Institute of Water Research
Annual Technical Report
FY 2002

Introduction

Introduction

The Institute of Water Research (IWR) at Michigan State University (MSU) continuously 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 MSU's 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 FY2001 Annual Technical Report.) We also encourage accessing our web site which offers a more comprehensive resource on IWR activities, goals, and accomplishments; www.iwr.msu.edu.

Research Program

Areas of Relevant Research The management of water resources, appropriate policies, and data acquisition and modeling continue to be at the forefront of the State Legislatures agenda and numerous environmental and agricultural organizations. Our contribution to informing the debate involved numerous meetings, personal discussions, and most importantly, the enhancement of web-based information to aid in the informed decision-making process.

Research The key underlying effort is to provide an integrated approach to surface and groundwater assessment and management while allowing individuals to examine particular impacts on specific components of the hydrologic cycle, i.e. irrigation for crop production, all potentially impacting the aquifer draw down and horizontal flow to wetlands and streams. We continue to use new information technologies as they are developed in order to assist in presenting physiographic and human characterization of activities across watersheds of the state. Such integrated presentations continue to be provided, to the maximum extent possible, via the web and new enhanced delivery software.

Natural Resources Integrated Information System

Basic Information

Title:	Natural Resources Integrated Information System
Project Number:	2002MI1B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	Eighth
Research Category:	None
Focus Category:	Management and Planning, Water Quality, Models
Descriptors:	None
Principal Investigators:	Jon Bartholic

Publication

1. Brown, E.M., D. Ouyang, A.J. Asher, J.F. Bartholic. 2001. Interactive Distributed Conservation Planning. Poster presented at the Integrated Decision-Making for Watershed Management Symposium: Processes and Tools, Blacksburg, VA, January 7-9. Proceedings on CD, 10 pp.
2. Bartholic, J., K. Wayland, L. Bruhn, S. Witter, C. Fridgen. 2001. MSUs Virtual Watershed Program: An Internet-based Academic Credit or Professional Certificate Program in Watershed Management. Presented at the National Association of Environmental Professionals 26th Annual Conference, Arlington, VA, June 24-28; in press.
3. Witter, S.G., R. Kline-Robach, D.T. Long, J.F. Bartholic, and F. Poston. 2001. MSU-Water: A New Way of Addressing Water Quality Challenges. Published in the University Council on Water Resources, Feb. 2001, pp. 47-59.
4. Ma, Y., J. Bartholic, A.J. Asher, Y. Shi, O. Da, J. Grigar, 2001. NPS Assessment Model: An Example of AGNPS Application for Watershed Erosion and Phosphorus Sedimentation, Institute of Water Research, Michigan State University. Published in the Journal of Spatial Hydrology, on-line at www.spatialhydrology.com/journal/index.htm, Current Issue: Vol. 1, No. 1 Fall 2001, (must have Adobe Acrobat Reader), 8 pp.
5. Brown, E.M., D. Ouyang, A.J. Asher, J.F. Bartholic. 2002. Interactive Distributed Conservation Planning, Institute of Water Research, Michigan State University. Journal of American Water Resources Association: Special Issue on Integrated Decision-Making for Watershed Management; August 2002.
6. Kerr, J., D. Ouyang, and J. Bartholic. 2002. Targeting Watershed Interventions for Reduction of Nonpoint Source Pollution. Department of Resource Development and Institute of Water Research, Michigan State University. Journal of Soil and Water Conservation; submitted paper. Research

funded by the U.S. Geological Survey with technical assistance from the Michigan Natural Resource Conservation Service-Steve Law.

Michigan Institute of Water Research
Water Research Institute Program Report for FY 2002
Submitted by Dr. Jon Bartholic, Director

Introduction

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Project Number: 2002MI1B
Start: 03/01/02 (actual)
End: 02/28/03 (expected)
Title: Natural Resources Integrated Information System
Investigators: Jon F. Bartholic, Institute of Water Research, Michigan State University
Focus Categories: M & P, WQL, MOD
Congressional District: eighth
Descriptors: Data Analysis, Data Storage and Retrieval, Information Dissemination, System Analysis, Geographic Information Systems, Water Quality Management, Watershed Management

Areas of Relevant Research

The management of water resources, appropriate policies, and data acquisition and modeling continue to be at the forefront of the State Legislature's agenda and numerous environmental and agricultural organizations. Our contribution to informing the debate involved numerous meetings, personal discussions, and most importantly, the enhancement of web-based information to aid in the informed decision-making process.

Research

The key underlying effort is to provide an integrated approach to surface and groundwater assessment and management while allowing individuals to examine particular impacts on specific components of the hydrologic cycle, i.e. irrigation for crop production, all potentially impacting the aquifer draw down and horizontal flow to wetlands and streams. We continue to use new information technologies as they are developed in order to assist in presenting physiographic and human characterization of activities across watersheds of the state. Such integrated presentations continue to be provided, to the maximum extent possible, via the web and new enhanced delivery software.

Results and Benefits

Our web-based offerings continue to expand. A Nation-Wide Digital Watershed web site has been developed to allow individuals from across the United States locate themselves by using their address, watershed, or by regional areas established by the EPA. The illustration shows the software developed in the IWR that can be applied to a national situation. The data used in the system was acquired from EPA Basin data via the web. The site for Michigan allows users to zero-in on the eight-digit watersheds and then down to the 12-digit watershed system known as "Know Your Watershed." A special web site was prepared for the Kalamazoo Watershed project to assist them in prioritizing and developing a watershed management strategy. A substantial effort has been completed using all the digital orthoquads (DOQQ) available across Michigan. These have been acquired and seamlessly integrated with quality control and compression algorithms. This information now serves as a backdrop on our "Know Your Watershed" web site. The DOQQ integrated data set is also used as a backdrop for soils information on IWRs new EZMapper web site. This site was specifically designed to aid with Comprehensive Nutrient Management Plan development for agricultural farms throughout the state. The system allows downloading of software to outline fields and utilize the available data.

