Indiana Water Resources Research Center Annual Technical Report FY 2011

Introduction

This report covers the activities of the Indiana Water Resources Research Center (IWRRC) for the period March 1, 2011 to February 28, 2012 and is reported by Ronald F. Turco, Director of the center. The report is provided to meet requirements and obligations under the 104 (B) of the USGS water centers program. The objectives of the fiscal year 2011 program of the IWRRC have been: (1) to continue to engage the water community in the State of Indiana as related to water research and education with a major focus on the Wabash River and Wabash River Watershed Basin; (2) to chair the dedicated water community at Purdue University– the Purdue Water Community (http://www.purdue.edu/dp/water/about.php); (3) Foster a research programs that encompass water issues related to: contaminants that is primarily focused on the Wabash River and in support of the projects aid in the development of grant submission for major efforts; (4) continue to support an outreach program related to water and water quality (in particular rural water protection/safety) and (5) to strengthen interactions with State regulatory agencies and Federal Agencies via active participation in a series of well water protection education programs, meetings with USGS, The Nature Conservancy, Indiana Department of Natural Resources and direct interaction with the legislative study committees of the Indiana House of Representatives.

In the last year we have supported externally reviewed 104(B) projects, maintained a functional website (www.iwrrc.org) been involved in the development, submission and management of number of grant proposals. We are planning on revising the website this year. In terms of web resources we have maintained the digital library of most of our back issues of water center reports and made them available via the Purdue University Library at “IWRRC Technical Reports”(http://docs.lib.purdue.edu/watertech/). We closed out our CEAP grant that was funded a number of years ago. This project has led to a number of interactions and secondary projects. We continue to work with Cites of Lafayette West Lafayette, Indiana and the Wabash River Enhancement Corporation (WREC) to facilitate discussions on long-range planning for River Redevelopment. We closed out our “bridging grant” Developing a watershed management plan (WMP) for the Middle Wabash-Little Vermillion Basin (HUCs 05120108-010, 05120108-020, and 05120108-030). However, we are now in the implementation portion of the project "Region of the Great Bend of the Wabash River Implementation project” where the IWRRC is active in helping to evaluate projects for potential cost-share under the implementation effort. This collaboration has led to second project entitled “Deer Creek-Sugar Creek Watershed Management Plan and Implementation Program.” We are drawing on the lessons learned from our “Great Bend” effort as we move to the Northeast and provide input on the water quality issues in the adjacent counties. This new location adds a new level of difficulty as faring in the Deer Creek area is based in animal production. The IWRRC has been active with the Purdue University water community (PWC) and have facilitated a number of campus wide meetings to engage this group. We have been primarily interested in developing grant applications and revitalizing contacts with the Indianapolis USGS office. The PWC strategic plan includes interactions with the IWRRC. International, we are now working with Purdue’s office of global engineering on a number of water projects including work in China and Mexico.

For this reporting period, we continue the strategic outreach alliance with the Purdue Pesticide Program office for the development of document and educational materials on methods to prevent water contamination. By leveraging our funds with the Purdue Pesticide Program office’s core efforts we are using the opportunity to include the IWRRC in many of their programs. Our efforts have established a constant and vital outreach effort that is associated with prevention rather than remediation of environmental problems. In the future we are increasing our support of the PPP office. The recent title: Pollution Prevention Through Better Management of Fertilizers, Pesticides, and Salts In Tanks and On Trailers; and Fiberglass Tanks for Storage, Transport, and Application.

Project 01: Program Administration and State Coordination

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. We have also stepped up our efforts to coordinate campus level interactions (helping to create the Purdue Water Community) with state and federal agencies. All of these efforts have the ultimate goal of improving the quality of water resources in the State of Indiana. We have used a limited amount of money on the administrative portion but it has allowed the IWRRC director some means to invest time in the efforts to integrate with state and federal agencies. Most of IWRRC funds are used for projects and the director’s time is contributed to the project. The IWRRC director has worked 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. Continued work with the “State Water Monitoring Council”. (https://engineering.purdue.edu/~inwater/conference/) leading to an online inventory of projects https://engineering.purdue.edu/~inwater/.

2. Work with community projects has continued including working with the Wabash River Enhancement Corporation (WREC) on a Volunteer Water Quality Monitoring project to allow opportunities for volunteer monitors to assess water quality conditions throughout the watershed. WREC its partners conducted a fall and spring Wabash River Sampling Blitz in 2011. During spring and fall blitz, nearly 200 volunteers sampled 210 stream sites collecting water quality samples, measuring temperature and transparency in the stream, and photographing conditions present at the time of sampling. Sample filtering and analysis of samples with test strips also occurred either at staging locations or within the stream sample sites. In total, five sampling blitzes have occurred during the current grant period: September 18, 2009; April 9, 2010; September 17, 2010; April 15, 2011 and September 16, 2011. During each event, volunteer groups sampled three to four stream sites collecting field measurements for temperature and transparency, using test strips to analyze pH and nitrate at a minimum, and filling sample bottles for laboratory analysis of E. coli, nitrate+nitrite, orthophosphorus, and total organic carbon. Sample results were mapped by subwatershed drainage and posted to www.wabashriver.net as soon as possible following the event. In total 600 unique volunteers participated in the sampling blitzes.

3. We have also continued working along with the Wabash River Enhancement Corporation, our partners, and education and outreach committees to provide numerous opportunities for watershed stakeholders to learn about the Wabash River and the Region of the Great Bend of the Wabash River watershed; facilitated education-based events; and coordinated programs to recognize the opportunities and commitments made by businesses and individuals throughout the watershed. Public meetings, the Clear-Blue-Green business certification program, field days, workshops, and the Wabash Sampling Blitz are just some of the activities used to educate our stakeholders.

4. The Wabash River runs some 764 km (475 mi), is situated across five 8-digit Hydrologic units (HUC), crosses 19 counties and at its full distance stretches from the Ohio border in the Northeast corner of the state to the Southwest corner where it combines with the Ohio River below Mount Vernon on its way to the Mississippi River. In the counties associated with the HUCs, the population is estimated at 2,388,658, fully one-third of the total population of the state. Working with Kent Wamsley from The Nature Conservancy (TNC) and Mark Pyron Ball State University we have established the Wabash River Research Consortium. This Wabash River Research Consortium is an extremely diverse group with representation from the Indiana Department of Natural Resources, Indiana Department of Environmental Management, Indiana State Department of Agriculture, NRCS, Fish and Wild Life, Purdue University, Our goal is simple: develop a coordinated research and management agenda for work on the Wabash River. The long-term goal of the effort

is to help re-establish the Wabash River as a healthy water body that provides quality recreation and economic value to the state.

5. Continued to work with Dr. Fred Whitford and the Purdue Pesticides Program Office to establish an outreach effort centered on water protection emphasizing pesticide and farmstead management. We are undertaking efforts to enhance this interaction.

Grant Applications Submitted thorough/with IWRRC:

a. (Funded) IDEM-319 $240,000 Region of the Great Bend of the Wabash River Implementation Project with L. Prokopy, S. Peel and R. Goforth.

b. (Funded) USDA-CAP: $2,875,642 Sustainable Production and Distribution of Bioenergy for the Central USA with J. Volenec, S. Brouder, others

c. (Funded) IDEM-319 $132,000 Deer Creek-Sugar Creek Watershed Management Plan and Implementation Program. Project with S. Peel and R. Goforth.

d. (Funded) ALCOA 95,000 Bauxite Residue in Soil. R. Turco.

e. (Funded and ongoing) USDA-AFRI Tracking the survival and distribution of Mycobacterium avium subsp paratuberculosis in the agroecosystem. $375,000. E. Rizaman, C. Wu and R. Turco.

f. (Funded and ongoing) SUNGRANTS: Optimization of biomass productivity and environmental sustainability for cellulosic feedstocks: Land capability and life cycle analysis. $875,000 S.M. Brouder, PI, R.F. Turco, J.J. Volenec, D.R. Smith and G. Ejeta CoPIs

g. (Funded and ongoing) USDA NRI, Managed Ecosystems. Ecological services of agro-biofuels: productivity, soil C storage, and air and water quality. $399,999. Submitted Dec. 2007. S.M. Brouder, PI, R.F. Turco, J.J. Volenec, D.R. Smith and G. Ejeta CoPIs. h. (Continued Funding) IDEM-319 Development and Demonstration of Outcomes-Based Evaluation Framework for the Indiana Nonpoint Source Program. Developed with Jane Frankenberger, and Linda Prokopy.

i. (Not funded) NRCS-CIG: $210,000 Cover crops and soil quality.

j. (Not funded) NSF: MRI: Acquisition of an IC/MS/MS System by Purdue University

k. (Closed) IDEM 319: Wabash River: Lafayette-West Lafayette Reach of the Wabash River Watershed Management Plan. Submitted in conjunction with the Wabash River Enchantment Corporation $700,000. L. Prokopy, L. Bowling, K. Wilson and R. Turco. Bridging grant approved for one year of additional support.

l. (Closed) 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 note funded: Creating sustainable drinking water supplies for Central Indiana: Innovations to achieve reductions in watershed and reservoir nutrient levels

External Board of Advisors Membership: Dr. Jack Wittman, Ph.D., CGWP, Layne Hydro Bloomington IN Dr. Bill Guertal Director, USGS Indiana Water Science Center, Indianapolis IN Mr. Jeff Martin, USGS Indiana Water Science Center, Indianapolis IN

Faculty Advisory Committee: Dr. Linda Lee, Professor and Director of ESE Dr. Jane Frankenberger, Agriculture and Biological Engineering Dr. Larry Nies, Civil and Environmental Engineering Dr. Inez Hua, Civil and Environmental Engineering

Research Program Introduction

None.

Nutrient and carbon delivery to streams in artificially drained landscapes of the Midwest: matrix flow, overland flow or macropore flow?

Basic Information

Title:	Nutrient and carbon delivery to streams in artificially drained landscapes of the Midwest: matrix flow, overland flow or macropore flow?
Project Number:	2007IN227G
Start Date:	4/1/2008
End Date:	3/31/2011
Funding Source:	104G
Congressional District:	7
Research Category:	Ground-water Flow and Transport
Focus Category:	Solute Transport, Surface Water, Hydrology
Descriptors:	
Principal Investigators:	, Nancy T. Baker, Jeffrey W Frey

Publications

1. Cuadra, P.E., P. Vidon, 2009. Natural Variability in Dissolved Organic Carbon and Dissolved Organic Nitrogen Transport in Artificially Drained Landscapes of the U.S. Midwest. Abstract#B34A-04. American Geophysical Union Joint Assembly, Toronto, ON, Canada, May 2009
2. Cuadra, P.E., P. Vidon, 2009. Natural Variability in Dissolved Organic Carbon and Dissolved Organic Nitrogen Transport in Artificially Drained Landscapes of the U.S. Midwest. Abstract#B34A-04. American Geophysical Union Joint Assembly, Toronto, ON, Canada, May 2009
3. Vidon, P. and P.E. Cuadra*, 2010. Impact of precipitation characteristics on soil hydrology in tile-drained landscapes. Hydrological Processes, DOI: 10.1002/hyp.7627 (Online – Early View).
4. Cuadra*, P.E., and P. Vidon. Storm nitrogen dynamics in tile-drain flow in the US Midwest. Biogeochemistry (in review).
5. Vidon, P., and Cuadra*, P.E. Phosphorus dynamics in tile-drain flow during storms in the US Midwest. Agricultural Water Management (in review).
6. Cuadra, P.E., P. Vidon, 2009. Natural Variability in Dissolved Organic Carbon and Dissolved Organic Nitrogen Transport in Artificially Drained Landscapes of the U.S. Midwest. Abstract#B34A-04. American Geophysical Union Joint Assembly, Toronto, ON, Canada, May 2009
7. Vidon, P. and P.E. Cuadra*, 2010. Impact of precipitation characteristics on soil hydrology in tile-drained landscapes. Hydrological Processes, DOI: 10.1002/hyp.7627 (Online – Early View).
8. Cuadra*, P.E., and P. Vidon. Storm nitrogen dynamics in tile-drain flow in the US Midwest. Biogeochemistry (in review).
9. Vidon, P., and Cuadra*, P.E. Phosphorus dynamics in tile-drain flow during storms in the US Midwest. Agricultural Water Management (in review).
10. Cuadra, P.E., P. Vidon, 2009. Natural Variability in Dissolved Organic Carbon and Dissolved Organic Nitrogen Transport in Artificially Drained Landscapes of the U.S. Midwest. Abstract#B34A-04. American Geophysical Union Joint Assembly, Toronto, ON, Canada, May 2009
11. Vidon, P. and P.E. Cuadra*, 2010. Impact of precipitation characteristics on soil hydrology in

tile-drained landscapes. Hydrological Processes, 24:1821-1833, DOI: 10.1002/hyp.7627.

12. Cuadra*, P.E., and P. Vidon. Storm nitrogen dynamics in tile-drain flow in the US Midwest. Biogeochemistry (in review).
13. Vidon, P., and Cuadra*, P.E., 2011. Phosphorus dynamics in tile-drain flow during storms in the US Midwest. Agricultural Water Management, 98:532-540, DOI:10.1016/j.agwat.2010.09.010.
14. Cuadra*, P.E., and P. Vidon, 2011. Storm nitrogen dynamics in tile-drain flow in the US Midwest. Biogeochemistry, DOI: 10.1007/s10533-010-9502-x (OnLine First)
15. Vidon, P, Hubbard*, H., Cuadra* P., and Hennessy* M. Stormflow generation in artificially drained landscapes of the US Midwest: Matrix flow, macropore flow or overland flow. In preparation.

<u>Final Report for Award # 08HQGR0052</u>

04/08-04/11, (PI) P. Vidon, (Co-PIs) J.W. Frey, N.T. Baker. USGS-NIWR National Competitive Grant Program (Award # 08HQGR0052).

<u>Title:</u> Nutrient and carbon delivery to streams in artificially drained landscapes of the Midwest: matrix flow, overland flow or macropore flow? $129,042

Abstract / Summary

Understanding the processes controlling the delivery of nitrogen, phosphorus and carbon to streams in artificially drained landscapes of the Midwest is of critical importance to developing comprehensive nutrient management strategies at the watershed scale. Most nutrient and carbon losses in artificially drained landscapes of the Midwest occur during precipitation events through tile drain flow and overland flow. In addition, recent research has identified preferential flow through soil macropores as an important export mechanism contributing to tile drain flow. There is nevertheless a lack of empirical data documenting the relative importance of overland flow (OLF), matrix flow (MF) and preferential flow through soil macropores (PF) on nitrogen, phosphorus and dissolved organic carbon (DOC) losses to streams. For this project, we measure the relative importance of OLF, MF and PF during 6-8 storms over a two-year period in an artificially drained Midwestern watershed, and identify the changes in the nature of in-stream nitrogen (nitrate, ammonium, total Kjeldahl nitrogen (TKN)), phosphorus (soluble reactive phosphorus (SRP), total phosphorus (TP)), and DOC (aromaticity) during storms.

Fieldwork took place in a small first order watershed located in the larger the White River watershed in Indiana, USA. Water quality data have been collected in precipitation and at 2-4 hour intervals during storms in overland flow, tile flow and the stream. Results stress the non-linear behavior of N and P export to tile drains and streams during storms. Results also indicate the importance of macropore flow in P transport to tile-drains in the US Midwest, and the fact that overland flow does not appears to significantly impact stream water quality with respect to N, P and C.

By providing a direct quantification of the relative importance of each water delivery pathway to NPC transport to streams for a variety of storms and crop development conditions, data collected as part of this project provide an increased understanding of the processes controlling NPC delivery to streams, and provide tools to better target best management practices (BMP) to minimize the impact of agriculture on raw rural water quality in the Midwest.

Problem

Phosphorus, nitrogen and carbon losses to streams affect aquatic productivity, food web structure, and water quality (Martin et al., 1999; Dalzell et al., 2005). Understanding the processes controlling the delivery of these solutes to streams is therefore of paramount importance in order to develop comprehensive watershed nutrient management strategies.

It is well established that most nutrient exports occur during episodic high flow periods (Royer et al., 2006) and that nutrient concentration in streams, hydrological processes and flowpaths often change rapidly during precipitation events in response to variations in precipitation intensity/duration and pre-event moisture conditions (Creed and Band, 1998; Sidle et al., 2000; Hangen et al. 2001; Wigington et al. 2003; Inamdar et al., 2004). The nature of dissolved organic carbon (DOC) (aromaticity, relative abundance of humic/non-humic substances) in streams also often varies during storms, indicating a change in the sources of DOC as a function of discharge (Katsuyama and Ohte, 2002; Hood et al 2006).

High nutrient losses and quick changes in nutrient and carbon concentration/nature during storms stress the importance of conducting research aimed at thoroughly understanding nutrient dynamics and flowpaths during storms. This will increase our ability to predict nutrient and carbon losses at the watershed scale with more precision in the years to come. It is especially important to address this issue in artificially drained landscapes of the Midwest, as agricultural states like Indiana, Ohio and Illinois have been identified as major contributors to excess nutrients in the Mississippi River (Goolsby et al., 2000; Royer et al. 2006).

Recent research has identified preferential flow through soil macropores as an important transport mechanism for solute transport during precipitation events in artificially drained landscapes of the Midwest (Kung et al., 2000a; Stone and Wilson, 2006). Nutrient losses via overland flow in artificially drained landscapes have also been shown to influence the dynamics of NPC losses to streams (Kurz et al., 2005; Royer et al., 2006). Nevertheless, there is a dearth of empirical data documenting the relative importance of overland flow (OLF), matrix flow (MF), and preferential flow through soil macropores (PF) during storms and/or the relative importance of each of these processes on the delivery of nutrients and carbon to streams in artificially drained landscapes of the Midwest.

Research Objectives

Primary objective 1: Identify the relative importance of overland flow, stream bank seepage, matrix flow and preferential flow through soil macropores to streamflow during storms in artificially drained landscapes of the Midwest.

