

Institute of Water Research

Annual Technical Report

FY 2001

Introduction

The Institute of Water Research (IWR) at Michigan State University (MSU) provides timely information for addressing contemporary land and water resource issues through coordinated multidisciplinary efforts using advanced information and networking systems. The IWR endeavors to strengthen MSUs efforts in nontraditional education, outreach, and interdisciplinary studies utilizing available advanced technology, and partnerships with local, state, regional, and federal organizations and individuals. Activities include coordinating education and training programs on surface and ground water protection, land use and watershed management, and many others. An extended introduction can be found in our FY99 Annual Technical Report. We also encourage you to access our web site which offers a more comprehensive resource on IWR activities, goals, and accomplishments; www.iwr.msu.edu.

Numerous federal and state agencies are increasing their emphasis on examining water problems from the watershed perspective. The watershed perspective is being emphasized in the reauthorization of the Clean Water Act, the new Farm Bill as well as several other pieces of legislation. Because of our Institutes long term position relative to national and state water programs, we function as a coordinator to assist with linkages, support education, research, and outreach with and among agencies in the broad water arena. Accordingly, we are in a unique position to facilitate watershed policy, planning, and management with a multi-disciplinary perspective. Our proposed effort includes three major thrusts. The first is the enhancement of integrated watershed systems that can be used for analysis of various management options. The second is extended education where the internet and advanced computer systems in addition to traditional conferences and workshops are used to extend new knowledge to agencies, organizations, and local level watershed and land use groups. The third involves developing a networking infrastructure to facilitate cooperation among partners such as the USDA, Natural Resource Conservation Service, USEPA, and state Departments of Natural Resources, Environmental Quality, and Agriculture, as well as township associations and county organizations.

We will promote the dissemination and application of results through the thrusts of extended education, networking, and strong partnerships with other organizations. Thus, an excellent opportunity exists to disseminate and assure application of knowledge. Consistent with a watershed approach, emphasis will be placed on assisting individuals in understanding the interactions of human land use practices and activities on surface and groundwater. This will be accomplished by working with local professionals, practitioners, consultants, and in educating local decision makers about watershed functions and related policy options for the facilitation of water quality protection. The extensive use of extended education over the internet using hypertext techniques will greatly facilitate the effectiveness of wide dissemination throughout the state and region relative to watershed education and applicable policies. Further, many of these modules and approaches can be used nation-wide.

Develop an information exchange integrated support system for watershed studies with emphasis on land use and resource stewardship. The system will support research, studies by faculty and graduate students in several departments, and planning and management by local, county, state, and federal agencies.

Integrate concepts and activities in watershed systems and extended education through a networking infrastructure of organizations and digital communication pathways with integrated distributed data sources and partners. A computer/network based Natural Resources Integrated Information System (NRIIS) will be developed with graphical interface and search mechanisms to access models, data, information, and GIS/graphic tools. Graduate students will use the system a) to facilitate their research, b) see how their study is part of a larger system, and c) gain experience with NRIIS and its power for enhancing research, technology, and information transfer and communication for informed natural resource policy, planning, and management decisions.

Research Program

The Institute recently developed an interactive watershed information system that can be used over the Internet. This web site provides several layers of data that can be integrated or viewed separately. The system, Understanding Your Watershed: An Interactive Mapping Program to Explore Michigan Watersheds, is designed for use as a convenient and versatile tool that provides access to data sets, maps, and reports. Lakes, rivers, and streams; drainage patterns; wetlands; topographic contour lines; roads and highways; and digital orthophotography are some of the data layers that are available through this system. Through the use of this innovative tool, planners will have unique opportunities to visualize and understand the complexity of land-water interrelationships critical to the development of effective watershed plans. Watershed planners will have the ability to identify and prioritize critical areas that pose risks for erosion or nutrient loading to surface waters. This key part of the watershed planning process will be more firmly based on scientific data and information. This interactive geographical information system (GIS) can be used as a complement to Developing a Watershed Plan for a Water Quality Introductory Guide to address many of the steps described in the Guide.

Over the past few years, IWR has conducted research in water quality/nonpoint source pollution (NPS), particularly in the areas of soil erosion, sediment transport and nutrient loading, and assessing Best Management Practices (BMPs) using computer models. Watershed Information System, soil erosion assessment tool and watershed spatial database have been developed to facilitate land use and watershed planning, and expedite the process of decision making. The widely accepted erosion model Revised Universal Soil Loss Equation (RUSLE) has been computerized and the RUSLE Online website has been completely redesigned to provide the full functionality of soil erosion assessment. Watershed Information System provides watershed planners and others not only data, but information on farmlands, elevation, wetlands, streams and potential risk areas to assist in prioritizing their resources and make informed decisions. Our efforts have also involved building watershed spatial database which includes digital soils, digital elevation model (DEM), digital aerial photographs, 8- and 14-digit watershed boundaries, water bodies, wetlands, and other watershed related datasets.

In the research on targeting watershed interventions for reduction of nonpoint source pollution, we used the soil erosion model RUSLE to estimate soil erosion and sediment and phosphorous loading under alternative conservation practices and targeting approaches in Michigan's Stony Creek watershed. Using an erosion/sediment delivery model, analyzes likely erosion levels under alternative targeting options. The model focuses on the impact of altering the quarter mile we buffer treatment zone. Digital soils and digital

elevation model (DEM) data are used in this study. Simulations have been conducted to evaluate the effects of crop rotations, tillage practices, slopes and the width of filter strips on sediment and phosphorus loadings. The analysis shows that promoting the use of no-till and targeting steeper areas within the riparian corridor can bring the greatest reduction in sedimentation and phosphorous loads.

The RUSLE Online website provides a user-friendly interface and free access to soil conservationists, agricultural extension personnel and others for quick assessment of soil erosion. Users can easily choose their county, soils, crops, tillage practices and other field information to estimate the soil loss for multi-year planning. The program has been used by USDA-NRCS county agents, MSU Extension personnel, and online virtual university courses and others. IWR has also developed an EZ-Mapper bundled with digital soils data to help farmers, certified crop consultants and others to more effectively work on Comprehensive Nutrient Management Planning (CNMP). This program eliminates the hassle and time-consuming process to create a farmstead map. IWR has also provided training to interested parties. In cooperation with the USDA-NRCS, IWR has also evaluated the Windows Pesticide Screening Tool, or Win-PST, in Michigan counties. Risk maps have been generated for St. Joseph County and used by local extension personnel and crop consultants.

Development of the user-friendly RUSLE Online has greatly enhanced the efficiency of soil erosion assessment process. It can now be used for multi-year crop planning in minimizing soil erosion. Watershed Information System can turn spatial data into helpful information in assisting decision-making. Study on targeting watershed interventions for reduction of nonpoint source pollution will help local and federal governments to prioritize their funding for areas that have most environmental benefit. Pesticide risk maps can guide farmers for pesticide applications and in choosing alternatives and implementing best management practices to minimize pollution in potentially high-risk areas.

Building a Landscape Context for Lake Ecological Processes

Basic Information

Title:	Building a Landscape Context for Lake Ecological Processes
Project Number:	2001MI2561B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	8
Research Category:	Not Applicable
Focus Category:	Ecology, None, None
Descriptors:	Ecosystems
Principal Investigators:	Patricia A Soranno, Mary Therese Bremigan

Publication

1. N/A

State: Michigan
Project Number: MI2561
Title: Building a Landscape Context for Lake Ecological Processes
Project Type: Research Project
Focus Category: Ecology
Keywords: Ecosystems
Start Date: 03/01/2000
End Date: 02/28/2002
Congressional District: Eighth
PI: Patricia A. Soranno, Associate Professor, MSU
 Email: soranno@msu.edu; Phone: (517) 432-4330

Mary T. Bremigan, Professor, MSU
 Email: bremigan@msu.edu; Phone: (517) 432-3831

Principal Investigator Name(s): Patricia Soranno and Mary Bremigan

TITLE OF PROJECT: Classifying Michigan lakes by integrating fish assemblages,
 landscape features and water quality

Progress made by objective.

Objective 1: Organize lakes into landscape context 'groups' and develop landscape-context model

For this objective, we must first build the landscape-context database as well as the lake variable databases to test the model; and then develop the landscape-context model. We have collected all of the relevant databases (see below), and are just now starting to develop the model.

Description of databases:

Michigan Lakes GIS data coverage

All lakes given a Humphreys-Green code (new-key code). Includes the lake coverage, lake area, and location information.

Landscape-context GIS data coverage:

For the above lakes, various landscape context variables have been collected and added to a new table (ecoregion, watershed area, land use, % wetland, groundwater input, landscape position, etc.)

Historic fish database

Based on MIDNR Fisheries Division historical fish mean length at age summaries that have been entered electronically from records at the IFR or obtained from the MIDNR Fisheries Division Fish Collection System. The database includes mean length at age estimates for a number of fish species from ~598 (of the ~700 STORET) lakes collected during ~1960-1999.

Water quality data from STORET:

Public lakes that were sampled by the DEQ in the 1970-1980's as part of their monitoring program. About 700 lakes >20ha (all public) were sampled at some point in this time period. Data include total phosphorus, total nitrogen, alkalinity, chlorophyll, Secchi, average depth.

54-Lake macrophyte field database from 2001-2002

Lakes were chosen in a stratified-random design based on Secchi depth, mean depth and lake size.

Remotely-sensed Secchi and plants from 2001:

Using Landsat images from 2001, Secchi depth and plant cover will be estimated in as many lakes as possible from Landsat images. Only lakes within 3 Landsat images in a single path can be used (this results in many of the lakes of the lower peninsula, but not all).