IWR, Purdue University, and EPA Region 5 organized a workshop that examined web-based tools for land use and watershed planning. The Mapper is now under way to serve-up these tools across all states within Region 5, along with obtaining the same data that would be common for each state.

The web-available Mapping is used extensively in IWRs Virtual Watershed Management courses. This past year we completed Module 4 in the series for Watershed Management Certification. There are now over 200 students registered per year in this course series.

Our work with the Michigan Department of Environmental Quality (DEQ) continues at a high level. With funding, between $700,000 and $1M dollars per year, is largely the result of the Institutes' responsibilities recognized statewide.

Our strategic plan for the Michigan Institute of Water Research (IWR) over the next five years has been developed and submitted to the Director of the Michigan Agricultural Experiment Station, the Dean of the College of Agriculture and Natural Resources at Michigan State University (CANR-MSU), and subsequently to the Office of the Vice President for Research and Development. The strategic plan outlines a number of key strengthening components for the MI IWR. (1) The affiliate positions within the Institute. These positions might be 25% time in the IWR and 75% in a discipline department. A group of affiliates would greatly strengthen the discourse relative to problems and techniques for solving them as well as the information dissemination. Additionally, adjunct faculty are generally somewhat less involved but enhanced mutual awareness of our programs would greatly enrich the pool of expertise of water scientists from which we could draw upon in order to more effectively address issues of concern within IWR. (2) Enhanced funding for the IWR: New Fiscal Support: Facilitating a competitive grants program in the water arena has been proposed. Preliminary discussions relative to the plan are leading to the strong possibility of adjunct and joint affiliate positions, but any new funding is on hold in light of the State's budget difficulties.

Related Research
We continue to obtain synergistic impacts by closely aligning our efforts with support from such organizations as the Corps of Engineers, USDA, US Forest Service and numerous other agencies and NGO's. This past year we received a grant from the Corps of Engineers for $60,000 which involves estimating sediment delivery from each of the eight-digit watersheds within the entire U.S. side of the Great Lakes Basin. This database is not only of value to the Corps in prioritizing their efforts but also provides us with a broad set of additional information that we can use in other programs, and for assisting with the prioritization of high risk areas for erosion throughout the region. USDA funds involve a coordinating effort of outreach and research among all states within the EPA Region V. IWR personnel are partially funded through this regional project which coordinates and facilitates the communication of research methodologies, approaches, and results from our research and aides with region-wide outreach programming.

Training Potential
New graduates and graduate training continue to be a high priority of IWR. Unfortunately, graduate stipends have increased to the extent that a 1/2 time graduate student with fringe benefits, requires from $30,000-$40,000 (per year). We will make every effort to continue incorporating graduate students but with the high cost, it is increasingly difficult to employ more than a few students at any given time.

Water quality trends of Michigan inland lakes and their relationship to ecoregions:1974-2001

Basic Information

Title:	Water quality trends of Michigan inland lakes and their relationship to ecoregions:1974-2001
Project Number:	2002MI2B
Start Date:	3/1/2002
End Date:	3/1/2003
Funding Source:	104B
Congressional District:	8
Research Category:	Water Quality
Focus Category:	Water Quality, None, None
Descriptors:	
Principal Investigators:	Patricia A Soranno, Laura Christine Bruhn

Publication

1. Bruhn, L.C. (2002) A State-wide Assessment of water clarity trends in Michigan lakes: 1974-2001. M.S. thesis, Michigan State University, December 2002.
2. Bruhn, L.C., and P.A. Soranno. (In review) Water clarity trends in Michigan lakes and their relationship to ecoregion and land use/cover: 1974-2001. Currently in review as of 7/10/03 at: Lake and Reservoir Management.

State: Michigan
Project Number: 2002MI2B
Title: Water quality trends of Michigan inland lakes and their relationship to ecoregions: 1974-2001
Project Type: Research Project
Focus Category: Water Quality (WQL)
Keywords: Michigan, Lake, Water-quality trends, Secchi depth, Volunteer-monitoring
Start Date: 3/01/2002
End Date: 3/01/2003
Congressional District: 8
PI: Patricia A. Soranno, Assistant Professor, Department of Fisheries and Wildlife
Email: soranno@msu.edu
Phone: 517-432-4330
Research Assistant: Laura C. Bruhn, Graduate Assistant, Department of Resource Development
Email: bruhnlau@msu.edu
Phone: 517-432-7582

The nearly 11,000 inland lakes in Michigan are valued ecosystems susceptible to degradation due to anthropogenic stresses. Few, if any, long-term programs have been implemented by state agencies monitoring the inland lakes of Michigan. However, Michigan does have a lake-volunteer sampling program; the Cooperative Lakes Monitoring Program (CLMP).

The first objective was to assess statewide water quality trends from the early 1970s to present using data from the volunteer CLMP program. For this analysis we used 71 inland lakes that were distributed across the state which had volunteer-collected Secchi depth (SD). Water clarity in most of these lakes has either increased or stayed the same since the 1970s. Thirty-one percent of the lakes significantly increased in water clarity, 63% had no significant trend, and 6% significantly decreased in water clarity.

The second objective was to examine the relationship between lake water clarity and ecoregion, and land use/cover. CLMP program data collected from 1974-1983 from 54 lakes for which we had land use data, was analyzed using t-tests, regressions, and analysis of covariance. The mean SD was significantly lower for the southern ecoregion than the northern ecoregion, but a few significant regressions between land use/cover and water clarity across lakes was detected. In general, significant differences in SD existed between the ecoregions, however effects of land use on SD is more difficult to identify.

These analyses have expanded our knowledge of water quality trends in Michigan inland lakes. Volunteer monitoring programs such as Michigan's CLMP provide an invaluable contribution to water quality information and can assist in setting priorities for statewide lake monitoring and management. The Institute of Water Research is continuing to investigate the technical feasibility of integrating these data into an interactive, web-based Geographic Information Systems (GIS) tool.

Training Potential
This research project served as graduate student Laura Bruhn's thesis research for partial fulfillment of her Master of Science degree. Additionally, one undergraduate student was employed to help organize and compile the water quality data.

