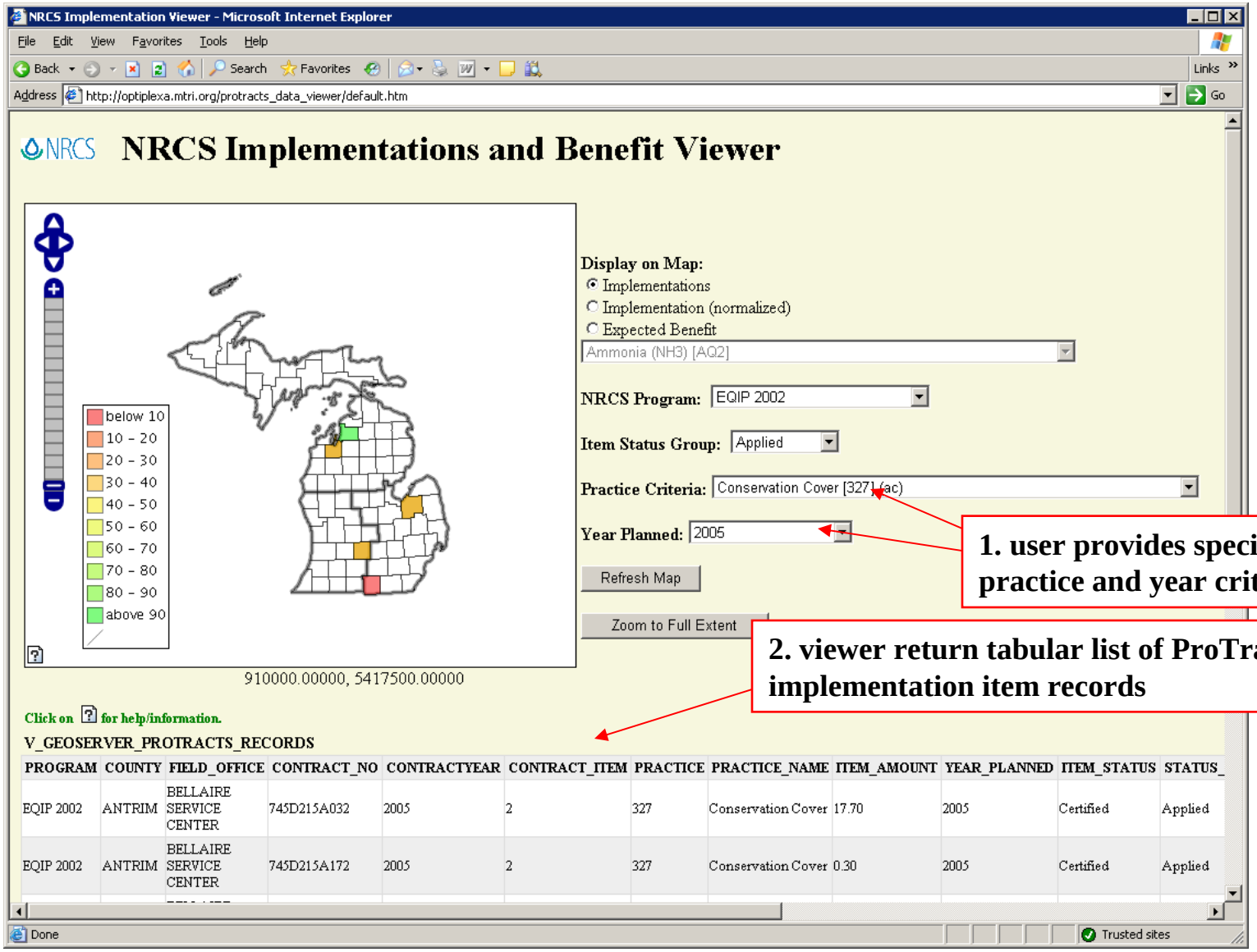


interactive map-based results

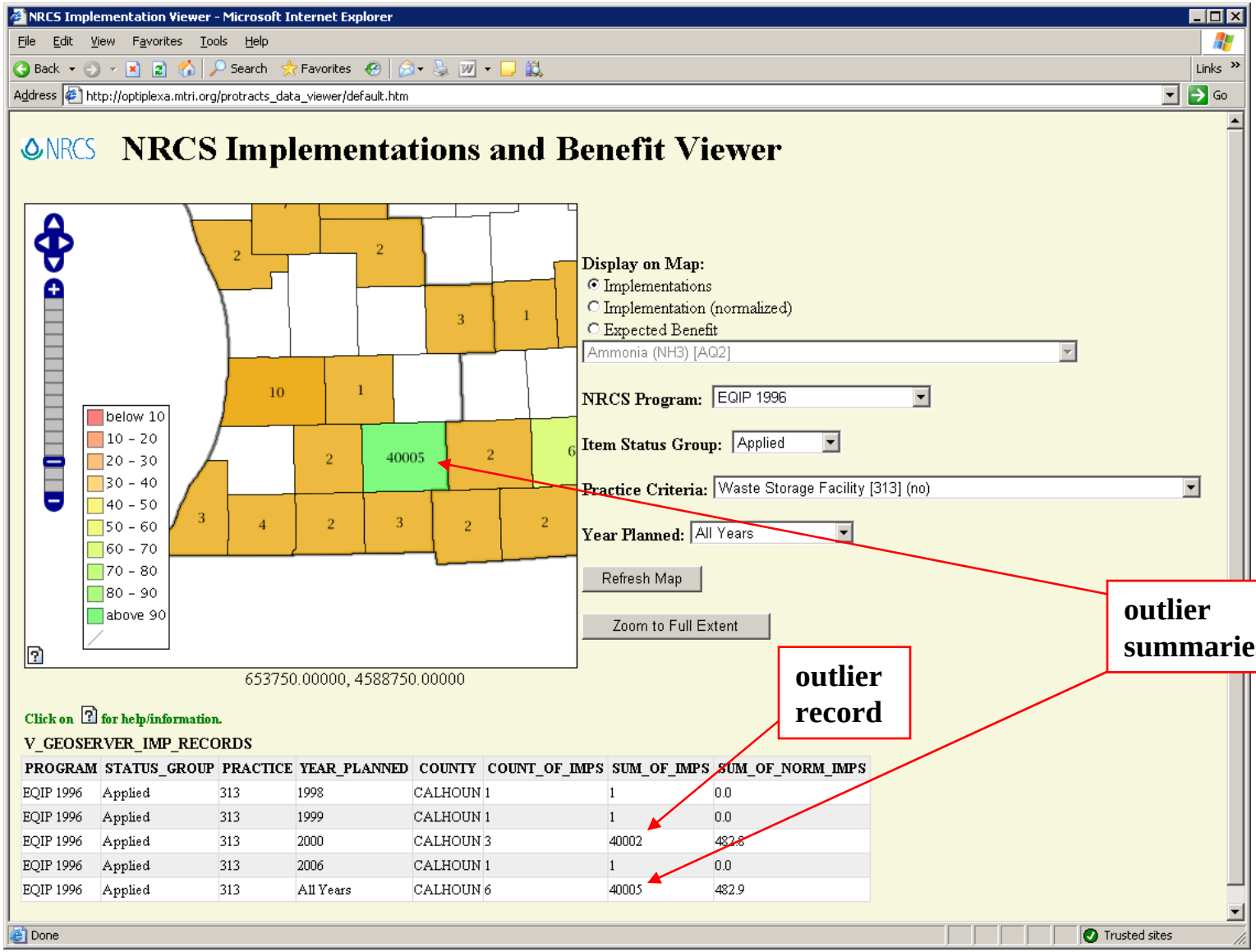
user-specified criteria for implementation records

