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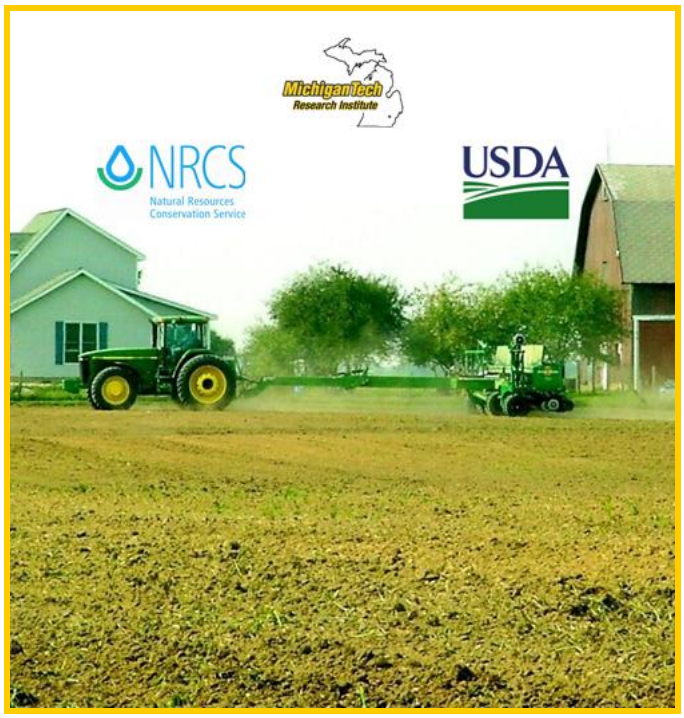

Evaluating the Impact of NRCS Programs: New Measures and Improved Communication

Overview of the Cooperative Agreement Project

Robert Shuchman, Nancy French, Colin Brooks, Tyler Erickson

May 2008

USDA NRCS

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Introduction: Project History and Goals

In 2003, the Department of Agriculture provided additional funds to the Michigan Natural Resources Conservation Service (MI-NRCS) to assist in developing new management and evaluation tools. Specifically, the Appropriations Committee provided funding "to conduct a Great Lakes pilot in Michigan for conservation program decision support capability to better evaluate and implement conservation programs in the Great Lakes Watershed." The cooperative agreement was renewed to provide funding to continue the project for a total of four years (Table 1). The intent of the funding was clarified in a colloquy between Senators Levin and Stabenow in November 2003 on the Senate floor. The work done on the project, presented in several reports complied annually, and summarized in this report, serves to satisfy this requirement. The Michigan Tech Research Institute (MTRI) has been working on this project through a cooperative agreement with the Natural Resources Conservation Service (NRCS) in Michigan to support MI-NRCS in its management and administration of agricultural conservation programs. This cooperative agreement began with MI-NRCS and the Altarum Institute and was transferred to MTRI in October of 2006.[1]

In the broadest sense, the goal of this multi-year project is to assist the NRCS to improve conservation program assessment and evaluation. This goal has two main elements:

- To assess the outcomes of the NRCS conservation programs including the economics of program investment versus environmental results;
- To enable improved communication and management of conservation-related information within and outside NRCS and providing better feedback to NRCS management so that programs can be managed effectively.

The intent of the cooperative agreement tasks is to provide useful and valid tools and products to support NRCS conservation goals and to improve MI-NRCS operations and program management. This project summary report presents a review of work performed over the four years of project activity. More detailed descriptions of this work can be found in reports compiled at the end of each year, including a new set of reports summarizing Year 4, the final year of the project.

Description of Project Tasks

Year 1 of the project, which was completed in September 2004 using FY2003 funding, consisted of three tasks. First, an environmental-centric NRCS program evaluation framework and method was developed. This task included creation of the framework used to assess program effectiveness and several targeted projects and case studies. The second task improved communication amongst conservation program stakeholders by developing a prototype web portal for improving communication between conservation program stakeholders. Third, an initial assessment was provided of program management choices possible in light of the evaluation from task one.

[1] On October 1, 2006, Altarum's Environmental and Emerging Technologies Division (EETD) (all personnel, equipment and contracts/grants) were divested and became the Ann Arbor based Michigan Tech Research Institute (MTRI).

Table 1: Cooperative Agreement Timeline

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

In Year 2, the project team solidified into a very effective working group comprised of both MI-NRCS and Institute staff that met every six to eight weeks to review and discuss technical progress and exchange data and results (Appendix A lists project personnel). The three tasks from Year 1 were continued in Year 2, although with a new structure, the addition of two new tasks, and a de-emphasis of the web-based information portal in favor of a web-based IMS for internal MI-NRCS use. The new tasks were an activity to help support the CEAP/Tiffin River Watershed project, a project being carried out by MI-NRCS for the USDA Conservation Effectiveness Assessment Project (CEAP), and an effort to improve the MI-NRCS technical assistance tracking system. The new Technical Assistance Tracking System (TATS) was to replace the outdated and difficult to use spreadsheet-based system that is used within MI-NRCS to help managers of conservation programs organize contracts and track progress.

Year 3 found a continuation of the Year 2 tasks with a consolidation of the assessment of management practice effectiveness with the program evaluation task. In the final year, this agreement includes five activities that have evolved based on project emphasis and MI-NRCS need. In Year 4 an additional task to provide georeferencing expertise to MI-NRCS was added. The two main goals of assessing program outcomes and improving communication remain the focus. The Year 4 tasks are:

1. Refinement of program evaluation approaches and the EQI
2. Development and Deployment of Technical Assistance Tracking System (TATS)
3. Support of Conservation Effects Assessment Program project in Tiffin Watershed
4. Development of MI-NRCS Internet Mapping Service (IMS)
5. Georeferencing of Wetland Airphotos

In this report, we summarize the purpose, approach, and accomplishments of the various tasks undertaken for this project. Detailed description of methods, results, and task accomplishments are described in greater detail in reports written at the close of each year, including new reports written to report on Year 4 activities (see Appendix B).

Project Structure and Process

The MTRI project team has operated in full cooperation with the MI-NRCS staff in order to effectively use the expertise and resources they provide. The project team fills the role of innovator and enabler for MI-NRCS by developing new management tools and being responsive to the needs of the MI-NRCS staff to compliment and enhance their capabilities. The tools and products developed under this cooperative agreement directly influence MI-NRCS, with the intention that some products can and will be transferred to other states as appropriate. Product development, therefore, is done with the Federal NRCS needs in mind, but through a state-level process as a testing/vetting resource.

The cooperative agreement has been conducted with MTRI providing input to MI-NRCS staff based on the goals and objectives jointly defined. Project update briefings occur every 6-8 weeks to highlight and discuss technical progress and next steps and to exchange data and results with the MI-NRCS. Extensive communication between MTRI team and MI-NRCS staff has enabled effective progress towards the project goals. Communication within and outside of MI-NRCS has been accomplished via the regularly scheduled update briefings, technical level meetings as needed, comprehensive annual reports, and external presentations & publications (see Appendix B for a list of reports, presentations, publications, and briefings). A highlight of the four-year effort was a May 2006 briefing to the *Field Office Business Tools Coordinating Council* at USDA Headquarters in Washington, DC. There, the team presented the project goals and progress and were provided with valuable feedback to help enhance the project outcomes.