Primary objective 2: Identify the relative importance of each of these water delivery pathways on nitrogen, phosphorus and carbon delivery to streams during storms. Particular attention will be given to characterizing the changes in the nature of N (nitrate, ammonium, total Kjeldahl nitrogen (TKN)), P (soluble reactive phosphorus (SRP), total phosphorus (TP)), and dissolved organic carbon (DOC) (aromaticity) losses to the stream during the storms studied.

Achieving these objectives will help manage raw rural water quality and quantity by allowing landscape managers to better target BMPs, as BMPs often influence soil moisture and water infiltration in soil, and therefore the relative importance of overland flow, matrix flow, and preferential flow through soil macropores. This broad objective is identified as an area of high priority in the RFP FY2007 of the Water Resources Research National Competitive Grant Program, section 104G (page 4).

Two corollary objectives will also be addressed as part of this project:

Corollary objective 1: By monitoring tile drain flow in two tile drains draining two fields under till and no-till, respectively, we will assess the impact of this best management practice (BMP) on raw rural water quality in the watershed.
Corollary objective 2: Assess the potential of using DOC and DOC Specific UV Absorbance (SUVA) to identify the relative contribution of various sources of water to the stream during storms. This objective will contribute to the development of better techniques to assess various components of the water cycle, which is a priority area for the 104G program in 2007 (RFP FY 2007, page 4).

Methodology

The project is field based in nature and is taking take place in the headwaters of Sugar Creek Watershed, in a small watershed (7.2 km^2), locally known as Leary Weber Ditch (LWD). Soils in LWD are suited for row crop agriculture such as corn and soybeans but require artificial drainage to lower the water table, removing ponded water, adding nutrients and ensuring good soil tilth. LWD is representative of many watersheds in the Midwest where poorly drained soils dominate and where artificial drainage is commonly used to lower the water table.

For this project, we quantified water and nutrient fluxes and delivery pathways in LWD for a total of 11 storms in years 1, 2 and 3. These storms varied in duration and intensity and 3 of them generated significant amounts of overland flow. For each storm, a stream water mass balance was performed. This approach allowed us to identify the relative contribution to discharge of overland flow, tile flow, stream bank seepage, and direct interception of precipitation by the stream. Hydrological tracers (cation, oxygen-18, chloride) were used to differentiate the relative contribution of new water (event water) and old water (pre-event water) to the stream during each storm, and to differentiate the relative importance of new water and old water in tile drain flow. In tile drains, old water was considered equivalent to matrix flow (MF) and new water equivalent to preferential flow through soil macropores (PF) (Stone and Wison, 2006). Nitrogen (nitrate, ammonium, total Kjeldahl nitrogen (TKN)), phosphorus (soluble reactive phosphorus (SRP), total phosphorus (TP)) and dissolved organic carbon (DOC) were measured in overland flow, tile drain flow, streamflow and precipitation to identify the relative importance of each water delivery pathway to nutrient and carbon losses to the stream. The change in the nature of DOC during each storm was also monitored to characterize changes in the sources of DOC to the stream during storms.

Results

Analysis of data for the whole watershed is still underway. However, three manuscripts looking at water, N and P dynamics in tile drains only for 2008 storms have been published (See list below). Additional manuscript investigating water, N, P and C dynamics at the whole watershed scale are currently in preparation with data from storms in 2009 and 2010.

Here, we first provide a summary of results from 2008 storms in tile drains (published), followed by a summary of results from the 2009-2010 period for the whole watershed (manuscripts in preparation).

2008 STORMS

In spring, although variations in antecedent water table depth imparted some variation in tile flow response to precipitation, bulk precipitation was the best predictor of mean tile flow, maximum tile flow, time to peak and runoff ratio. The contribution of macropore flow to total flow significantly increased with precipitation amount, and macropore flow represented between 11% and 50% of total drain flow, with peak contributions between 15% and 74% of flow. For large storms (>6 cm bulk precipitation), cations data indicated a dilution of groundwater with new water as discharge peaked. Although no clear dilution or concentration patterns for Mg^{2+} or K^{+} were observed for smaller tile flow generating events (<3 cm bulk precipitation), macropore flow still contributed between 11% and 17% of total flow for these moderate size storms.

Bulk precipitation amount had little impact on solute median concentrations in tile-drains during storms, but clearly impacted NO_3^- concentration patterns. For large storms (> 6 cm of bulk precipitation), large amounts of macropore flow (43-50% of total tile-drain flow) diluted NO_3^- rich groundwater as discharge peaked. This pattern was not observed for NH_4^+ and DON or for smaller tile-flow generating events (< 3cm) during which macropore flow contributions were limited (11-17% of total tile-drain flow). Precipitation amount was positively ($P<0.01$) correlated to NO_3^- and NH_4^+ export rates, but not to DON export rates. Limited variations in antecedent water table depth in spring had little influence on N dynamics for the storms studied. Although significant differences in flow characteristics were observed between tile-drains, solute concentration dynamics and macropore flow contributions to total tile-drain flow were similar for adjacent tile-drains. Generally, NO_3^- represented >80% of N load during storms, while DON and NH_4^+ represented only 2-14% and 1-7% of N load, respectively.

Depending on the storm, median concentrations varied between 0.006-0.025 mg/L for SRP and 0.057-0.176 mg/L for TP. For large storms (> 6 cm bulk precipitation), for which macropore flow represented between 43-50% of total tile-drain flow, SRP transport to tile-drains was primarily regulated by macropore flow. For smaller tile-flow generating events (<3 cm bulk precipitation), for which macropore flow only accounted for 11-17% of total tile-drain flow, SRP transport was primarily regulated by matrix flow. Total P transport to tile-drains was primarily regulated by macropore flow regardless of the storm. Soluble reactive P (0.01-1.83 mg/m^2/storm) and TP (0.10-8.64 mg/m^2/storm) export rates were extremely variable and positively significantly correlated to both mean discharge and bulk precipitation. Soluble reactive P accounted for 9.9-15.5% of TP fluxes for small tile-flow generating events (<3 cm bulk precipitation) and for 16.2-22.0% of TP fluxes for large precipitation events (>6 cm bulk precipitation). Although significant variations in tile-flow response to precipitation were observed, no significant differences in SRP and TP concentrations were observed between adjacent tile-drains.

2009-2010 STORMS

The following results were obtained based on the analysis of whole watershed data collected for 2009 and 2010, and will be included in manuscripts currently in preparation.

Figure 1 below illustrates the storms for which data were simultaneously collected in tile drains (TD1 and TD2), in overland flow (if any), and at the outlet of the watershed.

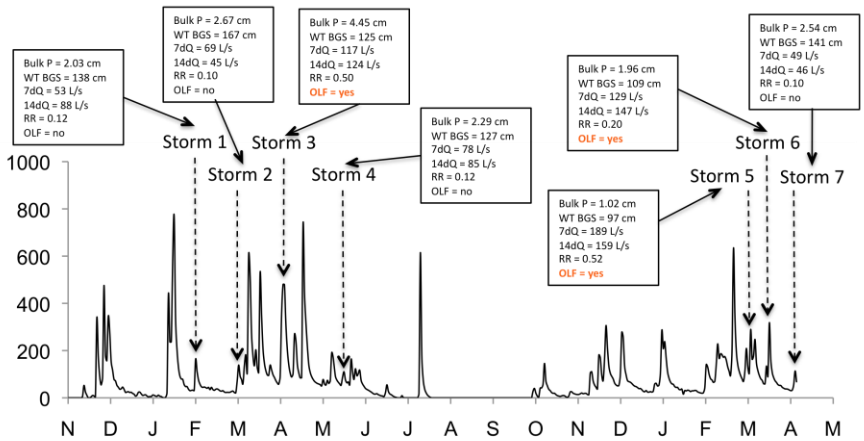


Figure 1: 2009 and 2010 storms for which data were simultaneously collected in tile drains (TD1 and TD2), in overland flow (if any), and at the outlet of the watershed

Detailed results (figures, tables) are not presented here because they are part of a series of manuscripts in preparation that will be submitted for publication in 2012. Only key points illustrating the most important aspects of our findings are listed below.

1 - Watershed hydrology:

At the watershed scale, matrix flow is the dominant source of water to the stream during most storms, with an average contribution of 67% of total stream flow over the 7 storms studied. Overland flow contributions to total stream flow vary widely for storms where overland flow occurred from 0% to 67% (average = 26%) and appear to be related to antecedent moisture conditions (e.g. antecedent water table depth, 7 day and 14 day-antecedent flow) more so than to bulk precipitation, at least for the range of storms studied (1.02 cm < bulk P < 4.45 cm) in spring when the soil is bare or vegetation low.

2 - Nitrogen dynamics at the watershed scale:

Our results illustrate that scaling relationships from tile drains to the whole watershed are nutrient specific and that yields, more so than concentration, can vary significantly from one tile drain to the next. The amount of NO3 loss to the stream during storms is most correlated to stream base flow nitrate concentrations, suggesting that the total NO3 flux for each storm, although also significantly correlated to bulk precipitation, is set at the onset of the storm by stream baseflow NO3 concentration. Individual storm analysis revealed that for the medium size spring storms (<5 cm bulk precipitation), overland flow is insignificant for NO3 and NH4 export, although previous studies suggest that overland flow may be a significant contributor to stream flow for larger storms (> 5 cm bulk precipitation). Finally, a simple mixing analysis revealed that groundwater seepage to the stream can account for approximately 27% to 28% of stream flow during storms, suggesting that maintaining healthy riparian zones to lower near stream NO3 concentration is beneficial, even in intensively tile drained watershed where a large fraction of water and associated solutes can bypass the riparian zone via tile drainage.

3 – Phosphorus dynamics at the watershed scale:

In general, TP concentrations are 2-5 times higher than SRP over the duration of the storm. When fluxes are calculated, TP fluxes are 1.3-3.4 times larger than SRP fluxes, which signifies that SRP typically account for approximately 39% of TP for the storms studied. From a watershed management standpoint, these results indicate that efforts should be made to reduce both SRP and particulate phosphorus (PP) (PP = TP – SRP) losses to tile drains and stream. Indeed, regardless of the location (i.e. tile drain or stream), PP represents at least 60% of TP over multiple storms, which suggest that from a mass balance perspective, PP losses are very important. However, SRP is more bioavailable than PP, and is therefore more likely to have a direct impact on ecosystem primary productivity (e.g. algae blooms), so from an ecosystem perspective SRP in likely more important than PP. Results also stress that although SRP concentrations are generally much higher in overland flow than in tile drains (Table 1), P losses via overland flow do not have any significant impact on P losses at the watershed scale. Consequently, although erosion control measures may have positive effects on water quality with respect to sediment losses and some pesticides losses, when P is the primary concern, measures reducing P losses via tile drains, be it SRP or PP, are likely to have the most effect on P exports at the watershed scale.

Results from this study also indicate that SRP concentration in the stream during storms do not appear to be statistically related to either pre-storm stream SRP concentration, antecedent moisture conditions or bulk precipitation. However, SRP fluxes (and to some extent TP fluxes) are positively correlated to bulk precipitation.

Together, these results suggest that P losses in artificially drained landscapes of US Midwest are primarily driven by hydrology but that further source reduction could potentially have a significant effect on overall P losses as current P losses are already limited by P availability for leaching.

4 - Carbon dynamics at the watershed scale:

For precipitation events between 1.02 cm and 4.45 cm of bulk precipitation, antecedent moisture conditions are more important than bulk precipitation in regulating the occurrence of overland flow and DOC concentrations in stream and tile drains. As DOC concentrations in the stream and tile drains increase during storms, DOC also becomes more aromatic. This corresponds to a shift in the source of DOC from low aromaticity DOC located in the mineral soil layer of the soil profile at baseflow, to more aromatic DOC located closer to the soil surface during storms. When stream DOC yields are compared to those observed in tile drains, storm DOC yields in tile drains are, on average, 42.2% larger than in the stream. Overall, these results suggest that if the frequency and intensity of large precipitation events increases in the US Midwest as climate continues to change in the coming years (as predicted), we will see not only a significant increase in the amount of DOC exported to streams, but also a higher fraction of highly aromatic DOC in streams.

Major Conclusions and Significance

Results presented above significantly increase our understanding of the hydrological functioning of tile-drained watersheds with respect to N, P, and C losses. In particular, results stress the non-linear behavior of N and P exports to tile drains and streams during storms. Results also stress the importance of macropore flow in P transport to tile-drains in the US Midwest, and the fact that overland flow does not appears to significantly impact stream water quality with respect to N, P and C.

Publications (* = graduate students)

Vidon, P., and Cuadra*, P.E., 2011. Phosphorus dynamics in tile-drain flow during storms in the US Midwest. Agricultural Water Management, 98:532-540, DOI:10.1016/j.agwat.2010.09.010.

Cuadra*, P.E., and P. Vidon, 2011. Storm nitrogen dynamics in tile-drain flow in the US Midwest. Biogeochemistry, DOI: 10.1007/s10533-010-9502-x (OnLine First)

Vidon, P. and P.E. Cuadra*, 2010. Impact of precipitation characteristics on soil hydrology in tile-drained landscapes. Hydrological Processes, 24:1821-1833, DOI: 10.1002/hyp.7627.

Vidon, P, Hubbard*, H., Cuadra* P., and Hennessy* M. Stormflow generation in artificially drained landscapes of the US Midwest: Matrix flow, macropore flow or overland flow. In preparation.

Vidon, P, Hubbard*, H., Cuadra* P., and Hennessy* M. Storm NO3- and NH4+ exports in streams and tile drains of the US Midwest. In preparation.

Vidon, P, Hubbard*, H., Cuadra* P., and Hennessy* M. Storm phosphorous concentrations and fluxes in artificially drained landscapes of the US Midwest. In preparation.

Vidon, P, Hubbard*, H., Cuadra* P., and Hennessy* M. Storm dissolved organic carbon dynamics in artificially drained landscapes of the US Midwest. In preparation.

Presentations

Vidon, P, H. Hubbard, P. Cuadra, M. Hennessy, 2011. Impact of overland flow, macropore flow, and matrix flow on N and P dynamics in artificially drained lanscapes of the US Midwest. Abstract ID: B12D-06. American Geophysical Union Annual Meeting. San Francisco, California, December 2011.

Vidon, P, H. Hubbard, P. Cuadra, M. Hennessy, 2011. Impact of macropore flow on N and P dynamics in artificially drained landscapes of the US Midwest. Gordon Research Conference on Catchment Science: Interactions of Hydrology, Biology & Geochemistry, Lewiston, ME, July 2011.

Vidon, P., 2011. Recent advances in our understanding of nutrient dynamics in artificially drained landscapes of the US Midwest. Cross-Disciplinary Seminar in Hydrological and Biogeochemical Processes, SUNY-ESF, April 2011.

Vidon, P. 2010. Impact of macropore flow on N and P dynamics in artificially drained landscapes of the US Midwest. Department of Biological and Environmental Engineering, *Cornell University*, November 2010.

Vidon, P. 2010. Impact of land use and climate changes on water, nitrogen (N), phosphorus (P) and carbon (C) dynamics across scales. *SUNY-ESF*, March 2010.

Vidon, P, P.E. Cuadra*, 2010. Phosphorus dynamics in tile-drain flow during storms in the US Midwest. Annual meeting of the American Water Resources Association, Philadelphia, PA, November 2010

Vidon, P. 2009. Impact of land use and climate changes on water, nitrogen (N), phosphorus (P) and carbon (C) dynamics across scales. Irving K. Barber School of Arts and Sciences, *University of British Columbia Okanagan*, December 2009.

Vidon, P. 2009. Hydrological controls on water, nitrogen, and carbon cycling in the environment from the riparian zone to the watershed scale. Department of Earth Sciences colloquium Series, *IUPUI*, April 2009.

Hennessy*, M, P. Vidon, 2009. Constraining nitrogen, phosphorus and carbon exports in a Midwestern Agricultural Watershed. American Geophysical Union Joint Assembly, Abstract#H71B-07. page 5, Toronto, ON, Canada, May 2009.

Cuadra*, P.E., P. Vidon, 2009. Natural Variability in Dissolved Organic Carbon and Dissolved Organic Nitrogen Transport in Artificially Drained Landscapes of the U.S. Midwest. Abstract#B34A-04. Page 103, American Geophysical Union Joint Assembly, Toronto, ON, Canada, May 2009.

