Indiana Water Resources Research Center
Annual Technical Report
FY 2006

Introduction

This report covers the activities of the Indiana Water Resources Research Center for the period March 1, 2006 to February 28, 2007. The report is provided to meet requirements and obligations under the 104 (B) program. The objectives of the fiscal year 2006 program of the Indiana Water Resources Research Center (IWRRC) have been: (1) to engage the water community in the State of Indiana as related to water research and education; (2) to develop a suite of research programs that encompass several state water issues; (3) develop an outreach program related to water and water quality (in particular pesticides and septic systems) and (4) to strengthen interactions with State and Federal Agencies (largely through grant applications).

Briefly, in the last year we have supported three externally reviewed 104(B) projects, through a well developed interconnection between IWRRC and a USDA-CSREES facilitation grant (EPI-Net.org) we have helped organized and participated in workshops on water and water borne pathogens, participated in a visioning sessions on the future of Indiana's water resources (both quality and quantity), worked with our external and internal advisory boards, maintained a functional website (www.iwrrc.org) been involved in the development and submission of six proposals with one major collaborative watershed project receiving federal funding and one receiving state support, facilitated the submission of two proposals to the 104(G) program, worked with City of Lafayette, Indiana and the Wabash River Enhancement Corporation (WREC) to facilitate discussions on long-range planning for Wabash River Redevelopment. One of the 104 (G) submission Nutrient and carbon delivery to streams in artificially drained landscapes of the Midwest: matrix flow, overland flow or macropore flow? by Philippe Vidon ranked 5th in the national competition.

For this reporting period, we show the establishment of a strategic outreach alliance with the Purdue Pesticide Program office for the development of document and educational materials on the environmental impact of Aboveground Petroleum Tanks (PPP-73). This alliance with the pesticide programs office was also backed with support from a 104 (B) project on fungicides. The success of this outreach effort spawned the development of a second alliance where we have partnered with the Purdue Septic Systems Program to support them in the development of educational programs related to water quality and septic system installation and maintenance. In a prior year we supported (104 (B) money) the development of a septic system inventory system and usage of this system will be part of the new effort. In both outreach case we are providing a support to their core efforts and using the opportunity to include the IWRRC in many of their other programs. The long-term goal is establish a constant and vital outreach effort.

The IWRRC 104(B) research program included work on the environmental safety of fungicides to be used for combating Asian soybean rust in Indiana, development of the tools needed to establish a water quality monitoring program on the Wabash River and an investigation of the trace gas flux in riparian buffers along an urban-rural gradient.

Project 01: Program Administration and State Coordination

In general, the administrative portion of the project has been used to support the management of the IWRRC's research projects and to facilitate the development of other research projects. These projects have the ultimate goal of improving the quality of water resources in the State of Indiana. The funds in the administrative portion of the project have allowed the IWRRC director a means to invest time in the efforts to integrate with state and federal agencies. The IWRRC director has work with state and federal environmental agencies, the governments of Indiana's cities and counties and key citizen groups on water education and water resources planning activities. In this way, the results from the research projects can be transferred to interested individuals in the state. The IWRRC director will participate in important national and international meetings related to water and environmental protection.

Projects Areas

1. Working with the Wabash River Enhancement Corporation (WERC) in developing a strategy for improving the Wabash River. This relationship now underpins our major effort in the state, the Health of the Wabash. 2. Continued meetings with Dr. Lenore Tedesco Director of IUPUI-Center for Earth and Environmental Sciences (CEES). These meetings led to the development of a workshop, a proposal for submission to USDA and an ongoing strategy for working with the state's environmental programs. 3. Preliminary development of a white paper on a water quantity and biofuel production. 4. Working with Dr. Fred Whitford and the Purdue Pesticides Program Office to establish an outreach effort centered on water protection emphasizing pesticide management, rural water quality and protection. 5. Working with Dr. Brad Lee, Purdue's septic system expert. We have now elevated the role of the IWRRC in water protection as related to septic systems management. Indiana, like most of the Midwest, is dependent on septic systems for waste handling. We are developing a program to better educate the professional installer and developing educational materials to support this effort. 6. Meetings with staff at Indiana Save the Dunes. As part of wetlands enhancement program and pathogen tracking programs we are continuing to work with Save the Dunes. 7. Continued an ongoing interaction with the Lake LaSalle homeowners and water management group to review and recommend management priorities for improving the water quality in Lake LaSalle. 8. Continued interactions with a number of consulting firms related to water quality issues.

Grant Applications Submitted thorough/with IWRRC:

a. (Funded) USDA Conservation Effects Assessment Program. $660,000. Watershed-Scale Evaluation of BMP Effectiveness and Acceptability: Eagle Creek Watershed, Indiana. Developed with Jane Frankenberg, Lenore Tedesco, Jerry Shively, Linda Prokopy. This was an outgrowth of an effort submitted last year to EPA but not funded: Creating sustainable drinking water supplies for Central Indiana: Innovations to achieve reductions in watershed and reservoir nutrient levels.

b. (Funded) USEPA Fate of hormones in tile-drained fields and impact to aquatic organisms under different animal waste management practices. Linda Lee, S. Brouder, C. Jafvert, M. Sepulveda and R. Turco.

c. (Pending) NSF Critical Zone Observatory Program. Critical Zone Observatory for Managed EcoSystems (CZOMES). S. Brouder, C. Jafvert, G. Michalski, W.V. Sigler, R. Turco, P. Owens, M. Crawford. $4,000,000. (Establishes a water quality observatory in the St. Joseph Watershed.) .

d. (Continued Funding) IDEM-319Development and Demonstration of Outcomes-Based Evaluation Framework for the Indiana Nonpoint Source Program. Developed with Jane Frankenberger, Linda Prokopy, and Shorna Broussard. Additional support has been given to Linda Prokopy for work on Social Indicators.

e. (Continued Funding) Advanced Concepts and Technologies International, LLC Improved Detection & Remediation of NBC/CBRN/TIC/TIM Contaminants in Potable Water. Developed with Drs. Inez Hua and Chad Jafvert. IWRRC provided organizational and management input.

f. (Continued Funding) Center for the Environment. Living Laboratories on the Wabash (LLOW). Developed with Kim Wilson, Linda Prokopy, Larry Nies and Dan Sheperson. This proposal now serves as a major driving force for many of the IWRRC's efforts.

g. (Not Funded) USDA-NRI Tracking the survival and distribution of Mycobacterium avium subsp paratuberculosis in the agroecosystem: implications for animal health. E. Rizaman, C. Wu and R. Turco.

h. (Not Funded) US Army. Enhanced destruction and detection of chemical agents for improved water security. I. Hua, C. Jafvert and R. Turco.

i. (Not Funded) US EPA. The Wabash Network: A River of Change. R. Turco, L. Prokopy, K. Wilson, L. Bowling, C. Jafvert.

j. (Not Funded) WERF. Stormwater BMPs: assessment and implementation for watershed protection. R. Turco, L. Prokopy, K. Wilson, L. Bowling, C. Jafvert. and L. Nies.

External Board of Advisors Membership: Dr. Lenore Tedesco, Director Center for Earth and Environmental Science, Indianapolis IN Dr. Jack Wittman, President, Wittman Hydrosciences, Bloomington IN Dr. John C. Steinmetz, Director, Indiana Geological Survey Indiana University Bloomington IN Dr. Dennis Wichelns, Executive Director, The Rivers Institute at Hanover College, Hanover IN Ms. Christine Livingston, Watershed Coordinator, Save the Dunes, Michigan City, IN Dr. Linda Lee, Associate Director Center for the Environment, Purdue University Ms. Martha Clark-Mettler, Director Watersheds Program IDEM, Indianapolis IN

Faculty Advisory Committee: Dr. Linda Lee, Associate Director Center for the Environment Dr. Jane Frankenberger, Agriculture and Biological Engineering Dr. Larry Nies, Civil and Environmental Engineering Dr. Inez Hua, Civil and Environmental Engineering Dr. Dev Niyogi, Agronomy Department, and State Climatologist

The Director's Key Program Areas:

LLOW Project Focus for 2006: A significant portion of the Directors' time is spent in coordination of larger water related research efforts. Of note is our continuing effort with the Living Laboratories on the Wabash (LLOW) project. Many of our proposal submissions are now derived from this group as the effort has become a cornerstone for our efforts. Of note was the recent Wabash River Vision meeting (http://www.wabashrivervision.org/). This effort was a product of the LLOW group and the LLOW group is receiving direct project support from IWRRC. Dr. Turco is a key member of the LLOW group. The IWRRC is playing a major role in directing efforts that will focus attention on Indiana's greatest river. The focus of the Living Laboratories On the Wabash (LLOW) Project will be to develop a plan of work to establish a discovery, learning and outreach project for the 1,410 acre floodplain along the Wabash River between U.S. Highways 52 and 231 (see attached map). Partnering with the Wabash River Enhancement Corporation (WREC) and the Center for Earth and Environmental Science (CEES) at IUPUI, the LLOW team will use C4E funding for the following. The goal of the LLOW team is to establish a living laboratory' that will integrate discovery, learning and outreach and act as a model for other river communities in Indiana and elsewhere. This will be accomplished through graduate and undergraduate research and service-learning projects, development of a community participation process and public educational programs, and improved participation and coordination between local, state and federal agencies.

Conservation Effects Assessment Program (CEAP) Focus for 2006: Watershed-Scale Evaluation of BMP Effectiveness and Acceptability: Eagle Creek Watershed, Indiana. Over the last 30 years, the implementation of best management practices (BMPs) has been a mainstay of conservation programs designed to improve water quality while maintaining agricultural productivity. While the value of BMPs can be demonstrated at the small scale, the aggregated effects across a watershed are unclear and largely undocumented. This project integrates a watershed investigation with a social and economic benefits analysis and education program by bring together experts in modeling, social sciences, and economics with a research group managing both historical data and ongoing watershed sample collections. Our target watershed is the 77,000 acre Eagle Creek Watershed north of Indianapolis, which feeds into Eagle Creek and the city's major storage reservoir. Eagle Creek Reservoir supplies water for the Indianapolis water system and the city's 780,000 residents. In spite of the use of BMPs, water quality in the watershed has continued to decline. Our effort has two purposes: the first is to analyze and model an extensive water quality database for the watershed so that we can correlate trends in water quality with current BMPs and then using modeling, compare the trends in water quality to what would be achieved if different BMP management approaches were used. The model is constructed to allow us to explore different scenarios and management intensities. The second purpose of the project is to develop an understanding of the social and economic limitations to the adoption of BMPs and by analyzing the current social limitations to acceptance of water quality management alternatives devise strategies to accelerate positive change. In essence, we will use real data to drive scenario modeling as a means to inform our educational program so that we can influence decision making about practices in the Eagle Creek Watershed. As we have a long-term data set, the impact of this process can be fully assessed and documented.

The Environmental Pathogens Information Network (EPI-Net) 2006: EPI-Net is a keystone organization that provides a stable, centralized resource of water microbiological contamination and environmental pathogens related information, encourages information sharing, connects a network of stakeholders, regulatory officials and technical experts, provides a reliable point of references and increases our ability to develop a coherent national research agenda and good public policy. Epi-net's impact is found in our help to the general public as they work to understand the science and possible environmental consequences of pathogenic bacteria in the environment. The purpose of this information network is to provide the scientific and user communities with a centralized source of information about environmental pathogens, in a way that benefits both the scientific regulatory community. Epi-Net will also better inform our citizens of the problems associated with pathogens and provides prevention approaches. The overarching goal of EPINet is to develop and then transfer the fullest possible understanding of how microbial pathogens enter into and then function in watersheds so that we can properly manage and prevent the spread of microorganisms (and the diseases they cause). To reach that goal EPI-Net developed a series of workshops and information packages that are held in various U.S locations and available in the website www.epi-net.org.

EPI-Net Goals: 1. Develop a nationally representative advisory structure with members from government, academia, and private sector research organizations forming the science board and draw from national farm, commodity, land-use groups and county and state government organizations to form the stakeholder group. 2. Actively mine the wealth of existing environmental microbiology (e.g., E. coli) data and information available from both the refereed literature and state and federal sources to create an on-line information repository and facilitate data sharing to produce a level of common knowledge that will lay the foundation for discussions between the science and stakeholder groups. EPINet will provide this information in a timely, integrated manner. We will present a coherent, holistic approach to information management, emphasizing the significant, but often overlooked, connections that are key to advancing science and developing understanding. 3. Integrate science and stakeholder values within the regulatory framework 4. Use the information mined from the literature to create synthesis documents that will serve to establish the background knowledge for workshop participations and others. 5. Develop a robust and useable internet resource for information transfer and both synchronous and asynchronous communication. 6. Hold workshops and working group meetings to discuss and formulate a common vocabulary/definitions, methods, data needs, and issues related to microbial pathogens in the environment and begin to frame a national education network. 7. Provide input to the biocriteria TMDL process to address the technical complexities and to successfully engage stakeholders so that effective use is made of the TMDL tool in meeting the objectives of the Clean Water Act (CWA).

Research Program

Grant No. 05HQGR0177 Integrating ACOE Sediment Runoff Predictive Tool into DW-L-THIA System

Basic Information

Title:	Grant No. 05HQGR0177 Integrating ACOE Sediment Runoff Predictive Tool into DW-L-THIA System
Project Number:	2005IN209S
Start Date:	9/1/2005
End Date:	8/31/2006
Funding Source:	Supplemental
Congressional District:	4th
Research Category:	Water Quality
Focus Category:	Sediments, Water Quality, None
Descriptors:	
Principal Investigators:	Bernard Engel

Publication

1. Zhai,tong, Yi Shi, Rick Farnsworth, Bernard A. Engel, Jon Bartholic, Larry Theller,Glenn O'Neil, David F. Bucaro. In preparation. An interoperable, multi-host Web-GIS based hydrologic and erosion modeling system. Submitted to: Journal of American Water Resources Association.