Task Activities and Outcomes

A review of the activities and outcomes of the MI-NRCS/MTRI Cooperative Agreement is presented based on the two main project goals, evaluation of conservation program effectiveness and improved communication and information management. Specific project tasks changed over the four years of the project, but these two goals remained the driver of program activities.

Assessment of NRCS Conservation Program Effectiveness

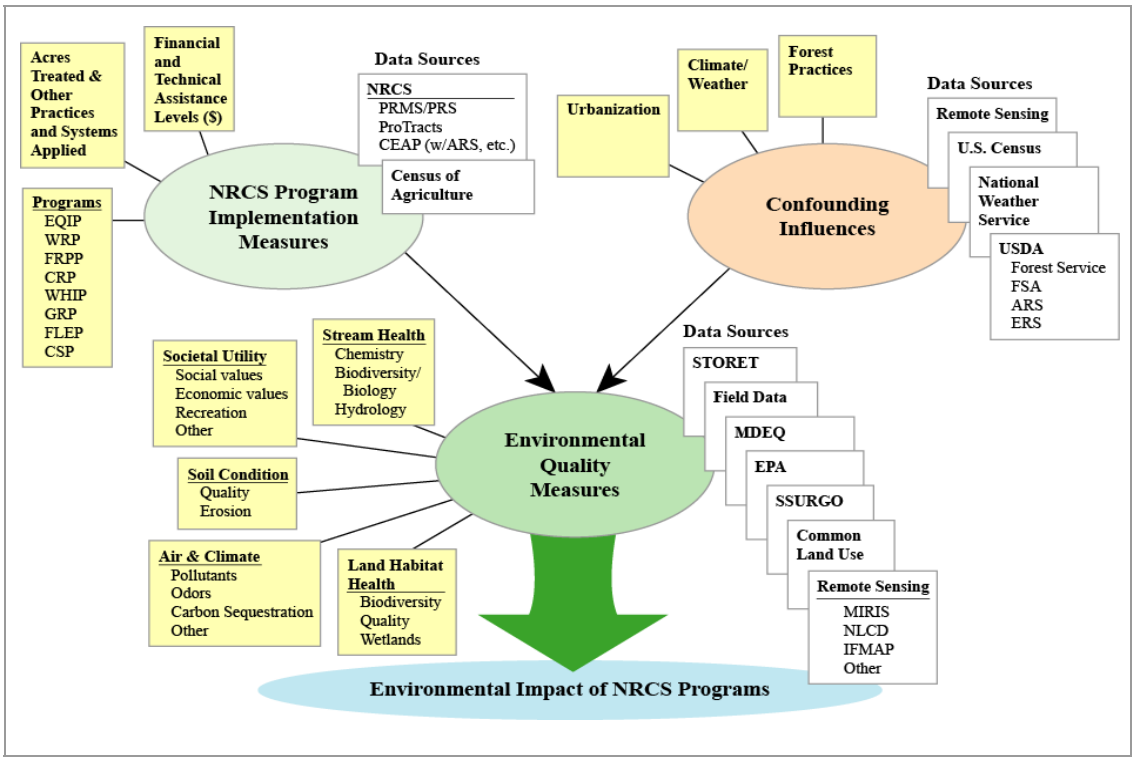
The specific programs administered by NRCS, of which the Environmental Quality Incentives Program (EQIP), the Wetlands Reserve Program (WRP), and the Farm and Ranch Land Protection Program (FRPP) are the largest three in Michigan as measured by total funding levels, seek to "conserve, maintain, and improve" natural resources and the environment. NRCS pursues these objectives by offering financial and technical assistance to farmers to implement specific practices that are known to or thought to improve environmental quality. Therefore, the evaluation approach developed for this project seeks to associate measures of program implementation with independent measures of environmental quality. The initial review in Year 1 of available data to assess statewide program effectiveness for Michigan clearly showed that evaluation of the environmental effects of NRCS programs is a complex and challenging problem given that our land, water, and air are subject to numerous influences, most of which are not directly under the control of NRCS programs. To accomplish this difficult assessment, an approach has been developed to compare NRCS program implementation activity to environmental outcomes. A framework to construct this approach was developed and data on conservation program activity and information on environmental quality have been collected and analyzed. The result has been a conceptual approach to assessing conservation effectiveness, a method of quantifying conservation program implementation level of effort, and a method of combining measures of environmental quality over time into an index-based measure.

Conservation Program Evaluation Framework and the Environmental Quality Index (EQI)

In Year 1 of the Cooperative Agreement, the project team started addressing the question of NRCS conservation effectiveness by developing an evaluation framework. This conceptual model of NRCS program implementation, environmental quality, and confounding effects has been developed to be implemented across counties and/or watersheds to provide statistical insight into questions of the effects of NRCS programs (Figure 1). An initial version of the conceptual model shown in Figure 1 was developed in Year 1 of the project and modified based on MI-NRCS staff feedback in Year 2 of the project. A report detailing the development of this framework was provided in Year 1 report: *Framework for Evaluating NRCS Programs and Proposed Environmental Quality Metric*, and further described in the Year 2 report: *Revised Framework for Evaluating NRCS Programs and Proposed Modifications to Environmental Quality Index*.

The conceptual model presented in Figure 1 contains three main components. The idea is to understand the influence of NRCS programs on environmental quality (light green and dark green circles). In a world perfectly designed for evaluation, NRCS programs would be the only changes that affect the environment. The real world, however, is far more complicated, and NRCS programs exist against a backdrop of other, confounding influences (the orange circle) that also affect environmental quality (for example, urbanization, land cover change, and climate). As a result, these confounding influences also must be measured and accounted for.

Figure 1: Conceptual Model of Proposed NRCS Evaluation Approach



The mathematical feasibility of a stable and useful environmental quality index (EQI) for NRCS was demonstrated in Year 2 of the cooperative agreement (see Year 2 report: *Revised Framework for Evaluating NRCS Programs and Proposed Modifications to the Environmental Quality Index*). The approach that has been developed begins by identifying resource concerns that NRCS programs address in their prescribed practices. The effects of these practices that are observable are then measured or modeled using a variety of information collection resources These resources include remotely sensed imagery, Geographic Information System (GIS) data layers, and results from published models. The EQI is then used to combine these inputs into a metric that can be compared to NRCS program implementations. Figure 2 summarizes this process. A report on the initial development, structure, and planned content of the EQI was written in Year 3: *Evaluation Activities and EQI Development, Year 3*. A review of the final configuration and content of the EQI is provided in the Year 4 reports: *The Environmental Quality Index Approach: Concepts, Methods and Demonstration for Conservation Program Assessment* and *Inputs to the Environmental Quality Index*.

In the four years of the cooperative agreement, the MTRI team has pursued independent sources of environmental quality data pertinent to assessment of agricultural programs and practice effectiveness. The Year 1 report *Summary of Environmental Data Available for Michigan* describes the first attempts to identify these measures under this project. Efforts have concentrated on data that was geospatially defined based on remote sensing data and products and on products and data collected or modeled by agencies and organizations that collect environmental data, such as the U.S. Environmental Protection Agency (US-EPA) and the Conservation Technology Information Center (CTIC). These efforts build from MTRI's extensive experience with remote sensing and GIS, take advantage of existing well-documented data sources, and enable the EQI to eventually be applied for multiple time periods.