Grant Submissions n/a

Students

Graduate students: 3
Undergraduate Researchers: 4

USGS Award No. G10AP00154 The Great Lakes Tributary Modeling Program 516(e): Purdue University and Michigan State University

Basic Information

Title:	USGS Award No. G10AP00154 The Great Lakes Tributary Modeling Program 516(e): Purdue University and Michigan State University
Project Number:	2010IN308S
Start Date:	9/7/2010
End Date:	8/31/2011
Funding Source:	Supplemental
Congressional District:	
Research Category:	Climate and Hydrologic Processes
Focus Category:	Sediments, Models, Management and Planning
Descriptors:	
Principal Investigators:	Bernard Engel, Bernard Engel

Publication

1. No Publications

General Status Report

May 20, 2012

Army Corps of Engineers 516(e): The Great Lakes Tributary Modeling Program
Work Plan for the Institute of Water Research (Michigan State University) and Purdue University

Abstract / Summary

The Michigan State University Institute for Water Resources (IWR), in coordination with Purdue University, is developing four on-line water-quality management (sediment reduction) decision support systems for four priority watersheds identified by the U.S. Environmental Protection Agency as part of the Great Lakes Restoration Initiative:

- Saginaw River (Lake Huron - MI)
- Genessee River (Lake Ontario - NY)
- Maumee River (Lake Erie - OH)
- Fox River (Lake Michigan - WI)

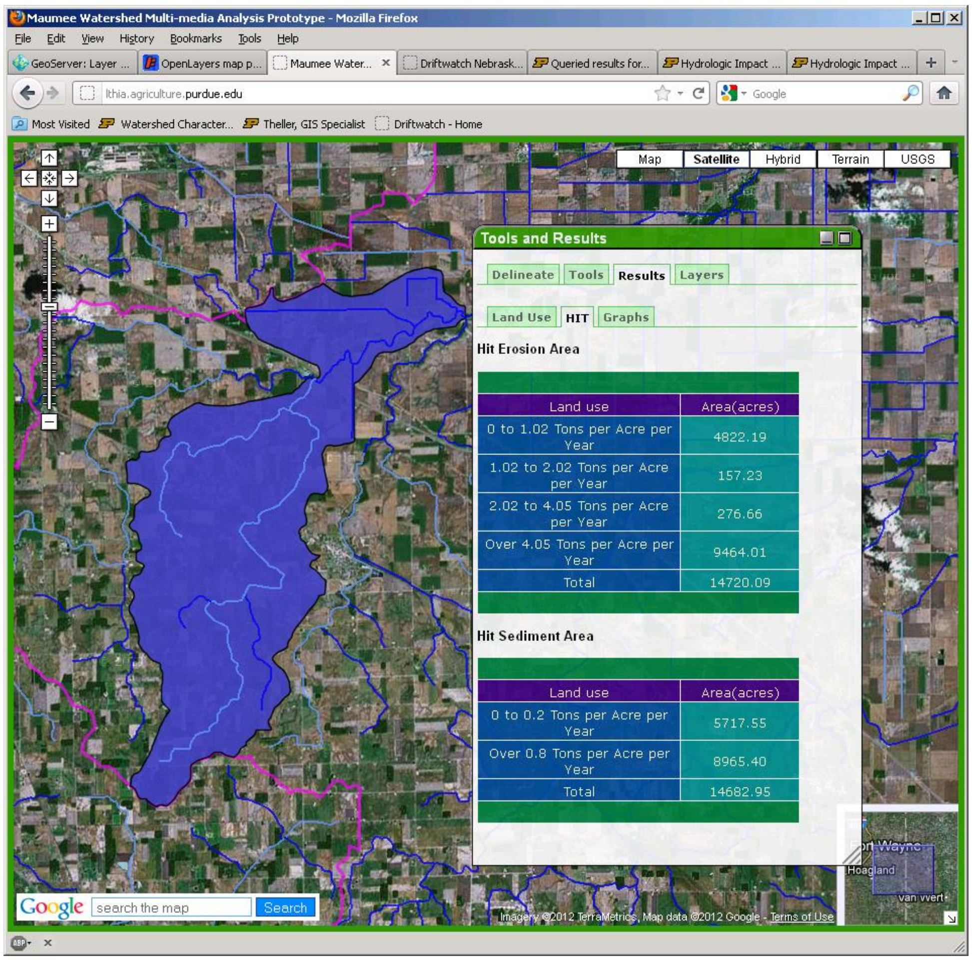
The 2011-2012 project phase involves three main components: modeling, system design/development, and outreach/tech transfer.

Project Description

The US Army Corps of Engineers (USACE) supported IWR and Purdue in the development of similar systems, Burns-Ditch/Trail Creek in 2007 and Swan Creek in 2009. The Swan Creek Watershed Management System (SCWMS) helps users identify and utilize tools to address agricultural and urban water quality issues in and around Toledo, OH. The proposed new systems for the Saginaw, Genesee, and Maumee watersheds will utilize the SCWMS as a template. For the Fox River watershed, IWR will develop a new interface that better integrates the tools of the SCWMS into a single mapping application. Through its success, the Fox River system could serve as a new decision support system template, readily expandable and scalable throughout the Great Lakes Basin.

IWR and Purdue will engage local partners in each of the watersheds to solicit user needs and feedback, and to facilitate technology transfer. In the Fox River, IWR and Purdue will conduct in-person hands-on training for users of the new system. In the other watersheds, IWR and Purdue will conduct webinars illustrating the new systems' utilities.

Research Objectives: Over the past decade, the Institute of Water Research (IWR), Purdue Agricultural and Biological Engineering Department, and the U.S. Army Corps of Engineers (USACE) have developed a strong working relationship through the Great Lakes Tributary Modeling Program. This relationship has yielded research on sediment loadings at multiple scales, GIS models for erosion and sediment loading risk, new and advanced modeling algorithms, multi-scaled prioritization maps, and on-line decision support systems to help users maintain and restore water quality in their watersheds. These achievements have been published in scientific journals, presented at numerous conferences, and disseminated through hands-on workshops. As a new decade begins, IWR and Purdue seek to strengthen the partnership with USACE by building on these earlier achievements to create new and more advanced decision support systems, faster and more efficient models, for broader geographic areas and larger, more diverse user-groups. The end result will be better tools in the hands of more decision makers, which will help keep more sediment on the land and out of the Great Lakes.



Results : The Purdue design team has created an improved version of the classic L-THIA (Long-Term Hydrologic Impact Assessment) online watershed delineation and non-point source pollution modeling tool. This new version includes these upgrades:

1) Larger regional extent. The model now operates throughout the Great Lakes basin and all EPA Region 5 states (MI, NM, IL, IN, OH, WI).

2) Now runs one single model for all states and the Great Lakes Region; as opposed to separate state models of various vintage.
3) High and low-resolution data, subdivided by 8 digit HUC, can be employed. For example, the Saginaw Watershed has 10 meter data and is surrounded by other 8 digit HUC watersheds in the Great Lakes Region with 30 meter data.
4) Larger modeled area. Previous version could only calculate a watershed to the size of an HUC10 watershed, which can be misleading. New version can calculate a model to the size of an HUC8.
5) Better input data. The new National Land Cover Data for 2006 has replaced various landuse datasets stretching back to 1992.
6) The recently released national HUC outlines have replaced scattered versions from multiple states.
7) SSURGO soil series maps have been added for some additional areas where previously STATSGO soil association maps were used as input data.
8) Additional delineation styles: the entire Great Lakes Basin now has support for pre-defined HUC10 and HUC12 polygons as a delineation outline. This is a crucial upgrade for watershed managers.
9) Additional delineation styles: The user may now digitize a polygon as a delineation area (rather than use a watershed), allowing L-THIA to run on a specific area of interest. This makes employment of Low Impact Development practices more accessible.
10) Interoperability with Institute of Water Resources Models: Their HIT model outputs are displayed in the appropriate high-resolution watersheds.
11) User interface upgrade: the main model assumptions, which are curve number (CN) and event mean concentration (EMC), are exposed for user to see and to change if desired.
12) User interface upgrade: Land use editing for creation of scenario is more user friendly.
13) User interface upgrade: Plot routines are more flexible.
14) Technology upgrades: Several new techniques are employed to improve the model:
    a. Model is constructed in standard Python and ESRI ArcPy™ library.
    b. Input data is now stored as .tif image, the most common spatial raster format; previously input was in a Purdue-proprietary file format and was difficult to create.
    c. Adopted one common map projection for all input soil, landuse, and DEM data (same as USGS NLCD layers and others) rather than multiple state systems.
    d. Maps layers, including output watersheds, are presented as streaming data using Geoserver and a spatial database.
    e. All users' output may be viewed by administrator connection to the database, in desktop GIS software.
    f. Streaming data outputs are mobile-friendly, for mobile apps to consume output as data.

Major Conclusions and Significance. This project represents a large step forward in the usability of the popular L-THIA online tool. Web usage in 2010 was reported as 35,000+ page views. From preliminary focus group feedback, we feel this version will improve upon that.

Publications: None in the last six months. In the first two quarters of 2011 two webinar presentations were made, one to Corps of Engineers staff and one to the general public / stakeholder community. The webinar with stakeholders gained valuable insight to the path of development for the new tools.

Two Powerpoint™ presentations were made at Ann Arbor, at the Great Lakes Tributary Modeling Program 516(e) Annual All-Hands Meeting of the Corps of Engineers with the Great Lakes Commission.

Grant Submissions: None yet.

Students: Two graduate students and two undergraduates are working on various phases of this project.

Student	Program	Department
Youn Shik Park	PhD	ABE
Zhiwei Zhang	PhD	FNR
Karl Theller	BS	CS
Nick Flanagan	BS	CS

How does agricultural activity influence stream ecosystem nitrogen cycling? A multi-stressor assessment of synergistic and antagonistic effects.

Basic Information

Title:	How does agricultural activity influence stream ecosystem nitrogen cycling? A multi-stressor assessment of synergistic and antagonistic effects.
Project Number:	2011IN311B
Start Date:	3/1/2011
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	IN-006
Research Category:	Climate and Hydrologic Processes
Focus Category:	Agriculture, Ecology, Hydrology
Descriptors:	None
Principal Investigators:	Melody J. Bernot

Publications

1. Raffel, A, C Olinger, MJ Bernot. In Press. Frequency and abundance of herbicides in central Indiana streams. Proceedings of the Indiana Academy of Sciences.
2. Denton, R, MJ Bernot. In Press. Effects of multiple agricultural chemicals on northern leopard frog, Lithobates pipiens, larvae. Proceedings of the Indiana Academy of Sciences.

Project Id: 2011IN311B

Title: *How does agricultural activity influence stream ecosystem nitrogen cycling? A multi-stressor assessment of synergistic and antagonistic effects.*

Project Type: Research

Start Date: 3/01/2011 **End Date:** 2/28/2012

Congressional District: IN-006

Focus categories: AG, ECL, HYDROL, NPP, ST, SW, TS, WQL

Keywords: agricultural contaminants, nonpoint pollution, streams, toxicology

Principal Investigators:

Melody J. Bernot
Assistant Professor
Department of Biology
Ball State University
Muncie, IN 47306
765.285.8828 (Office)
765.285.8804 (Fax)
mjbernot@bsu.edu

Randall J. Bernot
Assistant Professor
Department of Biology
Ball State University
Muncie, IN 47306
765.285.8844 (Office)
765.285.8804 (Fax)
rjbernot@bsu.edu

Abstract / Summary

Stream ecosystems are influenced by multiple stressors associated with agricultural activities including increased nitrogen (N), herbicides, and fungicides from agricultural runoff. Basic descriptive field research was combined with laboratory experimental studies to provide a more complete and integrative assessment of agricultural influence on stream ecosystems. The research was novel in its multi-stressor approach and was guided by two project components with related research questions:

1. **Quantify spatial and temporal variability of multiple agricultural stressors:** What factors control NO_3-N, glyphosate, and chlorothalonil concentrations across central Indiana headwater streams and do these agricultural stressors co-vary?
2. **Quantify synergistic and antagonistic effects of agricultural stressors *in vitro*:** At what concentrations do NO_3-N, glyphosate, and chlorothalonil alter ecosystem processes and does this concentration change when multiple stressors are present?

The abundance of agricultural chemicals was measured in eighteen headwater streams of the Upper White River Watershed (UWRW) of central Indiana. Sites were selected to represent a range of agriculture activity within the watershed. Sites were sampled seasonally to assess temporal variation in herbicide abundance and the influence of physiochemical factors. Pearson correlation coefficients were used to assess independent variables influencing stream herbicide concentrations. All sites had measurable concentrations of atrazine and metolachlor, though concentrations varied seasonally. These data indicate concentrations of atrazine and metolachlor in central Indiana streams are temporally variable, being highest in late spring. Concentrations measured were comparable to other studies in agricultural areas and frequently exceeded concentrations known to have adverse effects on aquatic organisms.

Problem:

This study was conducted in the Upper White River Watershed, a tributary to the Wabash River and **one of the most degraded watersheds in the country**. Nonpoint source pollution from agricultural activity poses a particular problem for water quality management because the responsibility is spread among entire populations, complicating source identification and reduction. Agricultural activities are a primary contributor of non-point source pollution to watersheds as nitrogen (N), herbicides, fungicides, insecticides, and trace organic pollutants, all of which can affect the structure and function of these ecosystems.

Research Objectives:

We quantified the influence of herbicides and fungicides on stream ecosystems using a multi-stressor, stream ecosystem approach in central Indiana within the Upper White River Watershed. Two separate components addressed related questions and hypotheses:

1. **Descriptive assessment of agricultural stressors:**

— Research Questions: How do N, herbicide (as glyphosate), and fungicide (as chlorothalonil) concentrations vary across central Indiana headwater streams and what factors control this variation? Is ecosystem function (respiration, primary and secondary production) and structure (algal, invertebrate, and fish assemblages) influenced by observed concentration of N, herbicides, and fungicides?

2. **Multi-stressor experiments:**

— Research Questions: At what concentration do N, glyphosate, and chlorothalonil alter ecosystem functions? Does this concentration change when multiple stressors are present?

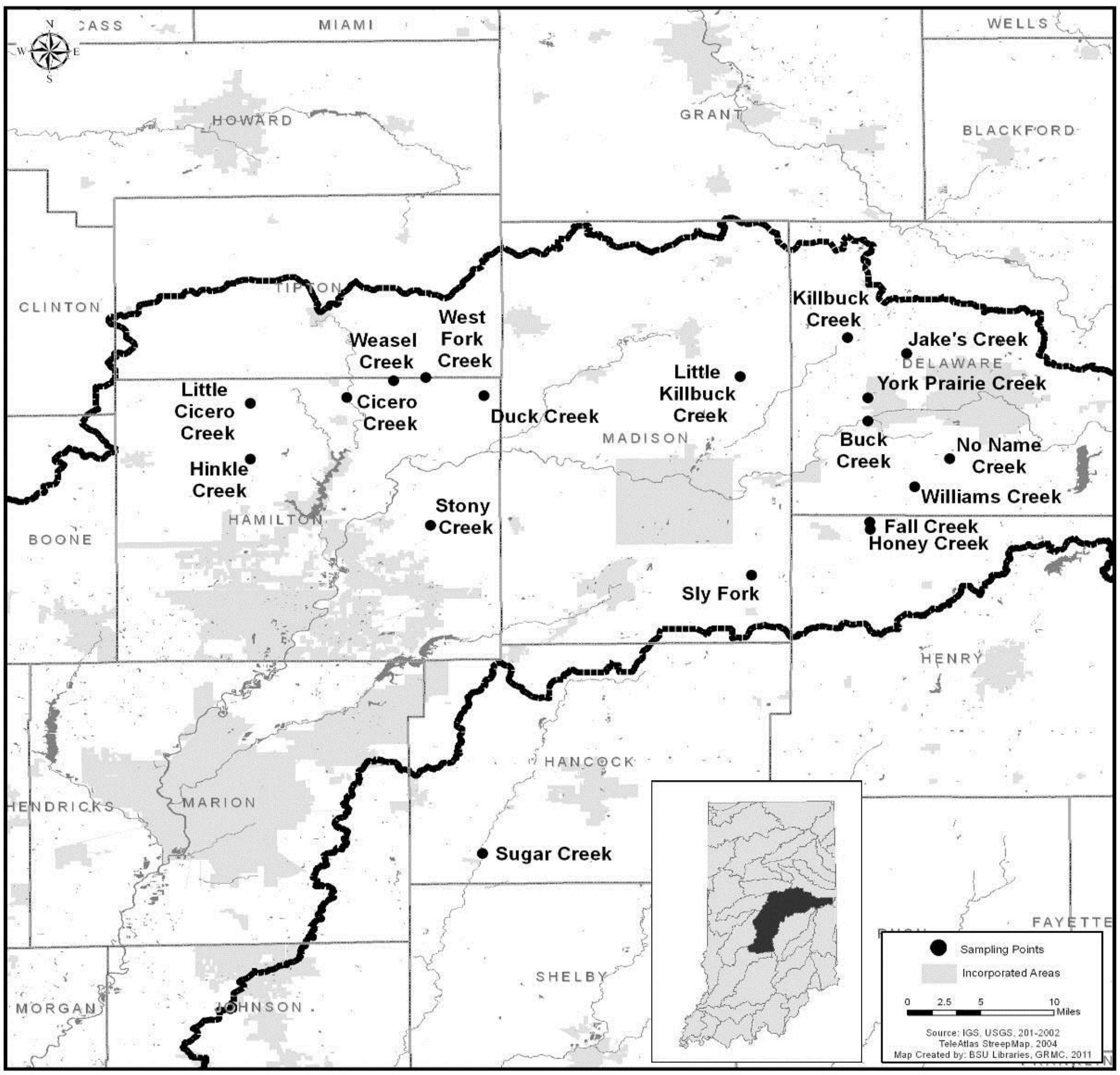


Figure 1.—The Upper White River Watershed (UWRW) in central Indiana with sampling locations (black circles). Surrounding land use is identified within the watershed.

Methodology:

Study Watershed and Descriptive Sampling: The Upper White River Watershed in central Indiana provided an excellent system to study the relationships between agricultural activity and stream ecosystem structure and function, as the basin has heavy agricultural activity (~70% of the watershed cover, primarily as corn and soybean row crop) and drains into the Mississippi River. We sampled 18 1^{st} to 3^{rd} order stream sites in the Upper White River Watershed selected to represent a range of agricultural activity and types. We used descriptive data to develop predictive models of relationships between agricultural activity, stressor concentrations, and stream structure and function using multiple regression and structural equation modeling techniques. At each site, multiple physiochemical and biological parameters were measured, in conjunction with agricultural stressors, at varying intervals to capture temporal and spatial variability. Specifically, water flow was measured using a Marsh McBirney Flow meter and stream physiochemical parameters (temperature, DO, pH, conductivity) were measured using a Hydrolab Minisonde. Water chemistry was measured by collecting grab samples of stream water in rinsed, acid washed bottles and filtering immediately for analysis of dissolved nutrients and herbicides and fungicides. Filters were retained for analysis of suspended particulate material and chlorophyll *a* concentrations. Water samples and filters were placed on ice for return to the laboratory and frozen the same day for later analysis. For all water samples, nitrate, phosphate, sulphate, and chloride were analyzed using a Dionex ion chromatograph with an AS4A anion column. Ammonium was measured using the phenol-hypochlorite spectrophotometric analysis. Replicate filtered water samples were kept on ice and delivered the same day to the Indiana State Department of Health Chemical Laboratories (ISDH; Indianapolis) for measurement of fungicides and herbicides via mass spectrometry. Additionally, two sediment samples were also be collected at each sampling event using a sediment corer for analysis of percent organic matter and elemental content. Channel and riparian characteristics potentially related to the biotic integrity of stream ecosystems were be measured at base flow and include average channel slope, large woody debris, riparian canopy, wetted width and active channel width, habitat type, sinuousity, and substratum class using standard methods.