IWRRC Report

Title: Sediment runoff predictive tool using the DW-L-THIA system

Submitted by: Bernie Engel, Purdue University, 225 S. University St., W. Lafayette, IN 47907-2093; engelb@purdue.edu

Funding Period: March 1, 2006 – February 28, 2007

Problem: Sediment and nutrient loadings from nonpoint sources are major contributors to water pollution in the Great Lakes region and throughout the world. Sediment loadings cause two highly adverse economic impacts on our ecosystem: lost productivity from unnecessary erosion and the costs of dredging for navigational and environmental purposes. To control and reduce these loadings to our rivers, lakes, and streams, public agencies and private land owners need effective tools for targeting practices that reduce the volume of sediment leaving the land.

Research Objectives: The goal of this effort is to create a tool that integrates a GIS-based sediment runoff predictive tool into Digital Watershed (DW) and the Long-Term Hydrologic Impact Assessment (L-THIA) system and its associated tools so the resulting modeling and decision support tool can be easily accessed and used by a wide variety of expertise levels in determining the effects of development and different agricultural practices to the sediment loadings within two tributaries to Lake Michigan in Northwest Indiana; Burns Ditch/Little Calumet East Branch and Trail Creek.

Methodology:

Erosion modeling

To estimate soil erosion, sediment yield, and the impact of implementing BMPs, the Revised Universal Soil Loss Equation model (RUSLE) was chosen. RUSLE is an erosion prediction model that estimates long-term average annual soil loss resulting from the detachment of soil due to raindrop splash and overland runoff from field slopes in specific cropping and management systems and from rangeland (Renard and Ferreira, 1993). RUSLE is a replacement for the Universal Soil Loss Equation (USLE) and retains its six factors in that equation, as shown below.

$$\mathbf{A = R \bullet K \bullet LS \bullet C \bullet P}$$

where **A** is the long-term average annual soil loss (ton acre^{-1} yr^{-1}), **R** is rainfall erosivity in [(hundreds of ft-ton) inch acre^{-1}hr^{-1}yr^{-1}], **K** is the soil erodibility in [ton acre^{-1} (hundreds of ft-ton)$^{-1}$inch^{-1} acre hr], **LS** is the dimensionless slope length and steepness factor, and **C** and **P** represent the dimensionless impacts of cropping and management systems and of erosion control practices, respectively. The RUSLE model was first developed by the USDA-Agricultural Research Service and was first released in 1993. It has been widely used by USDA-Natural Resources Conservation Service (NRCS) nationally, and it has been adopted internationally as well. There is a wealth of information and data available for its application for many locations.

The RUSLE model predicts long-term average annual erosion. In this project, however, the desired erosion related estimate is the sediment yield. Soil erosion refers to the soil dislodged from its original location due to rainfall and/or overland runoff. Not all of the dislodged soil, however, is transported in runoff water to a nearby stream or lake. A portion of the eroded soil is deposited at lower points in the watershed whenever runoff slows down. The amount of eroded soil that actually reaches a stream or other water body is called sediment. Hence, for a given watershed, the long-term average annual sediment yield is estimated by multiplying the long-term average annual soil erosion potential by a sediment delivery ratio. The sediment delivery ratio is the ratio between the actual lost sediment to the total erosion (detached soil) from a watershed. The sediment delivery ratio varies between 0 and 1. There are different ways to determine sediment delivery ratio for a watershed. In this project, a relationship between watershed size and sediment delivery ratio is used.

In this project, the RUSLE equation is applied to a watershed by way of multiplying the raster (or grid) data layers (10 meter resolution) for the factors in the RUSLE equation in a watershed. Then, total watershed soil loss is calculated by summing up soil loss from all cells in the watershed. Finally, the sum is multiplied by the sediment delivery ratio for the watershed to arrive at the sediment yield value in tons yr^{-1}.

The erosion BMPs considered for this project include both structural and non-structural BMPs. Non-structural BMPs include no tillage, reduced tillage, and conservation tillage on agricultural fields. No till refers to the total cover (100 percent) of soil surface with crop residue. Conservation tillage leaves at least 30 percent of the soil covered by crop residues. Reduced tillage is an in-between tillage type. Structural BMPs include sediment basins, grassed waterways, and riparian buffer strips. To represent the different types of BMPs in the RUSLE equation, the **C** and **P** factors are adjusted for each of the BMPs accordingly.

The Web-GIS based SDSS for erosion and water quality management

There are three common components in any Web-based modeling system, the user interface, backend server databases and modeling programs, and the Web server situated in between handling Hypertext Transfer Protocol (HTTP) connection and Common Gateway Interface (CGI) or Internet Server Application Programming Interface (ISAPI) calls.

The Purdue Web-GIS interface is built using the open source MapServer (http://mapserver.gis.umn.edu/) software with a java applet front end. It handles watershed delineation based on a user-specified outlet point and user digitization of areas within a delineated watershed for land use change or erosion BMP implementation. Its hydrologic models, introduced earlier, can provide before and after land use change hydrologic impact assessment for the delineated watershed.

The MSU Digital Watershed Web-GIS system is built using Internet Mapping software from ESRI. It stores the raster data layers for the **K**, **LS**, and **C** factors for RUSLE simulation for the project area. The default **P** factor is assumed to be 1.

Through the interoperable approach, described later, watershed and BMP area boundaries are first delineated by the Purdue Web-GIS system and sent to the MSU Digital Watershed system, which are used to clip raster layers of the erosion factors. BMP type specific **C** or **P** factors are then incorporated into the corresponding raster data layers for the user-defined areas. Then, the RUSLE model is run for the watershed to calculate total erosion, which is then modified by a sediment delivery ratio to arrive at long-term average annual sediment yield for the watershed. The results are then displayed back in the user's Web browser.

Interoperability

The interoperability operations of data passing and other related operations are carried out behind the scenes without the need of explicit intervention by the user. This ensures seamless integration of the two Web-GIS systems. The watershed management system links the two physically separate Web-GIS systems by passing dynamically re-projected vector GIS data and modeling results between them.

Users can identify a drainage outlet point on a stream line within the MSU Digital Watershed Web-GIS environment. The outlet point's latitude and longitude coordinates are sent to the Purdue Web-GIS system, where they are re-projected to the Universal Transverse Mercator (UTM) Coordinate System, Zone 16 coordinates for the project area. Then, the Purdue Web-GIS uses the point to delineate a watershed based on DEM derived flow accumulation and flow path data. From within the Purdue Web-GIS environment, users can delineate watersheds and digitize areas within the watershed to assign land use change or apply erosion BMPs. The boundaries of the watershed and the digitized areas are saved on the Purdue Web-GIS as ESRI shapefiles, which is then re-projected from UTM zone 16 coordinates to Latitude-Longitude coordinates. The locations of the shapefiles in the Purdue Web-GIS system's file structure are then sent to the MSU Digital Watershed, which in turn retrieves the shapefiles and uses them as masks for clipping data layers for erosion calculations.

In the traffic in both directions, information (latitude-longitude coordinates or Web address of the boundary shapefiles) is passed through Hypertext Transfer Protocol (HTTP) Common Gateway Interface (CGI) or Internet Server Application Programming Interface (ISAPI) calls on programs that reside on destination Web Servers.

Principal Findings

Summary

A Web-GIS watershed management system was developed as part of the Great Lakes Tributary Modeling Program administered by the U.S. Army Corps of Engineers. The system targets the Burns Ditch and Trail Creek watersheds in northwestern Indiana that drain into Lake Michigan. The system is built on the basis of two existing Web-GIS modeling/mapping systems hosted at Purdue University and Michigan State University. The two systems were made interoperable by passing GIS data through HTTP CGI/ISAPI calls to programs on destination servers. New

capabilities were developed in the two systems. Specifically, the Purdue Web-GIS was extended to represent common tillage BMPs (no-till, reduced tillage, and conservation tillage) and structural BMPs (sediment basin, grassed waterways, and riparian buffer strips) through a new online digitizing tool for location specific assignment of land use change and BMP applications within a watershed. The MSU Digital Watershed Web-GIS was extended to include erosion and sedimentation predication capabilities.

The two enhanced Web-GIS systems were seamlessly integrated into a Web-based SDSS that allows users to delineate watersheds, make land use changes, apply erosion BMPs in a delineated watershed, and run hydrologic and erosion models to assess the impact on hydrology, NPS pollution, and sediment yield due to land use change or BMPs. Multiple scenarios can be evaluated and compared in one analysis session.

The SDSS was disseminated at a workshop for local stakeholders and was very well received. The SDSS has proven to be a user-friendly decision support system that allows grassroots efforts in the land management decision making process. Future improvement of the system will focus on the expansion of the BMP types that can be represented in the system.

Results and Significance

The watershed management system for the Burns Ditch and Trail Creek watersheds is available online at http://danpatch.ecn.purdue.edu/~eqip/erosion/. Users can choose entry of the SDSS from either the Purdue Web-GIS interface or MSU Digital Watershed interface based on their preference. Both ways will lead to the same system capability.

From the initial entry page, may it be from Purdue Web-GIS or MSU Digital Watershed, the user would zoom to identify the area of interest and nearby stream, and then initiate watershed delineation by a single click on the stream. A watershed is delineated in approximately ten seconds based on the user specified outlet point and underlying DEM data. The user can then activate the online digitizing interface to either manually digitize areas in which BMPs will be implemented or allow the system to determine the contributing areas in the case of grassed waterways and sediment basin structural BMPs. Then, the user specifies the type of BMP for the digitized area using the land use/BMP dialog box. For grassed waterways, the user also needs to digitize a line inside the contributing area to define the location of the waterway. Tillage BMPs can only be applied to agricultural land uses. Once the changes are made and saved by the online digitizing tool, a before and after land use and BMP summary is given, along with a modeling toolbox for hydrologic and erosion modeling. The available models can then be used to obtain a quantitative estimate of the impact from the land use changes made or BMPs applied. The whole process can be repeated for the same delineated watershed as many times as the user would like. This allows multiple management scenarios to be evaluated and compared.

Major Conclusions

A Web-GIS watershed management system was developed to estimate erosion and runoff from watersheds. The system targets the Burns Ditch and Trail Creek watersheds in northwestern Indiana that drain into Lake Michigan. The system allows users to estimate the impacts of common tillage BMPs (no-till, reduced tillage, and conservation tillage) and structural BMPs (sediment basin, grassed waterways, and riparian buffer strips) on erosion and runoff. Stakeholder impact has been very positive regarding the web-based tool.

Publications

A draft manuscript has been prepared for submission to a journal.

Tong Zhai, Yi Shi, Rick Farnsworth, Bernard A. Engel, Jon Bartholic, Larry Theller,Glenn O'Neil, David F. Bucaro. In preparation. An interoperable, multi-host Web-GIS based hydrologic and erosion modeling system. Journal of American Water Resources Association.

Students

Graduate Students:/Undergraduate Students: Tong Zhai, post doctoral research assistant in Agricultural and Biological Engineering

Wireless Monitoring of Purdue's Constructed Wetland

Basic Information

Title:	Wireless Monitoring of Purdue's Constructed Wetland
Project Number:	2006IN187B
Start Date:	3/1/2006
End Date:	5/31/2007
Funding Source:	104B
Congressional District:	4th
Research Category:	Water Quality
Focus Category:	Nutrients, Education, Water Quality
Descriptors:	None
Principal Investigators:	Chad Jafvert, Rao S. Govindaraju

Publication

IWRRC Report

Title: Wireless Monitoring of Purdue's Constructed Wetlands

Submitted by: Chad Jafvert and Rao Govindaraju, Purdue University, School of Civil Engineering, 550 Stadium Mall Drive, West Lafayette, IN 47907

Funding Period: March 1, 2006 – February 28, 2007

Problem: "The purpose of this proposal is to request funds for the purchase of water quality monitoring instrumentation and wireless routers to be installed at Purdue's constructed wetlands and maintained by Purdue University undergraduate students enrolled in the EPICS course: Constructed Wetlands/Water Quality."

Research Objectives: This projects focus is on: (1) employing innovative wireless continuous monitoring strategies for assessing water quality at remote locations, (2) training undergraduate students in sensor and wireless technologies as they relate to environmental assessment and protection, and (3) leveraging project infrastructure and results to attract additional resources to the State of Indiana to monitor environmental parameters at a broader scale (i.e., watershed level).

Methodology: Monitoring hardware and instrumentation was purchased in late spring of 2006, and arrived in the middle of the Fall semester. This was too late in the semester for undergraduate student involvement. However, in the Spring semester, the instruments were set-up and evaluated within the laboratory, testing the probes and wireless communication software and hardware. During this time, it was decided to install the monitoring equipment on the Wabash River rather than at the constructed wetlands. A suitable location on the river was identified, with this location being a pedestrian bridge approximately 4 miles Northeast of Campus - at the Davis Ferry Bridge, part of the Wabash Heritage Trial owned by Tippecanoe County. In Fall 2006, a consent to encroach was approved by the County Commissioners to install a 4 inch pipe from the bridge through which cables and tubing could be encased for monitoring the river. The hardware will be installed this summer (2007) by a graduate student in Civil Engineering with the help of a SURF (summer undergraduate Research Fellowship) student, who is working on the project over the summer. In the Fall semester (2007), students in EPICS will maintain the site, and work on software to display the data on the class webpage.

Principal Findings: None to date.

Summary: Instrumentation has been purchased to monitor several water quality parameters within a local water body. Initially, the water quality station was to be deployed at a local constructed wetlands; however due to local interest in the Wabash River, the station will be deployed on a pedestrian bridge near Lafayette IN. Parameters to be measured include: dissolved oxygen, water and air temperature, water conductivity, turbidity, and pH. Students enrolled in a service learning course entitled: "Constructed Wetlands/Water Quality" have been working with the Tippecanoe County Soil and Water

Conservation District to implement the project. Students in the course have programmed the datalogger and designed the station for implementation in the field by this summer (2007).

Results and Significance There are no data to report at this time.

Major Conclusions There is no major conclusion at this time.