Manuscripts in preparation:
Soranno, P.A., M.T. Bremigan. The organization of lakes on the landscape: clustering of landscape features. To be submitted to Ecosystems.

Cheruvelil, K.S. and P.A. Soranno. Predicting macrophyte cover and Eurasian watermilfoil (EWM) presence from multi-scaled landscape and lake features. To be submitted to Ecosystems.

Cheruvelil, K.S., P.A. Soranno, T. Wagner, M.T. Bremigan, N.A. Nate, and J.E. Breck. In prep. Predicting lake water quality from multi-scaled landscape features. To be submitted to Canadian Journal of Fisheries and Aquatic Sciences.

Wagner, T., Bremigan, M.T , K.S. Cheruvelil, P.A. Soranno, N.A. Nate, and J.E. Breck. In prep. Predicting fish growth rates using landscape features and water quality. To be submitted to Canadian Journal of Fisheries and Aquatic Sciences.

Bremigan, M.T., P.A. Soranno. The classification of lakes using landscape features. To be submitted to Fisheries.

Invited research presentation:
Soranno, P.A. The role of landscape context on lake chemistry and biology. Invited presentation to the Grand Valley State University Annis Water Resources Institute. March 20, 2003.

Research Presentation:
Webster, K.E., P.A. Soranno, K.L. Ness and R.J Bouchard. Lake littoral zones and shoreline development: scientific and social challenges to maintaining the ecological integrity of lakes. North American Lake Management Society Meeting, Mashantucket, CT. November 4 - 8, 2003.

Develop a GIS-based Soil Erosion and Sediment Assessment System (SESAS)

Basic Information

Title:	Develop a GIS-based Soil Erosion and Sediment Assessment System (SESAS)
Project Number:	2002MI4B
Start Date:	1/1/2001
End Date:	1/1/2002
Funding Source:	104B
Congressional District:	Eighth
Research Category:	Not Applicable
Focus Category:	Non Point Pollution, Sediments, Models
Descriptors:	
Principal Investigators:	Da Ouyang

Publication

1. J. Kerr, D. Ouyang, and J. Bartholic, 2003. Targeting Watershed Interventions for Reduction of Nonpoint Source Pollution. Submitted to Journal of Soil and Water Conservation.
2. Da Ouyang, J. Bartholic, and J. Selegean. 2003. Soil Erosion and Sediment Assessment in the Great Lakes Basin. Presented at the 2003 Annual Conference of National Association of Environmental Professionals. San Antonio, TX.

Title: Develop a GIS-Based Soil Erosion and Sediment Assessment System (SESAS)
Project Number:
Project Type: Research
Start Date: 03/01/2002
End Date: 02/28/2003
Funding Source: US Geological Survey
Congressional District: Eighth
Keywords: Soil Erosion; Sedimentation; Water Quality; GIS; Modeling.
Primary PI: Da Ouyang, Institute of Water Research, Michigan State University

Problem and Research Objectives:
Agricultural nonpoint source (NPS) pollution is considered the leading cause of water pollution in the United States. Sediment and phosphorus are two major contributors that are responsible for water pollution. While soil erosion degrades productivity, it also causes water quality problems through sediment and nutrients. Excessive fertilization, particularly from phosphorus, leads to eutrophication which deteriorates surface water quality. Efforts have been made to minimize agricultural nonpoint source pollution by, for example, implementing best management practices (BMP). Controlling agricultural nonpoint source pollution requires good information and knowledge for identifying the source areas and quantifying the pollutant loadings. A water monitoring program is helpful but costly. A scientifically based model can provide an alternative approach to provide a quantitative estimation on soil erosion, sediment and nutrient loadings, and to help identify the source areas.

The goal of this research is to investigate various agricultural nonpoint source pollution models, and develop a GIS based and spatially distributed approach to better estimate soil erosion, sediment and phosphorus loading in an agricultural watershed context.

Methodology:
A small agricultural watershed, Marshall Drain Watershed, was selected as the study area. This watershed is approximately 400 acres with 90 percent agricultural land use. It is a sub-watershed of the Sycamore Creek watershed, located in Ingham County, Michigan. Agricultural nonpoint source pollution, particularly sediments, have been identified as the major cause of water pollution in the watershed. A multi-year water quality and land use/tillage management monitoring program was been conducted in the watershed from 1990-1997. Data from this monitoring program are used in this study.

A Spatially Explicit Sediment Delivery Model (SEDMOD) and the Revised Universal Soil Loss Equation (RUSLE) are used in this study. These two models are integrated into Soil Erosion and Sediment Assessment System or SESAS. It is GIS based and capable of calculating soil erosion, sediment yield, and phosphorus loading. The results showed SESAS estimated sediment and phosphorus loading with an improved accuracy compared to other models. Input data required to run the model are minimum and readily available. The results of this research demonstrate the benefits of using a spatially explicit model combined with GIS technology. SESAS allows users to identify the source areas and estimate NPS loadings which may lead to cost-effective watershed planning and management for minimizing agricultural nonpoint source pollution.

The Revised Universal Soil Loss Equation (RUSLE) developed by the United States Department of Agriculture (USDA), is the most widely used erosion model. It estimates an annual average soil loss in tons per acre per year. The equation has a general format with the product of six factors:

$$A = R * K * LS * C * P$$

where A = estimated average soil loss in tons per acre per year
R = rainfall-runoff erosivity factor
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = cover-management factor
P = support practice factor

SEDMOD is expressed as follows:

$$SDR = 39\ A^{-1/8} + \Delta DP$$

Where SDR = sediment delivery ratio
A = watershed area in square km
Δ DP = difference between the composite delivery potential and its mean value

Delivery Potential layer can determined as follows:

$$DP = (SG)r(SG)w + (SS)r(SS)w + (SR)r(SR)w + (SP)r(SP)w + (ST)r(ST)w + (OF)r(OF)w$$

Where SG = slope gradient
SS = slope shape
SR = surface roughness
SP = stream proximity
ST = soil texture
OF = overland flow index
r = parameter rating (1-100)
w = weighting factor (0-1)

After gross soil loss and sediment delivery ratio are determined, sediment load can be estimated as follows:

$$SY = A * SDR$$

Where SY = Sediment Yield
A = Gross Soil Loss
SDR = Sediment Delivery Ratio

Principle Findings and Significance:

Sediment Delivery Ratios

For a comparison study, two models were used to estimate sediment delivery ratio in the Marshall Drain Watershed. One is the newly developed spatially distributed model SEDMOD; the second was the spatially lumped empirical model equation. The reason for choosing this equation for comparison is that it was found in a previous study conducted in the Saginaw Bay watershed of Michigan. This model provides more accurate results than other spatially lumped statistical models that were tested in the study watershed (Ouyang and Bartholic 1997).