Citizen Lake Monitoring Secchi data(historical):

About 70 lakes throughout the state have Secchi data from this program with > 8 years of data. Laura is currently compiling these data into an Access database.

Objective 2: Test hypothesis 1

We will determine if lake chemistry and biological variables are predicted by the landscape-context model. This objective will be completed once objective 1 is completed.

Publications that have resulted from this research.

Although no publications were published last year from this research activity, we have several manuscripts in progress that will be submitted in the coming year.

Manuscript 1: Predicting lake water quality and macrophyte cover from multi-scaled landscape features.Data:

Landscape features (PREDICTOR variable) – Local, subregional, and regional landscape variables (such as: watershed area, lake area, lake mean depth, ecoregion, lake order/landscape position, groundwater input, lake connectivity to streams, etc.). Data obtained from Michigan lakes GIS data coverage (Breck) and Landscape-context GIS data coverage (Soranno).

Water quality variables (RESPONSE variable) – Variables such as: total phosphorus, chlorophyll, Secchi depth and alkalinity. Data obtained from STORET data of ~700 public lakes from 1980's-era data collection (Breck). [If there is a problem with using old STORET data, then we may just use present-day CLMP data (Secchi only) from 2001. However, alkalinity data (from the 1970-80's is OK to use since alkalinity doesn't change much through time.]

Macrophyte % cover (RESPONSE variable) -- Collected from remotely sensed data (Nelson) for as many of the 700 lakes as possible, OR collected from 54 lakes sampled in 2001 and 2002 (Cheruvilil) if the remote sensing approach doesn't work.

Analysis: Hierarchical linear modeling (multiple landscape features as predictor variables; individual water quality and macrophyte variables as response variables). Each water quality/macrophyte response variable will have its own model developed. Hopefully, an overall model can be determined, but individual models must be analyzed first. This is analogous to a multiple regression approach, so we will NOT come up with lake classes per se. Rather we are looking for what explains the most variability in the response variables. However, we could take these results and the variables that are significant and they could form the basis for a lake classification effort afterwards. It will be interesting to compare our approach to the approach by Wiley and Seelbach for streams.

Estimated completion date: **December 2002**

Manuscript 2: Predicting fish growth rates using landscape, water quality and macrophyte variables.Data:

- Landscape features (PREDICTOR variable) – Local, subregional, and regional landscape variables (such as: watershed area, lake area, lake mean depth, ecoregion, lake order/landscape position, groundwater input, lake connectivity to stream, etc.). Data obtained from Michigan lakes GIS data coverage (Breck) and Landscape-context GIS data coverage (Soranno).
- Water quality variables (PREDICTOR variable) – Variables such as: total phosphorus, chlorophyll, Secchi depth and alkalinity. Data obtained from STORET* data of ~700 public lakes from 1980's-era data collection (Breck). [If there is a problem with using old STORET data, then we may just use present-day CLMP data (Secchi only) from 2001. However, alkalinity data (from the 1970-80's is OK to use since alkalinity doesn't change much through time.)]
- Macrophyte % cover (PREDICTOR variable) -- Collected from remotely sensed data (2001 Landsat images) for as many of the 700 lakes as possible, OR collected from 54 lakes sampled in 2001-2002 (Cheruvilil) if the remote sensing approach doesn't work.
- Fish growth rates (RESPONSE variable)– Fisheries Division historic database (Nate) on the 700 above lakes that have STORET water quality. Analysis will be conducted for all species for which there are adequate data. [Will have to restrict fish growth data to lakes sampled as recent as possible to match plant data - in 1990's].

Analysis: Hierarchical linear modeling (multiple landscape features, water quality and macrophytes as predictor variables), and separate models for each fish species-specific growth parameter. Will also do the analysis just using landscape variables to see if landscape alone can predict fish growth. Then, water quality and plants will be added as additional predictor variables, allowing us to compare the relative ability of landscape versus internal lake features to predict fish growth. This is analogous to a multiple regression approach, so we will NOT come up with lake classes/groups per se. Rather we are looking for what explains the most variability in the response variable, i.e. fish growth.

Estimated completion date: **Summer 2003**

Outside sources of funding related to this research

We have received a research grant beginning August 2002 titled: *Managing Michigan Lakes: Evaluating Effects of Watersheds and Habitat Perturbation on Lake Resources* (Bremigan and Soranno, \$183,000), funded by the Michigan Department of Natural Resources – Fisheries Division. This funded grant is very complementary to our ongoing efforts and will augment some of our research objectives in this project.

Natural Resources Integrated Information System

Basic Information

Title:	Natural Resources Integrated Information System
Project Number:	2001MI3001B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	
Congressional District:	8
Research Category:	
Focus Category:	Management and Planning, Water Quality, Models
Descriptors:	Watershed Management, Water Quality Management, Geographic Information Systems, System Analysis, Information Dissemination, Storage and Retrieval, Data Analysis
Principal Investigators:	Jon F. Bartholic

Publication

1. Wolfson, LW, D. Mokma, G. Schultink, and E. Dersch. In Press. Development of a Wetland Information System for Assessing Wetland Functions. Lakes and Reservoirs: Research and Management.
2. Witter, Scott G., Ruth Kline-Robach, D.L. Long, Jon Bartholic and Fred Poston. 2001. MSU-WATER: A New Way of Addressing Water Quality Challenges. Water Resource Update, The Universities Council on Water Resources.
3. Mokma, D., G. Schultink, E. Dersch, and L. Wolfson. 2000. Methods and Guidelines for Local Wetland Protection and Related Land Use Planning. Special SAPMINAR Report, Michigan Agricultural Experiment Station, Michigan State University, East Lansing, MI. 16pp.
4. Brown, E., A. Peterson, R. Kline-Robach, K. Smith, and L. Wolfson. 2000. Developing a Watershed Management Plan for Water Quality: An Introductory Guide. Institute of Water Research, Michigan State University, East Lansing, MI. 52 pp.
5. Wandell, H. and L. Wolfson. 2000. A Citizens Guide for the Identification, Mapping, and Management of the Common Rooted Aquatic Plants of Michigan Lakes. WQ 55. Michigan State University Extension, East Lansing, MI. 90 pp.
6. Hart, S, M. Klepinger, H. Wandell, D. Garling, and L. Wolfson. 2000. Integrated Pest Management for Nuisance Exotics In Michigan Inland Lakes. WQ 56. Michigan State University Extension, East

Lansing, MI. 28 pp.

7. Wolfson, L. and M. Higgins. 2000. Aquatic Ecosystems, Unit 8, in Module 1: Virtual Watershed Program in Watershed Management. (www.h2oshed1.vu.msu.edu) Michigan State University, East Lansing, MI.
8. Wolfson, L. 2000. Prioritizing Pollutants, Sources, and Causes, Unit 6 in Module 2: Building and Implementing Watershed Management Plans. (www.h2oshed2.vu.msu.edu). Michigan State University, East Lansing, MI.
9. Schultink, Ger, R. Moore, L. Wolfson, J. Dischinger-Smedes. 2000. Guidelines for Wetland Identification and Evaluation: Needs and Opportunities for Local Protection. Agricultural Experiment Station, Research Report No. 572. Michigan State University, East Lansing, MI.
10. DIttri, F.M. 1999. Environmental Contamination and the Information Highway. In: Integrated Environmental Management: Development Information and Education in the Asian Pacific Region, Ann Arbor Press, Chelsea, MI, pp. 211-222.
11. DIttri, F.M. 1999. What Education and Information Systems Can Do To Help Solve Environmental Problems: A Summary. In: Integrated Environmental Management: Development Information and Education in the Asian Pacific Region, Ann Arbor Press, Chelsea, MI pp. 271-277.
12. Shi, Y, A.M. Shortridge, and J.F. Bartholic. 2002. Grid computing for real time distributed collaborative geoprocessing. *Advances in Spatial Data Handling: 10th International Symposium on Spatial Data*, Springer Verlag; ISBN: 3540438025; Bk&Cd-Rom edition
13. Kerr, J., Da Ouyang, and Jon Bartholic, 2002. Targeting Watershed Interventions for Reduction of Nonpoint Source Pollution. *Journal of Soil and Water Conservation*. (In review).

**MICHIGAN INSTITUTE OF WATER RESEARCH
ANNUAL TECHNICAL REPORT -- FY 2001**

Research Program – Basic Project Information

Research Synopsis – 2001MI3001B

Title: Natural Resources Integrated Information System

Project Number: 01

Start Date: 03/01/00 **End Date:** 02/28/01

Funding Source: 104B

Congressional District: 8

Research Category: Water Quality Management

Focus Category #1: M&P; **#2:** WQL; **#3:** MOD

Lead Institute: Michigan Institute of Water Research

Descriptors: Data Analysis, Data Storage and Retrieval, Information Dissemination, System Analysis, Geographic Information Systems, Water Quality Management, Watershed Management

Primary PI: Jon F. Bartholic, Institute of Water Research, Michigan State University

Other PIs: No Other PIs

Introduction

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Area of Relevant Research

Numerous federal and state agencies are increasing their emphasis on examining water problems from the watershed perspective. The watershed perspective is being emphasized in the reauthorization of the Clean Water Act, the new Farm Bill as well as several other pieces of legislation. Because of our Institute's long term position relative to national and state water programs, we function as a coordinator to assist with linkages, support education, research, and outreach with and among agencies in the broad water arena. Accordingly, we are in a unique position to facilitate watershed policy, planning, and management with a multi-disciplinary perspective. Our proposed effort includes three major thrusts. The first is the enhancement of integrated watershed systems that can be used for analysis of various management options. The second is extended education where the internet and advanced computer systems in addition to traditional conferences and workshops are used to extend new knowledge to agencies, organizations, and local level watershed and land use groups. The third involves developing a networking infrastructure to facilitate cooperation among partners such as the USDA, Natural

Resource Conservation Service, USEPA, and state Departments of Natural Resources, Environmental Quality, and Agriculture, as well as township associations and county organizations.