Publications See: http://epics.ecn.purdue.edu/cwwq/

Students: The service learning course EPICS: Constructed wetlands/Water Quality had an enrollment of 13 students in Spring 2007. Several of the students in this course worked on various aspects of this project, including analysis of grab samples for E. coli, suspended solids, and nitrate, and wireless communication. A graduate student in Civil Engineering has been worked with these students, and has designed and constructed the station to be installed on the pedestrian bridge. This summer (2007) a SURF (summer undergraduate Research Fellowship) student, has been working on final installation requirements for the station.

Environmental Risk Assessment of Soybean Rust Fungicides Use in Indiana

Basic Information

Title:	Environmental Risk Assessment of Soybean Rust Fungicides Use in Indiana
Project Number:	2006IN189B
Start Date:	3/1/2006
End Date:	2/28/2007
Funding Source:	104B
Congressional District:	4th
Research Category:	Biological Sciences
Focus Category:	Toxic Substances, Models, None
Descriptors:	None
Principal Investigators:	Hugo G Ochoa-Acuna, Bernard Engel, Leighanne Hahn

Publication

1. Cerbin S, Biallkowski W, Ochoa-Acuña H. 2006. Effect of Propiconazole and Strobilurin Fungicides alone or in combination on two algal species: Selenastrum capricornutum and Chlorella vulgaris. Society for Environmental Toxicology and Chemistry North America 27th Annual Meeting, Montreal, Quebec, Canada.
2. Ochoa-Acuña H, Bialkowski W, Cerbin S, Hahn L, Engel B. 2006. Probabilistic Evaluation of Potential Environmental Effects Caused by Soybean Fungicides use in Indiana. Society for Environmental Toxicology and Chemistry North America 27th Annual Meeting, Montreal, Quebec, Canada.
3. Bialkowski W, Cerbin S, Ochoa-Acuña H. 2006. Acute and Chronic Toxicities of Parathion and Propiconazole Mixtures on the Aquatic Invertebrate, Daphnia magna. Society for Environmental Toxicology and Chemistry North America 27th Annual Meeting, Montreal, Quebec, Canada.
4. Hahn L, Zhai T, Lim K, Ochoa-Acuña H, and Engel B. 2006. Potential Water Quality Impacts of Asian Soybean Rust Fungicide Applications in Indiana. Society for Environmental Toxicology and Chemistry North America 27th Annual Meeting, Montreal, Quebec, Canada.

Title: Environmental Risk Assessment of Soybean Rust Fungicides Use in Indiana

Submitted by: Hugo G. Ochoa-Acuña, Assistant Professor, Veterinary Pathobiology and Civil Engineering, Purdue University, 725 Harrison St. West Lafayette, IN 47907-2027, (765) 494 5796, hochoaac@purdue.edu; Bernard Engel, Professor and Head, Agricultural and Biological Engineering, Purdue University; Leighanne Hahn, Water Quality Program Specialist, Office of the Indiana State Chemist.

Funding Period: March 1, 2006 – February 28, 2007

Problem

We evaluated the environmental safety of fungicides to be used for combating Asian soybean rust in Indiana. Soybean rust is a highly contagious, fungal crop disease recently detected in several US states. A recent study conducted by the USDA (Livingstone et al. 2004) estimates that conditions are favorable for the development of soybean rust during most years for the Midwest. The introduction of this pest has prompted the EPA to approve emergency registration exceptions for use on soybeans for several fungicides in the U.S. To date, 14 active ingredients have been approved or are under consideration for use against soybean rust, of which only three (chlorothalonil, azoxystrobin, and pyraclostrobin) have been granted full registration for use on soybeans.

Fungicide losses into surface water may become significant as the management recommendation is to use fungicides at their maximum allowable rate to prevent development of resistant fungal strains. According to the USDA study mentioned above, 8.6 million acres are regularly planted with soybeans in Lake States (Michigan, Minnesota and Wisconsin), whereas the acreage normally planted in Indiana exceeds 5 million acres. Because of the large acreage devoted to produce soybeans, control of soybean rust will likely result in large amounts of new fungicides entering the state's environment. We have already predicted the potential concentration in field runoff of these fungicides for Indiana based on their recommended application patterns. However, we are unable to provide an accurate estimate of the environmental risks associated with these concentrations given the scarcity of effects data for aquatic organisms. Given this lack of adequate data, a major effort of this project was to test the acute and chronic toxicity of these chemicals on algae and zooplankton.

Published information allows to predict that the toxicity of these fungicides is likely to be significant for both human and ecological receptors. The majority of these products are conazoles, or azole antifungal agents. Some conazoles induce tumors in rats, and others induce adverse developmental and reproductive effects. The EPA considers tetraconazole and cyproconazole to be possible human carcinogens and has derived oral cancer slope factors for them. Although the ecological effects database for these fungicides is very limited, the data available indicate that several are extremely toxic to aquatic biota, including fish, invertebrates, and algae. In addition, several studies have documented significant potentiation of adverse effects of pyrethroid and organophosphorous insecticides by previous exposure to conazole fungicides in rats, birds, fish, and invertebrates (Pilling et al. 1995, Ronis and Badger 1995, Johnston et al. 1996, Levine and Oris 1999).

Research Objectives: The main objective of this study was to evaluate the potential environmental impact of soybean rust fungicides to inform the development of best management practices for controlling this disease. This investigation focused on the following specific objectives:

- ☞ Objective 1: Determine the toxicity of fungicides to unicellular algae (*Selenastrum capricornotum*).
- ☞ Objective 2: Determine the acute toxicity of fungicides to representative zooplankton (*Daphnia magna*).
- ☞ Objective 3: Determine the potential synergistic action of conazole fungicides and organophosphorous insecticides

Methodology:

a. Toxicity testing of algae:

Six concentrations of each fungicide along with a control group were tested simultaneously. All experiments were run using four replicates. Tests were conducted on 30 mL flasks or using a new methodology based on 96-well microtiter plates, with each well containing 300 µL of test solution. Tests solutions were prepared using standard algal growth medium, prepared per U.S EPA specifications (U.S. EPA 2002).

At the start of the test, each well was inoculated with 20 µL of an algal suspension containing approximately 3.7×10^5 cells/mL. Light was provided at a rate of 1500 lux 24 h/day. Plates were constantly shaken for the 3-day test period using an IKA MTS microplate orbital shaker (Wilmington, NC).

Algal concentrations were determined every 12 h using a Dynex Revelation MRX II automatic plate reader (Chantilly, VA) setting the wavelength to 680 nm. Previous studies have shown this wavelength provides the best fit between absorbance and count data of unicellular algae (Kasai et al. 1993, Ma et al. 2001). Calibration curves were checked for accuracy during each plate reading.

The percent growth inhibition was calculated by comparing the algal concentration in each treatment to the concentration of algae in the control groups after 72 h of exposure. Using these data, the fungicide concentration associated with a 50% decrease in algal biomass (i.e., the median inhibition concentration, or IC_{50}) was calculated.

b. Acute toxicity testing of zooplankton:

D. magna were exposed to the same six concentrations used in the algal tests. All experiments were run using four replicates. Tests were performed in 30-mL borosilicate glass beakers.

Tests were commenced by adding five 1-day old *D. magna* to each beaker. Beakers were checked twice daily for a period of four days. The number of surviving animals at different time intervals (24, 48, and 96 h) were used to calculate median lethal concentrations (LC_{50}) for each zooplankton and fungicide.

c. Synergistic action of propiconazole and parathion:

Animals that received pretreatments were first exposed in groups of 60 using 600-mL glass beakers containing 500 mL test solution. Following pretreatment, animals were separated in groups of five and transferred to 30 mL glass beakers for subsequent exposures to parathion.

All solutions were prepared ≤48 h prior to the initiation of testing. Technical grade propiconazole, parathion-methyl, and piperonyl butoxide were procured from Sigma Aldrich (St. Louis, MO, USA).

We selected the ergosterol biosynthesis inhibiting fungicide propiconazole because it is present in several soybean rust fungicide formulations and has been shown to act synergistically with organophosphorous insecticides in fish, birds, and mammals. It has been hypothesized thay conazole fungicides induce cytochrome P450-dependent monooxygenases that result in an increased oxidative activation of organophosphorous insecticides. However, there are no studies to date testing whether the same phenomena are observed in an invertebrate system, although in *Daphnia* dose-response experiments have demonstrated that the oxon metabolite is more toxic than the parent organophosphorous compound. We also used piperonyl butoxide in our experiments because it is known to act as a non-selective cytochrome inhibitor. If propiconazole enhances toxicity of parathion through activation of cytochrome P450-dependent monooxygenases, we expected to see a decrease in the joint toxicity when piperonyl butoxide is present.

This objective was carried out with a series of four separate experiments which constitute the MS thesis of Walter Bialkowski. Results from Objective 2 were used to ascertain the toxicity of chemicals in single exposures and to determine the concentration ranges to be used in the binary exposure experiments. Effect concentrations were established by exposing animals for 24 hours in 12.5, 25, 50, 100, 400 and 1600 µg/L propiconazole prior to treatment with parathion. An exposure duration threshold was determined by exposing animals to propiconazole for 2, 12, 24 and 48 hours prior to exposure with parathion. Another series of animals were exposed to parathion first, followed by exposure to propiconazole for the same time periods.

In experiment 1, *Daphnia* ≤24 hours old were placed in 600 mL beakers for 24 hour pretreatment exposures in one of four propiconazole concentrations: 0, 100, 400, and 1600 µg/L. Two replicates were included for each treatment. Following pretreatment, animals were allocated into 30 mL beakers containing 0, 2, 4, 8, and 16 µg/L. Six post-treatment replicates were used. In experiment 2, piperonyl butoxide was used to evaluate the influence of cytochrome enzymes in enhancing the toxicity of parathion. Pretreatment (24 h of propiconazole) and post treatment (72 h of parathion) exposures commenced as above. Pretreatments included 0, 100, and 400 µg/L propiconazole with or without 933 µg/L piperonyl butoxide. This concentration of piperonyl butoxide is one-tenth the experimental 48-h LC_{50}. In experiment 4, a 48 h immobilization test was performed using both contaminants simultaneously immobilization tests were performed by preparing solutions containing combinations (16) of 0, 50, 100, and 400 µg/L propiconazole and 0, 4, 8, and 16 µg/L parathion. In experiment 4, pretreatment durations were 8, 16, and 24 hours. Propiconazole concentrations were 0, 100, and 400 µg/L and included replicates with and without piperonyl butoxide (933 µg/L). The compliment of a total 96 hour exposure time consisted of the parathion post treatments (0, 8, and 16 µg/L). For example, animals receiving an 8 h pretreatment were transferred into appropriate parathion solutions for an additional 88 h (88 + 8 = 96).

Principal Findings

We found that several soybean rust fungicides can elicit significant toxicity to unicellular algae and invertebrates at concentrations expected to occur, at least during short (4-day) periods in edge-of-field runoff. In the case of algae, the safest fungicide of those tested was tebuconazole, whereas the least safe was azoxystrobin. In the case of the invertebrate *Daphnia magna*, the safest fungicide was trifloxystrobin because of its expected low runoff concentration. The least safe fungicide for invertebrates was propiconazole. It is important to note that these "least safe" fungicides are expected to reach concentrations in runoff that exceed concentrations associated with mortality of more than 50% of exposed organisms. In addition, our study described for the first time in an freshwater invertebrate a synergistic response between the fungicide propiconazole and the insecticide parathion. The study demonstrated that this enhancement of toxicity when organisms are exposed to these two chemicals sequentially or simultaneously is mediated by an enzyme systems similar to that implicated in this interaction in vertebrates. This is a very significant result because this synergism is likely to also occur among other conazole fungicides and organophosphorous insecticides. In addition, propiconazole by itself was proven to be significantly toxic to invertebrates at concentration expected in runoff so any increase in toxicity due to coeexposure to other chemicals is of significance.

Summary

We determined the potential environmental effects of fungicides to be used in fighting soybean rust. The EPA issued emergency exemption registrations for use of these fungicides to combat this newly introduced soybean disease. It is expected that combating this disease will require the use of large amounts of fungicides within Indiana, even though their safety to humans and aquatic organisms has not been adequately documented. Annual mean and 4-day peak surface water concentrations for fungicides predicted with a model using spatially overlaid data on fungicide and land use, soil characteristics, and weather were compared to effects data from toxicity tests conducted on unicellular algae and the invertebrate *Daphnia magna*. We found that azoxystrobin can be expected to reach concentrations in runoff associated with significant toxicity to algae and that the same would occur for propiconazole in the case of invertebrates. Our study also described a synergistic response between the fungicide propiconazole and the insecticide parathion. This enhanced toxic response is likely to also occur among other conazole fungicides and organophosphorous insecticides. Our results show that further studies are needed to better characterize the environmental safety of these fungicides.

Results and Significance

a. Fungicide concentrations in runoff

Using the National Agricultural Pesticide Risk Analysis (NAPRA) for predicting runoff and leaching pesticide concentrations, we developed runoff concentration distributions for Indiana that would occur under normal conditions when the fungicides are applied per label recommendations. The following figures show the distribution of runoff concentrations likely to be observed across Indiana. The annual 5th percentile values represent the annual average runoff concentration likely to be observed during the worst (i.e., more prone to high fungicide runoff) five out of a hundred years being simulated. The 4-day maximum, 50th percentile values represent the most likely (i.e., median or 50th percentile) maximum concentration measured over a 4-day period during the year; whereas the 4-day maximum concentration, 5th percentile values are also calculated from the maximum concentration measured over a 4-day period during the year, but observed only during the worst (i.e., more prone to high fungicide runoff) five out of a hundred years being simulated. In the case of the toxicity evaluation conducted under the present funding, the most relevant distributions are those representing 4-day maxima. Chronic algal toxicity tests are conducted over a period of 3-4 days and the relevant toxicity endpoint is the IC_{50} over that period. Exceedance of an IC_{50} by the simulated 4-day maximum values would indicate that a significant decrease in algal biomass might be observed. On the other hand, acute toxicity tests using invertebrates also last 4 days, so again the most relevant simulated concentrations are those calculated as the 4-day maximum.