Sediment delivery ratios were calculated for 1991 – 1997 using SEDMOD, which reflected the spatial variations and year-to-year different land uses. Table 1 lists the maximum, minimum, and mean sediment delivery ratios over the grid cells in the watershed. Although these statistical data for sediment delivery ratio were similar over the years, there are some spatial variations of sediment delivery ratios in watershed due to the changes in land use. Figure 1 shows sediment delivery ratios in the study watershed based on 1993 and 1996 data. The spatial distribution of sediment delivery ratios are slightly different from year to year due to land use change. Higher delivery ratios indicate areas that have potential to contribute more sediment.

Sediment delivery ratios were also calculated using an empirical model with drainage-area-based SDR which is a spatially and temporally lumped model. According to the equation, the calculated sediment delivery ratio is about 0.537 which is relatively high due to the small size of the watershed in which sediments have a short distance to travel to water systems.

Table 1. The Max/Min/Mean values of sediment delivery ratios in the study watershed

	1991	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Min.	0.23	0.25	0.25	0.24	0.22	0.21	0.21
Max.	1.00	1.00	1.00	1.00	1.00	1.00	0.99
Mean	0.365	0.364	0.364	0.364	0.365	0.365	0.365

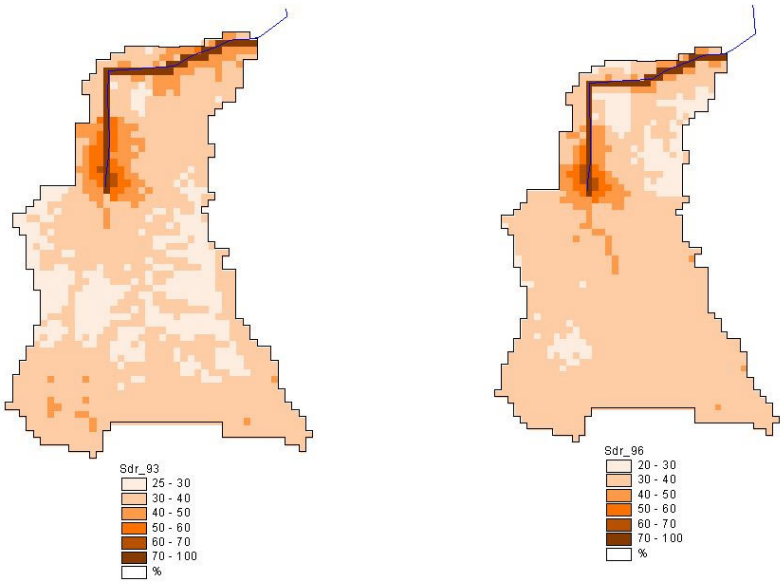

Figure 1. Sediment delivery ratios in the study watershed based on 1993 and 1996 data

Sediment Yield

With estimated soil erosion and sediment delivery ratios, the sediment yield can be determined. The model results and monitoring data are plotted in Figure 2. We used one of the most useful methods to evaluate the modeling results, which is called Model Efficiency (ME). Model efficiency was first used by Nash and Sutchliffe (1970) and later used by many researchers in water related modeling (Green and Stephenson, 1986; Risse et al. 1993; and Rapp et al. 2001). The value of ME for the model is 0.95, which is good. In the modeled and monitored data, the correlation coefficient is high ($R^2 = 0.95$) and with standard error SE = 0.85.

Once the sediment yield was calculated, one could estimate phosphorus loading based on sediment load and phosphorus-to-sediment ratio or phosphorus content in sediment. A previous study has shown that sediment attached phosphorus is a major form in phosphorus loading (Nelson and Logan, 1983). The estimated phosphorus load shows a similar pattern (see Figure 3).

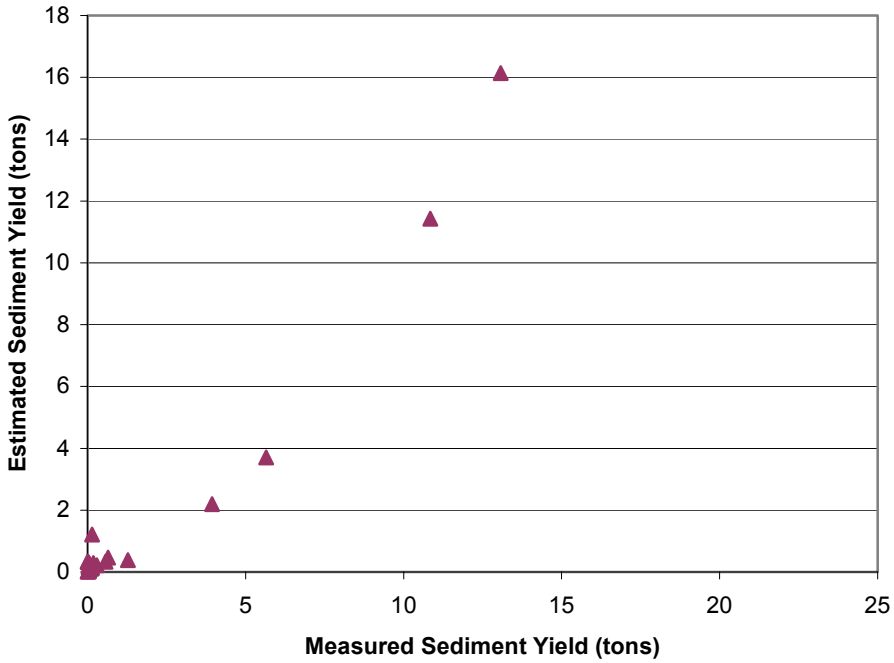

Figure 2. Monitoring sediment load and estimated sediment load from the model.