tabular results

2. Implementations and Benefit Viewer ProTracts Contract Item Records



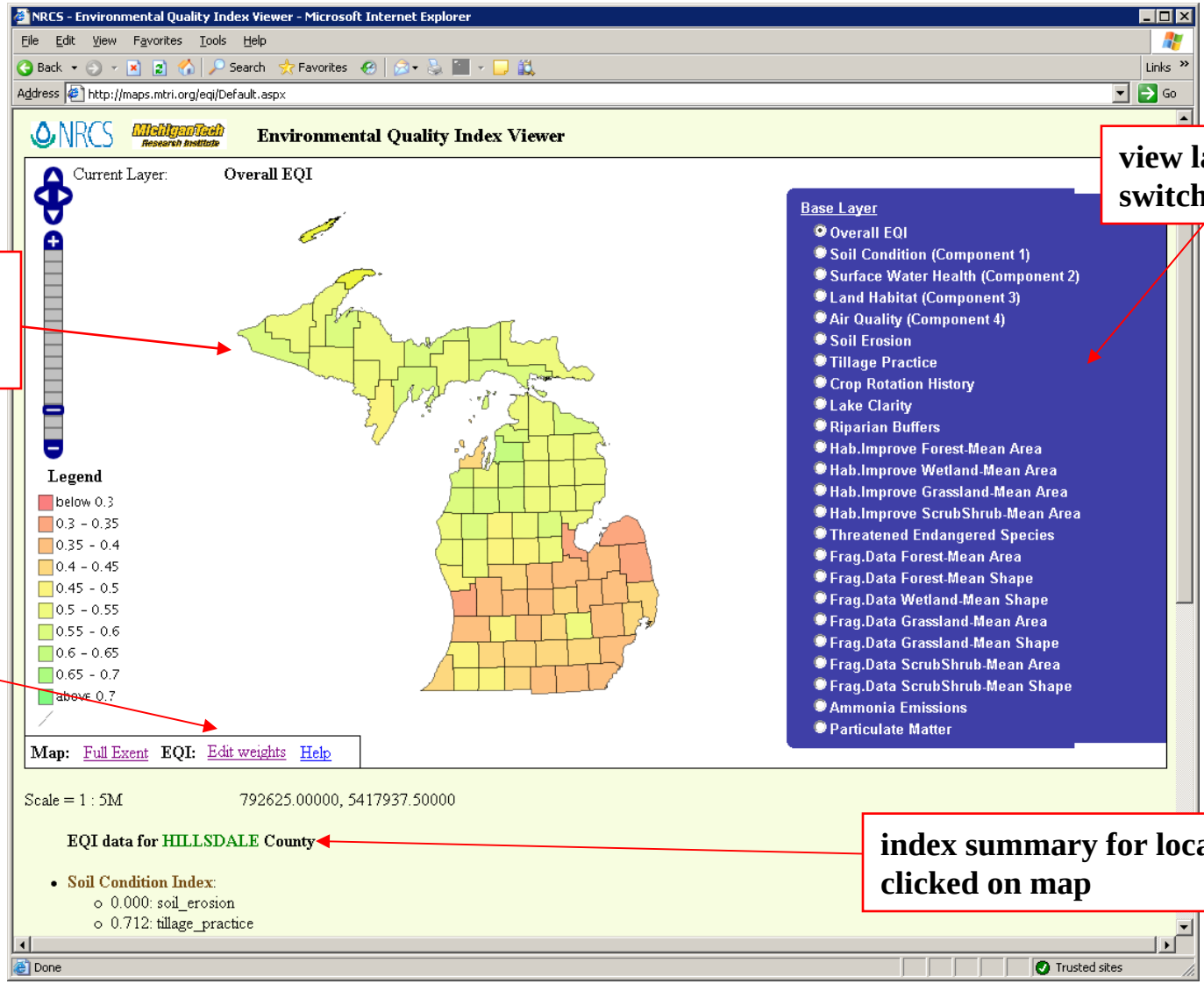
2. Implementations and Benefit Viewer Outlier Records Example



3. Environmental Quality Index (EQI) Viewer Features

- Activity Goals:
  - Communicate county-based index-based summaries of environmental quality
  - Allow users to interactively visualize EQI datasets to understand how a diverse collection of data inputs can be used to estimate overall environmental quality
  - Allow users to compare how different components of environmental quality vary between counties
  - Allow users to easily customize the EQI model to reflect particular user groups, by changing the model weighting coefficient

3. Environmental Quality Index (EQI) Viewer Overview Screenshot



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Air-photo Georeferencing

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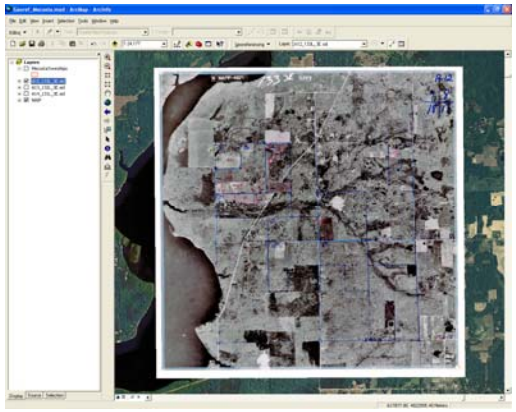
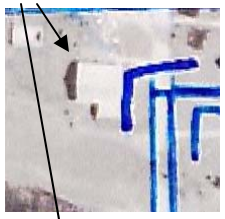


Georeferencing project

- NRCS had scanned 13,109 historical FSA aerial photos
- These had wetlands boundaries & other data useful to NRCS drawn on them
- **NRCS extracted historical wetlands information from the photos once georeferenced**
- NRCS requested MTRI help in georeferencing them – providing real-world geographic coordinates (UTM).
  - Useful at field level for NRCS staff
- MTRI used college interns and ESRI ArcGIS software to georeference photos to current (2005 NAIP) imagery
  - Included a rigorous Quality Control Process
- Created detailed documentation of our methodology
  - Could be applied to other imagery archives
- **We georeferenced 11,403 photos (87%) – covering 70 of Michigan's 83 counties (84%)**
  - We made regular periodic deliveries of completed counties to NRCS

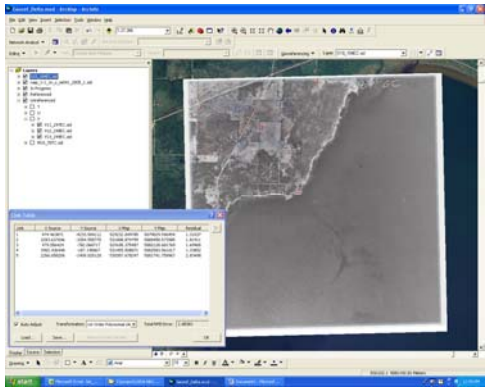
Example of location in common, used for georeferencing (building corner)



FSA image

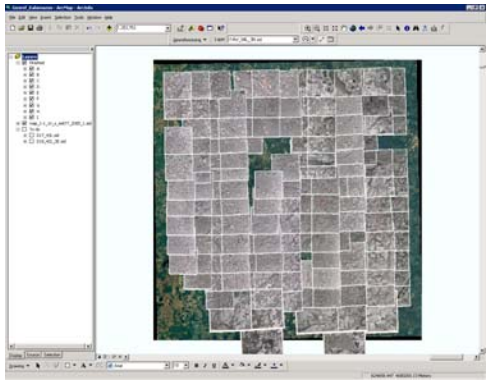
NAIP image

A completed, georeferenced photo



The counties completed for NRCS

An example of all the photos georeferenced for Kalamazoo Co.



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Support of the CEAP/Upper Tiffin River Watershed Project

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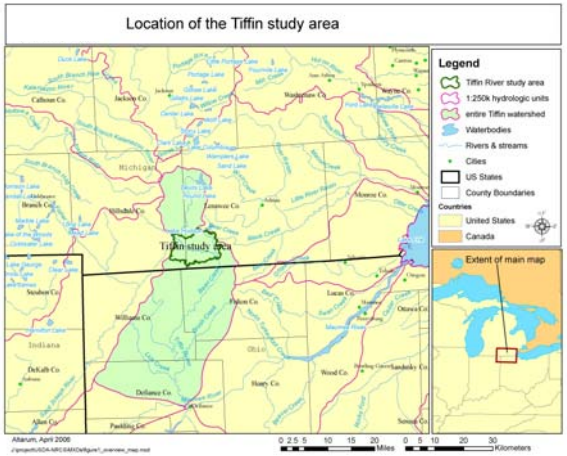
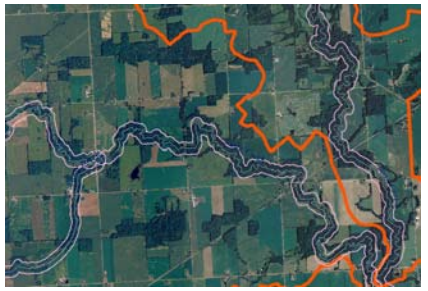
USDA NRCS

Goals of the Upper Tiffin River Watershed land use and water quality analysis

- Support NRCS in its CEAP project investigating impacts of agricultural practices on water quality issues
- Our role: use water quality collections, remote sensing, and geospatial analysis to investigate the relationship between land use / land cover and water quality in the Upper Tiffin River Watershed (Bean and Lime Creeks)
  - Is there a measurable effect of local land use / land cover on water quality?
  - What is an efficient water quality monitoring program for a Tiffin-like watershed?