Results and Benefits

We will promote the dissemination and application of results through the thrusts of extended education, networking, and strong partnerships with other organizations. Thus, an excellent opportunity exists to disseminate and assure application of knowledge. Consistent with a watershed approach, emphasis will be placed on assisting individuals in understanding the interactions of human land use practices and activities on surface and groundwater. This will be accomplished by working with local professionals, practitioners, consultants, and in educating local decision makers about watershed functions and related policy options for the facilitation of water quality protection. The extensive use of extended education over the internet using hypertext techniques will greatly facilitate the effectiveness of wide dissemination throughout the state and region relative to watershed education and applicable policies. Further, many of these modules and approaches can be used nation-wide.

Nature, Scope, and Objectives

Goal

Develop an information exchange integrated support system for watershed studies with emphasis on land use and resource stewardship. The system will support research, studies by faculty and graduate students in several departments, and planning and management by local, county, state, and federal agencies.

Objectives

1. Integrate concepts and activities in watershed systems and extended education through a networking infrastructure of organizations and digital communication pathways with integrated distributed data sources and partners.
2. A computer/network based Natural Resources Integrated Information System (NRIIS) will be developed with graphical interface and search mechanisms to access models, data, information, and GIS/graphic tools.
3. Graduate students will use the system a) to facilitate their research, b) see how their study is part of a larger system, and c) gain experience with NRIIS and its power for enhancing research, technology, and information transfer and communication for informed natural resource policy, planning, and management decisions.

Principle Findings and Significance

The Institute recently developed an interactive watershed information system that can be used over the Internet. This web site provides several layers of data that can be integrated or viewed separately. The system, "Understanding Your Watershed: An Interactive Mapping Program to Explore Michigan Watersheds," is designed for use as a convenient and versatile tool that provides access to data sets, maps, and reports. Lakes, rivers, and streams; drainage patterns; wetlands; topographic contour lines; roads and highways; and digital orthophotography are some of the data layers that are available through this system. Through the use of this innovative tool,

planners will have unique opportunities to visualize and understand the complexity of land-water interrelationships critical to the development of effective watershed plans. Watershed planners will have the ability to identify and prioritize critical areas that pose risks for erosion or nutrient loading to surface waters. This key part of the watershed planning process will be more firmly based on scientific data and information. This interactive geographical information system (GIS) can be used as a complement to Developing a Watershed Plan for a Water Quality Introductory Guide to address many of the steps described in the Guide.



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IMPACT: 2002/01 TO 2002/12

Development of the user-friendly RUSLE Online has greatly enhanced the efficiency of soil erosion assessment process. It can now be used for multi-year crop planning in minimizing soil erosion. Watershed Information System can turn spatial data into helpful information in assisting decision-making. Study on targeting watershed interventions for reduction of nonpoint source pollution will help local and federal governments to prioritize their funding for areas that have most environmental benefit. Pesticide risk maps can guide farmers for pesticide applications and in choosing alternatives and implementing best management practices to minimize pollution in potentially high-risk areas.

STUDENT SUPPORT

Category	Section 104 Base Grant	Competitive Awards	NIWR Internship	All Other	Total
Undergrad				6	6
Masters	1			10	11
PhD	1			4	5
Post Doc					0
Totals	2			20	22

NOTABLE AWARDS AND ACHIEVEMENTS

Laura Bruhn’s Master Student (Best Graduate Paper Award)
 Michigan State University’s Virtual Watershed Program:
 Development and Delivery of an Internet-Based Academic Credit or Professional Certificate Program in Watershed Management
 Environmental Practice Journal of the National Association of Environmental Professionals
 The Evergreen State College, Olympia, WA 98505

The University’s efforts in protection the groundwater supply that serves 50,000 people daily were recognized by the MDEQ in a Wellhead Protection Program recognition ceremony in 2002. Also in 2002, MSU became the first University in the U.S. to be recognized as a Groundwater Guardian Community by the Groundwater Foundation, a nonprofit organization that promotes proactive groundwater protection activities.

PUBLICATIONS

Wolfson, LW, D. Mokma, G. Schultink, and E. Dersch. In Press. Development of a Wetland Information System for Assessing Wetland Functions. Lakes and Reservoirs: Research and Management.

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D'Itri, F.M. 1999. What Education and Information Systems Can Do To Help Solve Environmental Problems: A Summary. In: *Integrated Environmental Management: Development Information and Education in the Asian Pacific Region*, Ann Arbor Press, Chelsea, MI pp. 271-277.

Shi, Y, A.M. Shortridge, and J.F. Bartholic. 2002. "Grid computing for real time distributed collaborative geoprocessing." *Advances in Spatial Data Handling: 10th International Symposium on Spatial Data*, Springer Verlag; ISBN: 3540438025; Bk&Cd-Rom edition

Kerr, J., Da Ouyang, and Jon Bartholic, 2002. Targeting Watershed Interventions for Reduction of Nonpoint Source Pollution. *Journal of Soil and Water Conservation*. (In review).

Watershed Based Optimization Approach for Identification and Management of Non-Point Source Pollution

Basic Information

Title:	Watershed Based Optimization Approach for Identification and Management of Non-Point Source Pollution
Project Number:	2001MI3061B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	
Congressional District:	8
Research Category:	
Focus Category:	Water Quality, Models, Law, Institutions, and Policy
Descriptors:	BMP maintenance, adoption, acceptance, stakeholders, policy analysis, water quality, watershed management, nonpoint source, Hydrologic models
Principal Investigators:	Scott Witter, Ouyang Da

Publication

1. Kerr, John, Da Ouyang and Jon Bartholic. 2002. Targeting Watershed Interventions for Reduction of Nonpoint Source Pollution. Journal of Soil and Water Conservation. (In review).

SYNOPSIS

Project Number: 02 (2001MI3061B)*

Start: 03/01/01 (actual)

End: 02/28/02 (expected)

Title: Watershed Based Optimization Approach for Identification and Management of Non-Point Source Pollution / **Sub-Title:** Targeting Watershed Interventions for Reduction of Nonpoint Source Pollution

Investigator(s): (Scott G. Witter-replaced), John Kerr, Department of Resources Development; Da Ouyang, Department of Crop and Soil Science, Michigan State University

Focus Categories: WQL, M & P, LIP

Congressional District: eighth

Descriptors: hydrologic models, nonpoint source, watershed management, water quality, policy analysis, stakeholders, acceptance, adoption, BMP maintenance

Abstract:

Watershed protection and soil conservation programs offer targeted cost-sharing in an effort to induce farmers to promote conservation on vulnerable lands. Relatively little information is available about how effectively Federal programs to reduce agricultural soil erosion and water pollution achieve their objectives. These programs offer broad eligibility criteria, covering all land within a certain distance of waterways. They provide cost-sharing for a range of conservation practices, including filter strips but excluding no-till because it does not involve additional net costs for farmers. This study uses a soil erosion model to estimate soil erosion and sediment and phosphorous loading under alternative conservation practices and targeting approaches in Michigan's Stony Creek watershed. The analysis shows that promoting the use of no-till and targeting steeper areas within the riparian corridor can bring the greatest reduction in sedimentation and phosphorous loads. Around half of Stony Creek farmers use no-till; steps to encourage its expansion could yield greater soil conservation benefits than focusing only on filter strips.

Introduction

Federally-funded programs to reduce soil erosion and water pollution associated with agriculture have been in place for decades, but relatively little is known about how effectively they achieve their objectives. This lack of information stems mainly from the fact that nonpoint source pollution from agriculture is impossible to measure with existing technology (Horan and Ribaudo 1999). It is only possible to estimate the extent to which conservation programs have encouraged the adoption of certain practices or removed environmentally risky land from cultivation and then assess the likely reduction of erosion in probabilistic terms. Even so, data are not easily found regarding the percentage of eligible land that is enrolled in conservation programs and the associated likely reduction in water pollution.

Conservation programs offer targeted subsidies in an effort to induce farmers to promote conservation on vulnerable lands. Targeting follows broad eligibility guidelines; for example, under several conservation programs all land within a quarter mile of a waterway may be eligible for 75% cost-sharing of conservation practices. Little is known about how cost-effectively these guidelines generate additional conservation investment relative to alternative targeting approaches.

This study uses a soil erosion model to explore alternative possibilities for targeting conservation programs in order to reduce nonpoint source pollution as cost-effectively as possible. It first analyzes the cost-effectiveness of existing targeting designs and then explores possible alternatives.

Background and Review of the Literature

Agricultural NPS problems

In the last quarter century the United States has made substantial progress in reducing water pollution, especially from point sources and hazardous waste sites. However, according to the EPA (<http://www.epa.gov/OWOW/watershed/framework.html>), nearly 40% of surveyed waters remain too polluted for fishing, swimming and other uses. Attention has turned from controlling the major point source polluters to reducing nonpoint source pollution, or pollution from dispersed sources such as individual homes, farms, or construction sites.

The primary water quality problems from agricultural nonpoint source pollution are sediment and nutrients (particularly phosphorus). Contribution of nonpoint source pollution from agricultural land use has been estimated at 64% of total suspended sediment and 76% of total phosphorus (Duda and Johnson, 1985). Overenrichment of nutrients in freshwater stimulates algal and rooted aquatic plant growth, and results in oxygen depletion, fish kills, odor problem and consequently eutrophication (Lee, 1971). It is estimated that the economic damage to surface water quality caused by sediment and nutrients from agricultural cropland ranges from 2.2 to 7 billion dollars each year in the United States (Lovejoy et al., 1997).