Multi-stressor experiments: Laboratory mesocosm experiments were conducted on microbial communities (as stream sediment), freshwater snails (*Physa*), and leopard frogs to test the direct effect of NO_3-N, glyphosate, and chlorothalonil on biological activity. Multiple concentrations of NO_3-N in conjunction with multiple concentrations and combinations of glyphosate and chlorothalonil were added to laboratory mesocosms with response surface modeling and Colby's equation utilized to identify synergistic and antagonistic effects on biological activity. Concentrations used were based on low, medium, and high concentrations of compounds measured during descriptive sampling as well as previously published data. *In situ* enrichment experiments were also conducted to quantify chemical transport and assimilation rates.

Results

Physiochemical characteristics.—The 18 sites selected for this study represented a range of headwater streams with variation among average width (1.80 -20.13 m), depth (0.17-0.58), velocity (0.03-0.28), and discharge (0.07-4.51 m/s) (Table 1). In addition, specific conductivity (422-769 µS/cm), dissolved oxygen (7.83-12.02 mg/L), and percent organic matter (0.59-11.72%) also varied among sites. Temperature (12.76-18.42 C º), pH (8.18-9.33), and salinity (0.26-0.39 ppt) were the least variable characteristics among sites.

Table 1.—Mean site physiochemical characteristics values for June, August, and November 2010 and May 2011 with standard deviation in parenthesis.

Site	Width (m)	Mean depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (C°)	pH	Specific Conductivity (µS/cm)	Total Dissolv Solids (g
Buck Creek	20.13 (3.04)	0.30 (0.12)	0.55 (0.27)	3.71 (2.78)	15.96 (4.53)	9.33 (0.28)	661.30 (134.25)	0.42 (0.09
Cicero Creek	15.00 (2.58)	0.54 (0.20)	0.36 (0.15)	3.14 (2.17)	17.39 (5.71)	8.18 (1.85)	538.90 (101.82)	0.34 (0.07
Duck Creek	12.53 (2.49)	0.44 (0.27)	0.33 (0.11)	1.84 (1.20)	17.03 (4.93)	8.75 (0.22)	768.78 (331.33)	0.48 (0.19
Fall Creek	1.80 (1.24)	0.31 (0.23)	0.06 (0.08)	0.07 (0.12)	12.76 (9.44)	6.88 (4.59)	492.45 (332.73)	0.32 (0.21
Hinkle Creek	2.23 (1.10)	0.27 (0.18)	0.16 (0.17)	0.17 (0.23)	16.09 (6.88)	8.87 (0.71)	596.63 (128.78)	0.38 (0.08
Honey Creek	4.83 (1.02)	0.14 (0.06)	0.23 (0.22)	0.21 (0.24)	16.23 (3.11)	9.06 (0.09)	661.85 (127.78)	0.40 (0.07
Jake's Creek	5.63 (2.41)	0.33 (0.22)	0.25 (0.24)	0.96 (1.59)	17.29 (5.17)	8.82 (0.34)	422.30 (297.19)	0.27 (0.19
Killbuck Creek	9.60 (1.55)	0.39 (0.22)	0.18 (0.12)	0.79 (0.78)	16.33 (4.51)	8.80 (0.38)	700.08 (126.05)	0.45 (0.08
Little Cicero Creek	7.93 (1.18)	0.33 (0.05)	0.20 (0.14)	0.59 (0.50)	17.38 (5.98)	9.04 (0.35)	635.18 (121.50)	0.41 (0.08
Little Killbuck	4.60 (1.25)	0.24 (0.14)	0.08 (0.09)	0.16 (0.24)	14.41 (4.48)	8.52 (0.64)	613.23 (124.69)	0.39 (0.08
No Name Creek	3.35 (0.62)	0.28 (0.12)	0.14 (0.15)	0.19 (0.23)	15.33 (3.69)	9.23 (0.35)	676.10 (113.95)	0.43 (0.07
Sly Fork	6.95 (2.28)	0.36 (0.15)	0.15 (0.08)	0.48 (0.46)	17.59 (4.01)	9.03 (0.25)	675.75 (93.43)	0.44 (0.04
Stony Creek	4.40 (1.71)	0.25 (0.13)	0.37 (0.28)	0.44 (0.44)	17.04 (4.83)	8.78 (0.40)	594.53 (130.18)	0.38 (0.08
Sugar Creek	15.30 (9.83)	0.58 (0.15)	0.34 (0.22)	4.51 (5.88)	18.42 (5.88)	9.28 (0.35)	587.30 (136.08)	0.38 (0.09
Weasel Creek	2.40 (0.70)	0.41 (0.34)	0.09 (0.03)	0.11 (0.10)	16.21 (6.35)	8.88 (0.20)	643.30 (118.93)	0.41 (0.08
West Fork	5.53 (2.36)	0.58 (0.06)	0.03 (0.04)	0.16 (0.21)	16.44 (6.10)	8.79 (0.50)	596.20 (119.95)	0.38 (0.08
Williams Creek	6.68 (1.49)	0.17 (0.09)	0.22 (0.19)	0.37 (0.47)	15.68 (4.34)	9.12 (0.12)	629.00 (87.40)	0.40 (0.06
York Prairie Creek	5.08 (0.81)	0.33 (0.32)	0.35 (0.16)	0.43 (0.21)	16.46 (4.17)	9.02 (0.50)	744.70 (116.04)	0.48 (0.07

Agricultural chemical concentrations.—Across all sampling periods, only four herbicides were at or above the detection limits including atrazine, metolachlor, acetochlor, and simazine. Agricultural chemicals which were not detected during any sampling event included hexachlorocycolpentadiene, propachlor, desethylatrazine, trifluralin, desisopropylatrazine, hexachlorobenzene, carbaryl, chloranthalonil, clomazone, pentachlorophenol, lindane, terbufos, heptachlor, chlorpyrifos, cyanazine, aldrin, pendimethalin, heptachlor epoxide, oxychlordane, gamma-Chlordane, alpha-chlordane, trans-Nonachlor, dieldrin, endrin, cis-Nonachlor, p,p'-DDT, bis (2-ethylhexyl) adipate, methoxychlor, bis (2-ethylhexyl) phthalate, and benzo[a]pyrene. In the June 2010 sampling, atrazine (0.52-4.5 µg/L) and metolachlor (0.86 -2.8 µg/L) were found detected at all sites. Acetochlor was detected at 10 sites (56% detection frequency; 0.68-2.1 µg/L) during the June sampling event and simazine was detected at 1 site (0.05% detection frequency; 0.92 µg/L) only during the June sampling event. The highest concentration of atrazine was also found during the June sampling event (4.5 µg/L) and was measured at Buck Creek, which was characterized by both urban and agricultural inputs. The August 2010 sampling event yielded concentrations that were below detection limits for all herbicides tested. In November 2010, all herbicides were below detection limits except for metolachlor. Little Killbuck (3.8 µg/L) and Stony Creek (1.1 µg/L) had metolachlor concentrations above detection limits. Across all sites and sampling events, the highest concentration of metolachlor was measured at Little Killbuck in November 2010. In May 201l, only one site, Stony Creek, had any herbicides that were above detection limits with measureable concentrations of atrazine (1.1 µg/L) and metolachlor (1.3 µg/L). Atrazine and metolachlor were also detected in sediments at maximum concentrations of 48.0 and 71.0 µg/kg, respectively. Concentrations measured were comparable to previous studies (Table 2).

Table 2. Comparison of mean dissolved concentrations of atrazine and metolachlor (µg/l) in this study relative to previous studies. ⍰

	Atrazine	Metolachlor	Study area
This Study	<0.28	0.11	Central Indiana
Raffel et al. 2011	0.52	0.86	Central Indiana
Larson et al. 1999	2.4	1.2	U.S (nationwide)

Factors influencing herbicide concentrations.—Depth and discharge were positively correlated with both atrazine (R=0.3472 p=0.0030; R=0.4228 p=0.0002, respectively) and metolachlor concentrations (R=0.3034 p=0.0101; R=0.3988 p=0.006, respectively). Dissolved nutrient concentrations were also correlated with herbicide concentrations. Specifically, nitrate (NO_3^--N) and ammonium (NH_4^+-N) were positively correlated with atrazine (R=0.6304 p=<0.0001; R=0.5114 p=<0.0001, respectively) and metolachlor concentration (R=0.5442 p=<0.0001; R=0.5483 p=<0.0001, respectively). Dissolved metolachlor was correlated with sediment atrazine and stream temperature (p<0.01). Sediment bound metolachlor was correlated with dissolved oxygen and dissolved atrazine (p<0.01). Temperature, pH, dissolved phosphate concentrations and sediment percent organic matter were not correlated with herbicide concentrations across sites (p>0.1).

Table 1. Mean dissolved concentrations for atrazine and metolachlor in µg/l. ⍰

	Atrazine	Metolachlor	Study area
This Study	<0.28	0.17	Central Indiana
Raffel et al. 2011	0.52	0.86	Central Indiana
Larson et al. 1999	2.4	1.2	U.S (nationwide)

Enrichment experiments—.Enrichment experiments in July quantified longer uptake rates for nitrate (312 m) and chlorothalonil (222 m) relative to carbaryl (102 m) and atrazine (30 m), suggesting greater retention of pesticides relative to nitrate. In October, uptake lengths for metolachlor (188 m) and atrazine (98 m) were longer, relative to nitrate (44m).

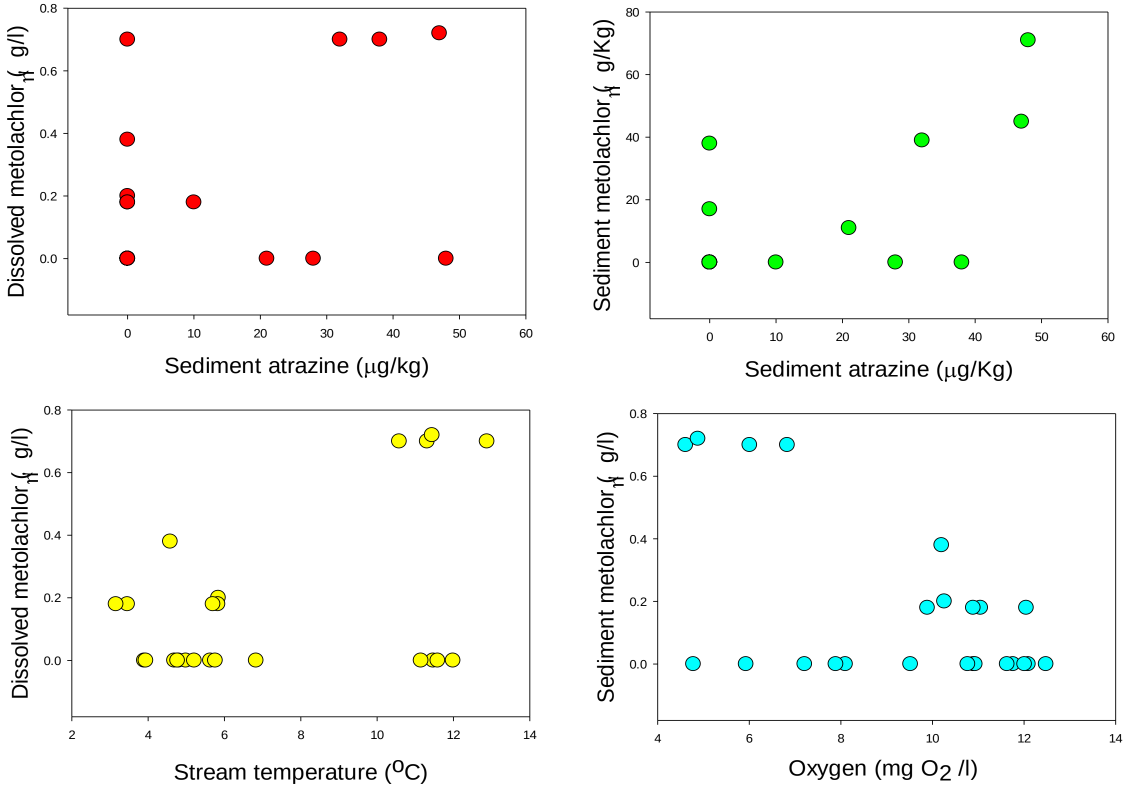


Figure 2. Relationships between A: Metolachlor sediment and atrazine; B: Sediment atrazine and sediment metolachlor; C: Temperature and metolachlor; and, D: Dissolved oxygen and metolachlor.

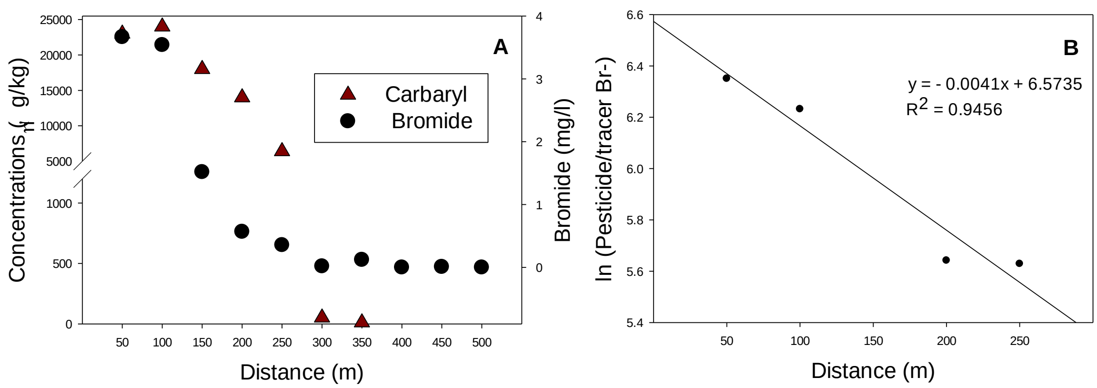


Figure 3. July 2011 enrichment of carbaryl. A: Dissolved concentrations of carbaryl and bromide; B: Bromide corrected concentrations of carbaryl . Bromide was used as a conservative tracer to separate stream hydrology from transport and retention of pesticides. Concentrations of carbaryl and chlorothalonil were corrected by using the formula natural logarithm of (Concentration of carbaryl/concentration of Bromide).

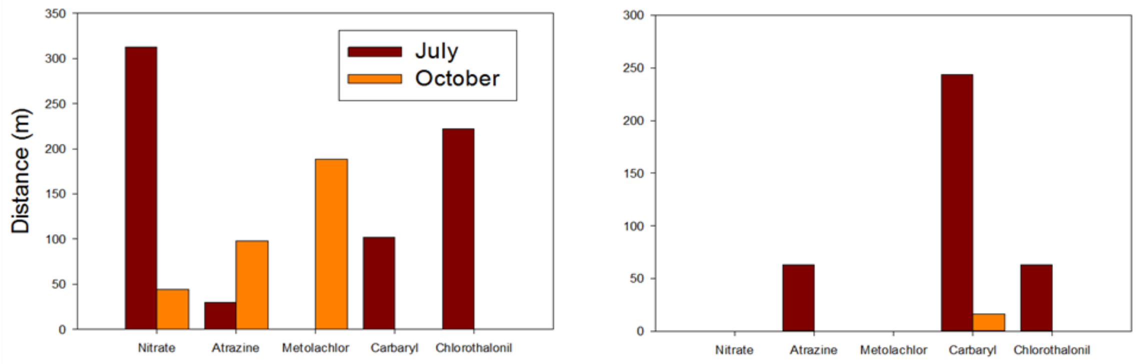


Figure 4. Uptake length of (A) Dissolved pesticides and (B) sediment bound pesticides for atrazine, metolachlor, carbaryl, and chlorothalonil, relative to nitrate, in July and October enrichment experiments.

Major Conclusions and Significance

These data suggest spatial and temporal variation in both abundance of pesticides as well as transport and retention within the ecosystem. Atrazine and metolachlor were detected in sediments suggesting accumulation from previous spraying seasons. Atrazine and metolachlor dissolved concentrations were within range of sub lethal effects on aquatic organisms. Atrazine had a shorter uptake length relative to nitrate, which could indicate a nitrate saturated stream and/or fast assimilation of the pesticide.

Publications

<u>Presentations</u>

Elias, D, MJ Bernot. 2012. Abundance and transport of atrazine, metolachlor, carbaryl, and chlorothalonil in central Indiana streams. Indiana Academy of Science. Indianapolis, IN. March.

Elias, D, MJ Bernot. 2012. Abundance and transport of atrazine, metolachlor, carbaryl, and chlorothalonil in central Indiana streams. Society for Freshwater Science. Louisville, KY. May.

Raffel, A, MJ Bernot. 2011. Frequency and abundance of metolachlor in central Indiana freshwaters. North American Benthological Society. Providence, RI. June.

Van Zant, K, MJ Bernot. 2011. Effects of pharmaceuticals on microbial production and respiration. Indiana Water Resources Association. Muncie, IN. May.

Raffel, A, MJ Bernot. 2011. Frequency and abundance of metolachlor in central Indiana freshwaters. Indiana Water Resources Association. Muncie, IN. May.

Raffel, A, MJ Bernot. 2011. Frequency and abundance of metolachlor in central Indiana freshwaters. Ball State University Student Symposium. April.

Olinger, C, MJ Bernot. 2011. Frequency and abundance of atrazine in central Indiana freshwaters. Ball State University Student Symposium. April.