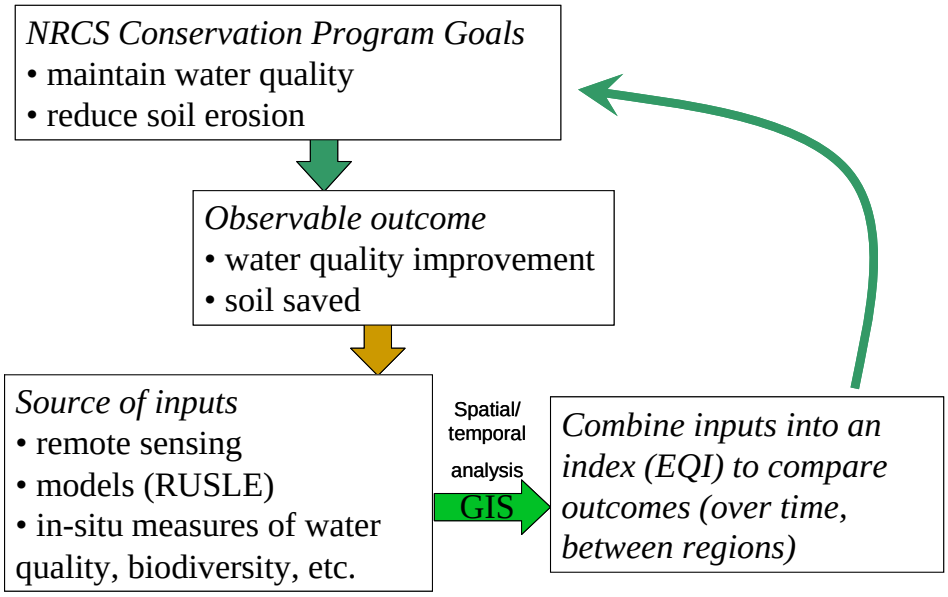


Figure 2. Overview of the process for development of the EQI

In Table 2, we list the measures within each of the four components of the EQI that were selected for use in the EQI with the help of the MI-NRCS staff. These were identified by considering NRCS resource concerns (the concerns that are targeted with conservation practice implementations) and discovering relevant and available information products, either measurements or model-based outputs. These ten inputs come from a variety of sources with varying level of data preparation and analysis needed before they are used in the EQI. Several data sets were considered for inclusion in the EQI that are not in the final version. All of the EQI inputs used are considered to be products that are repeatable or planned to be repeated in the future so that an EQI assessment can be completed for a future timeframe and compared over time. Details on the data sets used in the EQI and the unused data sets are given in the Year 4 report *Inputs to the Environmental Quality Index*.

Table 2. Components and inputs used in 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*	

Three of the EQI inputs are taken from existing data sources, while the list of final EQI inputs includes six that are derived from remote sensing data and products through methods developed at MTRI. Three remote sensing-derived inputs, riparian buffers, habitat improvement, and habitat fragmentation, use land cover maps developed by the National Oceanographic and Atmospheric Administration (NOAA). These maps are complete for 1995 and 2000, and are planned for 2005 and continuing on a five-year basis. A review of the three inputs that use this NOAA dataset is presented in the Year 4 report: *Using C-CAP Land Cover Products for EQI Inputs*. The algorithm to determine crop rotation for the soil condition component was developed based on research conducted in Year 3 of this project using MODIS image data and field information collected at the Tiffin River test site (see Year 3 report: *Geospatial Algorithms for Agricultural Applications: A Review of New Advanced Technologies*; and the Year 4 report: *Inputs to the Environmental Quality Index*). The lake clarity product, used as one of the water health inputs, uses an algorithm developed by MTRI from Landsat images and base maps developed by the US Geological Survey (USGS; Fuller et al. 2004). Details on development of the MTRI lake clarity algorithm and products are given in the report: *Remote Sensing of Lake Clarity*. The significance of having remote sensing-derived measures is that these products can be repeated for any time and place that appropriate remote sensing data are collected, which includes data from the past.

In order to calculate the EQI, MTRI has adopted a statistical approach rooted in factor analysis. This type of approach is best suited for taking a set of input measures (indicators) in a variety of units and reducing these to a smaller set of calibrated metrics in a normalized unit and has been demonstrated in several applications in the scientific literature (Burns et al. 2004) and described in more detail in the Year 4 report: *The Environmental Quality Index Approach: Concepts, Methods and Demonstration for Conservation Program Assessment*.

In the three years of development the EQI has gone through several forms as the project progressed. As finalized, it employs four components within the overall EQI: soil condition, surface water health, land habitat health, and air quality. Each component is built from a set of input datasets for that environmental component. Each component is weighted based on relevance to NRCS goals, and each input is weighted based on its relevance in determining the component score. Input and component weights were set based on feedback obtained though a workshop run by MTRI in September of 2007 where the opinion of MI-NRCS experts was solicited. In addition to expert opinion for assigning weights of inputs and EQI components, the expert panel provided their opinion on construction of the transformation functions needed to translate the input data into a scale that allows combination with the other inputs. The process and results of that workshop are reported in the Year 4 report entitled: *Evaluating the Impact of NRCS Programs: New Measures and Improved Communication: Report on the EQI Experts Meeting*. A detailed review of EQI development and calculation is given in the Year 4 report *The Environmental Quality Index: Concepts, Methods and Demonstration for Conservation Program Assessment.*

A web-based user interface was created to allow users to visualize the EQI data in an interactive mapping application. The interface allows users to change the component and datasets weights, and to instantly see the effect they have in the overall EQI. Technical details on how the EQI Data Viewer was implemented are contained in the Year 4 Report: *NRCS Data Viewers Technical Documentation*.

Quantifying Conservation Program Implementation

The NRCS conservation program evaluation task relies on NRCS data to obtain measures of program implementation. As an initial step to assessing the impact of conservation programs, an analysis was completed in Year 1 to determine the temporal, spatial, and descriptive extent of information on the

application of conservation practices in Michigan. The Year 1 report *Summary of NRCS Program Implementation and Practices Data* presents results of this Year 1 task.

The database investigated in Year 1 was the Performance Results System (PRS), formerly known as the Performance and Results Measurement System (PRMS). Through this initial assessment, it was determined that program data are not available at sufficient spatial-temporal resolution to enable full potential of remotely sensed data, so analysis at the county scale was decided to be the best approach for the project. In addition, program implementation data prior to 2000 was not reliable enough to be used for a thorough assessment.

In Year 4 a general level of conservation program effort was determined for the 1980's and 1990's using data collected in the Field Office Computing System (FOCS), which includes data transferred from the older field office planning system (CAMPS), so therefore includes implementations back to the mid-1980's and before. The FOCS archive database represents the best records of program activity for Michigan for the time period before c. 2000 (see Year 4 report *The Environmental Quality Index Approach: Concepts, Methods and Demonstration of the EQI for NRCS Conservation Program Assessment)*.