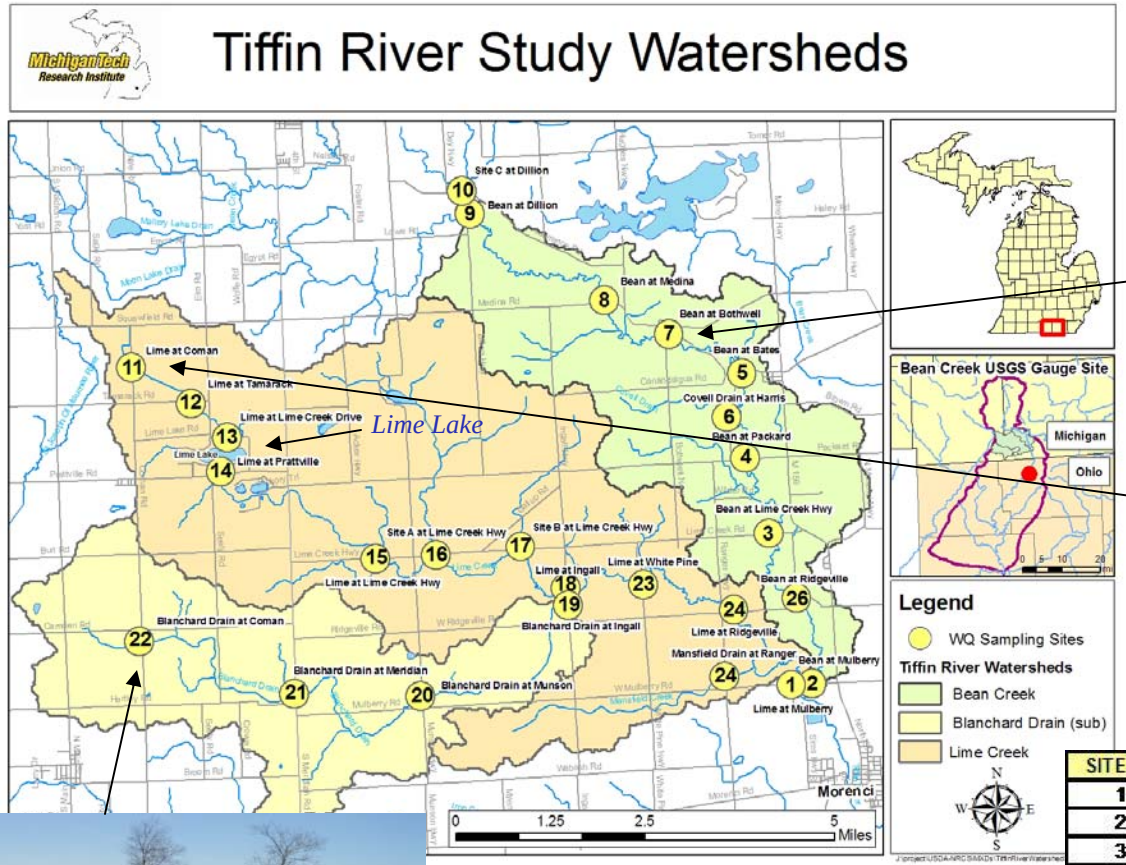


2005 aerial of Lime/Bean confluence

Collecting water quality data

Long-term monthly water quality database: locations of 26 sampling sites

- 26 sampling locations; USGS gauging station 3 miles downstream



Bean @ Bothwell (7)

Lime Creek @ Coman (11)

Blanchard Drain @ Coman (22)

SITE_ID	SITENAME	SITE_ID	SITENAME
1	Lime at Mulberry	14	Lime at Prattville
2	Bean at Mulberry	15	Lime at Lime Creek Hwy
3	Bean at Lime Creek Hwy	16	Site A at Lime Creek Hwy
4	Bean at Packard	17	Site B at Lime Creek Hwy
5	Bean at Bates	18	Lime at Ingall
6	Covell Drain at Harris	19	Blanchard Drain at Ingall
7	Bean at Bothwell	20	Blanchard Drain at Munson
8	Bean at Medina	21	Blanchard Drain at Meridian
9	Bean at Dillion	22	Blanchard Drain at Coman
10	Site C at Dillion	23	Lime at White Pine
11	Lime at Coman	24	Lime at Ridgeville
12	Lime at Tamarack	25	Mansfield Drain at Ranger
13	Lime at Lime Creek Drive	26	Bean at Ridgeville

Water quality data collection

- Used Horiba U-22 instrument
  - Near-instant calculation of water quality parameters
  - Instrument was calibrated regularly
  - Rapid download of formatted data into Excel
- Collects 10 water quality variables:

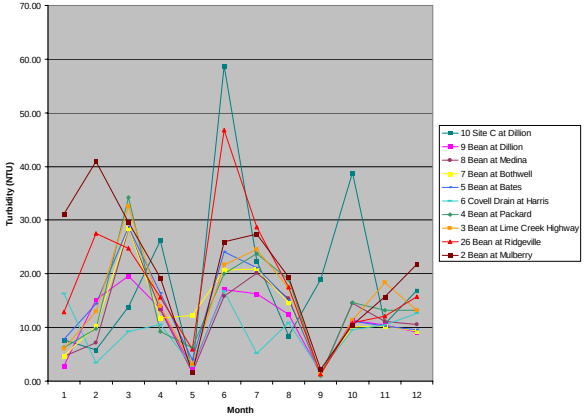
Parameter_ID	Shortname	Longname	Unit
1	pH	pH	-
2	COND	Conductivity	S/m
3	TURB	Turbidity	NTU
4	DO	Dissolved Oxygen	mg/L
5	Temp	Temperature	deg C
6	DEP	Depth	m
7	SAL	Salinity	%
8	TDS	Total Dissolved Solids	g/L
9	dt	Specific Gravity of Seawater	-
10	ORP	Oxidation Reduction Potential	mV

- Collected every month from April, 2005 – December 2007 (32 months total, 10 variables, 26 sites, 3 times per site)
  - Also sampled after 6 rain events, & night-time event
  - >30,000 data samples
  - Worked with NRCS Adrian office staff (Jason Freeman, Ann Shattuck, Jason Firster)

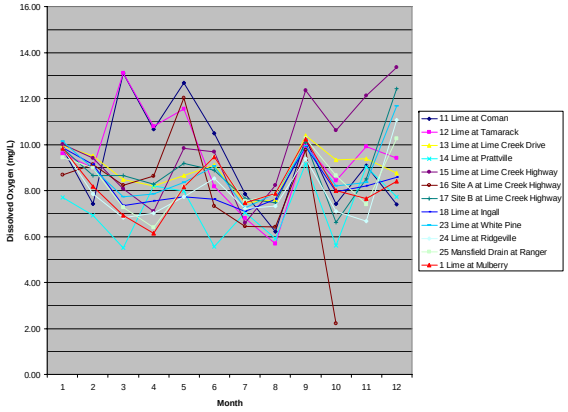
Examples of 3 year baseline stats: Bean, Lime, and Blanchard (Lime trib)