Raffel, A, MJ Bernot. 2011. Frequency and abundance of metolachlor in central Indiana freshwaters. Indiana Academy of Sciences, Indianapolis. March.

Olinger, C, MJ Bernot. 2011. Frequency and abundance of atrazine in central Indiana freshwaters. Indiana Academy of Sciences, Indianapolis. March.

Publications

Raffel, A, C Olinger, MJ Bernot. *In Press*. Frequency and abundance of herbicides in central Indiana streams. Proceedings of the Indiana Academy of Sciences.

Denton, R, MJ Bernot. *In Press*. Effects of multiple agricultural chemicals on northern leopard frog, *Lithobates pipiens*, larvae. Proceedings of the Indiana Academy of Sciences.

Grant Submissions:

Bernot, MJ. Pending. National Science Foundation Environmental Engineering. RUI: An integrated research and education plan to quantify abundance, transport, and fate of pharmaceuticals and personal care products (PPCPs) in freshwaters. Submitted February 2012. Total Requested: $135,000.

Bernot, RJ, Bernot, MJ. Pending. National Science Foundation Division of Ecosystem Biology. Preliminary Proposal: RUI: Scaling up from parasite effects on individual hosts to ecosystem-level processes. Submitted January 2012.

Bernot, MJ, Lepore, B. Pending. National Science Foundation Hydrologic Sciences. Transport and persistence of pharmaceuticals and primary care products (PPCPs) in freshwaters of central Indiana. Submitted December 2011. Total Requested: $381,268.

Elias, D. Transport of atrazine, metolachlor, carbaryl and chlorothalonil in freshwater ecosystems. Sigma Xi Grants in Aid of Research. Total Request: $1000.

Elias, D. Synergistic and antagonistic effects of atrazine, metolachlor, carbaryl and chlorothalonil on freshwater organisms. Ball State University AsPIRE. Total Request: $500. 2012-2013.

Elias, D. Frequency and abundance of atrazine, metolachlor, carbaryl and chlorothalonil in central Indiana freshwaters and sediment. Indiana Academy of Sciences. Total Request: $3,000.

Raffel, A. Abundance of metalochlor in central Indiana freshwaters. Ball State University Undergraduate Research Competition. Total Award: $500.

Raffel, A. Funded. Abundance of metalochlor in central Indiana freshwaters. Indiana Academy of Sciences. 2011-2012. Total Award: $2,347.

Raffel, A. Funded. Abundance of metalochlor in central Indiana freshwaters. Biology Undergraduate Research Competition. 2010-2011. Total Award: $500.

Olinger, C. Funded. Abundance of atrazine in central Indiana freshwaters. Biology Undergraduate Research Competition. 2010-2011. Total Award: $500.

Students

A total of 3 graduate students and 4 undergraduate students were involved with this project.

Niche breadth variation with seasonal changes in local habitats: fish assemblages of the Wabash River

Basic Information

Title:	Niche breadth variation with seasonal changes in local habitats: fish assemblages of the Wabash River
Project Number:	2011IN313B
Start Date:	3/1/2011
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	IN-006
Research Category:	Climate and Hydrologic Processes
Focus Category:	Ecology, Geomorphological Processes, Hydrogeochemistry
Descriptors:	None
Principal Investigators:	Mark Pyron

Publication

1. No Publications

Project Id: 2011IN313B

Title: Niche breadth variation with seasonal changes in local habitats: fish assemblages of the Wabash River

Project Type: Research

Start Date: 3/01/2011 **End Date:** 2/28/2012

Congressional District: Indiana 6th Congressional District

Focus Categories: ECL, GEOMOR, HYDGEO, HYDROL

Keywords: Fish assemblages, geomorphology, hydrology, substrates

Principal Investigators: Mark Pyron

Abstract / Summary Understanding the species- and assemblage-habitat relationships of large river fishes has been historically limited by the large size and spatial complexity of river ecosystems. However, a Geographic Information System (GIS) database constructed with spatially explicit physical data as well as information on occurrences of individual taxa can provide ecologists with appropriate tools to detect habitat use patterns for species and assemblages in these ecosystems. I tested hypotheses associated with environmental factors regulating river fish assemblages that have not been amenable with other analytical approaches. I applied a method for collecting and analyzing fish species data for a 30-km reach of the Wabash River to test the relationships between niche breadth, niche position, and species abundance. Niche breadth and niche position were calculated using environmental variables (bathymetry, riverbed sediment composition, woody debris presence, and flow velocity) assembled in a spatially explicit GIS framework.

Problem: The stream fishes of Indiana provide the state many positive returns including benefits to anglers, for ecosystem services, and as a portion of a natural heritage. Although there are several local extinctions, the majority of fish species that were here historically are still present. However, the current fish assemblages of Indiana have higher occurrences of species that are tolerant to human disturbances (Jacquemin & Pyron in review). There is a need to further our understanding of natural fish assemblages and how they respond to habitat changes.

The Wabash River includes the longest free-flowing stretch in the eastern U.S. and as such, is a unique system for study. Fish assemblages in the Wabash River vary spatially and temporally, and this variation appears to be caused in part by hydrologic variation. Fish assemblages change predictably from upstream to downstream (Vannote et al. 1980), with changes in river gradient and hydrology that produce increasingly smaller substrate particle sizes with decreasing gradient (Pyron & Lauer 2004). Temporal changes in fish assemblages vary with spatial scale. At local site scales, annual flood event frequency controls the substrate composition (Pyron et al. 2010) and local fish assemblage structure varies with substrate composition (Mueller & Pyron 2010). At a 230-km river distance spatial scale, the fish assemblage underwent gradual, predictable change during a 25-year period (Pyron et al. 2006). During this 25-year period, hydrologic alterations have increased (Pyron & Neumann 2008), and these alterations likely had negative impacts on stream assemblages.

The associations between stream fish species abundance, assemblage structure, and available habitat have been studied using two primary approaches (Jackson et al. 2001). The first approach relies on small-scale studies of microhabitat use or habitat partitioning and is often based on detailed measures of local habitat variation combined with subsequent observations of individual fish uses of the quantified habitats (e.g., Grossman & Freeman 1987). While useful for describing fish species distributions and assemblage structure at the scale of small stream reaches, Jackson et al. (2001) concluded that the accumulation of such detailed information would be overwhelming for describing species- and assemblage-habitat relationships at larger spatial scales. The second approach uses large-scale studies to test for assemblage patterns that are correlated with environmental variables. Such large-scale studies examine the effects of environmental variables on fish assemblage structure at watershed or larger scales (Hoeinghaus et al.

2007). While both approaches have merits, neither is sufficient to effectively determine how fish species are distributed relative to spatially explicit habitat availability in large rivers, which are intermediate between the smaller streams studied in the first approach and the watershed scale focused on in the second approach. Consequently, our understanding of the ecology of large river taxa is relatively limited.

Understanding the species- and assemblage-habitat relationships of large river fishes has been historically limited by the large size and spatial complexity of river ecosystems. However, a Geographic Information System (GIS) database constructed with spatially explicit physical data as well as information on occurrences of individual taxa can provide ecologists with appropriate tools to detect habitat use patterns for species and assemblages in these ecosystems (Fisher & Rahel 2004). This proposal describes a pilot study to demonstrate the potential for testing hypotheses associated with environmental factors regulating river fish assemblages that have not been amenable with other analytical approaches. We apply a method for collecting and analyzing fish species data for a 30-km river reach developed in small streams (Knouft et al., in press) to test the relationships between niche breadth, niche position, and species abundance. Niche breadth and niche position are calculated using environmental variables (bathymetry, riverbed sediment composition, woody debris presence, and flow velocity) assembled in a spatially explicit GIS framework. We will use three resolutions to determine at which scale niche breadth and position are correlated with population density, and how these relationships vary among two seasons.

Research Objectives: The project is a combination of field collections and GIS analyses. The field collections are for fishes and geomorphologic information for habitats.

1. Learn application of GIS to remotely collected data
2. Field collections
3. Analyses and report writing

Methodology: I collected environmental and fish assemblage data in the fall 2011. I collected channel bathymetry data using sonar-based depth measurements along a 10-km study reach of the Wabash River in Lafayette, Indiana. Sediment composition data was collected throughout the entire reach along transects at 100-m intervals, using a pole method (Mueller & Pyron 2010). Each transect extended from bank to bank and samples were at 10 equidistant locations per transect. At each location where the pole is probed into the sediment, a water velocity observation at 60 % of depth was collected, and a GPS waypoint recorded on a GPS unit. Woody debris locations throughout the reach was recorded as presence using a GPS unit.

I used a boat electrofisher to sample fishes along the 10-km. The boat is outfitted with a Smith-Root Model VIA electrofish box and associated booms and electrodes, and is operated at a frequency of 60 Hz and 8 AMPS. I sampled in a back-and-forth pattern from shore to shore. Electrofishing was conducted in a downstream direction with two crew members on the bow identifying stunned fish (spotters), one crew member piloting the boat, one crew member recording species identified by the spotters (recorder), and one crew member entering waypoints on a Trimble GeoXH handheld Global Positioning

System (GPS), which provides locality data at sub-30cm accuracy. Fishes stunned with the boat electrofisher were not captured; rather, spotters, who were selected based on their familiarity with Wabash River fish species, identified stunned fishes as they surfaced. This allowed me to efficiently sample the entire reach during a few days while at the same time maintaining species-level identification for most sampled fishes. The GPS unit was used to record waypoints representing the positions (latitude and longitude) of each fish or group of fishes identified by the spotters as the boat was piloted in a downstream direction at < 4 km / h. For each waypoint entered, the recorder noted all species identified by the spotters for that waypoint. Thus, waypoints provide spatially explicit data describing the locations in the river where one or more individual fishes were observed so that these data can be incorporated into a GIS for calculation of species-habitat associations.

Results. Analyses and final report will be completed by Sep 2012.
Major Conclusions and Significance Analyses and final report will be completed by Sep 2012.
Publications We expect to submit a manuscript in fall 2012.
Grant Submissions: na
Students The project included three graduate students.

Habitat Use and Movements of Shovelnose Sturgeon, Scaphirhynchus platorynchus, in the Wabash River, Indiana

Basic Information

Title:	Habitat Use and Movements of Shovelnose Sturgeon, Scaphirhynchus platorynchus, in the Wabash River, Indiana
Project Number:	2011IN314B
Start Date:	3/1/2011
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	IN-004
Research Category:	Ecological Processes
Focus Category:	Conservation, Ecology, None
Descriptors:	None
Principal Investigators:	Reuben R Goforth

Publication

1. No Publications

Project Id:	2011IN314B
Title:	Habitat Use and Movements of Shovelnose Sturgeon, *Scaphirhynchus platorynchus*, in the Wabash River, Indiana
Project Type:	Research
Start Date:	3/01/2011
End Date:	2/28/2012
Congressional District:	Indiana 4th
Focus Categories:	COV, ECL
Keywords:	River Fish Ecology, Shovelnose Sturgeon, *Scaphirhynchus platorynchus*¸ Fish Movements, Habitat Use
Principal Investigators:	Reuben R. Goforth, Ph.D. Assistant Professor of Aquatic Community Ecology Department of Forestry and Natural Resources 195 Marstellar Street West Lafayette, IN 47907 Voice: 765-494-0009 E-mail: rgoforth@purdue.edu

Abstract / Summary:
The shovelnose sturgeon (SNS, *Scaphirhynchus platorynchus*) is the only sturgeon species that still supports a sustainable commercial fishery in North America. Despite its importance as a source of roe for the caviar industry and generally high abundance in larger rivers of the Mississippi and Missouri River basins, few studies have described the species' ecology in the Wabash River. There is also recent evidence that SNS may be a sentinel species for the Wabash River because its preferred habitat appears to be significantly different from all other fish species. However, recent listing of the middle Mississippi River SNS population as federally threatened will likely result in greater commercial harvest in the Wabash River. Given that SNS likely fill a unique niche in the Wabash River and loss of this species could have serious ecological consequences, it is important to better understand the ecological and life history needs of this species to support sound management. This includes knowledge of habitat use both within and outside of the spawning season. Using funding provided by IWRRC, I have purchased 25 acoustic tags for surgical implantation into female SNS to track their movements and habitat use. To date, 11 tags have been implanted into female SNS in the Wabash River near West Lafayette, IN, and tracking of these tagged fish has begun. The remaining tags will be implanted into four additional female SNS in the same location, and the remaining 10 tags will be implanted into female sturgeon downriver in a location thought to be important for non-spawning activities. Tracking activities will continue through summer and fall 2012, and given a 4-yr expected lifespan for the tags, I will seek future funding to continue tracking activities in future years.

Problem:

The shovelnose sturgeon (SNS, *Scaphirhynchus platorynchus*) is the smallest North American sturgeon and is distributed throughout the Mississippi River drainage in several of its larger tributaries as well as the mainstem (Bailey and Cross 1954). This species was historically very abundant, although the range and population sizes of SNS have significantly decreased over the last century as a result of harvest, pollution, and habitat loss and alteration (Birstein 1993, Keenlyne 1997). Despite these declines, SNS numbers remain generally high throughout the species' albeit contracted range, including the Wabash River (IN), and it is currently the only North American sturgeon of the genus *Scaphrihynchus* that is not listed as endangered under the Federal Endangered Species Act.

While the commercial importance of SNS was historically low due largely to its small size and associated small roe yields, worldwide depletions of other sturgeon species that were once sources of caviar have resulted in redirected efforts to harvest SNS to meet caviar demands (Birstein 1993, 1997, Billard and Lecointre 2001, Quist et al. 2002, Pikitch et al. 2005, Tripp 2007). Thus, the SNS remains one of the few sturgeon species that can be legally harvested (Carlson et al. 1985, Keenlyne 1997). However, the middle Mississippi River SNS population, one of the most viable remaining populations, was recently closed to harvest due to listing of that population as threatened under the similarity of appearance provisions of the Endangered Species Act of 1973 (USFWS 2010). This SNS population overlaps with the critically endangered pallid sturgeon (S. albus), and it is difficult even for experts to distinguish between the two species under some conditions, hence the listing of middle Mississippi River SNS as threatened and closure of that fishery. While this change in management is certainly prudent and necessary, closure of the middle Mississippi River to SNS harvest will very likely create greater legal and illegal harvest pressures on the Wabash River SNS population where pallid sturgeon do not occur. While the Wabash River SNS population has been considered stable for some time, increased harvest of this relatively long-lived and late-maturing species in the Wabash River poses a potentially serious threat to the population.

The Wabash River is the longest reach of free flowing river east of the Mississippi River (Karns et al. 2006), and this long, unimpounded waterway is important for movements of migratory species, including SNS. Most SNS remain in the lower Wabash River (i.e., in the vicinity of river mile 100 (river km 161) throughout much of the year, although they move upstream to spawn in the Lafayette/West Lafayette reach of the Wabash during the early spring, moving back downstream following the spawning event in late June thru early July (Wellman 2010). Wellman (2010) documented movements of SNS spanning ≈200 miles (≈322 km), indicating that SNS utilize a large portion of the Wabash River for various life history events. It also appears that SNS preferentially use specific habitats during the spawning period (Wellman 2010), and a recent study by Pyron et al. (2011) suggests that SNS fill a niche that is not occupied by any other Wabash River fish species, at least in the spawning area. While these recent studies have revealed important ecological characteristics of SNS, many questions remain regarding their movements and habitat use beyond the spawning season. Further, recognition of their unique niche provides cause for concern for the Wabash River ecosystem if this species is overharvested and can no longer fill this niche, suggesting that they may be a sentinel species for this ecosystem. Given the high likelihood of increased harvest pressure and uncertainty regarding the consequences of the loss of the unique niche filled by SNS in the Wabash River, it is critical that we develop a better understanding of their habitat needs and movements both within and outside of the spawning season to help inform management of this species.

The Goforth lab at Purdue University has surgically implanted 54 acoustic tags in SNS over the past several years and has tracked movements of these tagged fish using both passive receivers and active tracking. The acoustic tags are very expensive (i.e., $350-400 each), and tracking using both passive and active technologies is time intensive. Further, we have been limited to tracking SNS movements between river miles 100 and 300 to date, and all movements downstream of Lafayette/West Lafayette are based solely on passive detections at stationary locations. Thus, movements of SNS beyond these areas and habitat use in downstream areas are currently unknown. However, a unique opportunity exists to further study SNS movements and habitat use with only a modest investment in additional tags and technician salary support. The Goforth lab has a contract with the Indiana Department of Natural Resources to conduct movement studies for the so-called Asian carp (*Hypopthalmichthys* spp.), and this study is providing opportunities to both greatly expand the study area within the Wabash River and offers many opportunities for field personnel to conduct movement data for these species. Thus, there are many opportunities to detect not only the tagged Asian carp, but also any other fish tagged using the same technology at no additional cost to that project. Funding by the IWRRC has provided 25 additional tags for SNS that can be detected during regular Asian carp tracking, thus providing an opportunity to gain additional information for SNS without significant personnel costs to the IWRRC. Additional funding from IWRRC has also provided the resources necessary for undergraduate technicians to conduct several float trips down the Wabash to provide opportunities to identify specific locations on the Wabash used by SNS outside the spawning season as well as habitat characteristics of these locations. The resulting data will provide a much more substantial foundation for managing the Wabash River SNS population in light of increased harvest pressures.

Research Objectives:

1) Implant 25 female SNS with Vemco V16-4L acoustic tags. Tags will be surgically implanted into the fish and the fish will be released back into the river following tag implantation.
2) Track the movements of the 25 tagged SNS over a 9-month period. Tagged SNS will be detected using 20 passive receivers deployed between Wabash river miles 100 and 425, including major tributary confluences. Data will be downloaded from these receivers on a regular basis as part of the Asian carp movements project. Field personnel will also conduct several float trips from river mile 300 to river mile 100 in order to use manual tracking equipment to detect the locations of tagged shovelnose sturgeon outside the spawning season.
3) Determine habitat characteristics of manually detected SNS. Habitat characteristics, including bottom water velocity and substrate type, will be measured for each manually detected SNS.