In Year 2, the project team was provided access to the Program Contracts System (ProTracts), a database that holds details on all planned and certified contracts and practices implemented under conservation program contracts. ProTracts came into general use in Michigan in 2004, so reliable program data is available for 2004 to the present. While the data contained in the ProTracts system provides an accurate accounting of program activity, a better comparison for an EQI-like assessment is a measure of the benefits provided in implementing the practices. For this project, MTRI has developed a method of quantifying the expected benefits from the combination of the many practice implementations put in place within each county each year using the Conservation Practice Physical Effects (CPPE) scoring system. CPPE scores have been developed for all NRCS-defined conservation practices in order to gauge the expected benefit that would be derived from practice implementation. The scoring system was developed to help evaluate the potential effects of conservation practices on resources when developing conservation practice contracts and providing technical assistance (see http://www.nm.nrcs.usda.gov/technical/fotg/section-5/CPPE.html). The Year 4 report: *The Environmental Quality Index Approach: Concepts, Methods and Demonstration of the EQI for NRCS Conservation Program Assessment* describe the CPPE weighting method in detail.

A web-based user interface was created to allow users to visualize the ProTracts implementation record data in an interactive mapping application. The interface allows users to change specify criteria to limit the records that are summarized. The interface also allows users to visualize the expected benefits for applied or planned implementations based on the CPPE scoring method. Technical details on how the ProTracts Data and Expected Benefit Viewer was implemented are contained in the Year 4 Report: *NRCS Data Viewers Technical Documentation*.

Accounting for Confounding Influences in Making EQI-based Program Assessments

Dealing with the confounding influences that are present in the assessment of NRCS program effectiveness is one of the more challenging steps. In the Year 4 report: *The Environmental Quality Index Approach: Concepts, Methods and Demonstration of the EQI for NRCS Conservation Program Assessment* approaches are demonstrated to control and account for non-NRCS changes that influence EQI scores. In this demonstration, a method to identify pairs of counties which have comparable land cover characteristics, but very different NRCS implementation levels is described. Counties with similar land cover and hydrologic density within each Michigan region were identified and grouped into clusters of similar counties using Ward's hierarchical clustering method (Figure 3). Land cover

similarities were based on the proportion of forest, agriculture, wetland, and shrub/scrubland in each county using the 1995 C-CAP land cover map (for a description of the C-CAP land cover products see Year 4 report: *Using C-CAP Land Cover Products for EQI Inputs*). Hydrologic density was included in order to account for the potential impact of a county land cover and land cover use on water quality. In addition, accounting for other variables though a multivariate regression analysis is demonstrated (the variability in county-level land cover change is demonstrated in the analysis described in the report). These approaches are examples of statistically-based methods of dealing with a variable system.

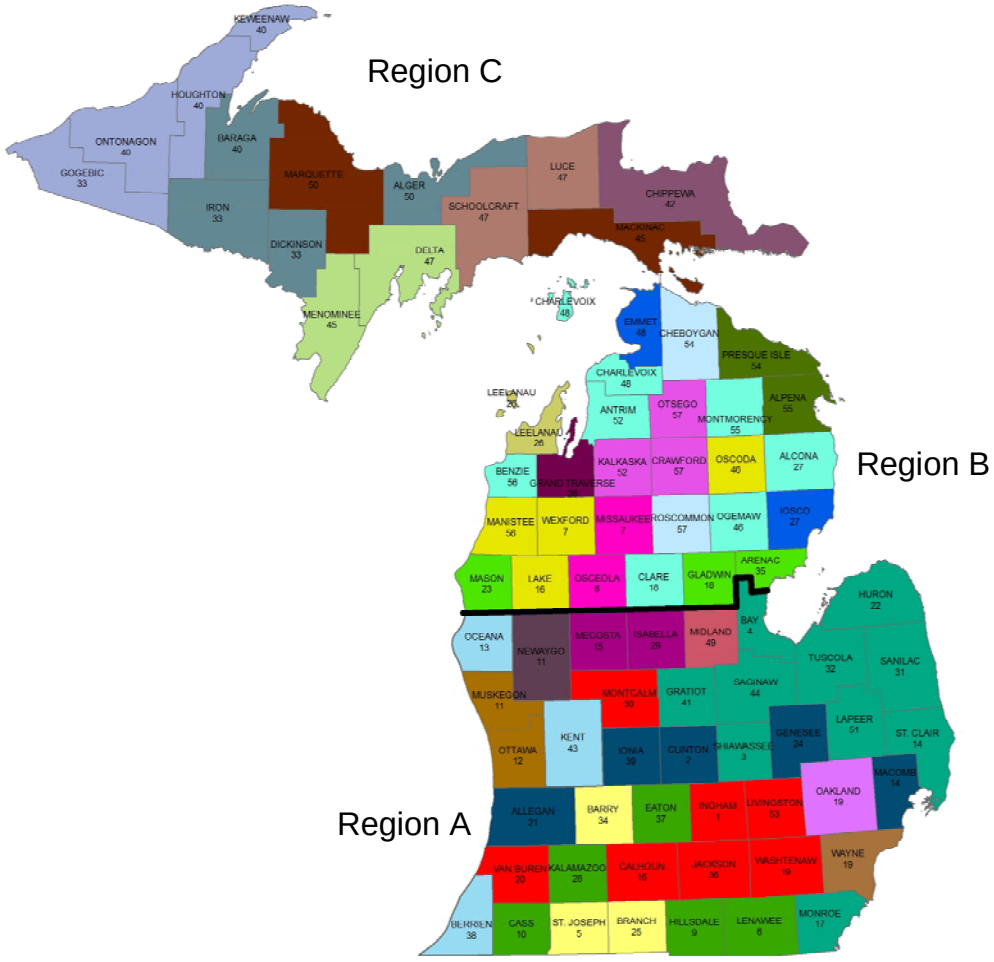


Figure 3. Map of county clusters determined for three geographic regions of Michigan. *Clusters were developed within each region using land cover and hydrologic density information to determine counties with similar land cover characteristics. Clusters were used to identify county pairs for the paired analysis.*

Support of the CEAP/Upper Tiffin River Watershed Project

In Year 2, the project team was asked to support a newly funded project to the MI-NRCS from the Conservation Effects Assessment Project (CEAP), an effort by USDA to assess the effectiveness of farming practices implemented under USDA conservation programs (Mausbach and Dedrick 2004

and see http://www.nrcs.usda.gov/TECHNICAL/NRI/ceap/). The Upper Tiffin River Watershed CEAP project was headed by Ruth Schaffer of the Michigan NRCS to assess the impacts of manure spreading and other waste treatment operations on water quality in the Michigan portion of the Upper Tiffin River Watershed (Figure 4).

Several activities were preformed by MTRI in support of the Tiffin River Watershed project. First, we were asked to help map land cover for the study region to provide to MI-NRCS for use in their modeling effort. Second, MTRI took on the task of conducting a detailed and comprehensive monitoring of stream water quality with a goal of characterizing the water quality within the Tiffin River Watershed.