	Turbidity 3 Year Statistics				DO 3 Year Statistics			
SITENAME	AVG (NOSTORM)	STDEV (NOSTORM)	MAX	MIN	AVG (NOSTORM)	STDEV (NOSTORM)	MIN	MAX
Bean at Dillion	16.07	47.87	312.00	0.00	8.39	2.30	3.20	13.79
Site C at Dillion	19.03	19.03	399.00	-4.80	8.15	8.15	3.55	12.83
Bean at Medina	9.29	13.50	462.00	0.00	8.28	2.08	3.50	13.72
Bean at Bothwell	12.60	21.68	178.00	-5.00	8.66	2.20	3.37	14.12
Bean at Bates	14.12	19.86	106.00	0.00	8.26	2.17	3.83	13.83
Covell Drain at Harris	6.66	8.67	98.70	0.00	8.42	2.16	4.37	14.50
Bean at Packard	11.07	15.15	144.00	0.00	8.31	2.13	3.62	14.03
Bean at Lime Creek Hwy	12.94	16.88	231.00	0.00	8.43	2.22	3.16	13.88
Bean at Ridgeville	33.29	112.54	792.00	0.00	8.49	2.19	3.37	13.57
Bean at Mulberry	17.37	21.07	195.00	0.00	8.43	2.49	3.26	13.88
Blanchard Drain at Coman	21.51	51.32	347.00	0.00	8.94	2.73	3.25	14.48
Blanchard Drain at Meridan	20.66	20.03	168.00	0.00	9.37	2.36	1.62	14.46
Blanchard Drain at Munson	22.28	22.95	160.00	0.00	9.13	2.67	2.50	14.84
Blanchard Drain at Ingall	17.78	28.58	340.00	0.00	8.56	2.23	3.74	14.06
Lime at Coman	74.65	184.65	910.00	0.00	9.56	3.91	1.85	19.99
Lime at Tamarack	24.46	32.68	225.00	0.00	9.68	3.73	3.46	19.99
Lime at Lime Creek Drive	27.09	26.11	277.00	0.00	8.78	2.38	3.94	13.52
Lime at Prattville	21.94	43.20	213.00	0.00	7.39	2.97	2.54	14.25
Lime at Lime Creek Hwy	27.43	36.36	198.00	0.00	9.46	2.71	3.48	15.14
Site A at Lime Creek Hwy	33.19	63.63	273.00	-2.00	8.08	3.16	2.19	15.78
Site B at Lime Creek Hwy	10.95	13.88	169.00	0.00	8.57	2.37	3.78	13.76
Lime at Ingall	17.70	34.67	255.00	0.00	8.06	1.94	4.05	13.24
Lime at White Pine	13.91	15.94	378.00	0.00	8.42	1.96	4.43	13.70
Lime at Ridgeville	12.24	17.88	217.00	-5.00	7.64	1.92	3.86	13.29
Mansfield Drain at Ranger	9.67	12.66	291.00	0.00	8.18	1.80	3.92	13.42
Lime at Mulberry	13.60	17.05	221.00	0.00	7.91	2.05	3.81	13.63

Monthly average Turbidity trends for Bean Creek



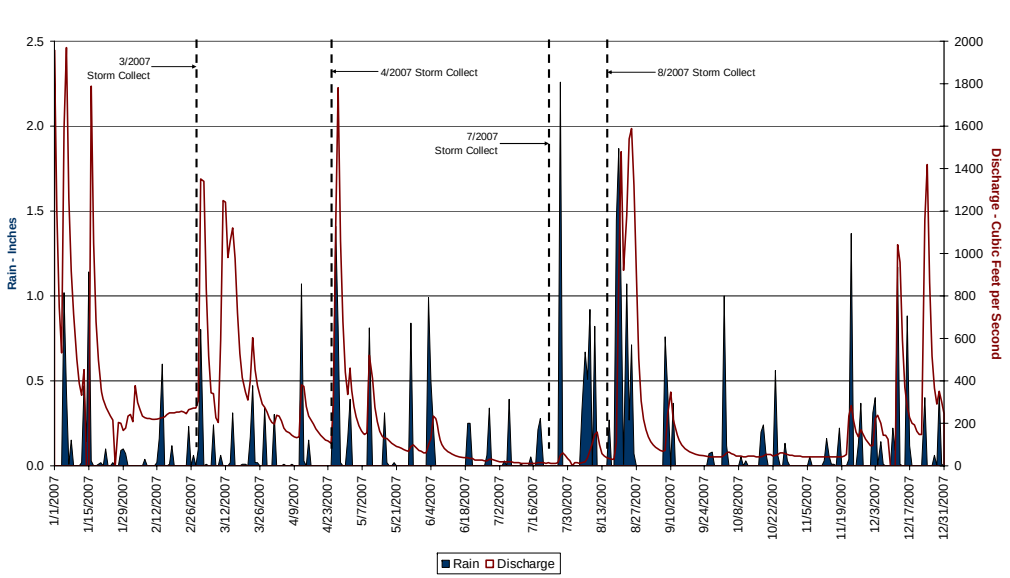
Monthly average DO trends for Lime Creek



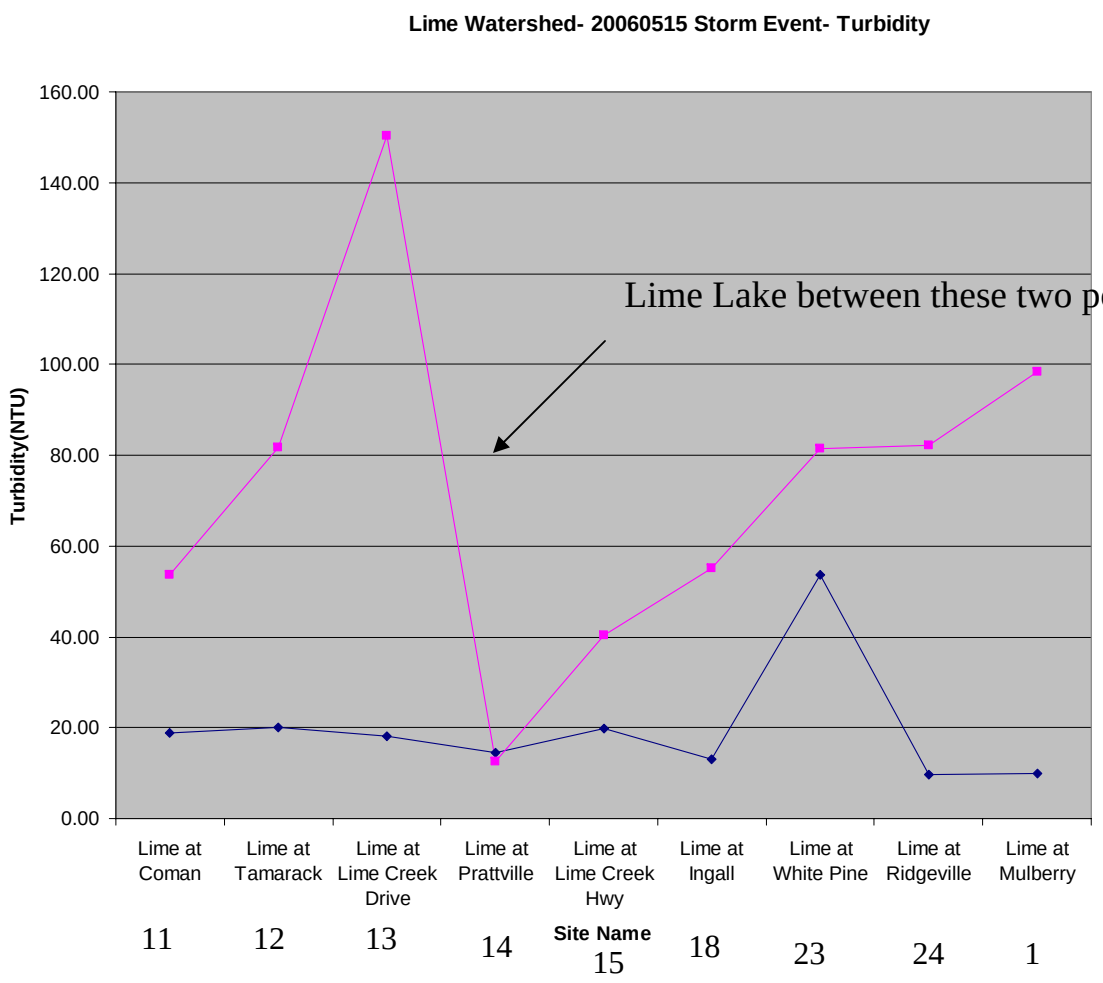
- Turbidity values – frequently high after storms
- DO – generally acceptable, but spring & summer issues exist (<7 mg/L below state standard)\
- Also done for pH, conductivity, temperature, total dissolved solids, ORP