Figure 1
Distribution of Indiana lands receiving runoff concentrations of Azoxystrobin under per-label application conditions (annual values in µg/L; 4-day values in mg/L).

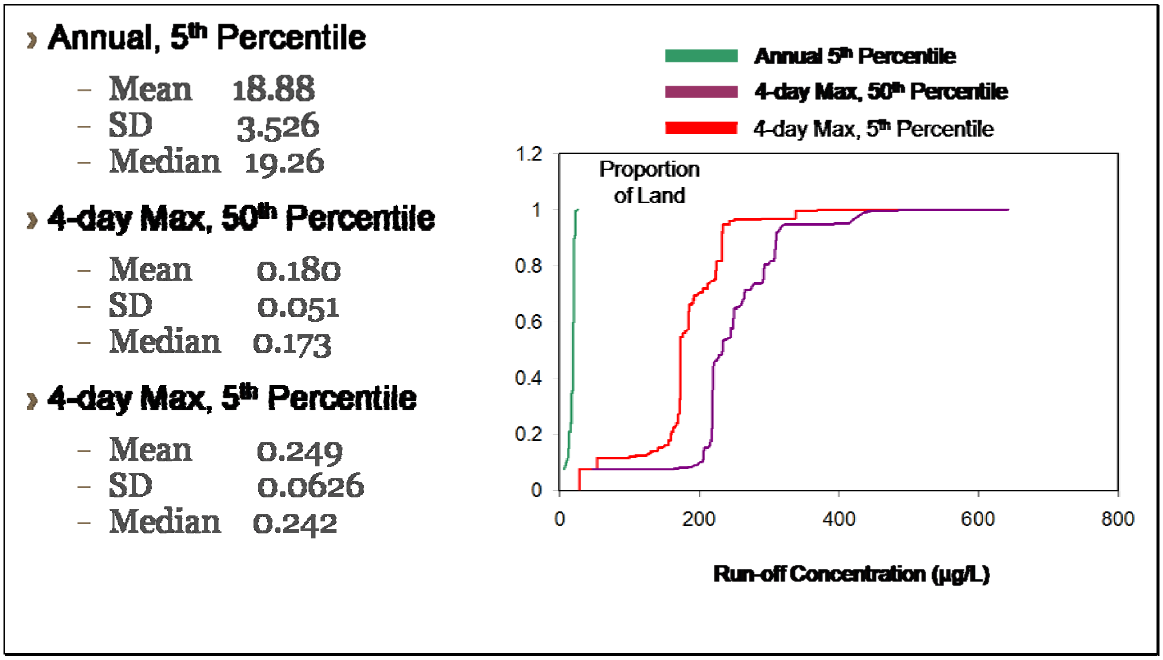


Figure 2
Distribution of Indiana lands receiving runoff concentrations of Myclobutanil under per-label application conditions (annual values in µg/L; 4-day values in mg/L).

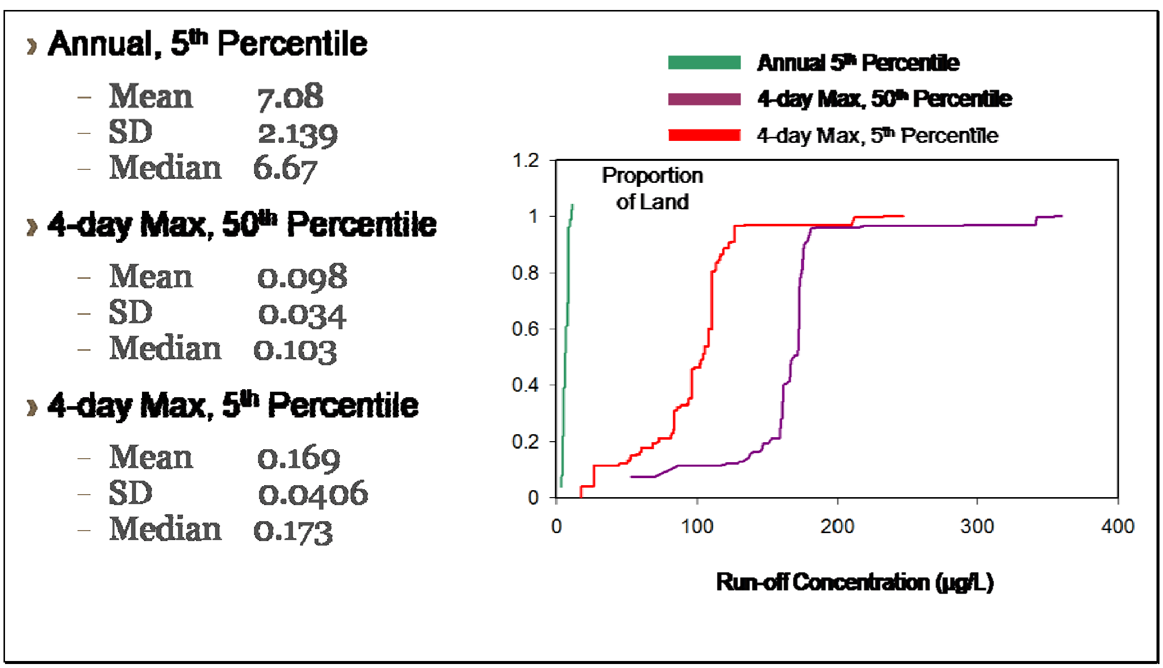


Figure 3

Distribution of Indiana lands receiving runoff concentrations of Propiconazole under per-label application conditions (annual values in µg/L; 4-day values in mg/L).

- **Annual, 5th Percentile**
  - Mean 26.9
  - SD 5.70
  - Median 26.16
- **4-day Max, 50th Percentile**
  - Mean 0.189
  - SD 0.0543
  - Median 0.192
- **4-day Max, 5th Percentile**
  - Mean 0.286
  - SD 0.0644
  - Median 0.278

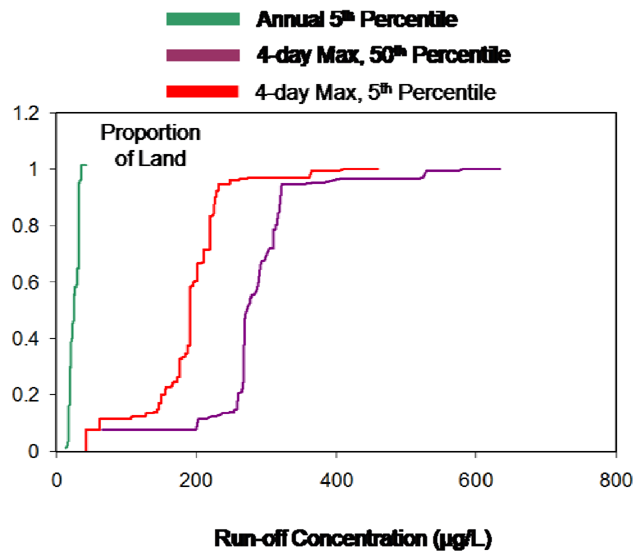


Figure 4

Distribution of Indiana lands receiving runoff concentrations of Tebuconazole under per-label application conditions (annual values in µg/L; 4-day values in mg/L).

- **Annual, 5th Percentile**
  - Mean 30.01
  - SD 6.30
  - Median 28.28
- **4-day Max, 50th Percentile**
  - Mean 0.106
  - SD 0.0279
  - Median 0.109
- **4-day Max, 5th Percentile**
  - Mean 0.153
  - SD 0.034
  - Median 0.149

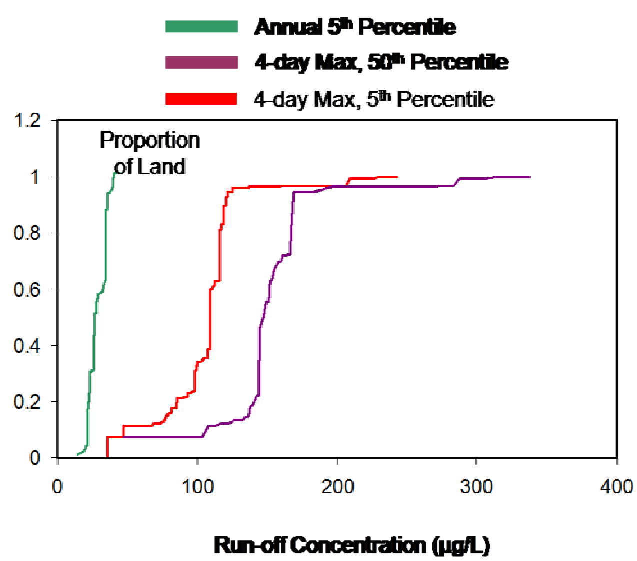
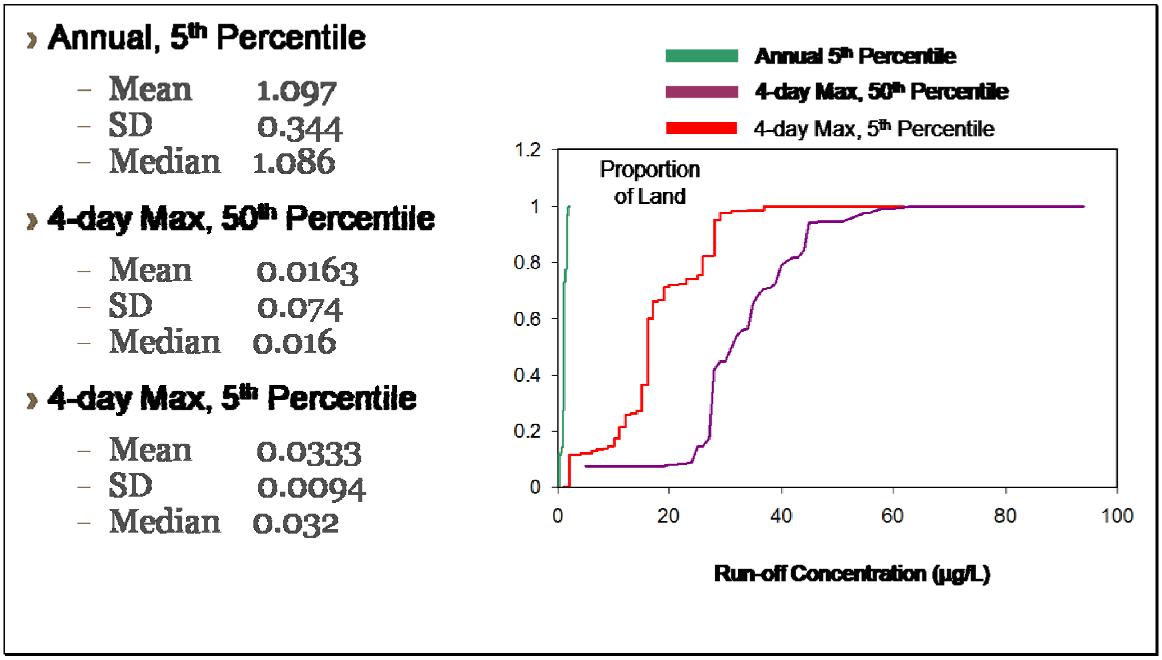


Figure 5

Distribution of Indiana lands receiving runoff concentrations of Trifloxystrobin under per-label application conditions (annual values in µg/L; 4-day values in mg/L).



b. Toxicity of soybean rust fungicides to algae

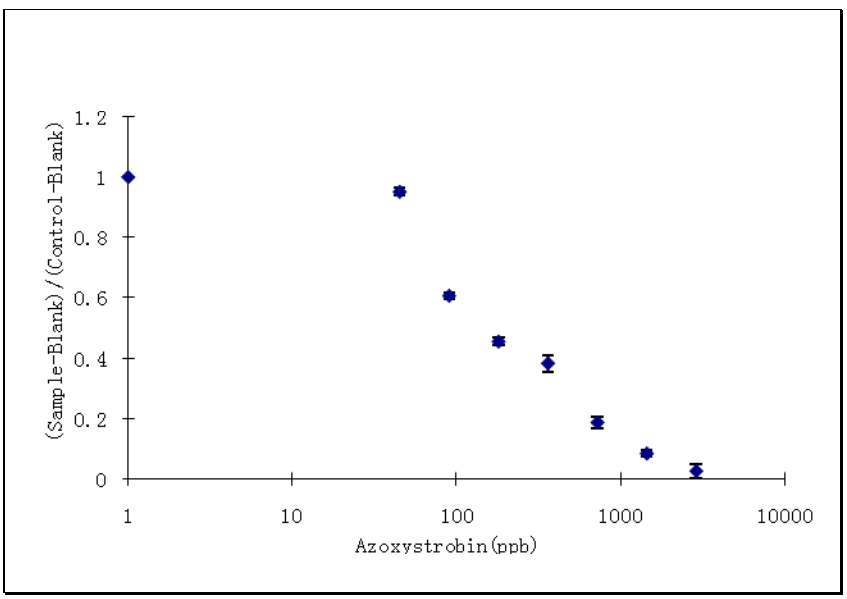
We tested the toxicity of some fungicide formulations to have a preliminary evaluation of the relative toxicity of soybean rust fungicides to algae. As can be seen in Table 1, the No Observe Effect Concentration (NOEC) and the IC_{50} varied by two orders of magnitude among the formulations tested. Although one of the fungicides tested seems unlikely to reach runoff concentrations that might have adverse effects on freshwater algae (e.g., tebuconazole), modeled concentrations for the other fungicides exceeded at least the NOEC after correction for the concentration of active ingredient in the formulation. Myclobutanil, azoxystrobin, and propiconazole all had 5th percentile 4-day maximum concentrations predicted to approach or exceed the IC_{50} over a significant proportion of Indiana's agricultural land.

Table 1
Fungicide formulations tested using freshwater algae, their calculated toxicity endpoints, and modeled runoff concentrations.