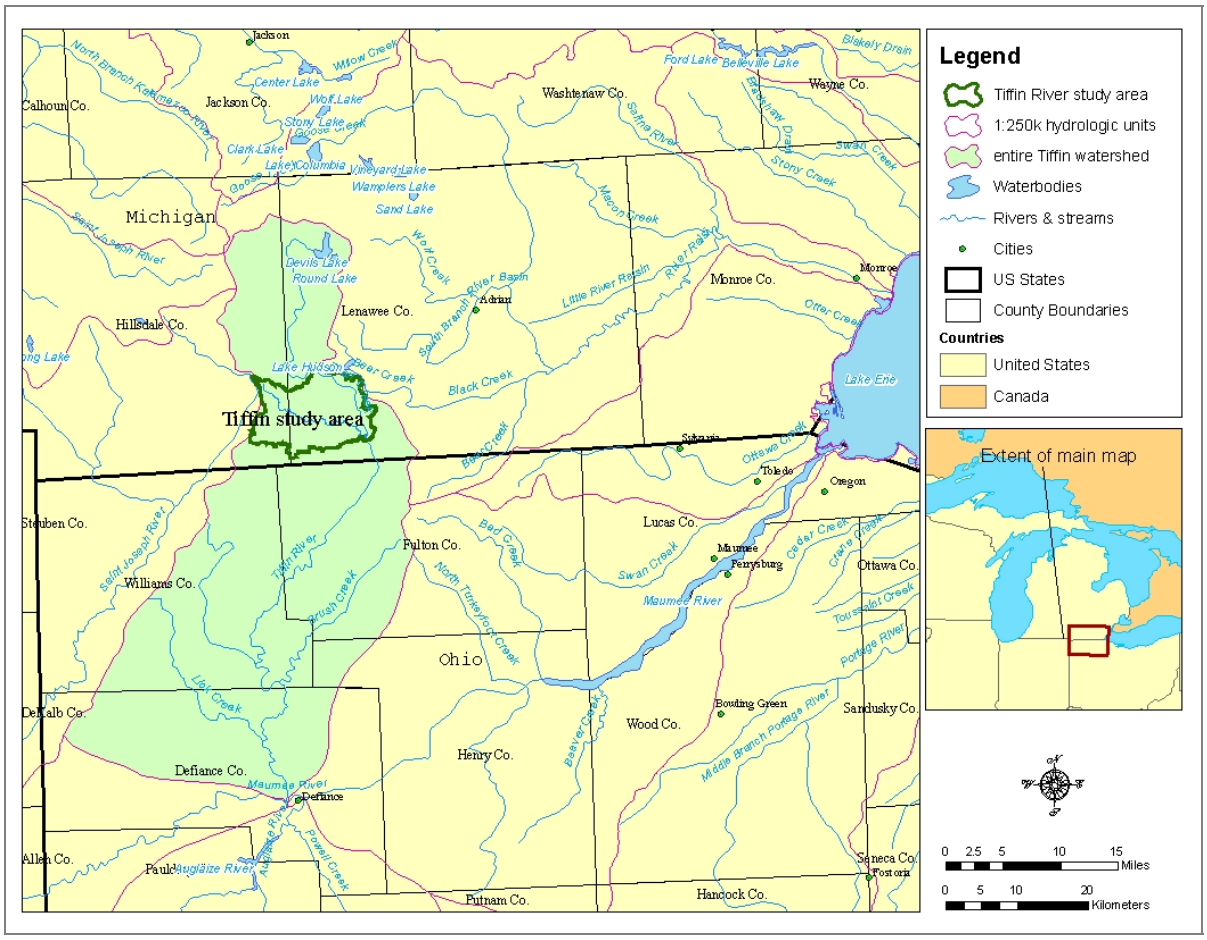


Figure 4: Location of the Tiffin River Watershed study area.

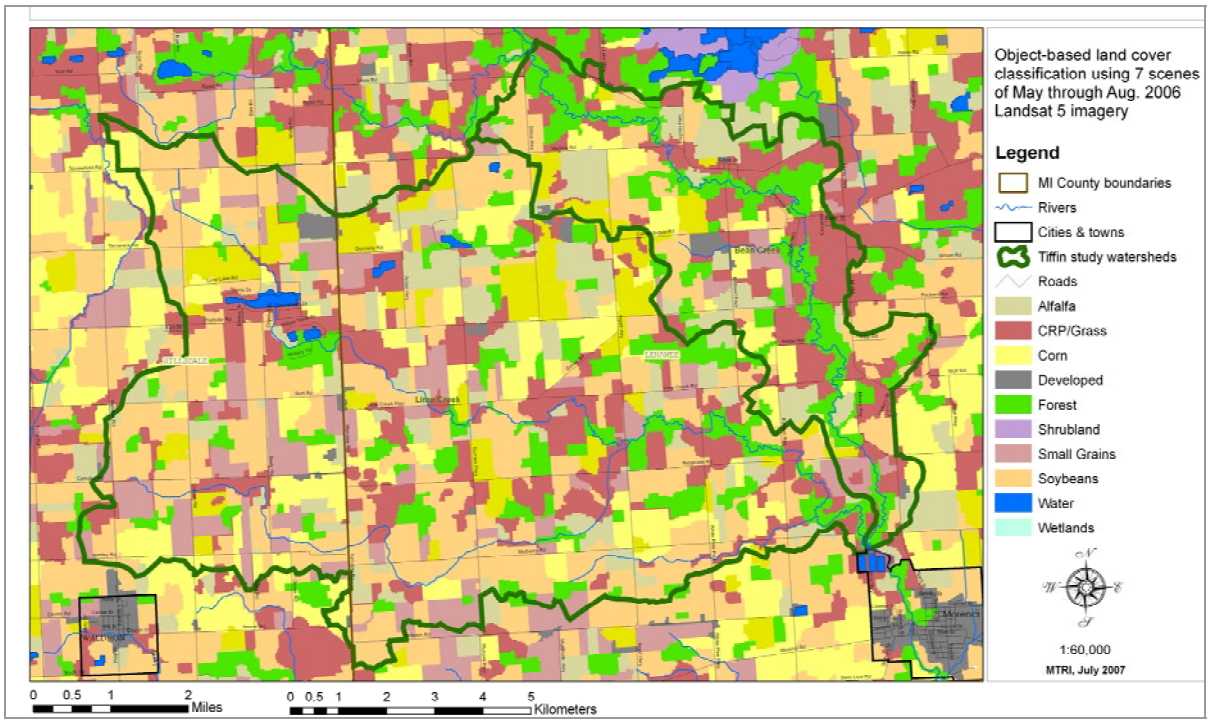


Figure 5: 2006 Object-based land cover classification for the Tiffin Study Site. *Classifications were completed for 2004 to 2006 in support of the CEAP/Upper Tiffin River research project.*

Mapping Land Cover in the Tiffin Study Area

MTRI developed agriculture-focused land use and land cover maps for 2004, 2005, and 2006 for the Tiffin River watershed in southeastern Michigan, using multiple dates of satellite imagery that captured changes in crop growth over the growing season. These maps represent an improvement in land use data currently available for the region due to their focus on specific crop types, accuracy, and timeliness. Up-to-date, accurate, and agriculture-focused land cover is useful for mapping change in the landscape and for relating agricultural crop practices to water quality. For these reasons, we developed the three dates of land use / land cover for the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) using advanced land classification methods. Details on the initial land classification work are given in the Year 2 report: *Mapping Agricultural Land Cover in the Tiffin River Watershed, Michigan*. The final land cover mapping work is described in the Year 4 report: *Land Use Land Cover Mapping in the Tiffin River Watershed*.