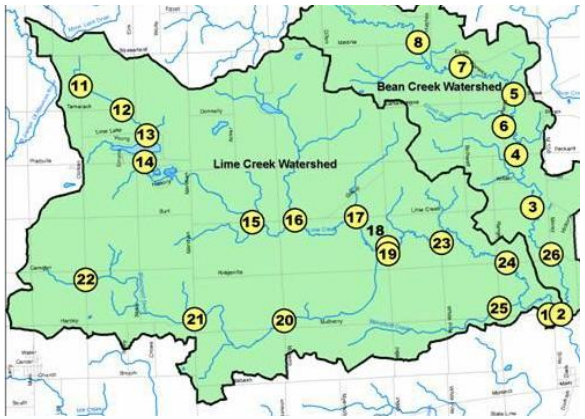
6 storm events captured

- Went out immediately after storm event (next day)
- 6 events: (7/27/07, 8/21/07 characterized)
  - July 1, 2005 – 82 cfs (up from 20 cfs), 0.26” rain (1 day)
  - May 15, 2006 – 860 cfs (up from 75 cfs), 3.54” rain (5 days)
  - March 2, 2007 – 1150 cfs (up from 300 cfs), 0.9” rain (2 days)
  - April 27, 2007 – 1650 cfs (up from 275 cfs), 2.61” rain (3 days)
  - July 27, 2007 – 55 cfs (up from 16 cfs), 2.26” rain (1 day)
  - August 21, 2007 – 1280 cfs (up from 785 cfs), 4.34” rain (3 days)
- Expect to see greatest response after these events



Turbidity trend after a storm: on smaller ag-dominated Lime Creek watershed





- Points go downstream – sudden drop is due to Lime Lake where sediment settles out
- May 15, 2006 storm event
- Turbidity values are higher on smaller, ag dominated watershed (max 150 vs. 60 NTUs)

- Storm events causing up to 10x increase in turbidity
- Lake settles turbidity to baseline levels (20-25 NTU)
- Values go back up – agricultural contribution restarts
- Cumulative effect clear, varies in intensity by season
- Turbidity max of 275 NTU before lake (3/2007); 375 after lake (7/2005) from baseline levels

Examples of summary stats for storms

- Averages for all storms (except 5/15/06 DO event)

Ph, turbidity increase consistently
Conductivity, ORP consistently decreases

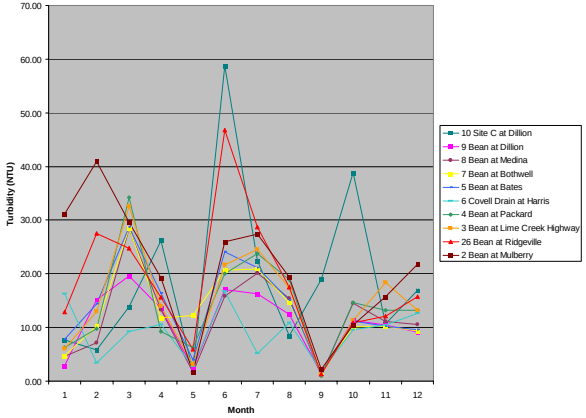
Overall Averages With Trends						
	Bean Creek		Lime Creek		Blanchard Drain	
Parameters	Before	After	Before	After	Before	After
pH	7.45	7.66	7.44	7.59	7.60	7.62
Conductivity	0.0639	0.0476	0.0870	0.0446	0.0751	0.0418
Turbidity	19.75	123.28	29.95	123.35	43.44	102.48
DO 2005/2007	8.98	8.06	8.34	7.64	8.73	7.65
DO 5/15/2006	3.45	11.86	4.08	9.49	3.70	9.48
Temperature	14.34	14.47	16.34	14.02	18.07	14.26
TDS	0.41	0.31	0.56	0.29	0.48	0.27
ORP	288.20	224.31	258.67	222.57	254.60	235.91

- Averages for all storms (except 5/15/06 DO event)
- Turbidity increases factor of 3 to 4 (average)
- pH decreases are about the same
  - In the range of 7.76 to 8.18; 6-9 acceptable; typical value for rain is 5.5
- Conductivity decreases at all sites – most for greatest agricultural cover

Recommendations for Focused Data Collections

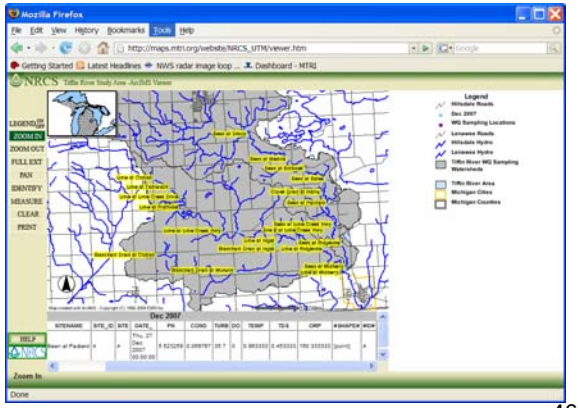
- What to collect: Turbidity, Dissolved Oxygen, and Conductivity are the most important parameters to measure (esp. for storms)
  - pH also important for non-storm, entire year comparison
- Where to collect:
  - Sampling sites are best located at river / road intersections
  - Design collection so sites can be done in one day
  - Sites above & below confluences recommended, including major tributaries
  - Include a mix of perennial vs. intermittent flow sites
  - A maximum of three-mile intervals will quantify water quality sufficiently
    - We did ½ mile to 1 mile intervals = 26 sites
    - 3 miles would be about 13 sites including tributary confluence points
- When to collect:
  - Measure storm events – that's where the response in water quality is
    - Use stream gauge to choose stream events, choose seasonal examples
  - Check sites during low-flow conditions to see which are year-round vs. intermittent
    - Can use USGS stream gauge where available
  - Measure seasonally once monthly baseline is established – Winter (Jan.), early Spring (April), late Spring (May/June), late summer (Aug/Sep), Fall (Nov.)
    - 5 collects per year instead of 12
- How to organize data: Import data into organized, documented database
  - We used PostgreSQL, an powerful free open source relational database
  - Delivered to NRCS with documentation
  - All data also made available to NRCS via web mapping site

Monthly average Turbidity trends for Bean Creek



Tiffin River ArcIMS Viewer:

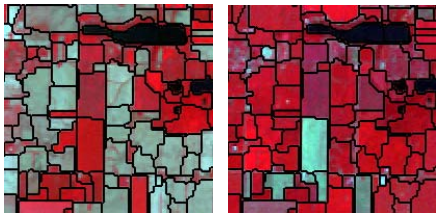
2005-2007 water quality data are available to NRCS via an interactive web-mapping site



Land Cover Mapping Input data: Imagery with CLU boundaries (including crop types)