Fungicide Formulation	Active Ingredient	Active ingredient concentration	NOEC (µg/L)	IC_{50} (µg/L)	4-day Maximum Runoff (µg/L)	
					50th perct.	5th perct.
Domark®	tetraconazole	20.70%	16	800	NA	NA
Folicur®	tebuconazole	38.70%	1500	5200	106	150
Laredo®	myclobutanil	25%	60	880	100	170
Quadris®	azoxystrobin	22.9	18	55	**180**	**250**
Tilt®	propiconazole	41.80%	25	600	190	290

To confirm the results obtained for Quadris®, we conducted toxicity tests of algae using the pure active ingredient. As can be seen in Figure 6, azoxystrobin elicited toxicity below 45 µg/L, with a calculated IC_{50} of 200 µg/L. The higher toxicity of the formulation, as compared to the active ingredient alone may be due to enhanced toxicity due to the presence of surfactants or other compounds in the formulation. We are currently performing these tests for all the other active ingredients.

Figure 6
Dose response curve of *Selenastrum capricornutum* unicellular alga biomass to azoxystrobin.



c. Toxicity of fungicides to the invertebrate *Daphnia magna*

We selected *Daphnia magna* as our model organism because of its importance in aquatic food webs and also because is a species routinely used in toxicity testing of water contaminants. *Daphnia* are members of the crusteacean Class Branchiopoda (Thorp and Covich 2001). Branchiopods are planktonic and have flat, leaflike appendages (called phylopods) that are used to collect suspended food1. Functionally, this Class is involved in aquatic communities as prey items for fish, birds, and other aquatic predators.

Because of their potential toxicity to invertebrates, as suggested by the literature and our results using algae, we focused this part of the funded project on azoxystrobin, trifloxystrobin, and propiconazole. Figures 7 through 9 show the increase in mortality of *Daphnia* in response to increases in the concentration of the three fungicides tested. Table 2 presents the NOEC and LC_{50} calculated from the data, as well as the simulated runoff concentrations for Indiana. For azoxystrobin and propiconazole, toxicity to invertebrates is likely under the simulated scenario, as the projected runoff concentrations are very close or even exceed the LC_{50}.

Figure 7
Dose response curve of *Daphnia magna* 4-day mortality to azoxystrobin.

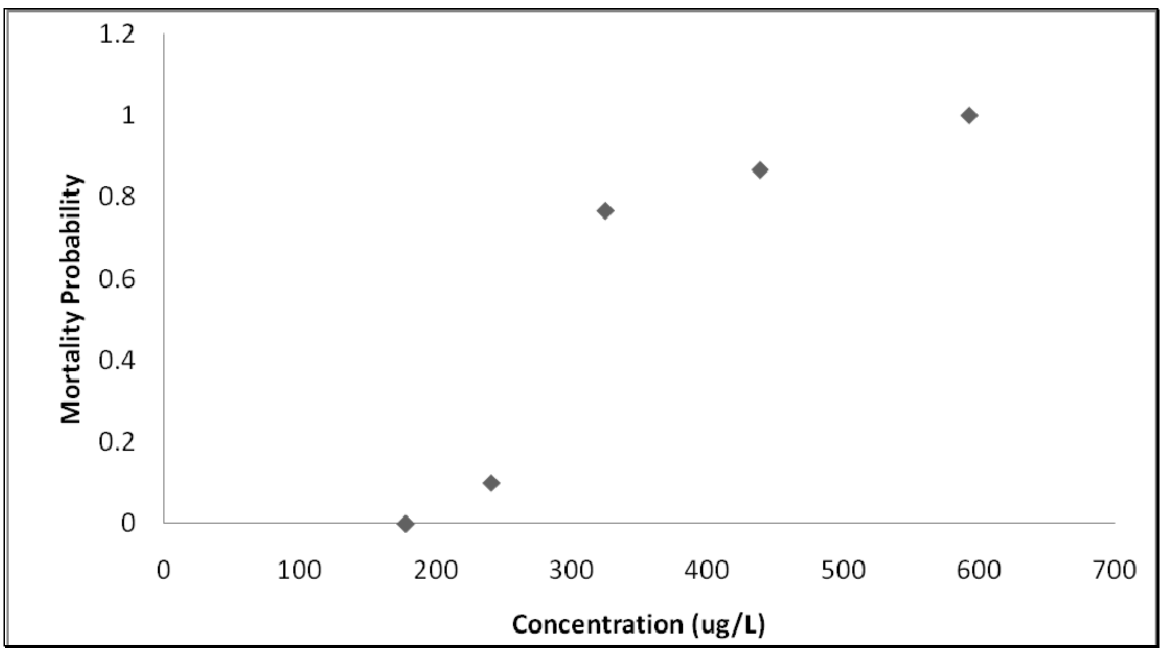


Figure 8
Dose response curve of *Daphnia magna* 4-day mortality to trifloxystrobin

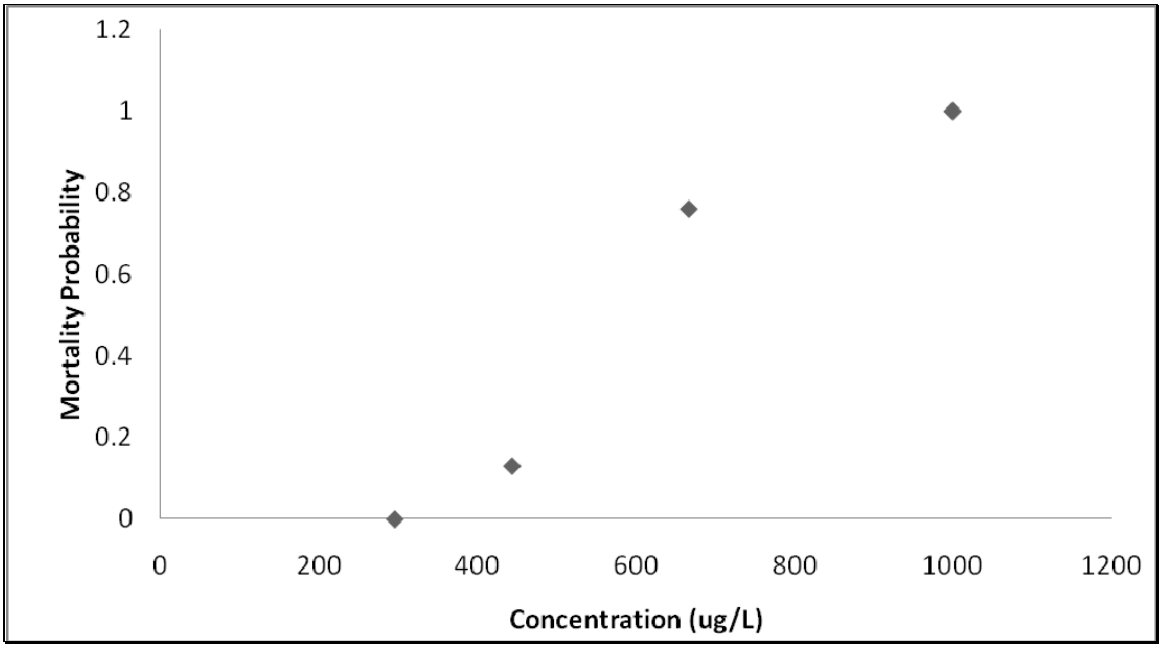


Figure 9
Dose response curve of *Daphnia magna* 4-day mortality to propiconazole

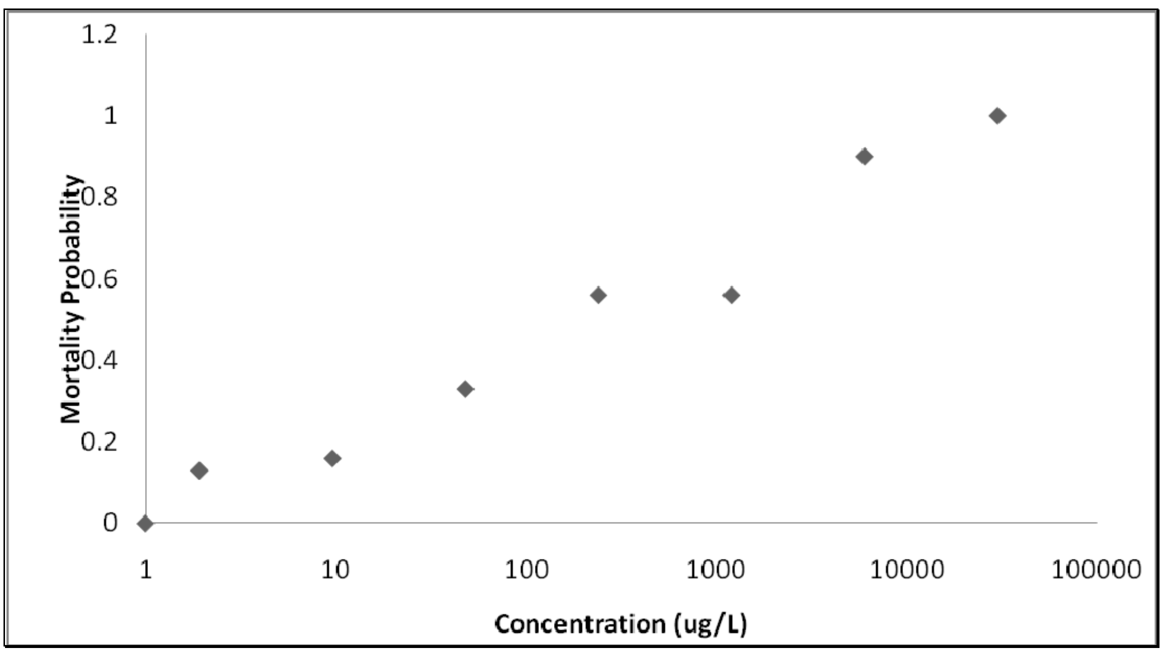


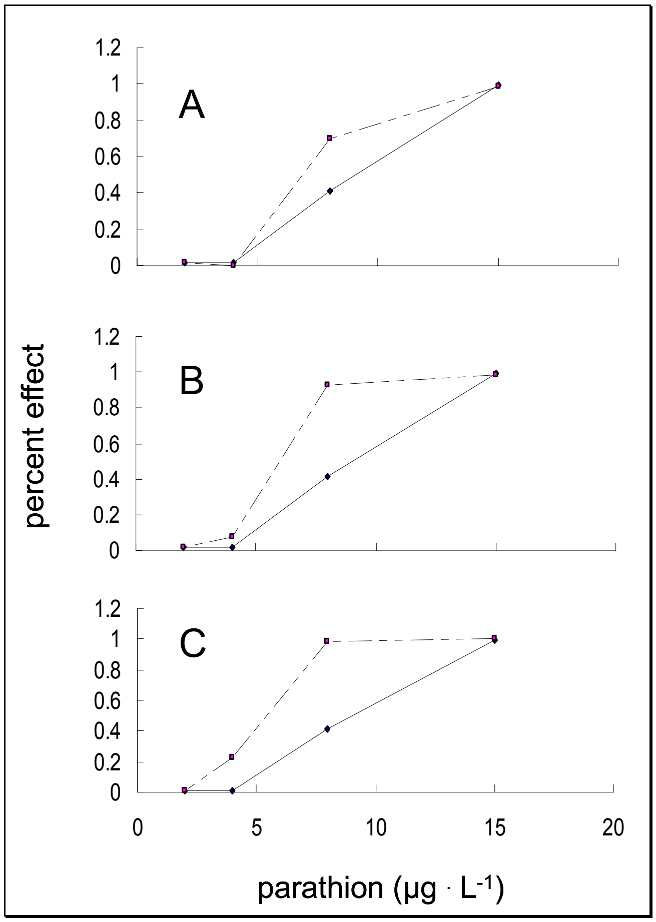
Table 2
Fungicide active ingredients tested using the invertebrate *Daphnia magna*, their calculated toxicity endpoints, and modeled runoff concentrations

Active Ingredient	**NOEC (µg/L)**	**LC_{50} (µg/L)**	**4-day Maximum Runoff (µg/L)**	
			50th perct.	**5th perct.**
azoxystrobin	180	310	180	250
trifloxystrobin	300	560	16	33
propiconazole	1	230	190	**290**

d. Synergistic action of propiconazole and parathion

Daphnia that received pretreatment with propiconazole for 24 h prior to 72 h exposure with 0, 4, 8, and 16 µg/L parathion demonstrated increased mortality relative to controls (i.e., groups exposed only to parathion) at several concentrations (Figure 10). These significant increases in toxicity are beyond what would be expected simply by exposing the animals to an additional chemical since the concentrations of propiconazole that elicited these responses were well below concentrations associated with direct toxicity.

Figure 10
Percent mortality of *Daphnia magna* exposed to 0, 4, 8, and 16 µg/L parathion. Solid lines indicate 24 h pretreatment with control solution; dashed lines represent 24 h pretreatment with 100 (A), 400 (B), and 1600 (C) µg/L propiconazole.



Piperonyl butoxide effectively eliminated the mortality observed in the 0, 100, and 400 µg/L propiconazole pretreated animals (Table 3). Treatment with 933 µg/L piperonyl butoxide alone had an effect on the survivability of *Daphnia* in one treatment (Table 3). This observation is most likely the result of random mortality events and is still below the observed mortality for the control. Two important observations were made: (1) animals receiving piperonyl butoxide in the pretreatment medium were less likely to die than animals treated with propiconazole alone, and, (2) pretreatment with piperonyl butoxide alone did not significantly affect the survivability of *Daphnia*. These results imply that by not causing mortality by itself, piperonyl butoxide is an effective cytochrome inhibitor for tests with *Daphnia*.