In-situ Water Quality Monitoring in the Tiffin Study Area

For the stream water quality task, MRTI was interested in documenting the local spatial and temporal variability that exists within the Bean and Lime Creek sub-watersheds. This goal was accomplished through a water quality sampling scheme that included making water quality measurements to test hypothesizes on the effects of outside forcing factors in the watershed.

Figure 6. Water quality data collection in the Tiffin River Study site. *Collections were made each month in 26 sites over 25 months.*

The water quality sampling scheme included a series of measurements at 26 sites in the Upper Tiffin River, with sites along part of the Bean Creek and all along Lime Creek and its sub-watersheds. Sampling locations were selected in order to obtain spatially complete coverage of the fluvial systems within each sub watershed. Sampling was conducted April 2005 to December 2007 to establish a baseline dataset. A Horiba U-22XD multi-parameter water quality monitoring device was used to collect (Figure 6) ten water quality data parameters, including Depth, Temperature, pH, Dissolved oxygen (DO), Conductivity, Turbidity.

Results of the data collection and analysis effort showed:

- Agricultural land use is highly correlated with water quality data in the Tiffin
- Agricultural land amounts can be used to predict changes in water quality data following storm events
- Separating Bean & Lime creeks meant data were analyzable – watersheds are affected differently by land use / land cover
- Regression- based relationships between land use and water quality 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 (this implies that a less expensive instrument may suffice)
- Conductivity is most strongly associated with soil type
- For ag types, corn grain & soybeans increase turbidity. Wetlands are too small a component (<1%) to likely be having a real impact
- Alfalfa, corn-silage, small grains decrease turbidity (+ forest)
- In spring, corn-grain decreases turbidity (and maybe wetlands)
- Planting more corn silage may increase turbidity, but this relationship varies by season

Our Tiffin River Watershed analysis provided significant insight into developing and executing a water quality measurement procedure. Specifically, we found that careful design of a sampling scheme is essential to the overall success of the program, and most importantly, time must be spent upfront outlining goals and objectives of the project. Once the purpose of measurement is determined we found that sampling site selection, frequency of sampling, and water quality parameters to measure are more straightforward and easy to determine.

A Year 3 presentation at the Soil and Water Conservation Society workshop held in Kansas City in October 2006, *Attachment I* of the Year 3 report: *Synopsis of Year 3 Activities* provides a concise overview the data collection activity. Details of the data collection, data analysis, and project conclusions are presented in the Year 4 report: *Report on In-situ Water Quality Monitoring over Three Years in the Upper Tiffin River, Michigan*

Improved Communication and Information Management

From the onset of the cooperative agreement project, one of the key purposes was to develop and deploy new data analysis and management tools for MI-NRCS to both assess the effectiveness and facilitate the management of NRCS conservation programs. In addition to the program evaluation activity described earlier in this report, several activities were undertaken to replace or enhance MI-NRCS's program management capability.

The Technical Assistance Tracking System (TATS)

The Technical Assistance Tracking System (TATS) was designed to be a web-based application for managing workload-related information for NRCS programs. The intended users of the TATS system are Michigan NRCS conservationists in the service center, area, and state offices. TATS was designed to replace and enhance the functionality provided by the Excel-based Farm Bill tracking tool in use by MI-NRCS staff. The application would provide a mechanism for district conservationists, assistant state conservationists for field operations, and state office staff members to:

- track, prioritize, and service assistance requests;
- track detailed program-specific workload information, status reviews, appeals, and contract modifications; and
- produce summary reports of workload levels by program and aggregating unit (i.e. service center or administrative area)

Although the application was intended for NRCS users in Michigan, potential future transition to national use was taken into account in design decisions.

In April 2007, the NRCS National Headquarters authorized a project to build a Customer Relationship Manager (CRM) tool for nation-wide deployment. Since there is expected to be significant overlap in the functionality provided by the CRM tool, and because the CRM tools is a conventionally funded project at the national level, the Michigan NRCS chose to redirect the development resources allocated to TATS toward participation in developing the requirements for the national CRM application. Details on development and functionality of the TATS are given in the Year 4 report: *Michigan NRCS Technical Assistance Tracking System (TATS)*.

Web-based Information Visualization Systems

In the final years of the project, three web-based interface systems were completed to help MI-NRCS staff work with the information products developed under the cooperative agreement. These applications were developed to provide a variety of functionality for a various user groups as described in detail in the Year 4 report: *NRCS Data Viewers Technical Documentation: Environmental Quality Index (EQI), Data Viewer ProTracts Data, and Expected Benefit Viewer*.

The first application, the EQI visualization system, provides a user-friendly web-based interface to view and manipulate the EQI calculations. This application allows users to map indexes of environmental quality for counties in the state of Michigan. Information on the concepts and inputs used for the EQI are given in the Year 4 reports: *The Environmental Quality Index Approach: Concepts, methods, and demonstration of the EQI approach for NRCS conservation program assessment* and *Inputs to the Environmental Quality Index*.

The second, the ProTracts Data and Expected Benefit Data Viewer, allows mapping of ProTracts contracts information and transformations of ProTracts data into program benefits via the CPPE scoring system. This application allows users to map summaries of ProTracts implementation data for counties in the state of Michigan. Information on the development and use of the Expected Benefits data is given in the Year 4 report: *The Environmental Quality Index Approach: Concepts, methods, and demonstration of the EQI approach for NRCS conservation program assessment.*

The third application, Tiffin River Study Area Viewer allows users to interactively map reference layers and water quality data collected for the water quality data collected for the CEAP/Tiffin

Watershed task Tiffin River watershed study area. Information on the collection and analysis of the water quality data collected for the Tiffin River Watershed study is given in the Year 4 report: *Report on In-situ Water Quality Monitoring over Three Years in the Upper Tiffin River, Michigan.*

During the development stages of the Environmental Quality Index (EQI) Data and ProTracts Data and Expected Benefit viewers, MTRI has come to realize the potential of leveraging open source geo-spatial technology. Incorporating software applications and components that utilize open standards (such as GeoServer and OpenLayers) to create powerful yet easy-to-use internet applications has led to innovative and efficient methods of understanding NRCS related data as well as sharing study results. Additionally, the technology becomes more appealing when combined with robust open source relational databases technologies like PostgreSQL and its GIS enabling counterpart - PostGIS. These database tools show a great deal of promise when integrated with "virtual globe" viewer software such as Google Earth in providing unique methods of accessing and visualizing large datasets in a three dimensional environment.

MTRI sees great promise for the NRCS in continuing in the direction of employing open source technology to meet its geo-spatial visualization needs. The utility and power of the GeoServer/OpenLayers combination along with the power of open source relational database management systems allows for a variety of new ways in exploiting data stores to desktop mapping applications.

Wetland Airphoto Georeferencing Task

The MTRI geospatial team georeferenced 11,403 scanned historical aerial Farm Services Agency (FSA) photos using ESRI Desktop ArcGIS (Figure 7). Methodology details and results of the georeferencing activity are presented in the Year 4 report: *Georeferencing of Scanned Historical FSA Aerial Photographs for Extraction of Wetlands Boundaries and Other Information for the Michigan NRCS.*

The georeferenced photos covered all of Michigan's Lower Peninsula, plus two Upper Peninsula Counties, accounting for 84% of Michigan's counties and 87% of the FSA scanned aerial photographs. The US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) asked MTRI to georeference these photos because of valuable wetlands boundaries information that was recorded in pen only on these photos, which dated mostly from the late 1980s to early 1990s. With accurate georeferencing, this information could be directly digitized into a geospatial database for use by NRCS and other interested parties. The NRCS is now engaged in digitizing the wetlands data from the aerial photographs now that our georeferencing for 70 higher-priority counties is complete.