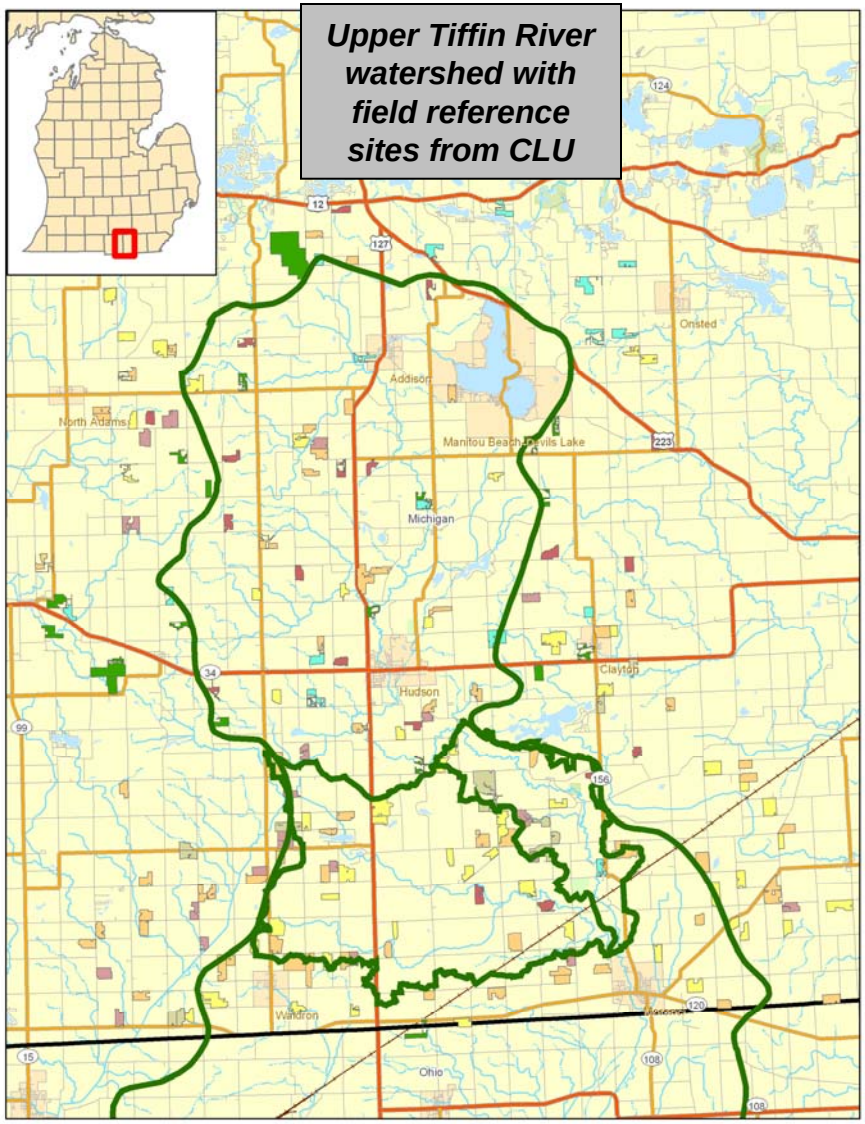
Examples of color-infrared satellite imagery showing crop cover change

6/6/05 8/8/05



Legend

- Tiffin River Study Watersheds
- Alfalfa
- CRP
- Corn
- Grassland
- Soy Beans
- Forest
- Wheat

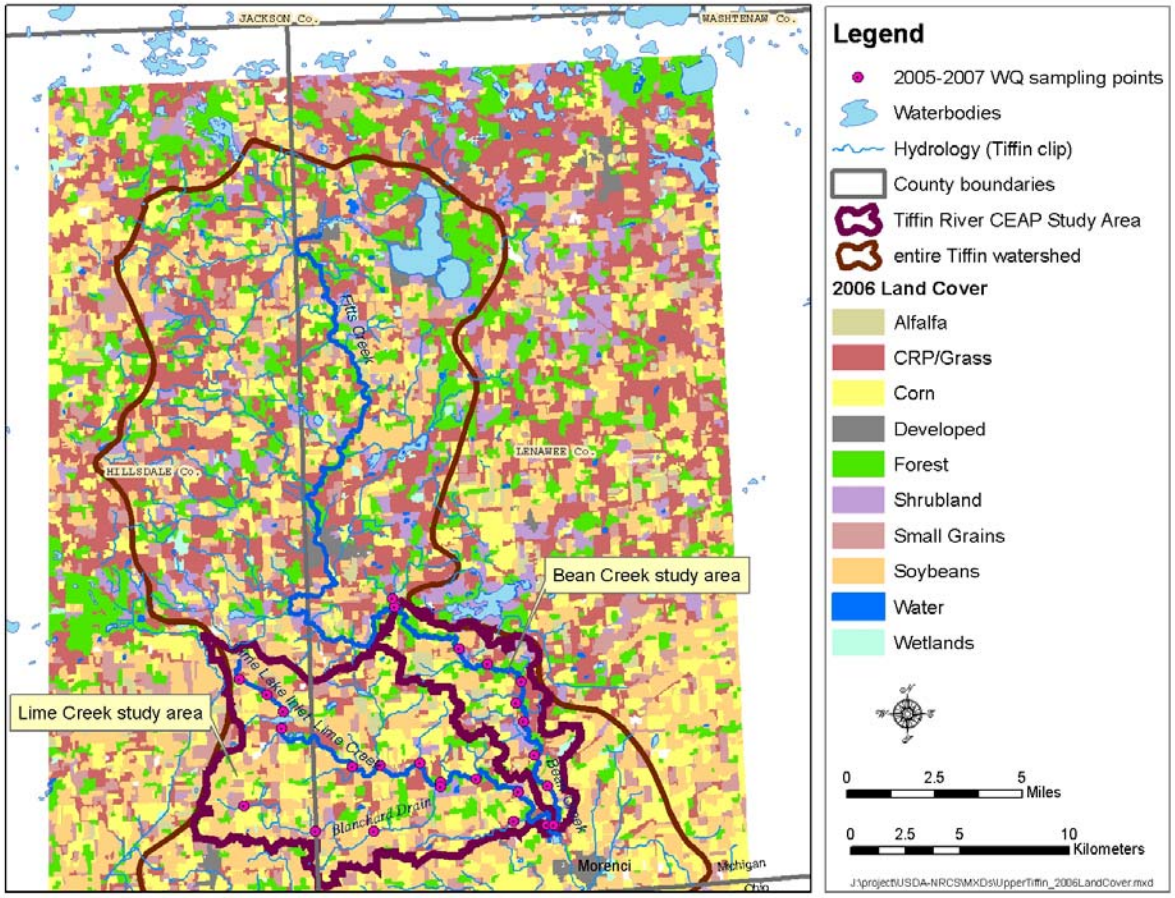


2006 Landsat TM scenes:

May 07, 2006
May 11, 2006
June 24, 2006
July 17, 2006
August 02, 2006
August 11, 2006

Data for 2005: Landsat TM scenes
April 18, 2005
May 4, 2005
May 20, 2005
June 6, 2005
July 7, 2005
August 8, 2005
September 9, 2005