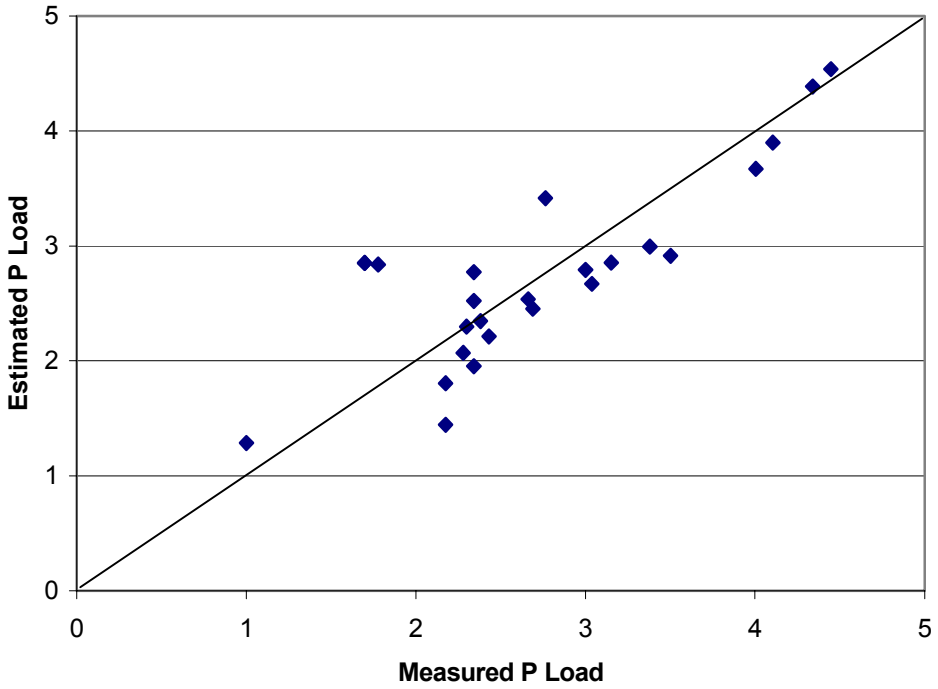

Figure 3. Monitoring phosphorus load and estimated load from the model.

Summary

In summary, the development of a GIS-Based Soil Erosion and Sediment Assessment System (SESAS) based on the spatially explicit sediment delivery model and the modified RUSLE, provides an easy-to-use tool for agricultural nonpoint source pollution assessment. The model estimates soil erosion, sediment delivery ratio, and sediment and phosphorus loading on a watershed basis with an improved accuracy. It has demonstrated the benefits of using spatially explicit models combined with GIS technology. This allows users to identify the source areas and estimate NPS loadings which may lead to a cost-effective watershed management plan for minimizing agricultural nonpoint source pollution.

Grid Computing for Real Time Distributed Collaborative Geoprocessing with Applications in Water Quality Management

Basic Information

Title:	Grid Computing for Real Time Distributed Collaborative Geoprocessing with Applications in Water Quality Management
Project Number:	2002MI5B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	Eighth
Research Category:	None
Focus Category:	Water Quality, Non Point Pollution, Management and Planning
Descriptors:	None
Principal Investigators:	Yi Shi, Yi Shi

Publication

1. Shi, Y, Shortridge, A. M., and Bartholic, J. F. 2002. Grid Computing for Real Time Distributed Collaborative Geoprocessing, in Advances in Spatial Data Handling: Proceedings of the 10th International Symposium on Spatial Data Handling, Springer Verlag; ISBN: 3540438025; July); Bk&Cd-Rom edition (September 2002).

Title: Grid Computing for Real Time Distributed Collaborative Geoprocessing--with Applications in Water Quality Management
Project Number: 2002MI4B
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: Yi Shi, Institute of Water Research, Michigan State University

Problem and Research Objective(s)
Grid computing has emerged as an important new field in the distributed computing arena (Foster et al., 2001; Foster & Kesselman, 1997). It focuses on large-scale resource sharing, innovative applications and, in some cases, high-performance orientation within a so-called Virtual Organization (VO). It has great capability to link multiple agencies with a network of shared data, software, and processors. The degree of integration that a VO Grid can achieve employing computing technologies is unprecedented. The hypothetical benefits of grid computing for spatial processing, in particular hydrologic applications, appear great. However we are unaware of any research exploring this new technology's potential. Distributed computing itself is not a new topic in geographic information science (Coleman et al., 1999; UCGIS, 1998). Parallelization of spatial operations has also been an area of active research (Magillo & Puppo, 1998; Hoel & Samet, 1996). We maintain that integrating the two topics via grid computing shows great promise for enhancing a variety of geospatial applications, particularly those with intensive computing requirements and a multi-organizational structure. Hydrologic modeling and water quality management stand to benefit tremendously from this integration.

We are conducting experiments on a water quality management VO testbed. Water quality management is a holistic activity that involves coordination among different organizations and collective decision-making based upon information from different sources. The ultimate goal is to model agricultural non-point source water contamination as part of an effort to improve water quality and support land use planning and agricultural production on a sustained basis. There is also an urgent need to educate the general public on water quality problems. Due to its organizational characteristics and modeling goals, water quality management is an excellent theme upon which to develop a VO/Grid computing testbed. This is a problem-oriented framework that contains data and methods for facilitating decision-making in a particular geographic region of a watershed. Our experiments are directed to the challenging task of distributing data and processing for a real time pollutant loading model across the network.

Methodology
Modern distributed and component GIS technologies and advanced distributed computing techniques are heavily used in this research. We draw upon our current experience with grid computing for basic hydrologic functionality to accomplish the more advanced objectives of this proposal.