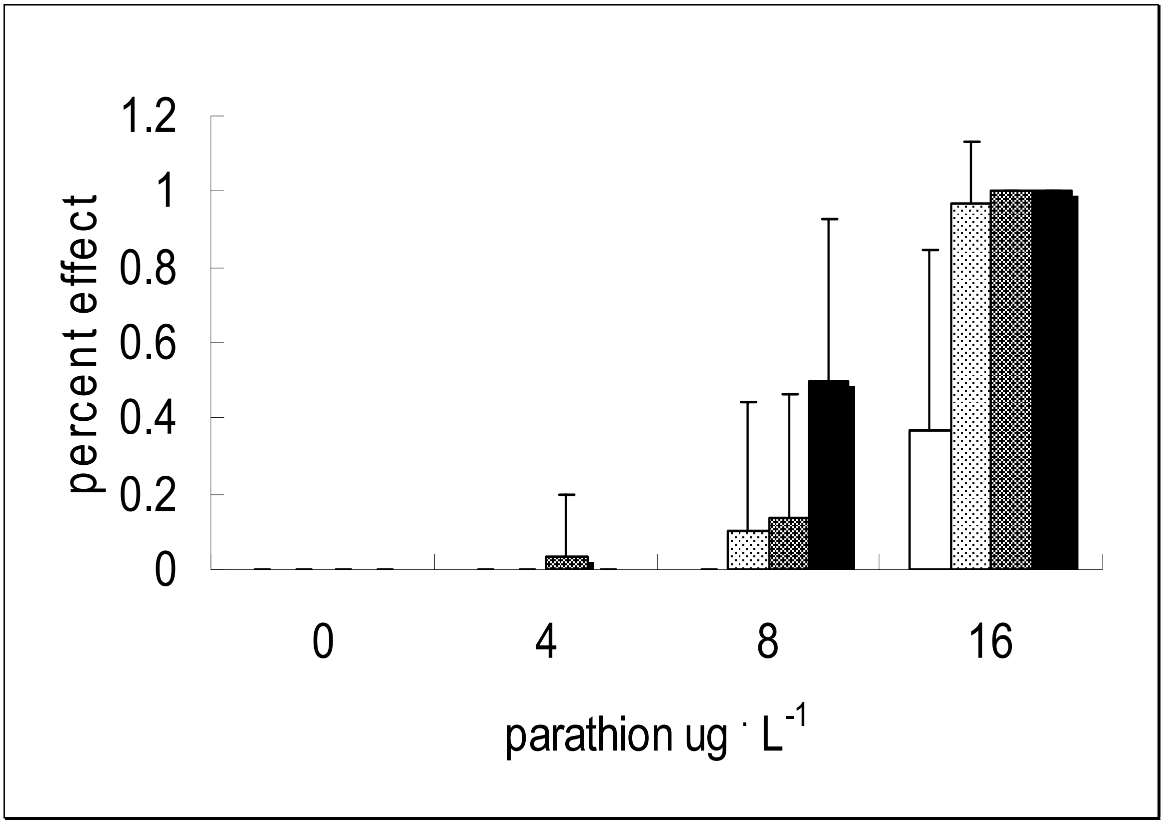
Table 3
Mortality probabilities for *Daphnia magna* exposed to 16 µg/L parathion following exposure with propiconazole pretreatments.

Mortality probabilities for *Daphnia magna* exposed to 16 µg/L parathion following exposure to various propiconazole pretreatments.			
		PBO[b]	
pretreatment duration[a]	propiconazole (µg/L)	absent	present
8	0	0	0.05
8	100	0.3	0.1
8	400	0.95[c]	0
16	0	0.85[c]	0
16	100	0.85[c]	0
16	400	1.0[c]	0
24	0	0.05	0
24	100	0.05	0
24	400	0.5	0

[a]Pretreatment exposure duration (h)
[b]933 µg/L piperonyl butoxide presence/absence in pretreatment
[c]P≤0.05 (T≤t) one-tailed paired differences of means

Daphnia magna exposed simultaneously to both propiconazole and parathion demonstrated similar dose-dependent responses as animals receiving pretreatments (Figure 11). No significant increases in mortality were observed for animals exposed in 0 or 4 µg/L parathion, regardless of the presence of propiconazole. However, significant increases were observed for animals exposed to 50 (P≤0.05), 100 (P≤0.05), and 400 µg/L (P≤0.001) propiconazole relative to controls at 8 µg/L. At 16 µg/L parathion all concentrations of propiconazole (50, 100, and 400 µg/L) significantly enhanced the toxic effect of parathion (P≤0.001).

Figure 11
Mortality probability of *Daphnia magna* simultaneously exposed to 0, 4, 8, and 16 µg/L parathion and to 0 50: 100: and 400: µg/L propiconazole. Error bars represent standard errors.



Major Conclusions

The large acreage annually devoted to soybean production and the need to prevent and treat soybean rust may result in significant fungicide inputs to our freshwater systems. The results of this study suggest that at least some fungicides to be used against soybean rust could reach concentrations in runoff associated with significant adverse effects to aquatic organisms that are the basis for healthy fisheries and a stable and productive aquatic ecosystem.

Publications: Several publications are in preparation, with at least two being part of the MS thesis by Walter Bialkowski, due to graduate in July 2007. In addition, the following oral and poster presentations are a result of the funded work:

Cerbin S, Biallkowski W, Ochoa-Acuña H. 2006. Effect of Propiconazole and Strobilurin Fungicides alone or in combination on two algal species: Selenastrum

capricornutum and Chlorella vulgaris. Society for Environmental Toxicology and Chemistry North America 27th Annual Meeting, Montreal, Quebec, Canada.

Ochoa-Acuña H, Bialkowski W, Cerbin S, Hahn L, Engel B. 2006. Probabilistic Evaluation of Potential Environmental Effects Caused by Soybean Fungicides use in Indiana. Society for Environmental Toxicology and Chemistry North America 27th Annual Meeting, Montreal, Quebec, Canada.

Bialkowski W, Cerbin S, Ochoa-Acuña H. 2006. Acute and Chronic Toxicities of Parathion and Propiconazole Mixtures on the Aquatic Invertebrate, *Daphnia magna*. Society for Environmental Toxicology and Chemistry North America 27th Annual Meeting, Montreal, Quebec, Canada.

Hahn L, Zhai T, Lim K, Ochoa-Acuña H, and Engel B. 2006. Potential Water Quality Impacts of Asian Soybean Rust Fungicide Applications in Indiana. Society for Environmental Toxicology and Chemistry North America 27th Annual Meeting, Montreal, Quebec, Canada.

Students

Graduate Students: Walter Bialkowski, MS student, Comparative Pathobiology; Guo Yu, PhD student, Civil Engineering

Undergraduate Students: Stefan Cerbin, Shelby Koon,

References

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Livingston M, Johansson R, Daberkow S, Roberts M, Ash M, and Breneman V. 2004. *Economic and Policy Implications of Wind-Borne Entry of Asian Soybean Rust into the United States*. United States Department of Agriculture, Outlook Report, # OCS04D02.

Pilling ED, Bromley-Challenor KAC, Walker CH, Jepson PC. 1995. Mechanism of synergism between the pyrethroid insecticide λ-cyhalothrin and the imidazole fungicide prochloraz, in the honeybee (Apis mellifera L.). *Pesticide Biochemistry and Physiology*, 51:1-11.

Ronis MJ, and Badger T. 1995. Toxic interactions between fungicides that inhibit ergosterol biosynthesis and phosphorothionate insecticides in the male rat and bobwhite quail (Colinus virginianus). *Toxicology and Applied Pharmacology*, 130:221-228.

Thorp, J.H. and Covich, A.P. 2001. Ecology and Classification of North American Freshwater Invertebrates. 2nd edition. Academic Press. London.

U.S. EPA (United States Environmental Protection Agency). 2002. *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*. EPA-821-R-02-013. Office of Water, Washington, D.C.

Trace Gas Fluxes in Riparian Buffers along an Urban Rural Gradient

Basic Information

Title:	Trace Gas Fluxes in Riparian Buffers along an Urban Rural Gradient
Project Number:	2006IN190B
Start Date:	3/1/2006
End Date:	2/28/2007
Funding Source:	104B
Congressional District:	7th
Research Category:	Climate and Hydrologic Processes
Focus Category:	Wetlands, None, None
Descriptors:	None
Principal Investigators:	Pierre-Andre Jacinthe

Publication

1. Jacinthe, P.A., L. Tedesco, R.C. Barr. 2006. Soil properties and trace gas fluxes in a newly-restored riparian forest. Annual meeting of the American Society of Agronomy, Indianapolis. Session 304, Abstract 831: http://a-c-s.confex.com/crops/2006am/techprogram/P24858.htm
2. Jacinthe, P.A., J.S. Bills, L. Tedesco, R.C. Barr. 2007. Hydro-climatic events and greenhouse gas dynamics in riparian forests. Fourth USDA Greenhouse Gas Conference, Baltimore. Session 11, Abstract 213. http://a-c-s.confex.com/a-c-s/usda/techprogram/P29334.htm

IWRRC Report

Title: *Trace gas flux in riparian buffers along an urban-rural gradient*

Submitted by:
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Funding Period: March 1, 2006 – February 28, 2007

Problem:
Riparian buffers are located at the interface between terrestrial and aquatic ecosystems. Owing to their landscape position and biogeochemistry, riparian buffers act as natural filters for a variety of water pollutants, and have been shown to be effective in reducing nutrient loadings to adjacent streams and rivers. The water quality protection benefits of these ecosystems are well documented (Hill, 1996; Lowrance et al., 1997; Mitsch et al., 2001; Hickey and Doran, 2004). The protection and restoration of riparian buffers have been recognized as a cost-effective approach to addressing nutrient enrichment problems in aquatic ecosystems (Lowrance et al., 1997; Mitsch et al., 2001).

Riparian ecosystems are flood-prone and are characterized by seasonally-high water tables. These events could lead to O_2 exclusion from soil pore space and development of suboxic conditions at or near the soil surface. These conditions would result in enhanced trace gas production in the most biologically-active upper soil layers, and most specifically could stimulate the production of nitrous oxide (N_2O) via denitrification and methane (CH_4) via methanogenesis. Denitrification is the process whereby, in the absence of O_2, nitrate (NO_3-N) is used as an alternative electron acceptor by soil microbes and is converted into nitrous oxide (N_2O) and dinitrogen (N_2). Methane production occurs via carbon dioxide (CO_2) reduction or via acetate fermentation under anoxic conditions.

The atmospheric trace gases CO_2, N_2O and CH_4 play important roles in the chemistry and energy balance of the earth's atmosphere. Relative to their pre-industrial level, atmospheric concentrations of these greenhouse gases (GHG) have increased 35, 15 and 145 %, respectively during the last 150 years (IPCC, 2001). Their accumulation in the atmosphere has been linked to climate warming (IPCC, 2001). Relative to CO_2, the global warming potentials (GWP) of N_2O and CH_4 are 310 and 21 times greater (IPCC, 2001). In addition, N_2O and CH_4 participate in stratospheric ozone depletion. The transfer of GHG from riparian buffers into the atmosphere is a concern and could offset their water quality improvement benefits. Therefore, information regarding GHG dynamics is an important component of our understanding of these ecosystems.

Several climatic, biological and hydrological factors could affect GHG dynamics in riparian zones. Trace gas fluxes may also be linked to pulses of nutrients input into the surface layer of riparian soils during flooding events and elevated water table. At the present, however, the impact of these factors on gas fluxes in riparian soils is unknown.

Our knowledge of CH_4 dynamics in forest soils is derived almost exclusively from research conducted in upland forests. Due to differences in hydrology and biochemistry, the transfer of this information to riparian ecosystems remains problematic. We therefore do not know whether riparian forests are net CH_4 sources or sinks. Consumption of CH_4 by upland forest soils is widely reported and corresponds to a global CH_4 sink estimated at 30 - 40 Tg CH_4 y^{-1} (Mosier et al., 1997). Research has shown that the oxidation of CH_4 by methanotrophs is very sensitive to environmental pollution (Hanson and Hanson 1996). For example, N fertilization and atmospheric deposition of N have been linked to recent decline in CH_4 oxidation in many temperate forests (Klemedtsson and Klemedtsson, 1997). Several studies in upland forest soils have reported lower rates of CH_4 consumption in urban than in rural forest soils (Castro et al., 1995; Goldman et al., 1995). In a study (Kaye et al., 2004) conducted in the Fort-Collins (Colorado) area, the average rate of CH_4 uptake in urban lawns was half the uptake rate recorded in grassland soils, some 20 km outside the city. Lower rates of CH_4 consumption in urban soils have been attributed to high atmospheric N inputs (Nadim et al., 2001), and deposition of organic and metal pollutants in urban forests (Goldman et al., 1995) creating an environment less than optimal for CH_4-oxidizing microbes. Compared to their upland counterparts, pollution severity is expected to be much greater in urban riparian forests as these ecosystems are affected by both airborne and waterborne pollutants.

There is a need to determine whether for example the removal of NO_3 in riparian zones could result in increased loading of N_2O in the atmosphere. However, despite attempts to come up with ecosystem-specific conversion factors (Groffman et al., 1998), it remains difficult to estimate N_2O emission rates from the amount of NO_3 removed in riparian zones. Part of this difficulty stems from the fact that some of the N_2O produced in riparian soils is reduced to N_2 within the soil profile prior to its transfer into the atmosphere. In a study of N_2O fluxes in several vegetated riparian buffers, Dhondt et al. (2004) reported both net N_2O emission and N_2O uptake with the latter suggesting N_2O conversion to N_2. Several factors control the reduction of N_2O to N_2 including depth of N_2O formation, mineral N availability, residence time and gas diffusivity, redox potential and temperature (Maag and Vinther, 1996; Jacinthe et al., 2000). Research is thus needed to assess the significance of N_2O reduction in buffer zones and elucidate the underlying bio-physical factors.