Controlling nonpoint source pollution requires that numerous minor polluters coordinate their actions to reduce pollution, one at a time. Each individual polluter may not make a tangible impact on environmental quality, but all polluters together create severe problems. Likewise, changing the behavior of one polluter will not make much difference, but if many people change their polluting ways the difference can be substantial. Homeowners, for example, would need to avoid disposing of motor oil into street sewers and take steps to minimize lawn fertilizer runoff. Construction sites would need to install protection devices to reduce the erosion of bare soil. Farms would need to adopt tillage and cultivation practices that generate less runoff and erosion, and they would need to install land use measures such as grass filter strips that capture eroding soil before it can be deposited into waterways.

The social problem confronting all types of pollution is that while the polluter enjoys exclusive benefits to the economic activity that causes pollution, the costs of that activity are shared with society at large in the form of pollution. By imposing the costs on others, the polluter has insufficient incentive to minimize pollution. With point source pollution, a combination of regulations or taxes can be imposed to change the polluter's behavior. Enforcing such arrangements is manageable because pollution sources can easily be identified and monitored. With nonpoint source pollution, on the other hand, the problem is more complex because the number of polluters is very high and each one's contribution is practically negligible. Enforcing elimination of pollution by every individual polluter becomes prohibitively costly.

Farm-level soil conservation adoption determinants

Agricultural pollution takes place primarily through runoff and soil erosion, which carries pollutants from agricultural chemicals off of farm fields and into drains, streams, and rivers. It has long been known that the costs of soil erosion in the United States are borne disproportionately off-farm. In other words, erosion has relatively little impact on agricultural production and its costs are manifested mainly in the form of soil erosion downstream (Crosson 1983).

Numerous studies in the 1980s aimed to identify factors that led some farmers to invest in soil conservation while others did not, with the hope that this information would facilitate the formation of policies that would encourage more widespread soil conservation (add citations.) Among other things, these studies found that perception of erosion was an important determinant of adoption of soil conservation measures (Ervin and Ervin 1982, Norris and Batie 1987, Gould et al. (1989). Better-educated farmers also invested more, other things being equal. Ervin and Ervin (1982) found that cost-sharing programs contributed to higher investment, but not necessarily on the lands that were most prone to erosion. Nielsen et al. (1989) also found that government programs contributed to investment, with one dollar in cost-sharing assistance yielding an additional fifty cents of private investment by the farmer. Set aside programs also contributed to private investment in soil conservation. While government programs did appear to generate conservation investment, Strohbehn et al. (1986) suggested that targeting them to lands with at least 15 tons per acre would yield more favorable benefit:cost ratios.

Targeting and incentives for cost effectiveness

If the benefits of soil conservation accrue primarily off-site and farmers have insufficient incentive to invest their own funds to generate those benefits, conservation programs must take steps to encourage investment. Several approaches are possible, including, either individually or in combination, imposing regulations requiring farmers to adopt conservation practices, subsidizing their cost, and appealing to farmers through education and moral suasion. The history of conservation programs in the United States and around the world shows elements of all of these approaches.

In the United States, programs have focused primarily on helping pay for the cost of conservation practices and paying for farmers to remove from cultivation land that bears a high risk of erosion. Programs are voluntary, although some farmers are required to participate in some ostensibly voluntary programs in order to be eligible for certain other attractive farm supports.

While there is widespread acceptance that farmers will need financial assistance to adopt soil conservation practices whose benefits will accrue only partially to them, there remain questions about how to design programs such that financial assistance will be as cost-effective as possible. Cost effectiveness entails achieving the greatest reduction in erosion at a given level of cost or, equivalently, achieving a given level of reduction in erosion at the least cost. Conceptually, this involves three interrelated goals:

- encouraging farmers to invest who would not have otherwise
- encouraging them to invest on land that is most vulnerable to erosion and nonpoint source pollution (as opposed to land where erosion problems are less severe).
- minimizing payments for conservation to farmers who would have invested even without payment.

Of course it is impossible to predict accurately where private investment might take place in the absence of special programs, and it is impossible to selectively subsidize those who would not have invested while asking others to invest on their own. The best that can be achieved is to intervene in a way that maximizes the likely reduction in erosion for the lowest cost. Horan and Ribaud (1999) recommend incentive-based approaches as the most efficient way to encourage soil conservation.

Current programs select certain blunt eligibility targets for recruiting farmers to participate and for sharing investment costs with them. A common approach is to pay farmers 75% of the cost of approved conservation practices like buffer strips, grass waterways, and streambank protection. All land within one quarter mile of waterways is eligible for such cost sharing.

Specific programs and what they do, how they are targeted

Soil conservation programs date back to the 1930s, when they were developed in response to the dust bowl and the great depression. The Agriculture Conservation Program (ACP), which was introduced in 1936, offered farmers cost-sharing for land conservation measures. This program evolved over the years and was augmented and ultimately replaced by other programs. Today, several major programs help farmers make conservation investments. They are funded by a variety of sources but mainly the US Department of Agriculture and the Environmental Protection Agency.

Highly Erodible Land Conservation (Sodbuster): This program, initiated as part of the 1986 Farm Bill, requires that farm program participants with highly erodible land adopt an approved soil conservation plan in order to remain eligible for certain other farm program benefits such as farm support payments. This program is voluntary, but when the agricultural economy is in hard times program benefits become very attractive and this program is effectively regulatory.

Conservation Reserve Program (CRP): This program, which dates back to the 1930s, focuses on land retirement both for the purpose of conservation and for reducing overproduction of agricultural commodities. The current version of the CRP was enacted in 1986 and reached 33.5 million acres through March, 2001, 2000 at a total cost of \$1.5 billion (USDA 2001). USDA economists estimate that it generates far more savings than it costs. It is particularly attractive to farmers because, in addition to paying for 50% of the cost of installing conservation measures, it pays them up to 90% of the annual rental value of land taken out of production. Farmland is eligible for enrollment only if it meets strict eligibility requirements using a ranking of all applications throughout the country.

Environmental Quality Incentives Program (EQIP): This program provides cost-share for installation of any among about 250 conservation structures or practices. It does not involve land retirement but rather conservation farming on working farms. Farmers are asked to engage in five- or ten year contracts involving financial and technical assistance and education. EQIP was introduced with the 1996 Farm Act, updating and bringing under one umbrella a number of previous programs. It was initially funded at \$200 million per year for 1997 through 2002, and then the total funding was raises to \$325 million in 2001.

Small Watershed Program: Funded under Public Law 83-566 in 1954 and commonly referred to as PL-566 funding, the Small Watershed Program helps people in watersheds smaller than 250,000 acres to organize conservancy districts, develop plans to manage soil and water resources within the area, and receive cost-sharing funds to implement approved plans. It promotes watershed protection, flood prevention, and water quality improvements, including reduction of runoff, erosion, and sedimentation. The program pays for 75% of nonstructural measures like buffer strips and up to 100% of certain flood control structures.

Clean Water Act Section 319:

Section 319 of the Clean Water Act provides funds for reducing nonpoint source pollution in navigable waters. Local organizations establish the programs, which receive major funding from the Environmental Protection Agency. A local funding match is required.

Setting: the Stony Creek Watershed¹

¹ Information in this section draws on the watershed plan document (NRCS 2001).

The current study draws on data from the Stony Creek Watershed in Central Lower Michigan, lying mostly in Clinton and Ionia Counties just north of Lansing. A PL-566 grant was recently implemented in the watershed, but farmers are also eligible for funding under the CRP and EQIP.

Stony Creek flows into the Maple River, which in turn is a major tributary of the Grand River. The watershed covers 113,600 acres, of which 80 percent is cropland, nine percent forest, and seven percent is urban or residential. At present rates of land conversion, development pressures from the Lansing area are likely to reduce cropped area to 74 percent by 2020. The present human population is around 15,500.

Corn, soybeans and alfalfa comprise almost 90 percent of cropped area in the watershed on farm sizes averaging about 250 hectares. More than half the farms are believed to have livestock and the total livestock population is relatively high with 41,000 head of cattle, 20,000 hogs, 2000 sheep and 1000 poultry. There are about 1200 acres of pasture in the watershed and animals have direct access to streams and drains in many areas.

Soil and water management problems in the watershed mainly concern runoff of nutrients and manure and sedimentation. Sheet and rill erosion on farmland are estimated to contribute over 80 percent of the sediment yield in the watershed, contributing approximately 153,000 pounds of phosphorous and 300,000 pounds of nitrogen annually. Livestock are the primary source of excessive nutrients and pathogenic microorganisms in surface and groundwater. Nutrients and pathogens damage water quality for aquatic life and recreation; Stony Creek is a recognized warm water fishery and also a source of recreation with one of Clinton County's six public boat access sites. Sediment damages aquatic habitat by limiting oxygen availability, and it the capacity and life expectancy and raises maintenance costs of structures such as roads, ditches, culverts and bridges.

Urbanization can lead to its own watershed problems; residential areas are a source of nitrogen, phosphorus and pathogens (?) due to failed septic systems. An increase in pavement intensifies the amount of runoff.

Watershed projects in Stony Creek

The Stony Creek watershed is the site of a PL 83-566 Small Watershed Program Grant that began in 2001 and will last seven years. The project calls for about \$1.5 million in funds to install conservation practices on 27 percent of the land area. Stony Creek has already been the site of a Section 319 grant that operated in the 1990s; farmers in the watershed are also eligible for funding under EPIQ and CRP.