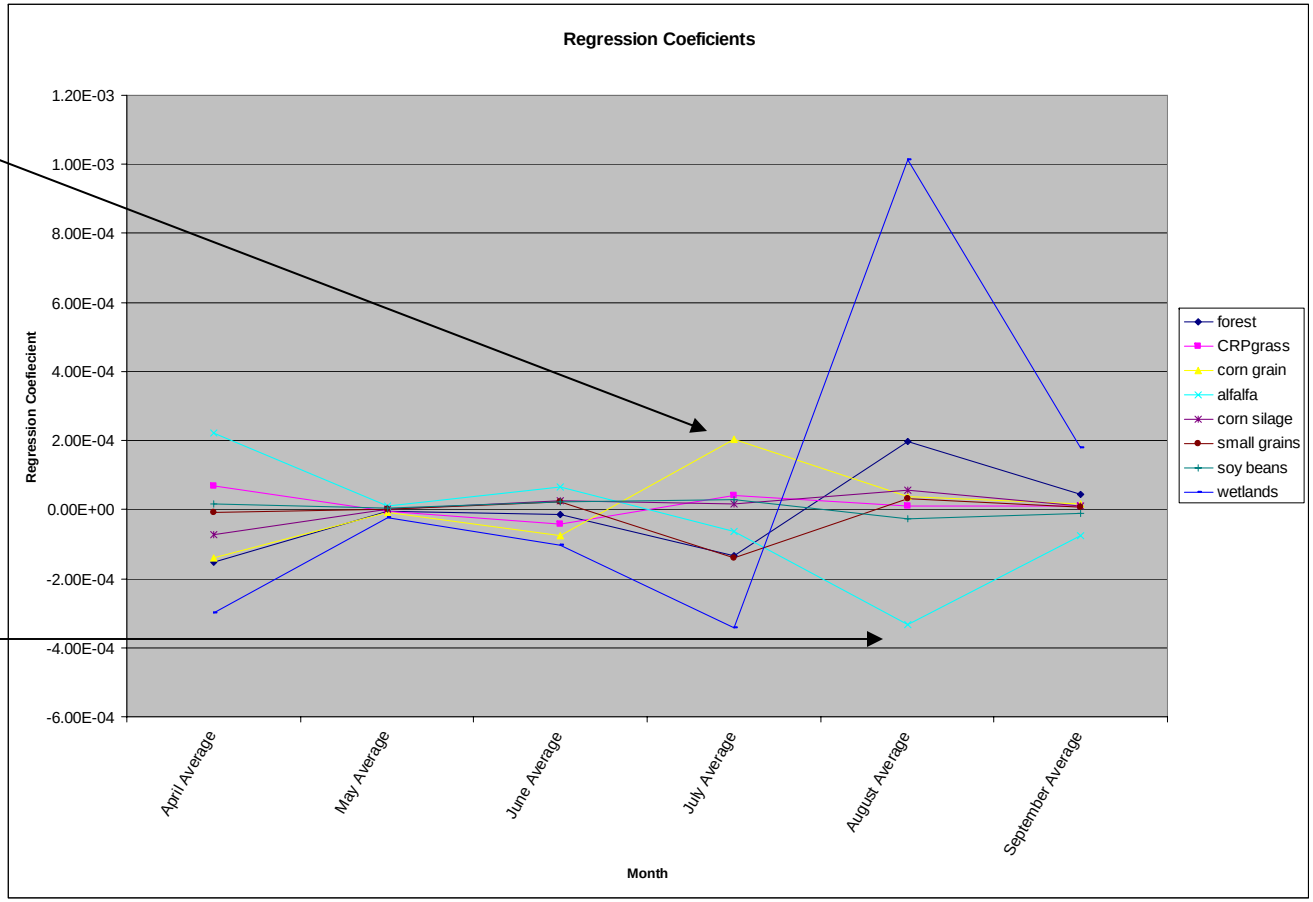
Classification results: entire Upper Tiffin Created high accuracy maps



- 2005 accuracy:
  - Overall ag: 85.6%
  - Alfalfa: 84.0%
  - Corn: 80.3%
  - Small grains: 98.2%
  - Soybeans: 83.5%
- 2006 accuracy:
  - Overall ag: 93.3%
  - Alfalfa: 80.0%
  - Corn: 95.7%
  - Small grains: 100%
  - Soybeans: 90.4%

How does land cover contribution change seasonally?

- Corn grain contributes to greater increase in turbidity in July, but lowers in April
  - Residue effect?
- Wetlands are only a very small % (>1% of watersheds), but impact may vary greatly – decrease turbidity in July, increase in August?
- Alfalfa – April increase, August decrease
  - April – bare fields, August – mostly cropped



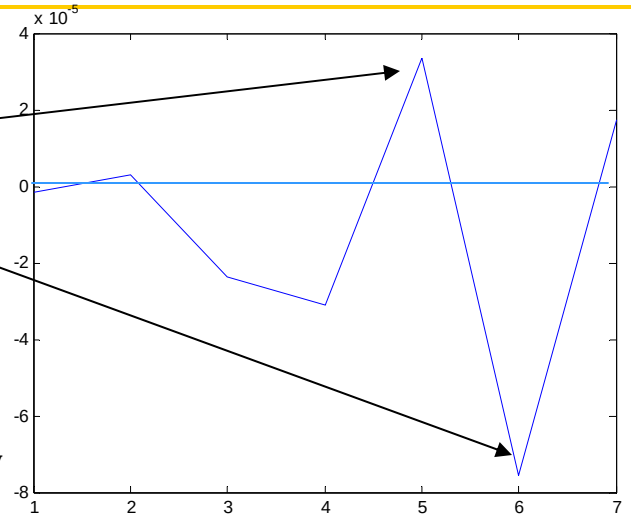
Related analysis:
Overall, for turbidity, CRP-Grass, soybeans, & alfalfa make the greatest predictive change in turbidity if you remove them from the equation

Turbidity & land cover connection

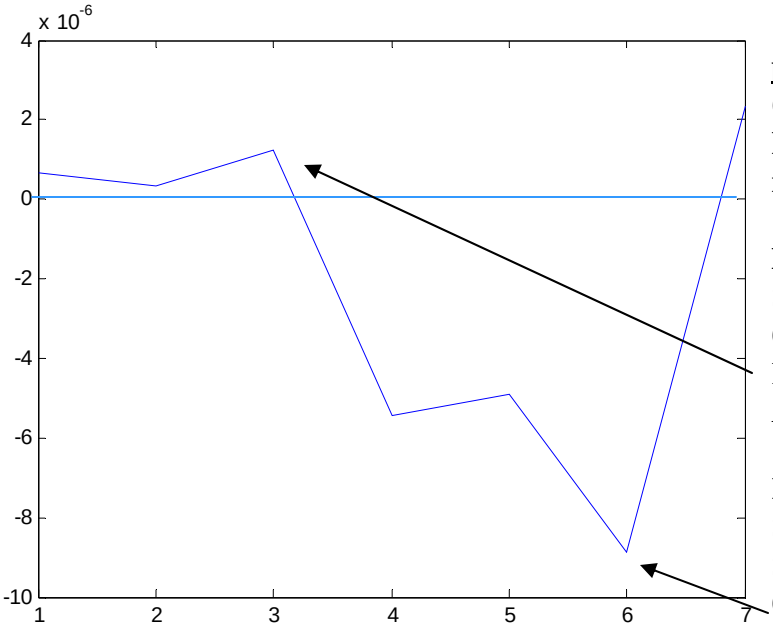
- Land use associated with increase in turbidity (over a year):
  - Corn Grain
  - Soybeans
  - CRP/grass
- Land use associated with decrease in turbidity:
  - Alfalfa
  - Corn Silage
    - However, causes greater turbidity in Spring
  - Small grains
  - Forest
- However… significant seasonal variations exist
  - May-July is greatest variation in parameters vs. land cover
  - In Spring, corn grain & wetlands decrease turbidity
    - high rainfall period
    - Corn grain holding soil on fields in spring

Are specific land cover types associated with changes in water quality parameters?

- Looked at relative contribution (and direction of contribution) of land cover variable to variation in regression equations



- Higher DO – shrubland
- Lower DO - Corn



pH

Crops that increase acidity have a high impact on the model

Decrease Acidity
Small Grain
CRP Grass – Lease impact
Forest
Alfafa – Most impact

Increase Acidity
Soybean
Shrubland
Corn - Most Impact

Regression coefs - pH
Small grains = 1, CRP grass = 2, Forest = 3, Soybean = 4, Shrubland = 5, Corn = 6, Alfalfa = 7
2005 data, local buffers

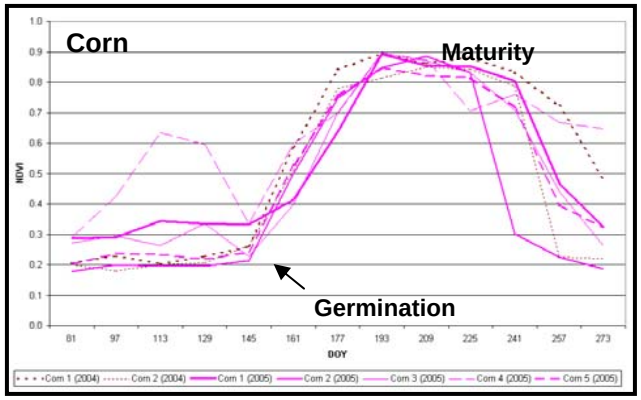
Major land cover & water quality conclusions

- Agricultural land use is highly correlated with water quality data in the Tiffin
- Agricultural land amounts can be used to predict changes in data following storm events
- Separating Bean & Lime creeks meant data were analyzable – watersheds are affected differently by land use / land cover
- Regression coefficients change from month-to-month, with late Spring / early summer having greatest variability
- Turbidity, DO, & conductivity are the most important parameters to measure if you can only choose certain variables (means a less expensive instrument can suffice)
- For ag types, corn grain & soybeans increase turbidity
  - Corn silage seasonal impact (April runoff) also associated with high turbidity
- Alfalfa & small grains decrease turbidity (+ forest)
- In Spring, corn-grain decreases turbidity (and possibly wetlands)
- Conductivity is most strongly associated with soil type
- Planting more corn silage may increase turbidity, but this relationship varies by season