First, we designed a general Internet-based integration framework for watershed management based on VO/Grid computing technologies using existing computing facilities. Then we created an example water quality management system that utilizes this framework. Hydrologic modeling algorithms were paralleled and datasets were partitioned to enable processing distribution across the Internet. Basic functionality for this system was developed using the MPI libraries and C++ software written by the investigators.

Principle Findings and Significance

In this research Grid, computing was described as an important recent development in the general area of distributed computing. This is due to its ability to link multiple agencies with a network of shared data, software, and processors. The innovation is the degree of integration that a VO employing such technologies can achieve.

We identified three major driving factors for the implementation of Grid-based geoprocessing. As network speeds continue to increase relative to single processing power, parallel implementations become relatively efficient. Second spatial partitioning for local operators is simple and very general. Partitioning for neighborhood operations ranges from simple (slope) to complex (flow accumulation). Complex partitioning problems restrict the utility of parallel implementations. Finally, algorithm complexity is a factor favoring parallelization, since users can take advantage of more powerful processors than are available on the local network.

The trend toward large-scale multi-agency geospatial projects involving the collaboration of dozens of scientists, policy-makers, and members of the public makes the virtual organization paradigm attractive. This research identified the utility of real-time distributed model processing for such organizations. We maintain that Grid technologies show great promise for enhancing a variety of geospatial applications, particularly those with intensive computing requirements and a multi-organizational structure.

Cited References

Coleman, D.J. (1999) "Geographical information systems in networked environments", in Longley, P.A., Goodchild, M.F., Maguire, D.J., and Rhind, D.W. (eds.), Geographic Information Systems, New York: Wiley, 317-329.

Foster, I., Kesselman, C., and Tuecke, S. (2001) "The anatomy of the Grid: enabling scalable virtual organizations", Intl. J. Supercomputer Applications (in press).

Foster, I., and Kesselman, C. (1997) "Globus: A Metacomputing Infrastructure Toolkit", Intl. J. Supercomputer Applications 11(2), 115-128.

Hoel, E.G., and Samet, H. (1994) "Performance of data-parallel spatial operations", Proceedings 20th Intl. Conf. On Very Large DataBases, September 1994, Santiago, Chile, 156-167.

Magillo, P., and Puppo, P. (1998) "Algorithms for parallel terrain modeling and visualization", in Healey, R., Dowers, S., Gittings, B., and Mineter, M. (eds.) Parallel processing algorithms for GIS, London: Taylor & Francis, 351-386.

UCGIS (1998) "Distributed Computing", Revised UCGIS White Papers. Online: http://www.ucgis.org/research_white/distrib.html, last checked 10/15/01.

Information Dissemination and Technology Transfer Training Programs

Basic Information

Title:	Information Dissemination and Technology Transfer Training Programs
Project Number:	2002MI7B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	Eighth
Research Category:	None
Focus Category:	Education, Groundwater, Surface Water
Descriptors:	None
Principal Investigators:	Lois G Wolfson

Publication

1. Wolfson, Lois, Del Mokma, Ger Schultink and Eckhart Dersch. 2002. Development and Use of a Wetlands Information System for Assessing Wetland Functions. Lakes & Reservoirs: Research and Management 7:207-216.
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

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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. Kline-Robach, Ruth and Scott G. Witter. 2002. MSU-WATER: A Campus-wide Approach to Water Resources Management. Presentation and paper for Integrated Trans-boundary Water Management. Conference co-sponsors include the Universities Council on Water Resources, Environmental & Water Resources Institute of ASCE, U.S. Army Corps of Engineers Institute for Water Resources and National Groundwater Association. July, 2002. Traverse City, MI.

INFORMATION DISSEMINATION AND TECHNOLOGY TRANSFER TRAINING PROGRAMS - FINAL REPORT FY 2002

Michigan has a wealth of water resources, including 11,000 inland lakes greater than 5 acres in size, over 36,000 miles of river channel, and a vast groundwater supply. It is also surrounded by four of the five Great Lakes, which make up 95 percent of the surface freshwater in the United States. Many of these lakes and streams have excellent water quality and 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.

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 land use activities, 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.

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, helps to inform scientists, legislators, and citizens of the most recent information available, and provides a mechanism for people to take action based on the science-based research that was presented to them. 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: **03/01/2002**
End Date: **02/28/2003**
Funding Source: **US Geological Survey**
Congressional District: **Eighth**
Lead Institute: **Michigan Institute of Water Research**
Descriptors: Water Quality; Watershed Management; Web based GIS; Lakescaping, MSU-Water
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 since continued to expand and improve in order to be more responsive to the informational needs of a wide variety of user groups. A variety of methods to disseminate information and provide innovative tools needed to help citizens solve or address water related issues have been utilized.

Conferences
In order to promote the maximum exchange of information, the combination conference/ workshop format has been one mode of communication utilized 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 Great Lakes: Current Issues, Future Challenges was held during Agriculture and Natural Resources Week (ANR Week) in March 2002 to focus on critical issues within the Great Lakes ecosystem. Issues included ballast water issues, sea lamprey control, disruption of food webs, water use and diversion, slant drilling and fisheries. Overall 125 people attended the session.
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The Institute also co-sponsored and coordinated the development and organization of a conference with two of the key outside professional water organizations in the state, Michigan Chapter, North American Lake Management Society and Michigan State Section, American Water Resources Association. The conference focused on several key issues concerning inland lakes and streams and was titled, “Aquatic Nuisance Species, Water Quality Standards and Emerging Technologies.” Approximately 60 people attended the conference.

Web-based Programming
The IWR continued expanding its web-based, interactive watershed information system by adding new layers of information including digital orthoquad photographs for the majority of the state and expanding the system for use across the U.S. *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. The addition of the photographs has helped citizens in visualizing the area around their property and viewing potential problem areas. The Michigan site can be accessed at www.hydra.iwr.msu.edu/water. The US site is available at: www.iwr.msu.edu/dw. Additionally, a fact sheet/newsletter, *The*

Watershed Post, can be viewed on the web site. The Post provides articles in .pdf format on a variety of watershed issues, particularly in Michigan.