Under the 566 grant, lands within a quarter mile of drains and waterways are eligible for 75% cost sharing for erosion control practices. NRCS staff are responsible for providing technical assistance and education to farmers in an effort to recruit them to apply for cost-sharing funds. NRCS staff stress that although the funding for technical assistance comes from the 566 grant, they help raise awareness of other funding options through EPIQ and

CRP as well, helping farmers determine which source is best for them. This raises the total funds available for investing in the watershed.

Funds support a large number of land treatments including but not limited to filter strips, diversions, critical area plantings, grade stabilization structures, grassed waterways, stream bank protection, livestock exclusion mechanisms and the like. Additional management practices that are not eligible for cost sharing but for which staff members provide technical assistance include prescribed grazing, wildlife upland habitat management, nutrient management, pest management, and residue management.

Project officials estimate that investment in the Stony Creek Watershed through the 566 grant will have numerous favorable effects:

- reduce overall annual erosion rates by 45 percent
- improve water quality at recreational sites, raising the number of annual visitor days by an estimated 5,300.
- Reduce sedimentation into Stony Creek by 45,000 tons per year
- Improving fish habitat on 13 miles of the creek
- Reducing annual phosphorous and nitrogen loadings by 73,600 and 147,000 pounds, respectively
- Restoring and enhancing 150 acres of wetlands
- Improving wildlife habitat throughout the watershed

The question remains how well targeted the funded interventions will be for the purpose of reducing erosion and runoff as cost-effectively as possible. As mentioned above, all lands within a quarter of a mile of drains and streams are eligible for cost-shared treatments, with 75 percent cost sharing by the project.

NRCS analysts also considered alternatives to the selected treatment plan; one involved making all lands in the entire watershed eligible while the other would treat only the agricultural lands in the riparian corridor. All three treatments were compared to the option of no treatment at all. Cost-benefit analysis was conducted for each one. Based on an estimate that 27% of lands would be treated, the selected plan had the highest estimated benefit:cost ratio at 1.19. The total treatment plan was too expensive, providing treatment to lands that were responsible for too little of the erosion, while the latter had insufficient impact because it did not treat nonagricultural land in the stream corridor.

NRCS officials indicate that it is difficult to be more precise in selecting targeting mechanisms. Programs are voluntary, so participation rates can only be estimated. Also, eligibility criteria have to be published in advance and there is no way to be more selective than offering the program to all lands within the quarter mile distance from the stream. Some critical lands in that area are likely to be untreated while some less critical lands are likely to be treated.

Inquiries revealed that data are not systematically collected on the average percentage of area that farmers choose to treat or the extent to which local officials feel that existing targeting treatments have served them well or could be improved upon. Officials must work on the basis of certain rules of thumb generated by limited information from erosion models and intuition gained through their experience in the field.

Analysis

The present study aims to provide a small amount of additional information that may be helpful for targeting. Using an erosion/sediment delivery model, it analyzes likely erosion levels under alternative targeting options. The model focuses on the impact of altering the quarter mile treatment zone; it is not designed to address the question of how variations in the subsidy level will alter farmers' likely participation rate.

Simulation of alternative watershed management intervention approaches

The Revised Universal Soil Loss Equation (RUSLE) (Renard., et al. 1997) is chosen in this study to calculate soil loss under various conditions. The procedures to estimate soil erosion in Michigan are followed as per (Grigar and Davis, 1995). RUSLE computes the average annual soil loss by using a functional relationship of several factors, expressed in an equation as

$$A = R K L S C P$$

where: A = computed spatial average soil loss and temporal average soil loss per unit of area. Usually, A is expressed in tons/acre/year (other units can also be used).

R = rainfall-runoff erosivity factor.

K = soil erodibility factor, i.e. the soil loss rate per erosion index unit for a specified soil as measured on a standard plot which is defined as a 72.6-ft (22.1 m) length of uniform 9% slope in continuous clean-tilled fallow.

L = slope length factor, i.e. the ratio of soil loss from the field slope length to soil loss from a 72.6-ft length under identical conditions.

S = slope steepness factor, i.e. the ratio of soil loss from the field slope gradient to soil loss from a 9% slope under otherwise identical conditions.

C = cover-management factor, i.e. the ratio of soil loss from an area with specified cover and management to soil loss from an identical area in tilled continuous fallow.

P = support practice factor, i.e. the ratio of soil loss with a support practice such as contouring, stripcropping, or terracing to soil loss with straight-row farming up and down the slope.

Digital soils and digital elevation model (DEM) data are used in this study. RUSLE factors are obtained from the technical guide provided by the State Office of NRCS in Michigan. Estimated sediment delivery ratio (0.288) based on the watershed size and phosphorus content in sediment are also used in estimating sediment and phosphorus loadings. In addition that sheet and rill erosions are estimated by RUSLE, streambank and gully erosions estimated by NRCS are used in this study.

Simulations have been conducted to evaluate the effects of crop rotations, tillage practices, slopes and the width of filter strips on sediment and phosphorus loadings.

Results and Discussion

At the outset it is important to keep in mind that the findings presented here are based on a modeling exercise, not actual measurements. The findings of the model are useful for indicating some broad areas of interest and concern.

Tillage practices

Different tillage practices can affect soil erosion and they are taken into account in the C factor in RUSLE. Table 1 displays total sheet and rill erosion, along with sediment and phosphorous loads for the entire watershed, for six different tillage practices. A corn-soybean cropping rotation is used as the baseline for these simulations.

Results in Table 1 demonstrate that implementing best management practices (BMPs) such as no till can greatly reduce erosion. In this case, no till can reduce sheet and rill erosion load by 85.7% and reduce sediment and phosphorus by 72% compared to fall plowing. These are effective practices that reduce erosion from its source – the field.

No till is currently practiced on about half of the land in the Stony Creek watershed, so the last column in the table reflects the existing situation. It offers a 41% reduction in erosion compared to fall plowing; this represents a major improvement thanks to the diffusion of no till over the last two decades. On the other hand, the results for 100% no till show clearly that major additional gains are possible.

Table 1. Soil erosion, sediment and phosphorus loading under different tillage practices (for corn-soybean)

	Fall Plow	Spring Plow	Mulch 10%	Mulch 20%	No till (100%)	No till (50%)
Sheet and Rill (tons)	241559.48	230056.68	184045.36	161039.65	34508.51	138034.00
Total erosion (tons)	257079.48	245576.68	199565.36	176559.65	50028.51	153554.00
Sediment (tons)	82282.13	78969.32	65718.06	59092.42	22651.45	52466.79
Phosphorus (tons)	175.26	168.20	139.98	125.87	48.25	111.75

Crop rotations

Simulations have been run for scenarios of different crop rotations including continuous corn and typical cropping patterns in Stony Creek Watershed such as corn-soybean, and soybean-wheat. Crops such as row crops and small grains have different effects on soil erosion. Table 2 lists the results of soil erosion, sediment and phosphorus loads for the entire watershed under different crop sequences. The baseline tillage system for this set of simulations is 50% no till as per the current situation in the watershed.

Table 2. Soil erosion, sediment and phosphorus loading under different crop sequences using current tillage practices (50% no till).

	Corn-Corn	Corn-Soybean	Soybean-Wheat
Sheet and Rill (tons)	166791.11	138034.00	51762.75
Total erosion (tons)	182311.11	153554.00	67282.75
Sediment (tons)	60748.84	52466.79	27620.67
Phosphorus (tons)	129.40	111.75	58.83

The results show that continuous corn generates the highest soil erosion rate and leads to a high sediment and phosphorus loading, followed by corn-soybean. Soybean-wheat has the lowest erosion rate and can reduce the sediment and phosphorus load by 55% compared to continuous corn.

Slopes

Since soil erosion is sensitive to slopes, different slopes have been analyzed in the watershed for the purpose of targeting cost-sharing for conservation practices. Table 3 lists the land coverage of different slopes and their contribution to total erosion under a corn-soybean system.

Table 3. Erosion for areas with different slopes

	Areas with slope ? 4%	Areas with slope ? 6%	Areas with slope ? 8%
Land Coverage (% of total area)	7.6	2.0	0.6

Erosion Contribution (% of total erosion)	12.1	3.5	1.1
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Table 3 shows that Stony Creek watershed has a relatively flat topography. Areas with a slope greater than 4% account for only 7.6% of the buffer zone, and slopes greater than 6% cover only 2% of the area. Only a tiny percentage of the area has slopes of at least 8%.

These small areas contribute more than their share of erosion, but due to their small size the overall contribution is small. Areas of at least 4% slope contribute 12.1% of total erosion. Areas with 6% of slope contribute 3.5% of erosion.

This table shows that targeting on the basis of slope is important, and it would be even more important in a watershed with a greater area of sloping land. It is important to keep in mind that the program anticipates installing BMPs on 27% of the land in the riparian corridor. The 7.6% of the land with at least 4% slope constitutes 12.1% of total erosion, so good targeting for slope has the potential to maximize cost-effectiveness.

Filter strip width

Phosphorus reduction coefficients listed in Table 4 have been used to estimate the effects of various buffer strip widths on phosphorus loading. These data are obtained from other research projects conducted by the World Resource Institute.

The figures in Table 4 show that increasing the width of a grass filter strip reduces phosphorous loading (by reducing erosion), but the percentage of reduction gradually falls as the width of the filter strip increases. There is no difference at all in the effectiveness of a 100-foot and 120-foot filter strip. A filter strip containing timber, on the other hand, becomes much more effective when it reaches 75 feet, at which point it becomes much more effective than just a grass filter strip. Constructed wetlands and sediment basins can also contribute a great deal to erosion reduction.