Research Objectives:

The transfer of greenhouse gases (GHG) from riparian soils into the atmosphere is a concern, but despite this recognition, field data are very limited. The paucity of data is even greater when it comes to urban riparian ecosystems, and to our knowledge, questions related to GHG dynamics in these ecosystems have not been explored in previous studies. In the US, urban development is expected to increase by 79 % during the next 2 decades (Alig et al, 2004) and, consequently urbanization could have measurable impacts on the biogeochemistry of riparian ecosystems. Thus, the objectives of the proposed research are to:

(1) investigate the spatial and seasonal variability of trace gas fluxes in riparian zones and identify underlying factors, and

(2) assess the impact of urbanization on the dynamics of trace gases in riparian ecosystems.

Methodology

Description of study sites

A study was conducted at three riparian forest sites in a 100-km transect along the White River in Central Indiana. Site 1 (Lilly Arbor) is located near downtown Indianapolis and includes restored riparian wood lots (trees planted in 1999) and non-forested areas (control) where a mixed vegetation of grasses and shrubs has established. This site is flooded twice a year on average. Site 2 (South West Way Park, IndyParks) is located 15 km south of Indianapolis and includes a mature forest (> 80 y old) experiencing 1-2 flooding events every year and an aggrading forest (45 y old) protected from flooding by a constructed levee. Site 3 (McCormick Creek State Park) is located 70 km south-east of Indianapolis in a rural setting and includes flood-prone (6 times/year) and flood-protected (once every 50-100 y) sections of a mature forest (> 80 y old).

At the Arbor site (site 1), 3 experimental plots (2 wooded and 1 control) were selected. In each plot, two study areas were delimited: one near the river margin (< 10 m) and the other 30-50 m from the river. At each of the other two sites, four study areas were delimited: two in the flood-prone and two in the flood-protected section of the forest.

Monitoring of trace gas fluxes

Trace gas fluxes monitoring began in Fall 2005 at site 1, and in Summer 2006 and the other two sites. Gas flux was monitored by the static soil cover technique with 4 chambers per study area. Chambers consisted of a PVC pipe (H: 30 cm, diam: 15 cm) inserted 5-cm into the ground. During measurement, the PVC pipe was closed with a lid fitted with a gas sampling port. Air samples were taken from inside the chamber headspace 0, 30 and 60 min after closing and stored in pre-evacuated glass vials sealed with gray butyl rubber septa. Within 2-3 days of collection, air samples were analyzed for CO_2, N_2O and CH_4 using a Varian (CP 3800) gas chromatograph fitted with 3 detectors and interfaced with a CombiPal auto-sampler. Trace gas flux was computed using the equation:

$$F = \left(\frac{\Delta C}{\Delta t}\right)\left(\frac{V}{A}\right)k$$

where, $\Delta C/\Delta t$ is the change in gas concentration inside the chamber (mass GHG m^{-3} air min^{-1}), V is the chamber volume (m^3), A is the area circumscribed by the chamber (m^2), and k is the time conversion factor (1440 min d^{-1}). A positive value of F corresponds to a net emission of gas from soil into the atmosphere. Conversely, a negative F value corresponds to a net transfer (uptake) of gas from the atmosphere into the soil.

At the time of sampling, soil temperature was recorded and soil samples (0-15 cm) were collected for determination of gravimetric of gravimetric moisture content.

Principal Findings

Summary

The water quality maintenance function of riparian buffers is well documented, but much less is known regarding the production of the greenhouse gases (GHG) carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in riparian ecosystems. This information is important given the implication of these gases in climate warming and atmospheric chemistry. In order to assess gas fluxes and identify soil processes controlling GHG dynamics in riparian zones, a study was conducted at three riparian sites along the White River in Central Indiana. Study sites included recently-restored (< 8 y) and mature (> 80 y) riparian forests, as well as flood-affected and flood-protected areas. Trace gas fluxes were monitored using the static chamber technique. All three riparian forests were net sink for CH_4 with greater uptake rate (mg CH_4-C m^{-2} d^{-1}) at the older riparian forests (average: -1.84) than at the newly restored site (-0.56). Contrary to expectation, CH_4 uptake rates were generally greater near the river margin than at upland locations (study wide average: -1.8 and -1.2 mg CH_4-C m^{-2} d^{-1}, respectively). Across all sites, CO_2 and N_2O emission was several-fold greater in flood-affected areas near the river margin compared to flood-protected upland locations. These trends are likely related to the preferential deposition of nutrients and coarser materials near the river channel than further upland and underscore the interconnection between fluvial geomorphic processes and GHG dynamics in riparian zones.

Results and Significance

Trace gas fluxes measured during this phase of the study are summarized in the graphs and tables below.

Table 1. Description of the riparian forest sites.

Riparian site	Year of establishment	Location	Description
Lilly Arbor	1999	Urban	- Site includes afforested plots (<7 y old) and shrub/grass dominated plots. - Flooding frequency: twice a year on average. Flooding generally occurs when discharge exceeds 11,500 cfs (325 $m^3 s^{-1}$).
Southwest Way Park	1961	Suburban	Riverward section: - Hardwood forest > 80 y old. - Flooding frequency: once every 2 y. Flood-protected section: - Cropland until 1961. Hardwood forest ~ 40 y old. - Protected from flooding by a constructed levee.
McCormick Creek State Park	1916	Rural	Riverward section: - Hardwood forest > 80 y old. - Flooding frequency: ~ 6 times a year. Upland section: - Located on 2nd and 3rd terrace - Hardwood forest: > 80 y old. - Flooding frequency: once every 50-100 years.

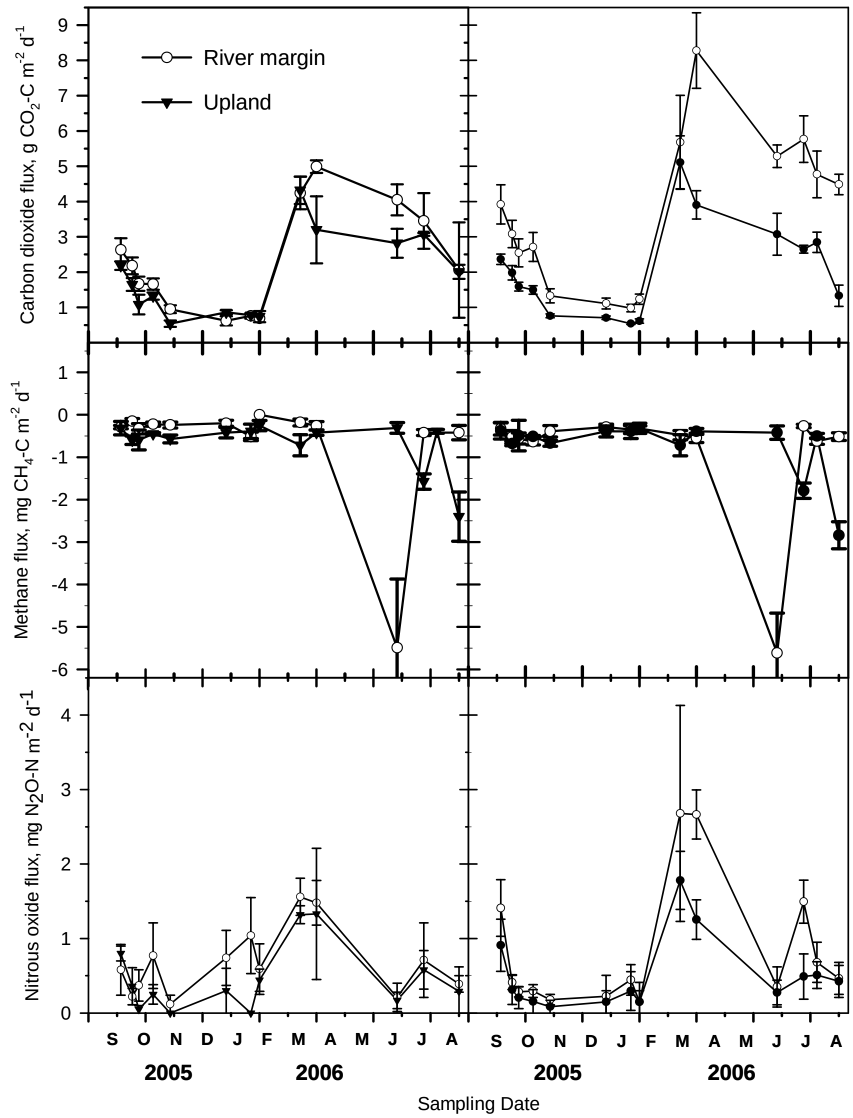

Fig. 1. Daily fluxes of carbon dioxide, methane and nitrous oxide at the Lilly Arbor site during the period September 2005 – October 2006. Graphs in the left and right panels correspond to fluxes measured in the grass/shrub-dominated plots and afforested plots, respectively.

Table 2. Average daily fluxes of greenhouse gases from riparian forest soils along the White River, Central Indiana. Values in parentheses are standard errors of the means.

Riparian sites†	Landscape position	Carbon dioxide	Methane	Nitrous oxide
		g CO_2-C m^{-2} d^{-1}	mg CO_2-C m^{-2} d^{-1}	mg CO_2-C m^{-2} d^{-1}
Lilly Arbor	River margin	3.49 (0.18)	-0.86 (0.1)	0.73 (0.1)
	Upland	1.94 (0.13)	-0.67 (0.1)	0.41 (0.06)
	Site average	2.1(0.14)	-0.56 (0.08)	0.53 (0.06)
Southwest Way Park	River margin	3.43 (0.34)	-2.51 (0.80)	0.68 (0.49)
	Upland	1.72 (0.36)	-1.73 (0.39)	0.29 (0.1)
	Site average	2.58 (0.28)	-2.12 (0.47)	0.51 (0.26)
McCormick's Creek Park	River margin	1.88 (0.37)	-1.92 (0.51)	1.66 (0.60)
	Upland	1.66 (0.18)	-1.20 (0.28)	0.32 (0.10)
	Site average	1.77 (0.71)	-1.56 (0.91)	0.99 (1.4)

† Duration of monitoring period: September 2005 – October 2006 at Arbor; June 2006 – March 2007 at Southwest Way Park; September 2006 – March 2007 at McCormick's Creek Park.

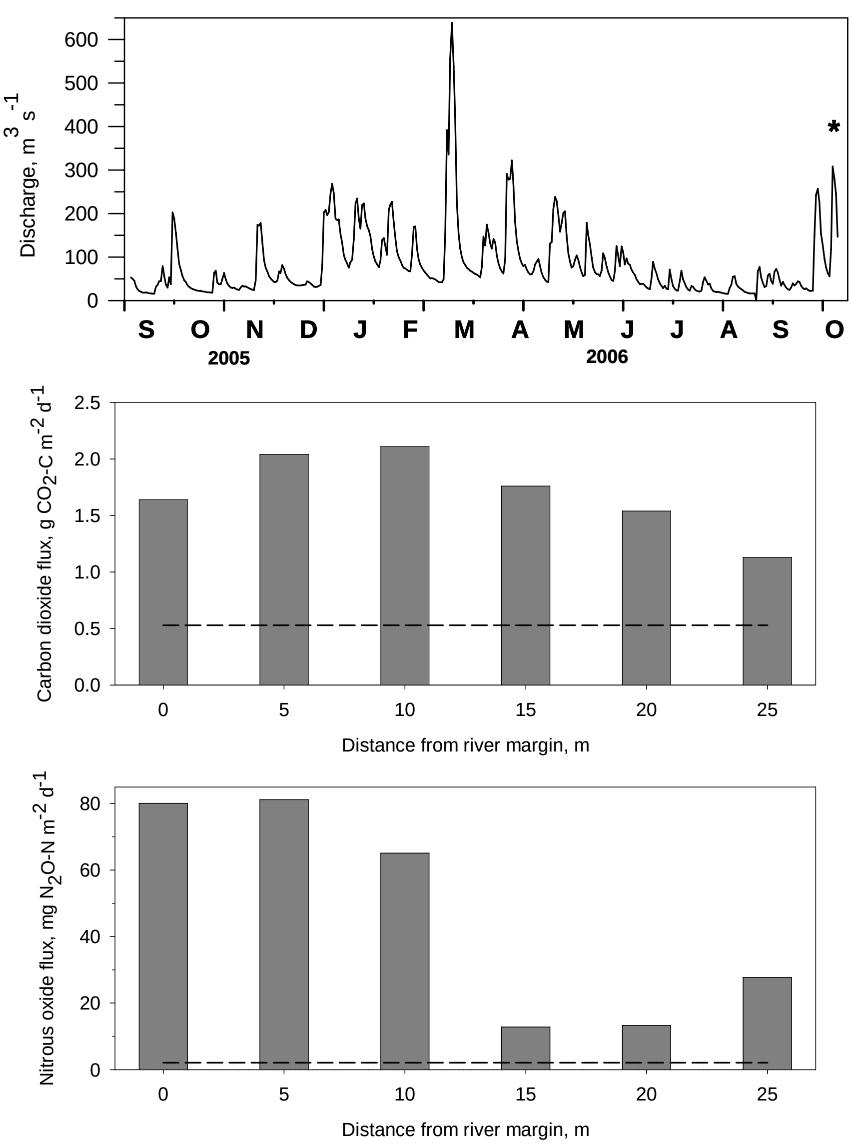

Fig. 2. Carbon dioxide and nitrous oxide fluxes after the flood of October 28, 2006 at the Lilly Arbor site. The dash line represents the non-flood average daily flux.

Major Conclusions

- Soils at the riparian zones are predominantly well drained Inceptisols (Genesee soil series, fluventic eutrudepts) but pockets of Mollisols and Alfisols are also found. Surface soil texture ranges from sandy loam to silt loam near the river channel and to clay loam in the flood-protected areas.

- At the recently-restored (< 8 y) riparian site, CO_2 and N_2O fluxes exhibited similar temporal trends (Fig. 1) and were significantly related (R^2: 0.3, P < 0.001). Fluxes were generally higher in early spring and lower in winter. A period of low river discharge (Fig. 2) and warm temperature between June and August 2006 coincided with the period of highest CH_4 uptake. For the other sites, due to the short (< 9 months) duration of the monitoring period, an evaluation of seasonal trend cannot be made at this time.