4) Communicate project results. My students and I will communicate the results of this project to State of Indiana agency personnel and other professional colleagues to help improve the information base for managing this species. Products will include poster presentations, oral presentations, at least one peer-reviewed journal article, and a final project report.

Methodology:
Twenty-five female SNS will be collected to be implanted with ultrasonic transmitters (11 completed to date). A 6 m electrofishing boat (Model SR16H; Smith-Root Inc., Seattle, Washington) will be used to collect fish downstream of the Interstate 65 bridge over the Wabash River. The boat equipment consists of a 230-V generator with a pulsator running 8-9 A of direct current at 120 pulses s^{-1} and 20-50% of range pulse width.

Upon capture, SNS weights (g) and fork lengths (mm) are recorded and each fish are externally tagged using a Floy T-bar anchor (Model FD-68B; Floy Tag & Mfg. Inc., Seattle, Washington) inserted near the base of the left pectoral fin. During processing, gravid females are chosen by visual inspection and then verified during tag implantation surgery. Fish considered to be candidates for ultrasonic tag implants are retained in pens (1.5 x 1 x 1 m dimensions; 2.5 cm mesh), and fish are surgically implanted with tags within a few hours after capture.

Candidate fish are sedated using electroanesthesia. Vemco ultrasonic transmitters (Model V16-4L, 24 g, 16 mm diameter, 68 mm length; Vemco, Halifax, Nova Scotia) are surgically implanted in the coelomic cavity of the SNS following procedures similar to those of Delonay et al. (2007). Transmitter weights are <2% of the fishes’ weights in accordance with the recommended criteria from Vemco. After implantation, the incisions are closed using absorbable monofilament sutures (PDS II, Ethicon Inc., Cornelia, Georgia), and the fish are released near the midpoint of the transect in which they were captured and GPS coordinates are recorded.

Twenty omnidirectional passive receivers (Vemco VR2W) are deployed on the river bottom from Wabash River Miles 100-425 (10 total VR2Ws), at three locations in the Little River, at two locations in the Tippecanoe River, and at approximately 1 km distances upstream of the confluences of the Eel River, Deer Creek, and Wildcat Creek (one VR2W in each). The VR2Ws are attached to custom cages and anchors developed by the Goforth lab at Purdue University. This combination of cages and anchors connected by a 30 m underwater cable has provided secure placement on the bottom of the river over two previous field seasons and allows for grappling of the cable in order to retrieve the VR2Ws.

Placement of the VR2Ws was determined in coordination with State of Indiana fisheries personnel including the following Wabash River locations: VR2Ws placed at ≈50 mile increments from River Miles 100 – 250 and VR2Ws placed at ≈25 mile increments from River Miles 300 – 425. This arrangement is sufficient to cover the full potential range of marked Asian carp and SNS based on maximum movements of silver (267 miles) and bighead (280 miles) carp observed in the Illinois River (Degranchamp et al. 2008) and movements of SNS (200 miles) observed in the Wabash River (Wellman 2010). The placement of VR2Ws just upstream of the confluences of several smaller streams/rivers should help to determine the relative use of these habitats by SNS as well, a component that has not been evaluated previously.

Active tracking is accomplished by deploying hydrophones from one of two tracking boats depending on river conditions (4.2 m Polarkraft and 6 m Alumnacraft). Both an omnidirectional and directional hydrophone (Vemco VH110, and Vemco VH165, respectively) connected to a manual receiver (Vemco VR100) are used by field crews on tracking boats to locate and identify tagged fish. First, the omnidirectional hydrophone is used to locate tagged SNS in the vicinity of the tracking boat as it is piloted downriver at <10 km/h. Once a fish is detected, the directional hydrophone is used to pinpoint the identified fish's location within the river channel. Signal strength from the direction the hydrophone is pointed is used to isolate the fish's location, and the tracking boat is then piloted in that direction. The position of the tagged sturgeon is recorded using a handheld GPS (GPSMap 60, Garmin Ltd., Olathe, Kansas) when signal strength detected by the directional hydrophone is strongest in all directions.

Manual tracking will be conducted during float trips conducted in July, August and September 2012 from river mile 300 down to river mile 100. Habitat measurements will be taken during manual tracking when tagged sturgeon are located. Depth (m) will be determined using a hand-held depth finder (Model SM-5; Speedtech Instruments, Great Falls, Virginia) and current velocity (m/s) will be recorded using a Flo-Mate (Model 2000; Marsh-McBirney, Loveland, Colorado) sensor deployed 10 cm off the bottom. Similar to the methods used by Mueller and Pyron (2010), substrate composition will be determined using a 3 m or 6 m copper pipe to probe the bottom. Substrate type will be categorized as one of six types (Wentworth, 1922): boulder, cobble, gravel, sand, fines, or hardpan.

Results:
While I had planned to have this work completed by March 2012, problems getting fish for tagging relative to the availability of project funds made this impossible. Therefore, the project activities are now taking place in 2012, and we have 11 of the 25 fish tagged to date, with additional tagging to be completed by the end of June 2012. We have begun tracking the tagged females, and have gotten signals from several individuals to date. Additional data and synthesized results will be available by 31-December-2012.

Major Conclusions and Significance:
This project is currently ongoing, and no conclusions can be drawn at this time. However, this project will provide a significant opportunity to observe the movements and habitat use of SNS as a value-added component of a much larger project to track Asian carp movements in the Wabash River. Much of the infrastructure and labor needed to conduct this study will be provided via ongoing activities of the Asian carp project, and thus the IWRRC has an opportunity to realize a significant research return based on a relatively modest investment in acoustic fish tags and technician salaries. The resulting data will help Indiana DNR personnel better evaluate the management needs of SNS in

the Wabash River, and I expect that the results will also be useful for agency personnel managing SNS populations in other parts of the Mississippi River basin.

Publications:
No publications based on project activities to date.

Grant Submissions:
No additional grant submissions have been made based on results from this project to date.

Students:
This project involves one Ph.D. student, Kensey Thurner, and one undergraduate student, Alison Lenaerts.

References Cited:

Bailey, R. M. and F. B. Cross. 1954. River sturgeons of American genus *Scaphirhynchus*: characters, distribution, and synonymy. Papers of the Michigan Academy of Science, Arts, and Letters 39:169-209.

Billard R. and G. Lecointre. 2001. Biology and conservation of sturgeon and paddlefish. Reviews in Fish Biology and Fisheries 10: 355–392, 2001.

Birstein, V. J. 1993. Sturgeons and paddlefishes:threatened fishes in need of conservation. Conservation Biology 7(4):773-787.

Carlson, D. M., W. L. Pflieger, L. Trial, and P.S. Haverland. 1985. Distribution, biology, and hybridization of *Scaphirhynchus albus* and *S. platorynchus* in the Missouri and Mississippi rivers. Environmental Biology of Fishes 14: 51–59.

Degranchamp, K. L., J. E. Garvey and R. E. Colombo. 2008. Movement and habitat selection by invasive Asian carps in a large river. Transactions of the American Fisheries Society 137: 45-56.

Delonay, A. J., D. M. Papoulias, M. L. Wildhaber, M. L. Annis, J. L. Bryan, S. A.Griffith, S.H. Holan and D. E. Tillitt. 2007a. Use of behavioral and physiological indicators to evaluate *Scaphirhynchus* sturgeon spawning success. Journal of Applied Ichthyology 23:428–435.

Karns, D. R., M. Pyron, and T. P. Simon. 2006. The Wabash River Symposium. Proceedings of the Indiana Academy of Science 115(2):79–81.

Keenlyne, K. D. 1997. Life history and status of the shovelnose sturgeon, *Scaphirhynchus platorynchus*. Environmental Biology of Fishes 48:291–298.

Mueller, R., Jr., and M. Pyron. 2010. Fish Assemblages and Substrates in the Middle Wabash River, USA. Copeia 1:47-53.

Pikitch, E. K., P. Doukakis, L. Lauck, P. Chakrabarty, and D. L. Erickson. 2005. Status, trends and management of sturgeon and paddlefish fisheries. Fish and Fisheries 6(3):233–265.

Pyron, M., R. Goforth, J. Beugly, S. Morlock, and M. Kim. 2011. A GIS approach to analysis of environmental variables to explain fish assemblage structure in a large river. River Systems 19(3): 239-247.

Quist, M. C., C. S. Guy, M. A. Pegg, P. J. Braaten, C. L. Pierce, V. H. Travnichek. 2002. Potential influence of harvest on shovelnose sturgeon populations in the Missouri River system. North American Journal of Fisheries Management 22:537-549.

Tripp, S. J. 2007. Understanding how harvest influences the life history and demographics of Shovelnose Sturgeon in the Middle Mississippi River. Master's Thesis. Southern Illinois University, Carbondale, IL.

USFWS (U.S. Fish and Wildlife Service). 2010. Endangered and Threatened Wildlife and Plants: Proposed Rule To List the Shovelnose Sturgeon as Threatened Due to Similarity of Appearance. Federal Register 75:2102-2104.

Wellman, M. D. 2010. Shovelnose sturgeon (*Scaphirhynchus platorynchus*) movements in the Wabash River, Indiana. Master's Thesis. Purdue University, West Lafayette, IN. 49 pp.

Wentworth, C. K. 1922. A scale of grade and class terms for clastic sediments. Journal of Geology 30:377–392.

Reduction of phosphorus concentration in the Wabash River by an environmentally-friendly nanoparticle

Basic Information

Title:	Reduction of phosphorus concentration in the Wabash River by an environmentally-friendly nanoparticle
Project Number:	2011IN315B
Start Date:	3/1/2011
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	IN-003
Research Category:	Water Quality
Focus Category:	Water Quality, Treatment, Non Point Pollution
Descriptors:	None
Principal Investigators:	Dong Chen

Publication

1. No Publications

Project ID:	2011IN315B
Title:	Reduction of phosphorus concentration in the Wabash River by an environmentally-friendly nanoparticle
Project Type:	Research
Start Date:	3/01/2011
End Date:	2/29/2012
Congressional District:	3
Focus Category:	AG, ECL, NPP, ST, SW, TS, WQL
Keywords:	Agriculture, phosphorus, eutrophication, gypsum, nano material, surface runoff, algae
Principal Investigator(s):	Dong Chen

Abstract

Nutrient losses, especially phosphorous (P) from farmlands to rivers via surface runoff are causing significant eutrophication problems because dissolved P is usually the limiting nutrient for algal blooms. Currently, available techniques to control eutrophication are surprisingly scarce. Gypsum is a common soil amendment and has a strong affinity to both P and soils. In this study, nano gypsum was synthesized through a chemical co-precipitation method. The results showed that gypsum reduced the amount of water extractable P (WEP) in soil incubation tests, suggesting less P loss from farmlands. More decrease in WEP occurred with a greater dosage of gypsum. Compared to conventional pelletized gypsum, nano gypsum further reduced WEP by providing a much greater specific surface area, higher solubility, better contact with the fertilizer and the soil particles, and superior dispersibility. The enhancement of nano gypsum is more apparent for a pelletized fertilizer than a powdered one. At the dosage of gypsum reflected by Ca/P weight ratio of 2.8, the WEP decreased by 29±5% with nano gypsum compared to 18±4% with pelletized gypsum when the pelletized fertilizer was used. In addition, the effect of nano gypsum on *Gloeotrichia ghosi* (a blue-green alga) growth was examined in the sterilized Upper Wabash River water spiked with the pelletized commercial fertilizer of 9.917 mg/L. No significant trend was observed between the concentration of chlorophyll *a* and the amounts of nano gypsum dosed after 14 days. The likely reason is although calcium released from gypsum precipitated orthophosphates out the water solution, the bottom growing *Gloeotrichia ghosi* might utilize the P from the precipitate. Since gypsum is the major product of the flue gas desulfurization (FGD) process in coal-fired power plants, this study demonstrated a potential beneficial reuse and reduction of the solid FGD waste.

Problem

Indiana is located within the Corn Belt and the Grain Belt. Agriculture accounts an important portion of the state’s GDP. However, fertilizers used in farming have brought significant threats to its aquatic environment. More specifically, surface runoff loaded with significant amounts of nitrogen (N) and phosphorous (P) is causing water body eutrophication, which is demonstrated by the overgrowth of algae. Eutrophication is bringing a series of adverse ecological and water quality problems such as fish kills, shifts in species composition, blooms of harmful algae, hypoxia in water body, as well as toxins, taste and odor in drinking water [1].

In the Upper Wabash River basin, which drains 18,655 km^2 of central Indiana and parts of western Ohio, the dominant land use is agriculture (92%) [2]. The Aggregate Nutrient Ecoregions are from VI to VII [1]. Based on the data in 2003, 30% of 111 samples from the Upper Wabash River were above eutrophic level [1]. In 2010, the State Department of Health cautioned Hoosiers of possible high levels of blue-green algae at many reservoirs and lakes [3]. Even worse, Grand Lake St. Marys in western Ohio, which has a spillway connected to Beaver Creek, a tributary of the Wabash River has been closed in the summer 2010 due to toxic algae blooms [4]. Consequently, it is of critical importance to prevent the river from eutrophication in order to protect the water quality, the ecosystem and the public health and welfare.

P, especially in soluble form is usually the limiting nutrient for algae growth [5], because the exchange of N between the atmosphere and a water body and fixation of atmospheric N by some blue-green algae, can be sufficient to prevent N from limiting biological productivity [6]. The physiological processes of algae growth are balanced when the cellular carbon, N and P atomic ratio is 106:16:1, respectively [7, 8]. The critical soluble P concentration is 10 μg/L [9], which if exceeded may accelerate the eutrophication of water. P in nature waters occurs almost solely as phosphates [5]. These are classified as orthophosphates (PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^{-}$, H_3PO_4), polyphosphates ($H_xP_yO_z^{n-}$ with y≥2), and organically bound phosphates. In these forms of phosphates, only soluble orthophosphates can be directly utilized by algae [10]. Polyphosphates and organic phosphates must undergo slow hydrolysis through abiotic and/or biotic reactions and convert to orthophosphates before being utilized by algae [11].

Although considerable progress has been made in understanding eutrophication, effective control techniques are surprisingly scarce. The conventional methods to reduce nutrients transport in surface runoff include improved farming practices (e.g., reduce tillage and avoid overdose) and soil testing. However, new evidences of water body eutrophication suggest these strategies are not enough. An ideal way is to retain P in the farmlands and deplete the existing soluble P in the river. More specifically, gypsum ($CaSO_4{\cdot}2H_2O$), which has a strong affinity to both P and soils, may be applied to the farmlands. The calcium cation released from gypsum not only can precipitate soluble P from surface runoff and rivers, but also can improve soil structural properties like aggregate stability of clay soil for erosion control [12]. Based on the PI's previous study, calcium has a strong affinity to natural organic matter in soils [13]. The efficiency of using gypsum to reduce P in surface runoff and precipitate P from water has been reported by several studies. In the study of Felton et al. [14], gypsum was used to control soluble P from poultry. 98% removal of P was achieved with the 1:1 mass mixing ratio between poultry and gypsum. Pietola [12] showed that gypsum significantly decreased the loss of P from both inorganic and manure fertilizers and reduced soil erosion. Consistently, Kordlaghari and Rowell [15] indicated that gypsum significantly increased the sorption of P in soil by forming calcium phosphate. Bastin et al. [16] reported about 5 mg/L soluble P was removed by 1 g/L of the mixture of iron oxide and gypsum. However, in these studies the efficiency was restricted by the limited surface area of gypsum particles. To the PI's best knowledge, the effect of nano gypsum has never been reported yet. Nano gypsum has the advantages of a much greater specific surface area, higher solubility, better contact with the fertilizers and soils, superior dispersibility and dose-saving capabilities compared to conventional pelletized gypsum. These advantages were expected to facilitate the reactions between P/gypsum and soils/gypsum. With a sufficient dosage, nano gypsum may maintain the reactivity and the affinity to both P and soils, and thus retain P in the farmlands.

Research Objectives

Three main objectives of this project are listed below.

i) Synthesize nano gypsum.
ii) Examine the efficiency of nano gypsum to retain P in soils. The levels of water extractable P (WEP) were investigated through soil incubation tests. The efficiency was compared among nano and commercial pelletized gypsums and blank soil samples without gypsum.
iii) Investigate the effect of nano gypsum on algal growth in the sterilized water sample from the Upper Wabash River. The purpose was to evaluate algal growth with respect to different dosages of nano gypsum, which might be carried away from farmlands to rivers via surface runoff.

Methodology

Sample analyses. All chemical reagents were of certified grade. The sample analyses followed the APHA/AWWA/WEF standard methods [5]. Calcium concentration was examined by an AAnalyst 200 atomic absorption spectrometer (PerkinElmer, Waltham, MA). Synthesized nano gypsum was imaged by a Philips CM-100 transmission electron microscope (TEM) (FEI Company, Hillsboro, OR) operated at 100kV. Energy dispersive x-ray (EDX) analysis was done with an Oxford INCA 250 X-MAX 80 silicon drift system with 80 mm collection window (Oxford Instruments, Peabody, MA). The elemental composition of the soil samples was examined by X-ray fluorescence (XRF). Before measurements, the sample was pressed into pellet using 9 g of the sample mixed with 1 g binder (Spectroblend). The mixture was pressed at a force of 25 tons per square inch. A quantitative measurement was done using ZSX Primus II Spectrometer (Rigaku Americas, Woodlands, TX) for majors and minors. The content of soil organic matter was quantified by the gravimetric method, i.e., drying ~5 g of soil sample at 103 ^{o}C followed by heating at 550 ^{o}C for 2 hours.