Table 4. Phosphorus loading reduction through various buffering methods

	Width of filter strips				
	25 ft.	50 ft.	75 ft.	100 ft.	120 ft.
Filter strip (grass)	23%	33%	43%	53%	53%
Filter strip (multispecies timber)	23%	33%	70%	70%	70%
Constructed wetland	42%				
Sediment basin	50%				

Applying these coefficients to the Stony Creek Watershed gives the results shown in figures 1 and 2. Figure 1 shows the effectiveness of a grass filter strip of different widths and different tillage practices in reducing sediment load; figure 2 shows the effects on reduction of phosphorous. While the specific numbers differ, the relationships across different filter strip widths and tillage practices are very similar. For filter strips, a wider buffer strip can generally reduce more sediment and phosphorus. For corn-soybean crop rotations, a filter strip with 25-100 feet wide installed along the entire riparian corridor can reduce sediment and phosphorus by 23-53%.

As mentioned above, farmers are not required to join the watershed project, and according to the project document only about 27% of land in the riparian corridor is expected to be enrolled in the program. Figures 3 and 4 show the expected reduction in erosion when only 27% of the riparian corridor is under best management practices, including no till and filter strips. Instead of the 23-53% reduction in sediment and phosphorous under 100% coverage, the reduction is about 6-14%.

A more striking result in Figures 3 and 4 is that tillage practices can have a much greater impact on reduction of sediment and phosphorous loading than filter strips installed in a limited amount of areas (e.g. 27% of buffer zone). The difference in sediment and phosphorous loadings across the different tillage practices dwarfs that across differences in filter strip lengths. This suggests that the watershed project could have greater impact by promoting no till than filter strips. Another promising approach might be to promote no till everywhere and focus the filter strips only on the steepest land (above 4%).

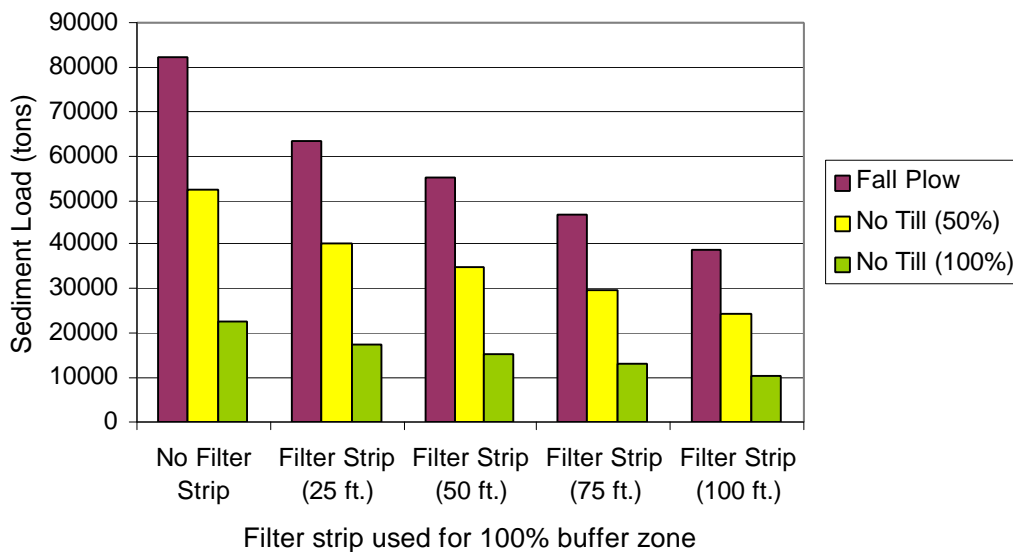


Figure 2. Sediment load under different tillage practices and different width of filter strips installed in 100% of buffer zone

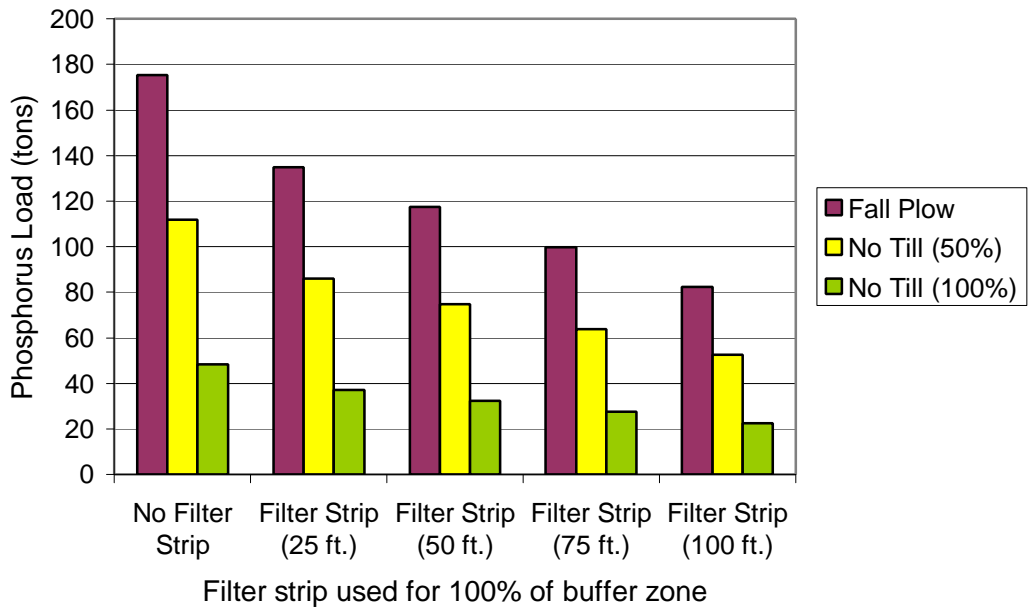


Figure 2. Phosphorus load under different tillage practices and different width of filter strips installed in 100% of buffer zone

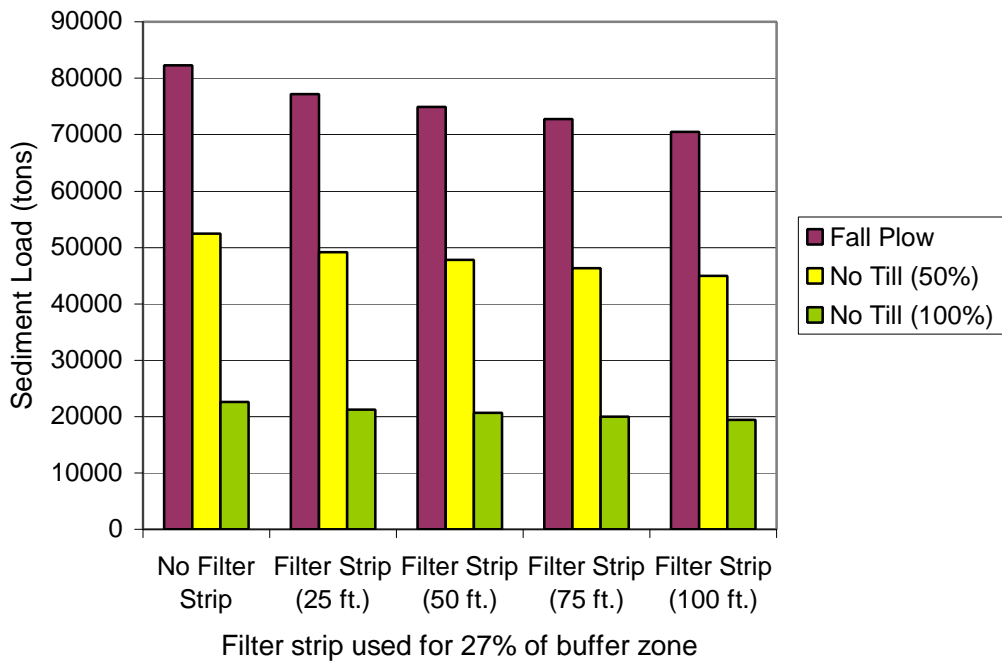


Figure 3. Sediment load under different tillage practices and different width of filter strips installed in 27% of buffer zone

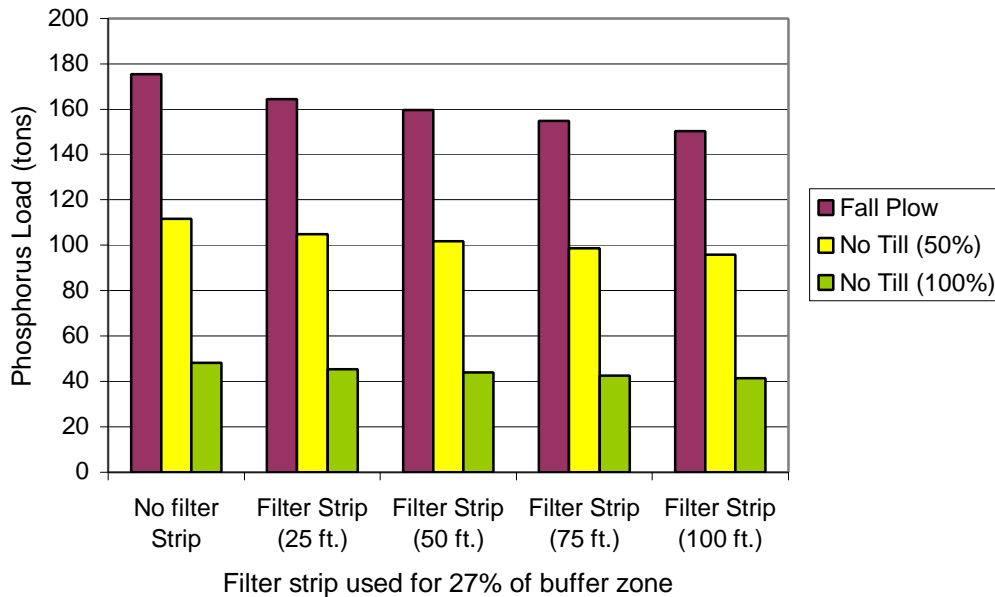


Figure 4. Phosphorus load under different tillage practices and different width of filter strips installed in 27% of buffer zone