- Across sites, CO_2 and N_2O fluxes were higher (1.1 -3 fold) near the river margin than at upland locations (Table 2).

- Contrary to expectation, the riparian forest soils were net CH_4 sink regardless of landscape position and flooding history (Table 2). In the summer and fall, CH_4 uptake rates averaged -0.56 and -1.84 mg CH_4-C m^{-2} d^{-1} in the aggrading and mature riparian forests, respectively.

- In addition to temperature and soil properties (texture, porosity) known to control GHG dynamics, preliminary data were collected to document alterations in GHG dynamics following flooding events. Vigorous pulses of N_2O emission (10-40 fold) were recorded in the days following the October 28 flooding event at the Lilly Arbor site (Fig. 2). These results suggest that, if the frequency of flooding events were to increase in the future, riparian forest ecosystems could have a greater impact on regional N_2O budget than their geographical coverage would indicate.

Publications

2 presentations at national meetings

Jacinthe, P.A., L. Tedesco, R.C. Barr. 2006. Soil properties and trace gas fluxes in a newly-restored riparian forest. Annual meeting of the American Society of Agronomy, *Indianapolis. Session 304, Abstract 831*: http://a-c-s.confex.com/crops/2006am/techprogram/P24858.htm

Jacinthe, P.A., J.S. Bills, L. Tedesco, R.C. Barr. 2007. Hydro-climatic events and greenhouse gas dynamics in riparian forests. Fourth USDA Greenhouse Gas Conference, Baltimore. *Session 11, Abstract 213.* http://a-c-s.confex.com/a-c-s/usda/techprogram/P29334.htm

Students

The following students have contributed to this project:

- Graduate Student: Jonathan S. Bills

- Undergraduate Students: Alice J. Enochs, Andrew Schroering, Codi Wieler, April Herman.

Information Transfer Program

Basic Information

Title:	
Project Number:	2004IN134B
Start Date:	9/1/2005
End Date:	5/1/2006
Funding Source:	104B
Congressional District:	
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	
Principal Investigators:	

Publication

Information transfer on Aboveground Petroleum Tanks

Basic Information

Title:	Information transfer on Aboveground Petroleum Tanks
Project Number:	2006IN240B
Start Date:	3/1/2006
End Date:	2/28/2007
Funding Source:	104B
Congressional District:	
Research Category:	Not Applicable
Focus Category:	Non Point Pollution, Toxic Substances, Agriculture
Descriptors:	Proper stroage of fuels
Principal Investigators:	Fred Whitford

Publication

1. Aboveground Petroleum Tanks: A pictorial guide. Extension Document PPP-73. 2007 Whitford, F., S. Hawkins, L. Holland et al. Available at: www.btny.purdue.edu/ppp/

IWRRC Report Information Transfer

Title: 2006 State Water Research Institute Program

Submitted by: Fred Whitford, Purdue Pesticide Programs. 915 West State Street, West Lafayette, Indiana, 47907.

Funding Period: March 1, 2006 – February 28, 2007

Results and Significance

The document called ***Aboveground Petroleum Tanks*** (PPP-73) has been written and edited. Our editor is currently is designing and laying out the publication into its final form. It is hoped to be to the printers within two months. It will then be placed on our website (www.btny.purdue.edu/ppp/), in our campus distribution center, copies provided to our field extension staff, handed out at various meetings, and selected occupations (e.g., agricultural and horticulture) sent a copy directly by mail. The acknowledgement currently contains the credit "Work was partially supported with outreach funding from the Indiana Water Resources Research Center (IWRRC) at Purdue University".

A total of sixteen Commercial Pesticide Applicator Training programs were held. Approximately, 1000 pesticide applicators seeking initial certification were trained. Protecting surface and ground water are discussed in detail.

Purdue Pesticide Programs is an Outreach Cooperator with the Indiana Water Resources Institute. In this endeavor, the following are ninety-six presentations that discussed surface- and groundwater pollution prevention strategies and emergency responses.

Educating the public on pesticide use. 2007. Whitley County Soil and Water Conservation District Annual Meeting. Columbia City, Indiana.

Herbicides and the environment. 2007. Initial Certification for Commercial Pesticide Applicators Category 6, Right-Of-Way Pest Control. West Lafayette, Indiana.

Exploding poly tanks and Well contamination on the farm. 2007. AgBest Winter Grower Meeting. Hartford City, Indiana.

Handling a pesticide spill on the highway. 2007. Indiana Pest Control Association Winter Workshop. Indianapolis, Indiana.

Poly tanks: nothing last forever. 2007. Pollerts' Crop Insurance Annual Meeting. Seymour, Indiana; Townsend Chemical. Columbus and Logansport, Indiana; White County Private Applicator Recertification Program. Reynolds, Indiana.

Breaking tanks and how to buy, use, and maintain. 2007. Northwestern Indiana Nursery and Landscape Association Certification Seminar. Merrillville, Indiana.

Being responsible with pesticides. 2007. Newton County Soil and Water Conservation District Annual Meeting. Morocco, Indiana.

Poly tanks do break down and Protecting the well. 2007. Boone County Private Applicator Recertification Program. Lebanon, Indiana.

Exploding tanks, Securing your load with chains and webs, and Preventing well contamination. 2007. Fayette, Union, and Wayne County Private Applicator Recertification Program. Liberty, Indiana.

Wellhead protection. 2007. John Deere Spray Center Training. Noblesville, Indiana.

Showing respect for pesticides, your health, and the environment. 2007. Allen County Soil and Water Conservation District. Fort Wayne, Indiana.

Exploding polytanks: inspect them now! 2007. Cygnet Enterprises Aquatic Management Winter Workshop. West Lafayette, Indiana.

All plastic tanks are not created equal. 2007. Tenbarge Education and Trade Show. Evansville, Indiana.

Managing fuel and oil products, Practical safety tips, and Securing your loads—equipment and plant protectants. 2007. Iowa Turfgrass Conference and Trade Show. Des Moines, Iowa.

Carrying farm products on the road: what transportation regulations cover farmers? Indiana Farm Bureau State Young Farmer Leadership Conference. Indianapolis, Indiana (2).

Poly storage tanks: nothing lasts forever. 2007. Purdue Pest Management Crop Management Workshops. Plymouth, Alexandria, North Vernon, Washington, and West Lafayette, Indiana.

Exploding tanks: Is your poly tank ready to explode? 2007. Professional Landscape Management School. Evansville, Indiana.

Poly tank inspection to prevent herbicide spills. 2007. National Railroad Contractors Association Weed Control Seminar. Indianapolis, Indiana.

So you think plastic storage tanks are leakproof. 2007. Indiana Green Expo. Indianapolis, Indiana.

Overview of agricultural tanks. 2007. Indiana Department of Transportation Facilities Managers. West Lafayette, Indiana.

Spills: what will your response be? 2007. South Carolina Vegetation Management Association. Columbia, South Carolina.

Is your poly tank ready to blow? Illiana Vegetable Growers' School. 2007. Schererville, Indiana.

Polytank wear and tear. 2006. Steuben County Private Applicator Recertification Program. Angola, Indiana.

Inspecting farm tanks and Preventing well contamination. Daviess County Private Applicator Recertification Program. Cannelburg, Indiana.

Polytank inspections, Securing pesticides and cargo on trucks and trailers, and Handling a pesticide spill. 2006. Pesticide Safety Makes Common Sense Workshop. Bingham Farms, Michigan.

Safe loading and transportation of pesticides. 2006. Clinton County Private Applicator Training Program. Frankfort, Indiana.

Exploding polytanks. 2006. Tippecanoe County Private Applicator Recertification Program. Americus, Indiana; Kokomo, Indiana.

Exploding Polytanks—why the leaks? 2006. Kentuckiana Crop Production Seminar. Owensboro, Kentucky.

Polytank selection, inspection and safety. 2006. Carroll County Private Applicator Pesticide Program. Delphi, Indiana.

Exploding tanks: how long do polytanks last? 2006. Turf and Ornamental Workshop. Noblesville, Indiana.
Environmental audits: what to look for and why. 2006. Midwest Agricultural Banking School. West Lafayette, Indiana.
When the spill happens to you: are you ready? 2006. Illinois Professional Turf Conference. St. Charles, Illinois.
Plastic tanks: they don't last as long as you think they do? 2006. Midwest Turf Foundation Winter Workshop. West Lafayette, Indiana.
How to respond when accidents happen and Pesticide safety. 2006. Mississippi Vegetation Management Association. Starkville, Mississippi.
Exploding polytanks. 2006. Miami County Private Applicator Recertification Program. Peru, Indiana.
Exploding polytanks. 2006. Ag and Natural Resources Extension In-Service Training. Lebanon, Indiana.
The Friday afternoon spill—are you ready. 2006. PLANET Green Industry Conference. Columbus, Ohio.
Spill control 2006. PestSure Insurance. Longmont, Colorado and New Orleans, Louisiana.
Handling a pesticide spill. 2006. National Pest Management Association PestWorld. Grapevine, Texas.
Calibrating and using pesticide and fertilizer equipment on the home lawn. 2006. Jasper County Mastergardener Program. Rensselear, Indiana.
Exploding polytanks. 2006. Indiana Flower Growers Conference. West Lafayette, Indiana.
You want me to look at what? A pesticide spill! Indiana Environmental Health Association Fall Conference. West Lafayette, Indiana.
Termites, carpenter ants, and wood destroying beetles and How to tell which pests is
Using pesticide and fertilizer equipment in the yard and Using pesticides safely around the home. 2006. Porter County Mastergardener Program. Valparaiso, Indiana.
Selecting personal protection equipment, Exploding polytanks, and Securing your pesticide load on your truck or trailer. 2006. Michigan Forestry and Park Association Arboriculture Conference. Midland, Michigan.
Exploding polytanks. 2006. Pasture Weed Control and Feldun Purdue Ag Center Farm Tour. Bedford, Indiana; Treaty Soil Dealer Annual Meeting. Union City, Ohio; Davis Purdue Agricultural Center. Butler, Indiana; Pinney Purdue Agriculture Center. Wanatah, Indiana; Precision Soya Grower Meeting. Bluffton and New Castle, Indiana.
Inspecting on-farm and commercial-use polytanks. 2006. Joint Indiana/Ohio Risk Coordinators Workshop. Richmond, Indiana.
Farm emergency planning and Exploding polytanks. 2006. Clinton County Private Applicator Recertification Program. 2006. Frankfort, Indiana.
Polytank container issues. 2006. Vigo County and Farm World Expo Private Applicator Recertification Program. Terre Haute, Indiana.
Designing your preplan. 2006. Penn Atlantic Nursery Trade Show (PANTS). Atlantic City, New Jersey.
What to do in the event of a spill: mock exercise. 2006. Indiana University Grounds Department Workshop. Bloomington, Indiana.

The cracking of polytanks. Indiana Christmas Tree Growers Association. Idaville, Indiana.

Using pesticides to commit crimes: how stupid can you get? North American Forensic entomology Association. 2006. West Lafayette, Indiana.

Pesticide safety: exploding tanks and contaminated wells. 2006. Adams County Purdue Field Day. Monroe, Indiana.

Phase 1 environmental audits: knowing what to look for in the real world. 2006. Indiana Society of Agri-Bankers Site Visit Workshop. Bainbridge and Fillmore, Indiana.

Exploding tanks, spilled cargo, and out-of-service trucks. 2006. Owen Soil and Water Conservation No-till Planter Workshop and Private Applicator Recertification Program. Spencer, Indiana.

Exploding tanks. 2006. Indiana Cooperative Risk Coordinators Group. West Lafayette, Indiana.

Water in and water out—preventing contamination from pesticides. 2006. Indiana Chapter American Backflow Prevention Association. Columbus, Indiana.

Hands-on spill response workshop. 2006. Mt. Pleasant, Michigan.

Rural safety and security planning. 2006. Emergency Preparedness and Premise ID program. 2006. Elkhart, Indiana.

Dealing with a herbicide spill. 2006. Southern Chapter International Society of Arboriculture Annual Conference and Trade Show. Birmingham, Alabama.

Securing the load. 2006. United States Department of Agriculture National Soil Erosion Research Laboratory. West Lafayette, Indiana.

Hazardous materials mock spill exercise. 2006. 92nd Annual Purdue Road School. West Lafayette, Indiana.

How to secure your load with commonly used devices. 2006. Henry County Private Applicator Recertification Program. New Castle, Indiana.

Securing your pesticide load with chains and webs. 2006. Hamilton County Private Applicator Recertification Program. Noblesville, Indiana.

Using chains and webs. 2006. Kova Ag Products Annual Meeting. Winamac, Indiana.

Pesticide applicator safety: chains and webs. 2006. Vegetation Management Association of Kentucky. Lexington, Kentucky.

Preplanning for emergencies and Securing your cargo to the truck and trailer. 2006. Michiana Golf Course Superintendents Association. Plymouth, Indiana.

Dealing with spill emergencies and Load securement and DOT regulations. 2006. Tri-State Conservation Tillage Expo. Auburn, Indiana.

Being responsible when using pesticides. 2006. Pulaski County Joint Extension Board and Soil and Water Conservation Annual Meeting. Francesville, Indiana.

DOT and load securement. 2006. Shelby County Private Applicator Recertification Program. Shelbyville, Indiana.

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	19	0	0	0	19
Masters	2	0	0	0	2
Ph.D.	2	0	0	0	2
Post-Doc.	0	0	0	1	1
Total	23	0	0	1	24

Notable Awards and Achievements

USDA Conservation Effects Assessment Program. $660,000. Watershed-Scale Evaluation of BMP Effectiveness and Acceptability: Eagle Creek Watershed, Indiana. Developed with Jane Frankenberg, Lenore Tedesco, Jerry Shively, Linda Prokopy.

USEPA Fate of hormones in tile-drained fields and impact to aquatic organisms under different animal waste management practices. Linda Lee, S. Brouder, C. Jafvert, M. Sepulveda and R. Turco.

Publications from Prior Projects

None