Inorganic P, Fe, Mg, and Al were analyzed using a PerkinElmer Optima 5300 DV ICP-OES (Waltham, MA) with a comparable method to US EPA 200.7. Total N was examined using the testing kits from Hach (Loveland, CO) following the Method 10071. Algal chlorophyll *a* content was measured by the spectrophotometric method of US EPA 10200H after extraction procedures. The UV-Vis spectrophotometer was Lambda 25 (PerkinElmer, Waltham, MA). The dissolved organic carbon (DOC) concentration was measured in the non-purgable organic carbon mode by a Shimadzu TOC-5000A analyzer.

Synthesis of nano gypsum. Nanoparticles of gypsum were prepared in the laboratory by the chemical co-precipitation method [17] through mixing calcium chloride and sodium dodecyl sulfate solutions. The precipitate was then dissolved in ethylene glycol before mixing with concentrated sulfuric acid. Finally, an aliquot of ethanol is added slowly with constant stirring to form a solution containing nano $CaSO_4 \cdot 2H_2O$ particles, which were harvested by centrifuge at 3000 rpm for 30 minute and purified by rinsing with ethanol several times. Finally the produced gypsum was dried in air followed by grinding with a mortar and a pestle manually to reverse partial aggregations.

Soil incubation tests of WEP. WEP directly relates to the potential P loss via surface runoff [14, 18]. The top soils collected from the 0-20 cm depth of agronomic soils in the Upper Wabash River watershed near Huntington, IN were used in soil incubation tests. The soil sample was dried in an oven at 50 ^{o}C, then crushed and sieved through a 2-mm screen. The coarse soil particles rejected by the sieve were discarded. Inorganic fertilizers (i.e., KH_2PO_4 powder (<1 mm) or Simplot^{TM} pellet (3±2 mm)) were dosed at a rate of 60 mg P/kg, equivalent to 135 kg P/ha, a P application rate to meet crop requirements [18]. The measured P content of the commercial fertilizer Simplot^{TM} pellet was 8% (wt). As a result, the added fertilizer was 15±0.2 mg Simplot^{TM} pellet or 5.3±0.2 mg powdered KH_2PO_4 per 20 g of soil. Various amounts of nano gypsum or commercial pelletized gypsum (4±3 mm) of Soil Doctor X™ were used in soil incubation tests. The measured calcium content in pelletized gypsum was 78% (wt) by the atomic absorption. At the beginning of incubation, the fertilizer was well mixed with 20 g of soil sample, followed by adding certain amount of gypsum and well mixed again. The mixture was incubated in 250-mL polyethylene bottles in the laboratory at 20±1 ^{o}C and 80% field capacity for

14 days. Holes had been made in the lids of the incubation bottles to allow air exchange and to prevent anaerobic conditions. Soil moist content was maintained constant at 80% field capacity by weighing and adding deionized water on a daily basis. At the end of the 14 days, the incubation soil mixtures were analyzed with 1:10 soils to deionized water, and agitated for 1 hr before filtration by a 0.45 μm membrane [18]. The total P concentration in the filtrate was examined. Duplicated tests were performed for quality assurance.

Effect of gypsum on algal growth. Water samples from the Upper Wabash River in Huntington, IN area were collected to examine the background nutrients (total P, total N, and organic carbon) and metallic concentrations. In addition, the water sample collected on 8/13/2011 was sterilized and used to grow algae in 300-mL glass beakers under a lighting system of a 100W fluorescence lamp. The river water was spiked with Simplot™ of 9.917 mg/L until totally dissolved before adding various amounts of nano gypsum. Finally the solution was sonicated for 20 minutes before inoculation with 1.0 mL of pure culture of *Gloeotrichia ghosi* (LB1920 from The University of Texas at Austin), a type of blue-green alga in fresh water. The growth was maintained at a constant temperature of 38±1 °C in a culture incubator (Model 153, Hach, Loveland, CO). It is reported that the temperature optima for algae growth lied above 30 °C [19]. The rate of algal growth was monitored by examinations of the optical density at 600 nm with time and the chlorophyll *a* content.

Results

Synthesized nano gypsum. A TEM image and the EDX result of the synthesized nano gypsum are shown in Figure 1. From the figure, the gypsum has the crystal form of needle-shape. The thickness of the gypsum crystal was in the range of 100~350 nm. The EDX result confirmed the major composition of Ca, S, and O of gypsum (Cu peak was from the copper grid used in TEM).

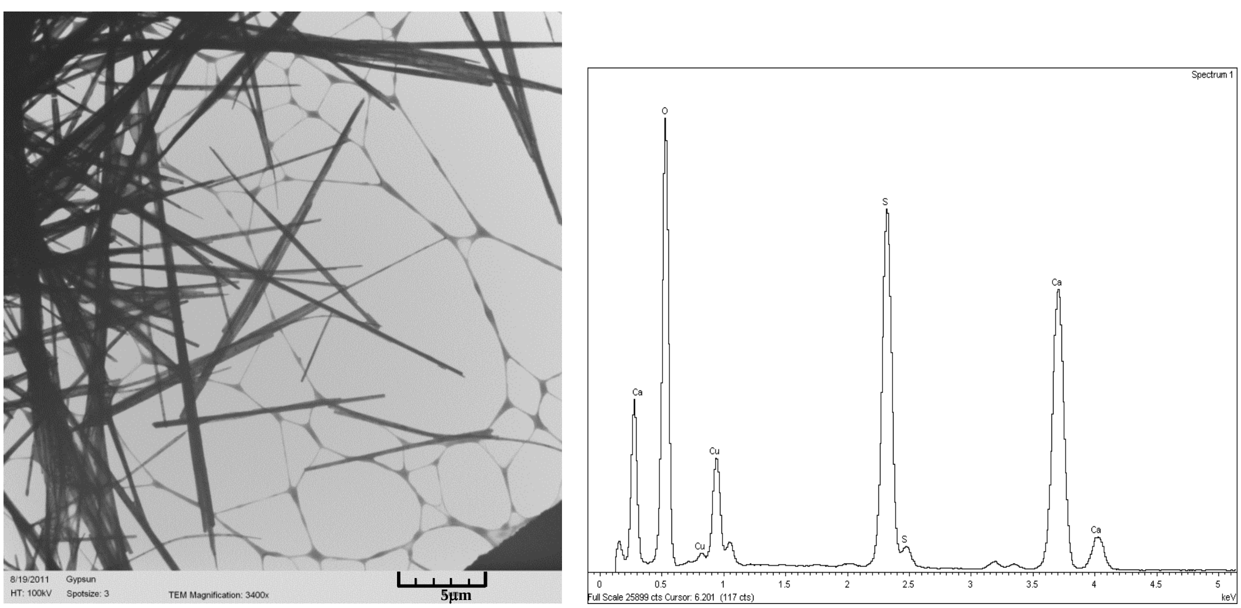


Figure 1. TEM image and EDX result of the synthesized nano gypsum. A copper grid was used in the TEM examination.

Soil incubation tests of WEP. The agronomic soil sample used in this study had a pH of 7.7. The field capacity was 0.37. The soil organic matter was 4.71±0.13% by weight. The major elemental compositions of the soil are shown in Table 1, which accounts for 96.5% of the total mass. The rest 3.5% are from minor elements including Cu, Zn, Cl, Sc, V, Cr, Ni, Rb, Sr, Y, Zr, Nb, Ba, and Pb.

Table 1. The major elemental compositions of the agronomic soil determined by XRF.

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	K_2O	MgO	Na_2O	TiO_2	MnO	Total Majors
% (mass)	70.6	11.9	5.1	2.6	2.5	2.2	0.9	0.6	0.1	96.5

At the end of 14 days of soil incubation test, the WEP was analyzed. As shown in Figure 2, more reduction of WEP occurred at a greater dosage of both nano and pelletized gypsums. However, nano gypsum reduced the concentration of WEP to a much greater extent than the pelletized gypsum from Soil Doctor X™ with the equivalent content of Ca. At the greatest dosage of gypsum reflected by Ca/P weight ratio of 2.8 (i.e., 14.8 mg nano gypsum vs. 15.2 mg Simplot™), the WEP decreased by 29±5% with nano gypsum compared to 18±4% with the pelletized gypsum.

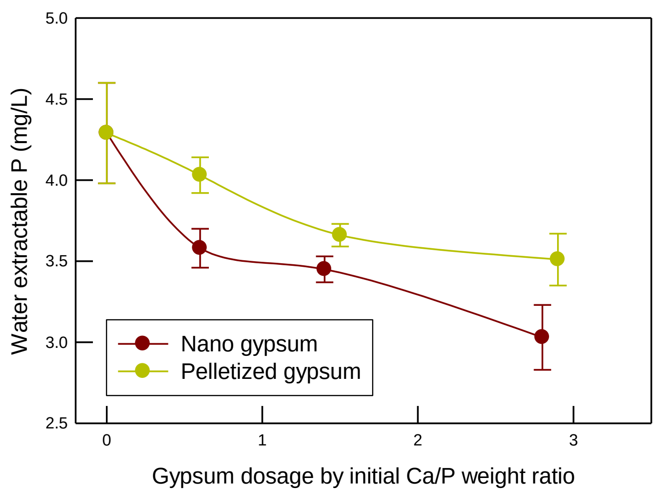


Figure 2. WEP with different types and dosages of gypsum after incubation of 14 days. At the beginning, 20 g of the soil sample was spiked with 15±0.2 mg Simplot™ pelletized fertilizer.

Gypsum has a medium solubility K_{sp}=3.16×10^{-5} (K_{sp}=4.93×10^{-5} for $CaSO_4$) [20]. The gradually released calcium cation (Ca^{2+}) from gypsum reacts with orthophosphates to form a precipitate of calcium phosphate of a much lower solubility (K_{sp}=2.07×10^{-33}) [20]. The calcium may also capture and complex with the slowly released orthophosphates from hydrolysis of polyphosphate and/or organic phosphates in soils or water bodies. The precipitate of calcium phosphate stays in soils. This effect reduced the concentration of WEP.

For powered fertilizer of KH_2PO_4 as shown in Figure 3, a higher dosage of gypsum resulted in a more decrease in WEP, which is in agreement with the pelletized fertilizer (Figure 2). However, nano gypsum had a slightly better effect in reducing the WEP than the pelletized gypsum. The likely reason is that smaller-sized KH_2PO_4 powder had a better contact with both types of gypsum and the soil particles than the pelletized fertilizer, thus the complexation among Ca, orthophosphates and the soil was more feasible. Nevertheless, nano gypsum still exhibited superior mixing and complexation effects and thus a greater reduction of WEP than the pelletized gypsum.

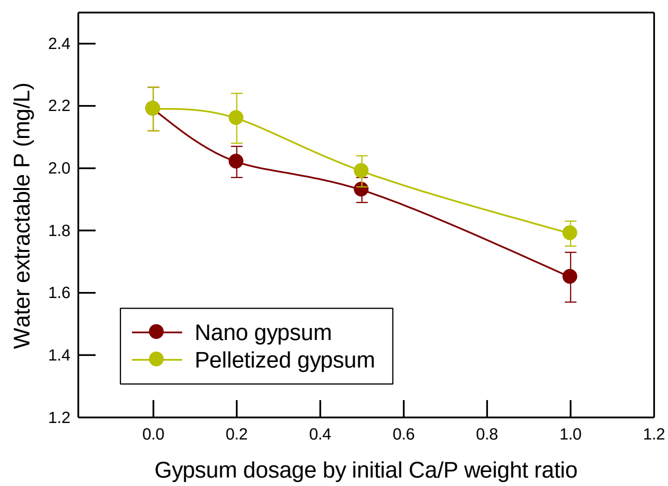


Figure 3. WEP with different types and dosages of gypsum after incubation of 14 days. At the beginning, 20 g of soil sample was spiked with 5.3±0.2 mg powdered KH_2PO_4.

Growth of alga in Wabash River water. The objective of this test was to examine the effect of nano gypsum on algal growth. The Upper Wabash River water sample was sterilized and spiked with 9.917 mg/L Simplot^{TM} for algal growth. The quality of the raw water before being sterilized is listed in Table 2. When different amounts of nano gypsum were added, white precipitate was observed with great dosages of gypsum, which was presumably calcium phosphate.

Table 2. Quality of the Upper Wabash River water sample (before addition of the fertilizer) used for growth of *Gloeotrichia ghosi*.

Items	pH	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Al (mg/L)	Fe (mg/L)	Total-P (mg/L)	Total-N (mg/L)
Values	7.3	34	55.3	0.2	0.3	0.5	0.12	1.89

Figure 4 is a microscopic image of *Gloeotrichia ghosi*, which had a filamentous structure. Figure 5 shows the photo of algal growth in the Wabash River water sample spiked with the fertilizer. Similar growth rate was observed despite different dosages of nano gypsum. The possible reason is that although calcium released from gypsum precipitated soluble orthophosphates out of the solution, the bottom growing *Gloeotrichia ghosi* might be able to utilize the P in precipitate form. In addition, it was reported that calcium was one of the essential elements to support algal growth [21].

Figure 4. Microscopic image of filamentous *Gloeotrichia ghosi*, a type of freshwater blue-green alga.

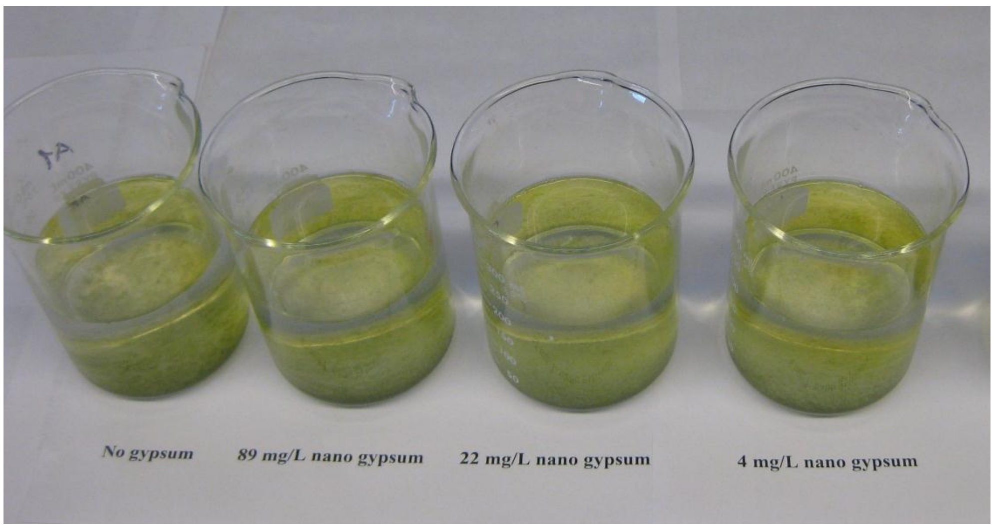


Figure 5. Photo of *Gloeotrichia ghosi* growing in sterilized Upper Wabash River sample spiked with 9.917 mg/L Simplot^{TM} fertilizer after incubation of 6 days. The incubation temperature was maintained at 38±1 ^{o}C.

At the end of 14 days of growth, the content of chlorophyll *a* was examined as shown in Figure 6. Consistent with Figure 5, the results of chlorophyll *a* content indicated no significant difference on the growth of *Gloeotrichia ghosi* with varied amounts of nano gypsum. The results suggest that the potential transport of nano gypsum from farmlands to surface waters via surface runoff unlikely affect bottom growing algae such as *Gloeotrichia ghosi*.

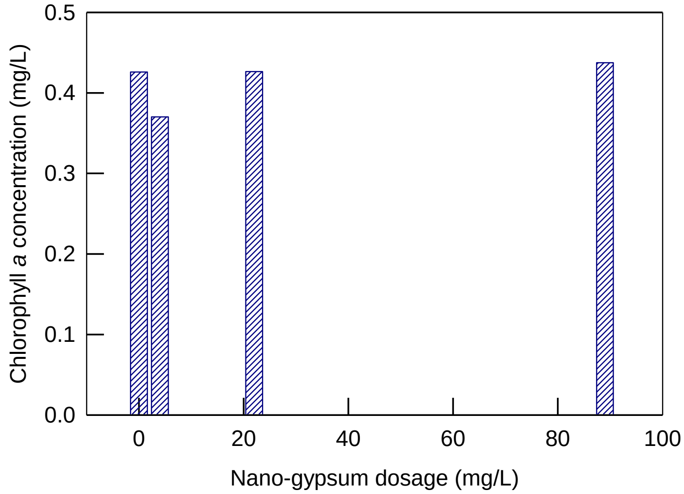


Figure 6. Chlorophyll *a* concentration with different dosages of nano gypsum after growing *Gloeotrichia ghosi* for 14 days. The incubation temperature was maintained at 38±1 ^{o}C.

Major Conclusions and Significance

This study investigated the effects of nano gypsum on the reduction of WEP from agronomic soil and on the growth of blue-green alga of *Gloeotrichia ghosi*. WEP directly relates to the amounts of nutrients loss from agricultural land via surface runoff. The results indicated that more decrease in WEP occurred at a higher dosage of either nano or pelletized gypsum. However, nano gypsum reduced WEP to a much greater extent than the pelletized gypsum, especially when the soil was spiked with the commercial pelletized fertilizer from Simplot^{TM}. For example, at the greatest dosage of gypsum reflected by Ca/P weight ratio of 2.8, the WEP decreased by 29±5% with nano gypsum compared to 18±4% decrease with the pelletized gypsum. Nevertheless, when powdered KH_2PO_4 was used instead of Simplot^{TM}, nano gypsum was slightly better than the pelletized gypsum in reducing WEP. The results suggest that mixing, contact and surface reactions among the soil, the gypsum, and the fertilizer particles are important to retain P in soil. In addition, the impact of nano gypsum on the growth of a blue-green alga of *Gloeotrichia ghosi* was also explored. The sterilized Upper Wabash River water sample spiked with 9.917 mg/L Simplot^{TM} fertilizer was used for algal growth test at 38±1 ^{o}C with light. Similar growth rate was observed despite varied dosages of nano gypsum from zero to 89 mg/L, although calcium released from gypsum precipitated soluble orthophosphates out of the water solution. The possible reason is that *Gloeotrichia ghosi* was growing at the bottom and thus might be able to utilize the P from the precipitate. This result suggests that potential transport of nano gypsum from farmlands to surface waters via surface runoff unlikely affect the bottom growing algae. Moreover, this study provides a potential beneficial use of the solid waste from the flue gas desulfurization (FGD) process in coal-fired power plants, because gypsum is the major component of FGD waste, which showed effectiveness in reduction of WEP from farmlands.