MSU-WATER

Institute staff members 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 presented several programs to other Universities on the lessons being learned from MSU-WATER and steps needed to get research and outreach specialists coordinating their efforts. MSU-WATER collaborators also worked with the Office of Chemical, Radiation and Biological Safety to write the watershed-based permit application for MSU. The permit was submitted to the Michigan Department of Environmental Quality (MDEQ) in March to comply with the Clean Water Act stormwater discharge requirements for Phase II communities. The permit activities and timeline were developed to parallel the work that is being done by other communities within the Red Cedar River Watershed. MSU-WATER coordinators have continued their involvement with the Greater Lansing Regional Committee on Phase II Nonpoint Source Pollution Prevention, whose members are working collaboratively to develop watershed management plans for their communities.

Two posters created by MSU undergraduate students were used as part of two displays set up at foot bridges across the river for three hours preceding the two largest football Saturday home games last October and November. The displays, partially run by Institute staff also included live macroinvertebrates and fish collected from the river. Hundreds of students, alumni, and other visitors to campus on these game days viewed the displays and voiced their amazement at the biological diversity in the river. In November, on the MSU/Minnesota game day, students had live displays of 16 different fish species they had collected from the river in two hours the previous day -- an incredible statement about the water quality in the river. This trial "Football Saturday" project appears to have been extremely effective and will likely be expanded next fall. An estimated 500 people viewed the displays.

In February, a group of MSU faculty and students, including Institute staff, presented a workshop session at the 7th Annual Institute on Service Learning, held on the campus of Central Michigan University. The workshop presentation about the Red Cedar River educational initiatives was entitled "Engaging Student Learning Through Campus Watershed Stewardship" and offered other educators a chance to learn about the activities that MSU is pursuing with respect to the river that runs across its campus.

Demonstrations and Exhibits

The Institute initiated a shoreline demonstration project at its Inland Lakes Research and Education Area. The overall goal of the project 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 members from the Institute and Department of Fisheries and Wildlife are contrasting good and poor techniques for erosion control and shoreline stabilization, using coconut logs, riprap, and a variety of native vegetation.

MSU convened Outdoor Expo in June 2002. The 3-day event 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 on the lake and taught how to test for various parameters, including light, dissolved oxygen, pH, temperature, and plankton and interpret the test results. Weather conditions were poor during the event and attendance was substantially lower than anticipated. Approximately 2800 people attended overall with about 200 taking part in the water testing.

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 FY02, the Institute developed a 4 square foot model that featured proper and improper land use practices, particularly in agricultural settings. Using recirculating water, the model also illustrated how runoff affects water quality in streams and lakes. Over the three-day period approximately 1100 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. In summer 2002, the Institute coordinated one of these regional meeting with the National Institutes of Water Resources meeting and brought 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.

Lectures, Workshops, and Training
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 typically ranges from approximately 25 to over 100 for each presentation.

In October, the 30th anniversary of the enactment of the Clean Water Act was celebrated. A number of local, state and national groups, including Institute staff, participated in National Water Monitoring Day by sampling the river water on campus with several classes. The students collected macroinvertebrates and conducted some water testing. USGS personnel also were present to demonstrate stream flow measurements and water sampling techniques.

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.

Institute staff took part in the Michigan Science Olympiad by serving as State Supervisor for Division C 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.

The IWR also participated in two Children's Water Festivals, one on the University campus and one near Detroit. Each event brought together from 1000-2000 elementary school children 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 held in the East Lansing area and eight were held in Detroit area. Each session had approximately 15-35 students.

Other activities involving training and/or presentations included:

- Planning and facilitating a two-day statewide workshop to discuss the refinement of the National Hydrography dataset with the Michigan Center for Geographic Information
- Coordinating strategic planning meeting for Tri-County Regional Planning Commission
- Presentation for Friends of the Red Cedar
- Training for Farm*A*Syst well management
- Multiple presentations for Spartan Writer's Camp
- Presentation for Environmental Science Teachers
- Workshop for the Extension Council Conference on water quality
- Presentation at the Rise Seminar Series
- Land Use Poster Forum
- Water well management presentation for the Ingham Conservation District

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, particularly Ms. Ruth Kline-Robach and Mr. Jeremiah Asher.

Information Transfer Program

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Student Support

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

Notable Awards and Achievements

Publications from Prior Projects

1. 2000MI3B ("Natural Resources Integrated Information System") - Conference Proceedings - Ouyang, Da., and J. Bartholic. 2001. Web-Based GIS Application for Soil Erosion Prediction. In: Proceedings of An International Symposium - Soil Erosion Research for the 21st Century. Honolulu, HI., 260-263.
2. 2000MI1O ("Information Dissemination and Technology Transfer Training Programs") - Other Publications - Wandell, H. and L. Wolfson. 2000. A Citizen’s Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan. MSU Extension Water Quality Series No. 55. Michigan State University Extension, Michigan State University, East Lansing, MI, 82.
3. 2000MI1O ("Information Dissemination and Technology Transfer Training Programs") - Other Publications - Wolfson, Lois, and Jon F. Bartholic. 2000. An Overview of Procedures and Techniques for Developing Watershed Management Plans for Michigan Communities. Kellogg Center.
4. 2000MI3B ("Natural Resources Integrated Information System") - Other Publications - 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.
5. 2002MI7B ("Information Dissemination and Technology Transfer Training Programs") - Articles in Refereed Scientific Journals - Wolfson, Lois., Del Mokma, Ger Schultink, and Eckhart Dersch. 2002. Development and use of a wetlands information system for assessing wetland functions. Lakes & Reservoirs: Research and Management, , 207-216.
6. 2000MI4B ("Watershed Based Optimization Approach for Identification and Management of Non-Point Source Pollution") - Other Publications - Ouyang, Da. 2000. Estimating Sediment Load in Sycamore Creek Watershed. Institute of Water Research, Michigan State University, East Lansing, Michigan 48823-5243.