Conclusion

It is important to stress that the findings presented here are based only on a model, not actual measurement in the watershed. The numbers should not be taken as precise, but rather as indicative of conditions under different management practices. The major findings can be summarized as follows:

1. Best management practices, particularly no till, can greatly reduce soil erosion and sediment/phosphorus loading. This “on-site” erosion control measure (which prevents erosion by keeping soil in place in the field) should be considered in combination of other “off-site” sediment/phosphorus reduction measures such as filter strip (which capture eroded soil before it can move into a waterway) in order to achieve the maximum benefits.
2. Targeting on the basis of slope can increase the cost-effectiveness per unit area covered. The Stony Creek Watershed is quite flat so the effects of this approach will not show a large magnitude in this particular case.
3. Regarding filter strips, key questions are both whether to install a filter strip at all and how wide it should be. Filter strips have a much larger quantitative impact on

reduction in erosion under fall plow than no till, even though the percentage reductions are similar. Filter strips are extremely important where fall plow is practiced, less so under no till. Perhaps a sensible targeting approach would be to focus as much as possible on encouraging no till and installing filter strips only on the steepest land. Determining the optimal width of a filter strip depends on the combination of how much erosion is reduced and what it costs; of course a wider strip costs more.

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Information Transfer Program

Legal, Financial, and Institutional Frameworks for Watershed Planning and Management

Basic Information

Title:	Legal, Financial, and Institutional Frameworks for Watershed Planning and Management
Project Number:	2001MI2581B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	8
Research Category:	Not Applicable
Focus Category:	Water Quality, Water Quantity, Management and Planning
Descriptors:	Planning, Watershed Management, Water Quantity, Water Quality
Principal Investigators:	Elaine M. Brown, Karen E. Vigmostad

Publication

State: Michigan
Project Number: MI2581
Title: Legal, Financial, and Institutional Frameworks for Watershed Planning and Management
Project Type: Information Transfer
Focus Category: Education
Keywords: Watershed, Management Planning
Start Date: 03/01/2000
End Date: 02/28/2002
Congressional District: Eighth
Principal Investigator Name(s): Elaine Brown and Karen Vigmostad

TITLE OF PROJECT: Legal, Financial, and Institutional Frameworks in Watershed Management, Module 4 in the Virtual Watershed Management Program, (<http://h2oshed4.vu.msu.edu>).

Introduction

In order to be successful, watershed managers throughout the world must understand and work within complex legal, institutional, and financial frameworks. The breadth and variety of international, federal, state, sub-state, and local laws, policies, and programs can be overwhelming. This fourth module in the Virtual Watershed Program introduces the *key legal, financial and institutional dimensions* of watershed management in the United States. While we use many Michigan examples, the information and resources can be used in any U.S. state. We have also tried to make the course relevant for international learners by focusing course work around the completion of a key legal, financial and institutional dimensions *watershed strategy* that can be used anywhere in the world.

Objective

This course is designed to give students a practical understanding of:

- The types of information that need to be gathered to address watershed issues;
- The institutional structure surrounding watershed issues;
- A basic understanding of how to find the laws that apply to the issues-such as eutrophication, nonpoint source pollution, and habitat loss- that need to be addressed;
- How to reach and get information from federal, state and local decision-makers about problems in your watershed;
- The types and sources of funding you might be able to utilize for problems in your watershed;
- How to understand and address conflicts in watershed issues.

Approach

This isn't strictly a book-learning course. Students connect to the watershed in which they live or work. While we cannot be there we encourage students to contact others in the watershed community. We will do this through students' main unifying assignment by studying an actual watershed strategy for a river or lake of choice. In the process of

studying that strategy students will talk to others, learn about actual plans and issues facing the watershed, and critically examine the strategy in use. As students learn new concepts - or apply those from previous modules - they will integrate them into their study. Homework assignments will help students collect information and gather data that can be used in study and analysis.

For the first assignment students will pick a watershed and begin to determine the pressing issues in that area. For this module they will focus on addressing just one or two of those pressing issues. If the investigation shows that the watershed is pristine with no known problems, a student would focus attention on finding the institutions, laws, and programs to prevent problems. Alternatively, if a watershed is degraded or impaired students would want to examine those factors that led to that condition. However, if students find an effective ongoing management activity in the watershed they would want to examine that activity and possibly suggest ways the process might be improved. The student may even want to tackle something that is not being addressed. For example there may be an ongoing effort to address TMDLs associated with nonpoint source pollution, but no effort to address aquatic nuisance species.

The staff of the Institute of Watershed Research, with contributions from outside expert contributors, prepared and initiated the fourth and final course in the Virtual Watershed Management series. The course was offered as Resource Development 891, Special Topics with nine students enrolled. All nine students were experienced professionals in watershed management representing several agencies or were advanced graduate students in MSU's resource departments.

The course, entitled, "Legal, Financial, and Institutional Frameworks in Watershed Management" consisted of 13 weekly lesson units, a midterm and final examination. Weekly unit topics included A History of Water Pollution Control in Michigan, 1890-2002; Socioeconomic Issues in Watershed Management; Understanding Watershed Conflicts; Phase II Stormwater Rules; Developing Local Policies; and Great Lakes Policy and Institutions. The course also included an on-going assignment requiring the students to examine their home watersheds in terms of the topics of the weekly lesson then prepare a brief but thorough description of how the various socioeconomic issues, conflicts and local policies applied to their home areas.

Eight of the lesson units were prepared by expert professionals working in some area of watershed management. These experts included: Mr. David Dempsey, Michigan Environmental Council; Dr. John Kerr, MSU Department of Resource Development; Dr. Karen Vigmostad, MSU Institute of Water Research; Mr. Fred E. Cowles, P.E. of the Michigan Department of Environmental Quality; and Dr. Michael J. Donahue of the Great Lakes Commission.

Information Dissemination and Technology Transfer

Basic Information

Title:	Information Dissemination and Technology Transfer
Project Number:	2001MI2961B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	8
Research Category:	Not Applicable
Focus Category:	Education, Groundwater, Surface Water
Descriptors:	Water Quality; Watershed Management; Macroinvertebrates; Water Chemistry; Monitoring; GIS
Principal Investigators:	Lois G Wolfson

Publication

1. Wolfson, LW, D. Mokma, G. Schultink, and E. Dersch. In Press. Development of a Wetland Information System for Assessing Wetland Functions. Lakes and Reservoirs: Research and Management.
2. Witter, Scott G., Ruth Kline-Robach, D.L. Long, Jon Bartholic and Fred Poston. 2001. MSU-WATER: A New Way of Addressing Water Quality Challenges. Water Resource Update, The Universities Council on Water Resources.
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Program in Watershed Management. (www.h2oshed1.vu.msu.edu) Michigan State University, East Lansing, MI.

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INFORMATION DISSEMINATION AND TECHNOLOGY TRANSFER TRAINING PROGRAMS - FY 2001

Michigan is surrounded by four of the five Great Lakes, has 11,000 inland lakes greater than 5 acres in size, over 32,000 miles of river channel, and a vast groundwater supply. These waters provide a wealth of resources for the diverse agricultural, industrial, and recreational opportunities of the state. However, as these activities continue to increase, both the quantity and quality of the state's water resources are at risk. It is paramount to keep the citizens of the state informed about water quality and quantity issues and how their actions can have major impacts on Michigan's water resources.

As land use impacts on water quality become more widespread, the need for action at the watershed level becomes more apparent. The movement of pollutants across a watershed is not constrained by political boundaries, and activities in one political jurisdiction may lead to water degradation in another. The difficulty in assessing impacts from erosion, nonpoint source pollution or shoreline development lies not only in the magnitude of the data collection efforts, but in the proper analysis and interpretation of the data needed for assessing the problem.

In order to determine if efforts being made to reduce pollutants are proving effective and to keep the citizens of the state up to date on water related issues, an education, training, and dissemination program is appropriate. An effective information dissemination and training program facilitates the transfer of information needed to protect the water resources in the state, and helps to inform scientists, legislators, and citizens of the most recent information available. For further effectiveness, agency personnel, riparians, educators, and others interested in protecting their water resources or in teaching others about it must understand the importance of collecting and/or analyzing information at the watershed level to ensure that reliable and appropriate information is being used to make sound decisions for water quality protection.

Title: Information Dissemination and Technology Transfer Training Programs

Project Number: 22

Start Date: 03/01/2001

End Date: 02/28/2002

Funding Source: US Geological Survey

Congressional District: Eighth

Lead Institute: Michigan Institute of Water Research

Descriptors: Water Quality; Watershed Management; Web based GIS; Monitoring

Primary PI: Lois G. Wolfson, Institute of Water Research, Michigan State University

Description of Projects

The Institute of Water Research Technology Transfer and Information Dissemination Program began in the early 1970s, and has been expanded and improved to be more responsive to the informational needs of a wide variety of user groups. A variety of mechanisms were utilized in FY 2001 to present the most current information on water related issues to citizens and targeted groups throughout the state.