For this project, MTRI developed a standardized methodology to rapidly and accurately georeference thousands of aerial photographs. Making use of Desktop ArcGIS tools, we used our experience with imagery archives and vector data to create a method that could be applied to quickly processing large collections of imagery collections into a useful data set with earth coordinates (Universal Transverse Mercator, in this case). The methodology used recent aerial imagery, accurate road vector data, visual image interpretation, and features in common between scanned photos to create the fast and accurate georeferencing. This methodology could easily be applied to other imagery data sets for the NRCS and other interested agencies.

Figure 7: A map of the counties georeferenced as part of this project. *70 of Michigan's 83 counties were georeferenced by MTRI staff.*

An important part of this project was the role that MTRI interns filled in completing the county georeferencing in a timely manner for NRCS. Between November, 2005 and May, 2008, the georeferencing process provided the opportunity for 19 interns to learn about GIS and remote sensing, including understanding imagery characteristics and processing spatial data.

Important outcomes from the Cooperative Agreement

In summary, the four-year cooperative agreement between Michigan NRCS and MTRI has resulted in the following important outcomes that support the goal of the project:

- A statewide conservation program effectiveness assessment approach has been developed for the Michigan NRCS. The approach:
  - Enables assessment of components of environmental quality relevant to NRCS conservation program goals;
  - Utilizes standardized GIS-based data sets
  - Allows for accounting of confounding influences;
  - Can be implemented based on geographic divisions other than counties, such as watersheds;
  - Is feasible at the conceptual level for any state NRCS office.
- Development and demonstration of the assessment methodology has identified important issues with the approach, many of which have been addressed. In particular:
  - Consistent recordkeeping through the ProTracts contract tracking system and Performance Results System (PRS) allows for a more complete set of electronically available data than was available before 2004.
  - Past program implementation information (contractual and technical assistance activities) is difficult to use in the formats collected and archived. Electronic recordkeeping was inconsistent prior to 2004; therefore it is difficult to adequately quantify application of NRCS conservation program activities before 2004.
  - Past environmental quality data is scarce, and often is not available at the spatial or temporal resolutions needed for a proper retrospective assessment of conservation program effectiveness. New datasets, identified through this project, are and should be available in the future to properly assess program effectiveness in the future.
  - Controlling for confounding influences is challenging. Assessment at more environmentally relevant geographic units and scales will help this issue.

    The assessment demonstrations provided through the project were done at the county scale/division due to the use of counties in program administration and recordkeeping. Conversion to watershed-based program implementations, administration, and assessment will help allow for more proper evaluation of non-program environmental influences (confounding factors).
- Development of the Environmental Quality Index (EQI) as a tool to assess conservation program effectiveness under this project has required MTRI to perform a comprehensive and thorough assessment of the utility of existing and soon to be available environmental quality data. This assessment has shown:
  - Although historic data is difficult to find for assessment of past practice effectiveness at the scale of counties, new data sets are available and additional data will be available in the near future that can be used in an EQI-like assessment. These data products hold promise for use in the EQI because they are repeatable and may be available as geospatially-defined products (maps). These data include:

    - ♦ Land cover data collected and mapped on a five-year interval is and will be available beginning with the c.2000 land cover products from the C-CAP program.
    - ♦ Model-based assessments of ammonia and methane emissions from farms as well as erosion (sediment and pollutant loading) and soil carbon sequestration are in the works by EPA and other agencies.
  - The project has demonstrated that remote sensing-based products in conjunction with GIS-based mapping can be used to develop and create low-cost, consistent measures that can be used in the EQI on regular intervals. With some additional effort, images contained in archives may be available to create additional products to do a more complete retrospective analysis of EQI change.
  - Beginning in circa 2000, low-cost satellite-based and model-based environmental data sets are available to adequately assess many factors important to NRCS conservation goals. The project has identified these data sets and provides guidance on collection and assessment of these data for program evaluation.
    - ♦ Remote sensing-derived data sets include land cover data, particulate data products, lake clarity, and crop type information;
    - ♦ Image sources are MODIS, Landsat, ASTER and, possibly, AWiFS;
    - ♦ Model-based information is available for soil erosion (STEPL), ammonia emissions, and, in the future, soil carbon and methane emissions.
- MTRI has developed of a method to use ProTracts-based practice implementation data for assessing level of conservation program effort by county. The method:
  - Combines raw implementation data with a measure of expected benefit using the Conservation Planning Physical Effects (CPPE) scoring system. The result is a measure that enhances the raw implementation records to get a measure based more closely on expected effects of a practice or set of practices.
  - Will benefit from more complete and accurate implementation data available via ProTracts and new program management systems under development.
- MTRI has demonstrated methods to control for variables for retrospective or future effectiveness assessments which confound the assessment target by:
  - Identifying similar counties using statistical analysis of county-level land cover characteristics.
  - Including variables in a multivariate regressions analysis method.
- MTRI investigated the utility of advanced muti-spectral remote sensing methods to map and characterize landscapes. We found:
  - Multi-temporal Landsat data analyzed using object-based methods leads to high-accuracy mapping of agricultural land cover at local to landscape scales. Land cover maps were completed for 2005, 2006 for the Upper Tiffin River area in Michigan.
  - Broad-scale MODIS data can be used to map regional & statewide crop type by detecting crop phenology using multiple images within growing seasons in order to map and quantify crop rotation.
  - Imagery collected with the ASTER multi-spectral system shows promise for mapping crop residue and some challenging agricultural land cover types such as small grains.