7. 2002MI5B ("Grid Computing for Real Time Distributed Collaborative Geoprocessing with Applications in Water Quality Management") - Conference Proceedings - Shi, Yi., Shortridge, A.M., and Bartholic, J.F. 2002. Grid computing for real time distributed collaborative geoprocessing. In: Advances in Spatial Data Handling. 10th International Symposium on Spatial Data, Springer Verlag.
8. 2000MI1O ("Information Dissemination and Technology Transfer Training Programs") - Other Publications - Schultink, G., R. Moore, L. Wolfson, and J. Dischinger-Smedes. 2000. Guidelines for Wetland Identification and Evaluation: Needs and Opportunities for Local Wetland Protection. Michigan Agricultural Experiment Station, Michigan State University, East Lansing, MI 48824, 82.
9. 2000MI1O ("Information Dissemination and Technology Transfer Training Programs") - Other Publications - D'Itri, Frank M. 2000. How to Survive a Research Intensive Environment II. MAES, OVPRGS, Kellogg Center.
10. 2000MI1O ("Information Dissemination and Technology Transfer Training Programs") - Other Publications - Hart, S, M. Klepinger, H. Wandell, D. Garling, and L. Wolfson. 2000. Integrated Pest Management for Nuisance Exotics In Michigan Inland Lakes. Water Quality Series No 56.. Michigan State University Extension, East Lansing, MI, 28.
11. 2002MI4B ("Develop a GIS-based Soil Erosion and Sediment Assessment System (SESAS)") - Articles in Refereed Scientific Journals - Da Ouyang, A. Jeremiah Asher, and Jon F. Bartholic. 2002. Interactive Distributed Conservation Planning. Journal American Water Resources Association, Huntsville AL 35801.
12. 2000MI3B ("Natural Resources Integrated Information System") - Dissertations - Brown, Elaine M. 2000. Lessons for Trading Program Design to Protect Water Quality: A Synetic Analysis of Air and Water Quality Protection Programs. M.S. Dissertation Department of Resource Development, East Lansing, Michigan 48824.
13. 2000MI3B ("Natural Resources Integrated Information System") - Water Resources Research Institute Reports - Ouyang, D., and J. Bartholic. 2000. Managing Atrazine Application Using Risk Assessment Maps. Project report submitted to Michigan Corn Growers Association. Institute of Water Research, Michigan State University, East Lansing, MI
14. 2000MI1O ("Information Dissemination and Technology Transfer Training Programs") - Other Publications - Wolfson, Lois G.. 2000. Michigan Irrigation: Opportunities and Challenges for Agriculture. Homer Nowlin Endowment, Kellogg Center.
15. 2001MI3001B ("Natural Resources Integrated Information System") - Articles in Refereed Scientific Journals - Bartholic, Jon F., Karen Wayland, Laura Bruhn, Scott Witter, and Cynthia Fridgen. 2002. 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, 23.
16. 2001MI3061B ("Watershed Based Optimization Approach for Identification and Management of Non-Point Source Pollution ") - Dissertations - Ouyang, Da. 2001. Modeling Sediment and Phosphorus Loading in a Small Agricultural Watershed. Ph.D. Dissertation Department of Crop and Soil Sciences, East Lansing MI 48824, 151.
17. 2001MI3001B ("Natural Resources Integrated Information System") - Conference Proceedings - Bartholic, Jon F., Karen Wayland, Laura Bruhn, Scott Witter, and Cynthia Fridgen. 2001. MSU's Virtual Watershed program An Internet-based Academic Credit or Professional Certificate Program in Watershed Management. Department of Resource Development, Michigan State University.
18. 2002MI1B ("Natural Resources Integrated Information System") - Conference Proceedings - Kline-Robach, Ruth., and Scott G. Witter. 2002. MSU-WATER: A Campus-Wide Approach to Watershed

Management. UCOWR, EWRI, CEIWR, NGWA, Traverse City, Michigan, 316-322.

19. 2000MI4B ("Watershed Based Optimization Approach for Identification and Management of Non-Point Source Pollution") - Articles in Refereed Scientific Journals - Witter, Scott G., Ruth Kline-Robach, D.L. Long, Jon Bartholic and Fred Poston. 2000. MSU-WATER: A New way of Addressing Water Quality Challenges in Water Resource Update. Universities Council on Water Resources.
20. 2000MI4B ("Watershed Based Optimization Approach for Identification and Management of Non-Point Source Pollution") - Water Resources Research Institute Reports - Ouyang, D. 2000. Project Report for NutrientNet: Methods for calculating phosphorus loadings. Submitted to the. World Resources Institute, Washington, D.C.
21. 2002MI4B ("Develop a GIS-based Soil Erosion and Sediment Assessment System (SESAS)") - Articles in Refereed Scientific Journals - Da Ouyang and Bartholic. 2002. Targeting Watershed Interventions for Reduction of Nonpoint Source Pollution.. Journal of Soil and Water Conservation (In review).
22. 2001MI3001B ("Natural Resources Integrated Information System") - Other Publications - Yongsheng, Ma, Jon F. Bartholic, Jeremiah A. Asher, Yi Shi, Da Ouyang, and Jerry Grigar. 2001. To Establish Morrow Lake NPS Assessment Model: An Example of AGNPS Application for Watershed Erosion and Phosphorus Sedimentation. Institute of Water Research, Michigan State University, 6.
23. 2001MI3001B ("Natural Resources Integrated Information System") - Other Publications - Bartholic, Jon. 2001. Presented at community forum; Understanding Our Water Supply. Big Rapids Middle School Auditorium, 500 Warren St., Big Rapids, MI.
24. 2001MI3061B ("Watershed Based Optimization Approach for Identification and Management of Non-Point Source Pollution ") - Water Resources Research Institute Reports - Ouyang, D., J. Bartholic. 2000. USGS Project Progress Report: Watershed Based Optimization Approach for Identification and Management of Non-Point Source Pollution.
25. 2002MI2B ("Water quality trends of Michigan inland lakes and their relationship to ecoregions:1974-2001") - Dissertations - Bruhn, Laura. 2003. Water clarity trends in Michigan lakes and their relationship to ecoregions and land use:1974-2001. M.S. Dissertation Resource Development, Institute of Water Research.