Conferences

In order to promote the maximum exchange of information, the combination conference/workshop format has often been selected as a vehicle for disseminating current research and information. These conferences are open to public participation and present new and current information, often providing recommendations for future research and outreach. A conference on Monitoring Michigan's Watersheds: Past, Present, and Future was held during Agriculture and Natural Resources Week (ANR Week) in March 2001 to focus on various aspects of monitoring. The conference included presentations on environmental indicators; meeting state water quality standards, estimating total maximum daily loads in a TMDL watershed, assessing trends in Michigan's fish populations and aquatic resources; monitoring exotic species; and designing a watershed information web site. Overall 148 people attended the session. Following the conference, the IWR hosted a reception and demonstration to give participants the chance to comment and evaluate IWR's prototype for a statewide watershed web site as well as some other web based programs developed by various state agencies.

The Institute also co-sponsored and coordinated the development and organization of a statewide Wellhead Protection Conference, *From Vision to Reality, Planning and Implementing Successful Wellhead Protection Programs*, in February 2002. This conference, held in cooperation with the Michigan Department of Environmental Quality, was attended by over 125 people and featured talks on successful wellhead protection programs throughout the state.

Virtual Watershed Module

The IWR completed its fourth module in its internet-based Virtual watershed course. This module focused on legal, financial and institutional frameworks for watershed management. It includes key legal and financial information for watershed management, such as an in-depth study of Clean Water Act programs. Participants who complete all four courses receive a Masters level Professional Certificate in Watershed Management. An additional online training course on Soils Management was also developed. This virtual university class was designed to address the issue of sedimentation and pollutants in water and was specifically designed for professional planning and engineering individuals, agency personnel, and those interested in practical applications of construction site erosion prevention and sediment control.

Web based Programming

A web-based, interactive watershed information system was developed to help watershed planners obtain comprehensive data for any watershed and assist in the development of watershed management plans. The system, *Understanding Your Watershed: An Interactive Mapping Program to Explore Michigan Watersheds*, uses web-based GIS to provide easy access to watersheds in the state corresponding to a 12-digit hydrologic unit, data layers that can be viewed in map format, digital panchromatic imagery, and models. This system is aimed at assisting and facilitating decision making concerning the identification and prioritization of areas where current land uses and activities on the land may negatively affect water quality. The system is intended to enhance the understanding of land use inter-relationships that contribute to pollution of water resources. It can be accessed at www.hydra.iwr.msu.edu/water. This interactive geographic information system (GIS) can be used as a complement to the booklet, *Developing a Watershed Management Plan for Water Quality*, a publication completed last year by the MSU Institute of Water Research and Department of Environmental Quality. The guide

details the process to develop a watershed plan in a clear, concise way. The new interactive GIS can be used as an important tool to take many of the steps described in the guide.

MSU Water

Institute staff are actively involved with MSU Water (Watershed Action Through Education and Research). One staff member has major responsibility in coordinating the research and outreach efforts of the program. During this fiscal year, Institute staff developed a brochure for the program, a poster that was presented at the MSU Land Use Forum, and gave several talks to various groups as well as present the information at national conferences.

Demonstrations and Exhibits

The Institute began development of a shoreline demonstration project. The overall goal is to illustrate how suburban lawns can be transformed into natural shoreline assemblages in order to control shoreline erosion, impede nutrient input, and improve wildlife habitat. Staff from the Institute and Department of Fisheries and Wildlife have recently installed coconut logs and rip-rap at the lake site to illustrate shore stabilization techniques with other erosion control techniques being planned.

Institute staff took part in the Michigan Science Olympiad by serving as State Supervisor for Water Quality in the state finals. This annual event attracts nearly 100 junior high and high schools across the state who competed in a variety of science related events. Winners of the event continued to the national finals.

MSU has implemented an annual event called Outdoor Expo which invites people throughout the state to learn about a variety of subjects that take place outdoors. The Institute teamed with the Department of Fisheries and Wildlife to demonstrate proper lake sampling techniques. Utilizing the University's pontoon, participants were taken out into the middle of the lake and taught how to test for various parameters and interpret the test results.

In late July, MSU's Ag Expo, an agricultural oriented exposition is held. Approximately 35,000 people attend this annual event. Each year the Institute features an educational exhibit. In FY01, the Institute focused on reducing shoreline erosion and enhancing water quality. Two small "lakes" were constructed and proper and improper techniques for maintaining water quality and reducing erosion were illustrated. Over the three day period approximately 1500 people viewed the demonstration and discussed management options with staff.

Regional Coordination of Activities

Institute personnel received outside funding to take part in coordinating Extension activities across six Great Lakes states. As part of this program, the Institute was successful in bringing together Institute directors from these states with the Water Quality Extension coordinators. The interaction has led to some potential training workshops and sharing of web based computer modeling for reducing leaching risks and more interaction with EPA.

Lectures, Workshops, and Training

A paper on wetlands functions was presented at the Shiga-Michigan Joint Symposium 2001 at the University of Shiga Prefecture in Hikone, Japan. The paper, based on the development and

use of a Wetlands Information System presented research findings on assessing wetland functions in relation to wetland size and type.

The Institute staff gave numerous presentations and several training sessions throughout the year on issues such as watershed management and developing watershed management plans, wetland functions and values, wellhead protection, indicator species for water quality testing, and nonpoint source pollution. Audience participation ranged from approximately 25 to over 100 for each presentation.

The Institute staff co-developed a comprehensive Powerpoint presentation on Farming Practices and Water Quality for the Michigan Agriculture Environmental Assurance Program (MAEAP) training. This presentation was presented throughout the state to those involved with MAEAP. The IWR also participated in the Children's Water Festival, an event that brings together nearly 1000 elementary school children from across the tri-county area to be introduced to a variety of natural resources and science-related topics. The IWR featured aquatic macroinvertebrates and their role as water quality indicators. Five sessions were given for various classes. Each session had approximately 30 to 40 attendees.

Personnel and Facilities

The Institute of Water Research maintains such facilities and equipment as the latest software packages for desktop publishing, GIS, video editing and photographic equipment to support its Information Dissemination Program. It also has microcomputers, three Sun Sparc-20 work station, scanner, color printer, and digital camera to enhance its educational programs. For field demonstrations and research related opportunities the Institute also has a Data Sonde mini-probe for measuring chemical parameters in lakes.

The Institute's technology transfer program is under the direction of Principal Investigator Dr. Lois G. Wolfson, with several Institute personnel contributing to the project, including Dr. Frank D'Itri, Ruth Kline-Robach, and Jeremiah Asher.

The following publications and programs were partially supported with information transfer funding or personnel:

Wolfson, LW, D. Mokma, G. Schultink, and E. Dersch. In Press. Development of a Wetland Information System for Assessing Wetland Functions. *Lakes and Reservoirs: Research and Management*.

Witter, Scott G., Ruth Kline-Robach, D.L. Long, Jon Bartholic and Fred Poston. 2001. MSU-WATER: A New Way of Addressing Water Quality Challenges. *Water Resource Update*, The Universities Council on Water Resources.

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Wandell, H. and L. Wolfson. 2000. A Citizen's Guide for the Identification, Mapping, and Management of the Common Rooted Aquatic Plants of Michigan Lakes. WQ 55. Michigan State University Extension, East Lansing, MI. 90 pp.

Hart, S, M. Klepinger, H. Wandell, D. Garling, and L. Wolfson. 2000. Integrated Pest Management for Nuisance Exotics In Michigan Inland Lakes. WQ 56. Michigan State University Extension, East Lansing, MI. 28 pp.

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D'Itri, F.M. 1999. Environmental Contamination and the Information Highway. In: Integrated Environmental Management: Development Information and Education in the Asian Pacific Region, Ann Arbor Press, Chelsea, MI, pp. 211-222.

D'Itri, F.M. 1999. What Education and Information Systems Can Do To Help Solve Environmental Problems: A Summary. In: Integrated Environmental Management: Development Information and Education in the Asian Pacific Region, Ann Arbor Press, Chelsea, MI pp. 271-277.

Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 RCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate		0	0	6	6
Masters	1	0	0	10	11
Ph.D.	1	0	0	4	5
Post-Doc.	0	0	0	0	0
Total	2	0	0	20	22

Notable Awards and Achievements

Laura Bruhns Master Student (Best Graduate Paper Award) Michigan State University's Virtual Watershed Program: Development and Delivery of an Internet-Based Academic Credit or Professional Certificate Program in Watershed Management Environmental Practice Journal of the National Association of Environmental Professionals The Evergreen State College, Olympia, WA 98505

The University's efforts in protection the groundwater supply that serves 50,000 people daily were recognized by the MDEQ in a Wellhead Protection Program recognition ceremony in 2002. Also in 2002, MSU became the first University in the U.S. to be recognized as a Groundwater Guardian Community by the Groundwater Foundation, a nonprofit organization that promotes proactive groundwater protection activities.

Publications from Prior Projects

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14. Ouyang, Da, Y.-T. Kang, and J. Bartholic. 1996. Environmental implications of phosphorus fertilizer and manure use in the Great Lakes watersheds. Agronomy Abstracts (1996). (On the 1996 ASA annual conference) pp. 281.
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16. D'Itri, Frank. 1997. Zebra Mussels and Aquatic Nuisance Species. Ann Arbor Press Chelsea, MI 48118 pp. 638.
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18. Bartholic, Jon. 1997. The State of the Great Lakes Annual Report, Profiling Agriculture in the Great Lakes Basin. Michigan Department of Environmental Quality, Office of the Great Lakes, pp. 24-25.
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21. D'Itri, Frank. 1998. Environmental Contamination: An Anthology. International Training Workshop on Environmental and Occupational Health,. U.S. National Institutes of Health and Bulgarian Ministry of Health, Velingrad, Bulgaria, pp. 56.
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