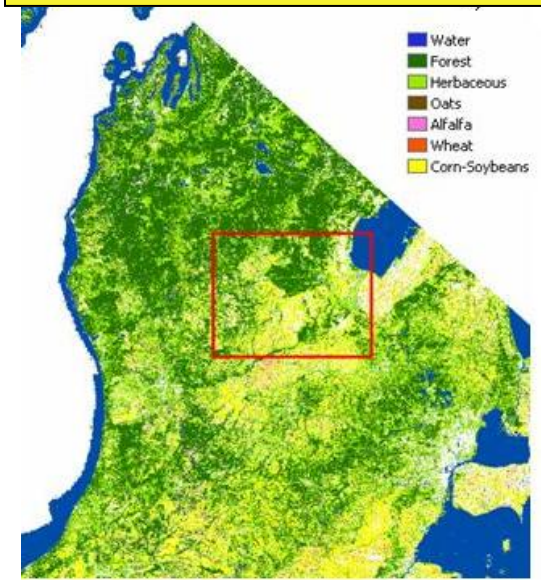
Additional tools developed under the program: Mapping of crop types statewide & crop residue

- Developed a tool to map crop types across the state
  - Used frequently-collected MODIS satellite images
    - Moderate resolution but daily overpasses
  - Developed algorithm to capture crop growth patterns over the growing season (NDVI-based)
  - Mapped corn, soybeans, wheat, oats, alfalfa, & soybeans (overall 80% accuracy)
  - Documented tool for NRCS, available as a report
  - Used methods for crop rotation mapping, continuing under NRCS CSREES grant
- Created enhanced algorithms to map crop residue levels for assessing levels of conservation tillage
  - Assessed Landsat images, ASTER images
  - Found MSACRI Landsat algorithm to be most promising
  - Documented progress for NRCS, available as an ASPRS 2007 conference proceedings paper
  - Continuing development under NRCS CSREES grant

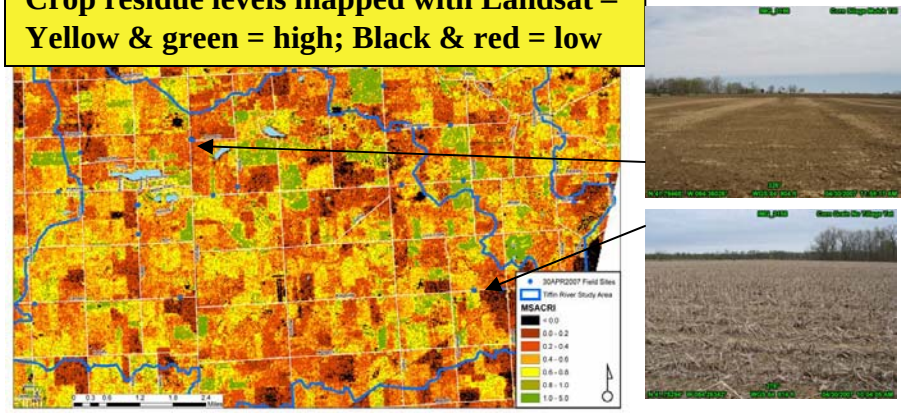
Example crop phenology biomass curve (for Corn)



Crop type map for 2005 using MODIS tool created using crop phenology curves

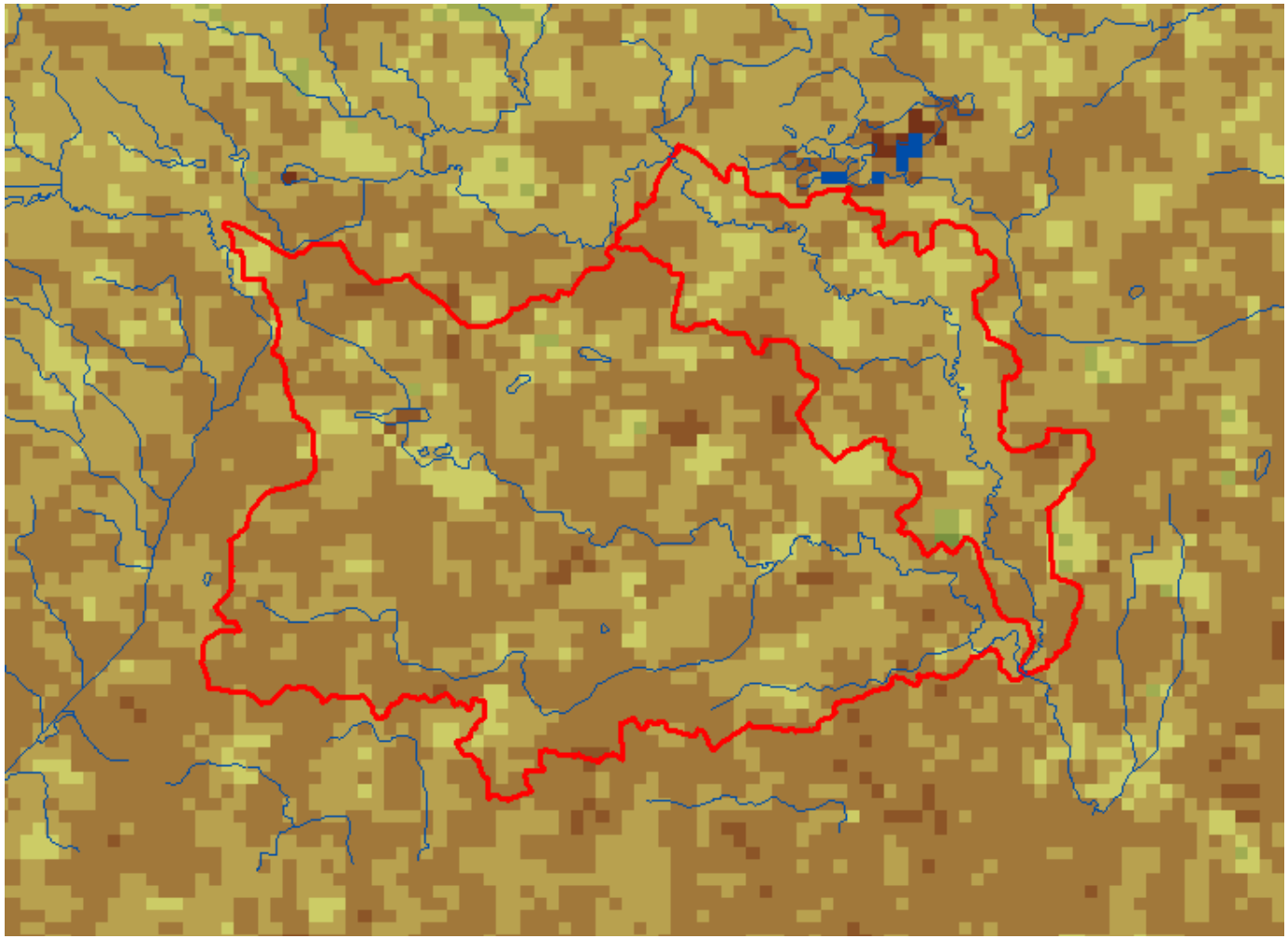


Crop residue levels mapped with Landsat – Yellow & green = high; Black & red = low



Remote Sensing of Crop Phenology

Animated MODIS Vegetation Index (NDVI)
Mar. 21 - Oct. 14, 2004



MichiganTech Research Institute

Recommended Next Steps

Final Project Briefing

Michigan NRCS State Office, East Lansing, MI

May 21, 2008

USDA NRCS

Recommended next steps

- Formalize process within NRCS so future EQI assessments can be performed efficiently (c.2010)
- Create geospatial tools to assess Michigan-NRCS implementation of CSP
- Generate a remote sensing-based lake clarity tool available for multiple time periods
- Continue development of Web-based information tools
  - Including providing training to NRCS staff on viewers
- Assist NRCS in development of geospatial data resources
  - e.g. complete Michigan FSA photograph georeferencing