- An assessment of water quality monitored monthly over a two-year period allowed a look at water quality factors as a function of land use (cropping) change.
  - We collected a 3-year (32 month) water quality database for the Tiffin River study area that includes monthly from 5/2005 to 12/2007, plus 6 storm events & 1 night collect.
    - ♦ Main parameters collected were: turbidity, dissolved oxygen (DO), pH, conductivity, total dissolved solids, temperature, and oxidation reduction potential (ORP)
  - Analysis of the water quality database shows storm events are the most effective way of capturing the effect of the surrounding landscape on water quality
    - ♦ Seasonal monitoring (one in Winter, Spring, Summer, and Fall) are effective to get annual baseline data
  - Our analysis shows that turbidity and dissolved oxygen are the most effective ways of characterizing water quality for watersheds; conductivity (and its related value of total dissolved solids) also shows utility.
  - Monitoring a less-dense network of water quality sampling locations will effectively characterize water quality – fewer points on Bean Creek, above & below Lime Lake (settling pond effect), near confluence points.
  - Water quality and land cover appear to have a stronger relationship at the immediate stream-side scale, with the proximity of nearby agriculture, forested riparian width, and geomorphology having an effect.
  - We did not find a straightforward relationship between water quality and land cover at the watershed scale in the Tiffin River sub-watersheds studied.
- The MTRI/University of Michigan-developed Automated Lagrangian Water-quality Analysis System (ALWAS) was deployed for water quality characterization 6 times in 2005 and one in 2006 in the Tiffin Watershed study area. ALWAS testing shows this technology to be particularly promising for small & large lake characterization.
- Development and demonstration of web-based information visualization and analysis systems have produced useful data tools for MI-NRCS and lead to a deeper understanding of their potential utility. Specifically:
  - MTRI-developed web-based tools were found of great value for implementation and mapping of EQI outputs and display of ProTracts data. These tools demonstrate the functionality of this type of system for displaying and customizing data viewing for management of NRCS programs.
  - Open-source geospatial software such as GeoServer and OpenLayers can be adapted to create powerful, user-friendly interfaces for understanding and sharing study results and NRCS data, especially when combined with relational databases.
  - ESRI ArcIMS software can be customized to display multi-attribute databases such as Tiffin water quality data for access by NRCS.
  - New 3-D "virtual globe" software such as Google Earth holds promise in providing methods of accessing and visualizing large datasets when integrated with customized relational database tools such as PostgresQL and PostGIS.
- Georeferencing of historical air photos for MI-NRCS use has enhanced the usability of this digital resource. In particular, MTRI has:
  - Completed georeferencing of historical FSA aerial photographs for 70 of 83 Michigan counties, resulting in approximately 11,400 photos that can now be displayed in standard GIS software.

- Developed a standard methodology at MTRI for helping agencies georeference aerial imagery collections in a consistent, timely, and accurate manner.
- Trained Michigan-based University students now entering the Michigan workforce in basic GIS tasks.

Possible Future Activities

The EQI approach developed under this cooperative agreement provides a blueprint for assessing NRCS conservation program effectiveness at a statewide scale. As progress is made on finding ways to assess NRCS conservation programs, the index-based approach developed under this project and described in these reports will provide the starting point for systems that will naturally evolve. Similarly, the web-based information products and analysis tools should also serve as a starting point to develop usable management support tools. As this project ends after four years of productive study, many future activities to continue the work can be identified. This section provides an overview of the suggested next steps that would follow naturally from the progress made under this project.

Assessment of NRCS Conservation Program Effectiveness – Next Steps

As USDA improves its assessment of conservation programs through the Conservation Effects Assessment Program (CEAP) and other efforts, approaches to make these assessments at the state or regional scale, as has been developed in this project, should be continued. Specifically, some further activities to continue the program assessment task started under this project are:

- Continue to seek out and identify new comprehensive data sets to serve as inputs to the EQI. These data must be consistent and reliable over time and space, and should be provided in formats compatible with GIS systems so issues of spatial scale and geographic division can be flexibly dealt with. Remote sensing-derived products allow for these characteristics, and are more available now than ever before.
- Assess the appropriateness of the Conservation Practice Physical Effects (CPPE) weighting method devised for use of program implementation data. The scoring system provided for the CPPE are based on studies conducted to understand the real-world impacts of practices on resources concerns. As more research is done, these scores will be updated. The validity of using this scoring system in the manner used here has not been tested, and should be. In order to properly evaluate program effectiveness, the expected impacts of practices need to be properly understood and quantified.
- Investigate better ways to account for confounding influences, including land cover variability, climate change, and the influence of factors not under the control of USDA under their conservation programs.
- Continue to look for ways of mapping land cover efficiently, as this capability is useful for many aspects of program evaluation. Some follow-on activities for land cover mapping are:
  - Fuse multi-resolution images with multi-temporal research to improve accuracy.
  - Apply more advanced Definiens eCognition capabilities in combination with classification and regression trees to differentiate challenging crop types and other land cover such as wetlands.
  - Investigate alternatives to Landsat to fill in likely future gap in data sources due to existing Landsat age (AWiFS could be a solution).
- Continue assessing the utility of water quality measurements for use by NRCS:
  - Further define how NRCS could effectively monitor water quality using limited variables at appropriate scales with inexpensive instrumentation.

  - Continue investigations of the connection between land cover and water quality in agricultural landscapes at multiple scales with more advanced methods.

Improved Communication and Information Management – Next Steps

The advent of more accessible and reliable geospatial technologies and information allows agencies who manage land, such as NRCS, to have access to improved information. With digital soils maps and common land unit (CLU) maps, these technologies will be available. Further development of information and information visualization and analysis tools will be needed. Additional activities that can be done to take advantage of this technology are:

- Continue development of Web-based information tools:
  - Further improve the user-friendly power of the GeoServer/OpenLayers combination to provide desktop mapping tools that meet NRCS data access and program evaluation needs
  - Investigate improved methods of helping NRCS to visualize and interpret large data sets
- Help NRCS develop and enhance geospatial data resources, as is being done with the georeferencing of digital historical FSA aerial photographs.

Acronym List

ALWAS Automated Lagrangian Water-Quality Assessment System

ASTER Advanced Spaceborne Thermal Emission and Reflection Radiometer

AWiFS Advanced Wide Field Sensor

CAMPS Computer Assisted Management and Planning System

C-CAP Coastal Change Analysis Program

CEAP Conservation Effectiveness Assesment Project

CLU Common Land Unit

CPPE Conservation Practice Physical Effects

CRM Customer Relationship Manager

CTIC Conservation Technology Information Center

DO Dissolved Oxygen

EETD Environmental and Emerging Technologies Division

EQI Environmental Quality Index

FOCS Field Office Computing System

FRPP Farm and Ranch Land Protection Program

FSA Farm Services Agency

GIS Geographic Information System

IMS Internet Mapping System

MODIS Moderate Resolution Imaging Spectroradiometer

MTRI Michigan Tech Research Institute

NOAA National Oceanic and Atmospheric Agency

NRCS National Resource Conservation Service

ORP Oxidation Reduction Potential

PRMS Performance and Results Measurement System

ProTracts Program Contacts System

PRS Performance Results System

RUSLE Revised Universal Soil Loss Equation

STEPL Spreadsheet Tool for Estimanting Pollutant Loads

TATS Technical Assistance Tracking System

References

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Fuller, L.M., Aichele S.S., and Minnerick R.J. 2004. "Predicting water quality by relating Secchi-disk transparency and chlorophyll a measurements to satellite imagery for Michigan Inland Lakes, August 2002." U.S. Geological Survey Scientific Investigations Report 2004-5086.

Mausbach, M.J. and A.R. Dedrick. 2004."The length we go: Measuring environmental benefits of conservation practices." *Journal of Soil and Water Conservation*, 59(5): 97-103.

Appendix A: List of Reports, Briefings, and Publications/ Conference Presentations

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

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.

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).

Appendix B: Cooperative Agreement Participants

MTRI

Mike	Billmire
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Altarum[2]

Evan	Caldwell
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MI-NRCS

Vickie	Anderson
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Stephen	Davis
Jason	Firster
Joseph	Freeman
Monica	Holley
Ruth	Shaffer
Ann	Shattuck
Brent	Stinson
Tom	VanWagner
Kevin	Wickey

[2] On October 1, 2006, Altarum's Environmental and Emerging Technologies Division (EETD) (all personnel, equipment and contracts/grants) were divested and became the Ann Arbor based Michigan Tech Research Institute (MTRI).