Publications and Outreach

A journal article is being prepared based on the research results from this study. In addition, this project was featured in a workshop series of "Lunch with an IPFW Scientist" to a group of local elementary students and their parents on May 12, 2012. Zachery Estes (PI's student) and Dong

Chen (PI) explained the basic knowledge of environmental engineering and science to the students and their parents by addressing the ecosystem of the Wabash River and the St Joseph River, water pollution and drinking water treatment processes. This activity improved public awareness of environmental protection and stimulated their interest in engineering and scientific research.

Grant Submissions

No grant has been submitted yet.

Students

The project employed three undergraduate students to conduct the research activities proposed in this study. They were systematically trained with fundamental research skills from theoretical, experimental, and analytical aspects. Paul Szostak did samples preparations, tests, and analyses in the laboratory. Ingrid Ballus and Sonia Tews participated in literature research.

References

1. Lowe, B.S., et al., *Occurrence and Distribution of Algal Biomass and Its Relation to Nutrients and Selected Basin Characteristics in Indiana Streams, 2001–2005*, 2008, U.S. Department of the Interior, U.S. Geological Survey.
2. Hoggatt, R.E., *Drainage areas of Indiana streams*, 1975, U.S. Geological Survey, Water Resources Division. p. 231.
3. IDEM. *Blue-Green Algae*. Oct 1, 2010.
4. OHEPA. *Grand Lake St. Marys Toxic Algae*. Fish Consumption Advisory — November 2010.
5. Eaton, A.D. and M.A.H. Franson, *Standard Methods for the Examination of Water and Wastewater*. 21th ed2005: APHA, AWWA, WEF.
6. Sharpley, A.N., S.J. Smith, and J.W. Naney, *Environmental Impact of Agricultural Nitrogen and Phosphorus Use.* Journal of Agricultural and Food Chemistry, 1987. **35**(5): p. 812-817.
7. Borchardt, M.A., *Nutrients*, in *Algal Ecology - Freshwate Benthic Ecosystems*, R.J. Stevenson, Bothwell, M. L., Lowe, R. L., Editor 1996, Academic Press: New York. p. 183-227.
8. Redfield, A.C., *The biological control of chemical factors in the environment.* American Scientist, 1958. **46**: p. 205-222.
9. Sawyer, C.N., *Fertilization of lakes by agricultural and urban drainage.* Journal of the New England Water Works Association, 1947. **61**: p. 109-127.
10. Tchobanoglous, G., F.L. Burton, and H.D. Stensel, *Wastewater Engineering : Treatment, Disposal, and Reuse*. 4th ed2003, New York: McGraw-Hill.
11. Holtan, H., Kamp-Nielsen, L., Stuanes, A. O. , *Phosphorus in soil, water and sediment: an overview* Hydrobiologia, 1988. **170**(1): p. 19-34.
12. Pietola, L., *Gypsum-based management practices to prevent phosphorus transportation.* NJF Report, 2008. **4**(4): p. 78-82.
13. Chen, D., et al., *Ultrasonic control of ceramic membrane fouling caused by natural organic matter and silica particles.* Journal of Membrane Science, 2006. **276**(1-2): p. 135-144.

14. Felton, G.K., K.J. Hughes, and E. Russek-Cohen, *Water-extractable phosphorus reduction in poultry litter with calcium- and iron-rich byproduct amendments.* Transactions of the ASABE, 2004. **47**(6): p. 2069-2077.
15. Kordlaghari, M.P. and D.L. Rowell, *The role of gypsum in the reactions of phosphate with soils.* Geoderma, 2006. **132**(1-2): p. 105-115.
16. Bastin, O., et al., *Phosphorus removal by a synthetic iron oxide-gypsum compound.* Ecological Engineering, 1999. **12**(3-4): p. 339-351.
17. Sawant, P.D. and A. Niranjane, *Formation of nanoparticles of sparingly soluble salts (CaSO4 and CaSO4 : Dy) using liquid-liquid separation method and application for detection of alpha-radiations.* Micro & Nano Letters, 2006. **1**(2): p. 108-111.
18. Leytem, A.B., J.T. Sims, and F.J. Coale, *Determination of phosphorus source coefficients for organic phosphorus sources: Laboratory studies.* Journal of Environmental Quality, 2004. **33**(1): p. 380-388.
19. Kratz, W.A. and J. Myers, *Nutrition and growth of several blue-green algae.* American Journal of Botany, 1955. **42**(3): p. 282-287.
20. *CRC Handbook of Chemistry and Physics*. 91st ed2010, Boca Raton, Fla.: CRC Press.
21. Allen, M.B. and D.I. Arnon, *Studies on Nitrogen-Fixing Blue-Green Algae. I. Growth and Nitrogen Fixation by Anabaena Cylindrica Lemm.* Plant Physiol, 1955. **30**(4): p. 366-72.

Towards a better understanding of E. coli ecology in open streams

Basic Information

Title:	Towards a better understanding of E. coli ecology in open streams
Project Number:	2011IN316B
Start Date:	3/1/2011
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	IN-004
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Ecology, Water Quality
Descriptors:	None
Principal Investigators:	Ronald F. Turco

Publication

1. No Publications

Project ID:	2011IN316B
Title:	Towards a better understanding of E. coli ecology in open streams
Project Type:	Research
Start Date:	3/01/2011
End Date:	2/29/2012
Congressional District:	4
Focus Category:	NPP, ECL, WQL
Keywords:	E. coli, Water Quality
Principal Investigator(s):	Ronald F. Turco, Department of Agronomy Purdue University Purdue Water Community

Abstract / Summary
Fecal pollution of surface waters is a issues for all parts of the United States. We are interested in how the bacterial population structure and density is altered as stream water moves from the headwaters of a small stream to the interface with the larger Wabash River and if the bacterial population structure is altered as the water passes by municipal input sources such as the Lafayette/West Lafayette area. This intial round of work shows that small streams are contributing a number of E coli, but the concentrations are modulated to some degree by the volume of water in the larger river system. The role of input mixing on the community structure in the larger, and smaller systems, is still under investigation. The implications of the work are of interest to those developing TDMLs or those trying to understand how to control bacterial loading to water sources.

Problem: Inputs of fecal pollution is a continual issue for the Wabash River as well as other river systems in the United States. Our current work has shown the numbers of indicator bacteria *Escherichia coli (E. coli)* typically exceed the state limits for full body contact in both the river and the watershed systems that feed the river. This investigation stems directly from our ongoing efforts and is related to questions concerning the distribution of the bacteria in the open water system and what is controlling their population structure and numbers. We are interested in how the bacterial population structure and density is altered as stream water moves from the headwaters of a small stream to the interface with the Wabash River and if the bacterial population structure is altered as the water passes by municipal input sources such as the Lafayette/West Lafayette area. We are also interested in the possible occurrence of a stable small water system “signature” based on the development of a DNA profile for the water. It can be assumed that the fecal bacteria originate from multiple sources and are able to survive in the water systems, what is unclear is the role of proximity of possible bacterial sources to controlling the population structure at any given second location. That is, how is the population structure modulated as function of input source? For example, if we sample at the exit point of a tributary at the Wabash River, are the numbers and type of bacteria an additive result of all inputs on the stream or do they reflect only the nearest inputs? Bacterial fingerprinting technologies can improve bacterial source tracking and problem area identification but may actually reflect the most recent input and not reflect the overall community.

Research Objectives: 1) Understand the role of small stream inputs to the overall population numbers of a large river system such as the Wabash River and 2) Understand the influence of importance of small stream inputs to the *E.coli* population structure of at the confluence area of larger receiving bodies.

Methodology: Sampling of the three streams and two Wabash River sites was done weekly between March 2009 and May 2012. As a means of establishing our sampling resolution levels a small section of the Wabash River between the confluence with Little Pine Creek and the S.R. 26 Bridge in Lafayette, Indiana was repeatedly sampled on July 18, 2011 via boat and shore access. Areas sampled included single point sampling in the river, sampling of the confluence area of Little Pine Creek and Wea Creek, and two transects of five sample points each across the river. A sample was also collected in Little

Pine and Wea Creek where there was no influence from the river. Data collected at each sample site included. *E. coli*, temperature, turbidity, conductivity, dissolved oxygen, and pH. Enumeration of *E. coli* was done using the IDEXX Colilert method. Temperature, conductivity, pH, dissolved oxygen, and turbidity measurements were collected using a Hach Quanta sonde at river sites and a YSI 6829v2-2 sonde at stream sites.

Methodology for the DNA work is nearly complete. In general, water samples will be collected from sites along Little Pine and up and down stream on the Wabash River confluence. One of the samples will be collected near the surface while the other will be collected near the bottom of the ditch. These samples will be combined to form one sample for each collection site. Water will be filtered then the retained cells washed from the filter. DNA will be extracted from the washed filter using MPBio FastDNA Spin Kits. Two primer sets will be used. One will be a general bacteria primer while the other will amplify *E. coli* and *Shigella* species only.

Results

Weekly Sampling

As part of an on-going Wabash River 319 project, weekly sampling events have occurred between March of 2009 and May of 2012. Figure 1 shows weekly data for *E. coli* at each of the five sites plotted with 15-minute flow values and a line for the state standard. These sampling events have provided the underpinning for our questions on the microbiology in the river. We find some seasonal variability in *E. coli* levels at each of the sites with the highest levels generally occurring in spring and summer. Little Pine constantly exceeds the state standard of 235 cfu/100 mL. These data suggest a reoccurring bacterial population exists in both the Wabash River and the smaller systems but total number is not informative on the survival patterns are related to source. Our questions are found in understanding the population dynamics in terms of cell growth, reproduction and dilution of numbers.

Wabash River, Little Pine and Little Wea High Intensity Sampling

High intensity results are summarized in Table 1. A map of sample site locations is shown in Figure 1. Temperatures did not vary in the Wabash River, but temperature does show a slight increase when moving up stream from site one. In Little Pine and Wea Creek, temperatures were noticeably lower than in the Wabash River. At this sampling time, *E. coli* levels at all sites were low and below the state standard of 235 cfu/100mL. Levels in the Wabash River were similar at all sites with the exception of one site (16) which was about twice the average.

Two cross river transects were collected. Transect 1 is between our smaller river systems while transect 2 was done just downstream of the Lafayette wastewater treatment plant that is located on the south side of the river. In both cases, the cross river numbers were similar to the midpoint value. However, each of the smaller streams had higher levels of *E. coli* than the river and suggests that the higher volume of water in the Wabash is diluting *E. coli* as it enters the river. This particularly evident when considering sampling points 11 and 15, a Wabash River site and the Wea Creek input point, respectively. The higher levels from Wea Creek are lost a short distance down steam of the input. However, it doubtful the cells have died in this short distance.

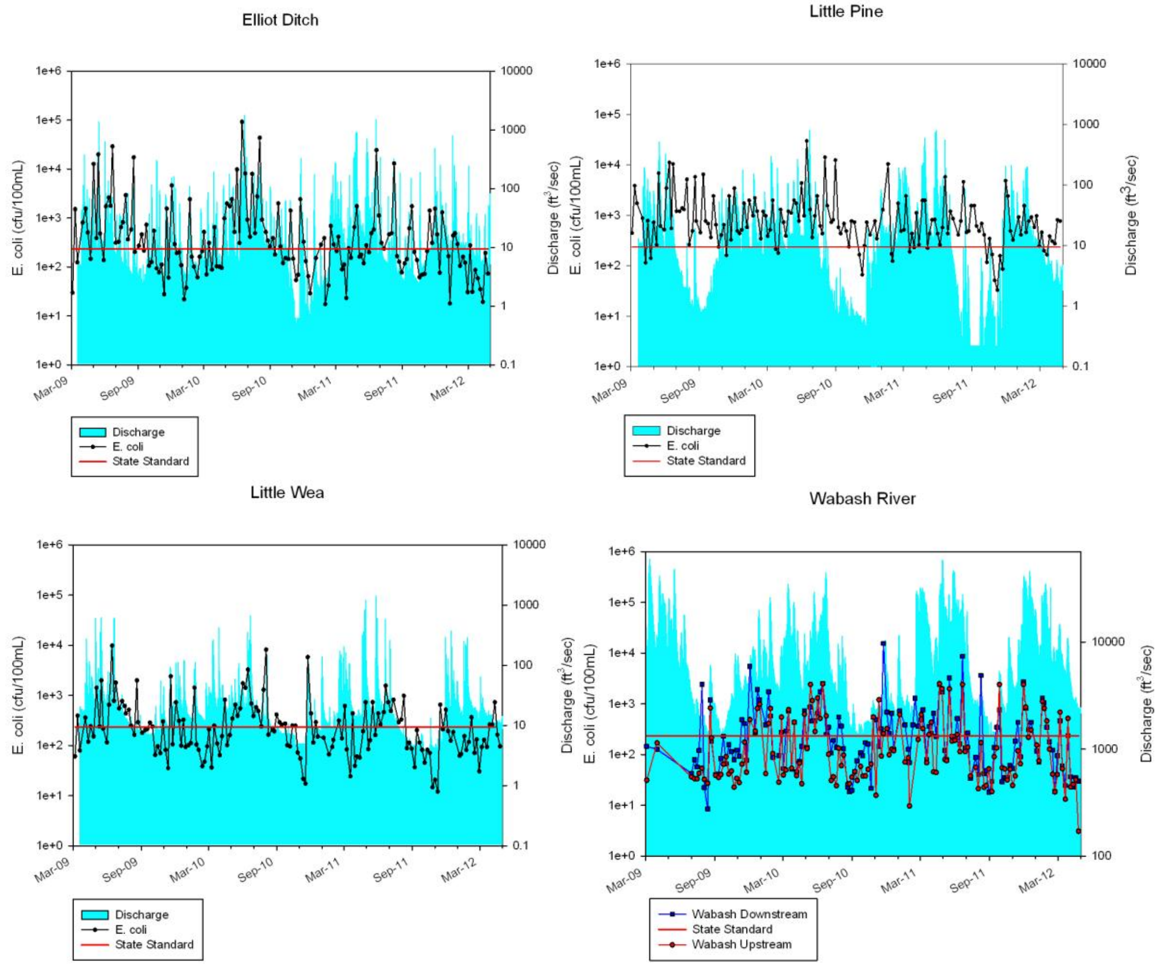


Figure 1. Weekly E. coli data plotted with discharge (cfs) for Elliot Ditch, Little Pine, Little Wea and the two Wabash River sites. The state standard of 235 cfu/100mL is shown as a line.

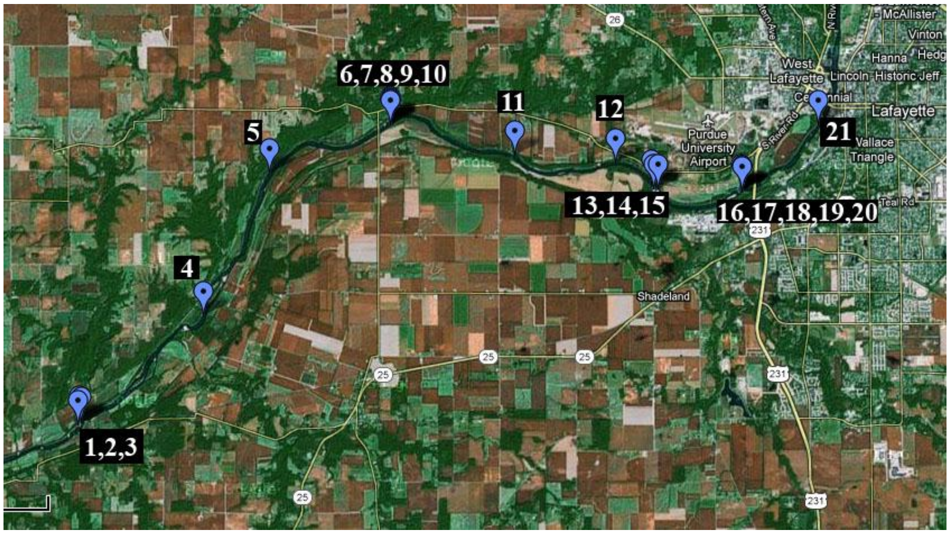


Figure 2. Sample site locations with site numbers.

Sample Site	Temp. °C	*E. coli* cfu/100mL	Description
1	27.60	7.4	River at Little Pine
2	27.64	27.9	Confluence of river and Little Pine
3	23.68	95.8	Little Pine
4	27.70	13.1	River
5	27.87	15.6	River
6	27.60	18.5	River south shore (transect 1)
7	27.69	15.8	River south (transect 1)
8	27.77	20.9	River middle (transect 1)
9	27.91	15.8	River north (transect 1)
10	27.86	14.8	River north shore (transect 1)
11	28.10	18.5	River
12	28.33	18.3	River
13	28.33	23.8	River at Wea Creek
14	28.32	16.0	Confluence of river and Wea Creek
15	22.48	167.4	Wea Creek
16	28.20	44.8	River south shore (transect 2)
17	28.24	22.6	River south (transect 2)
18	28.26	19.9	River middle (transect 2)
19	28.32	27.9	River north (transect 2)
20	28.45	15.8	River north shore (transect 2)
21	28.50	23.3	River

Table 1. Summary of data for one day sampling event on the Wabash River near Lafayette, Indiana

Major Conclusions and Significance

This project is ongoing but is proving insight into questions about the survival and distribution of bacteria in the river systems. We are not aware of any efforts to characterize the population profile of a given body of water, for example Wea Creek or the Little Pine, as far as the contribution to population structure in the larger receiving water. While the consideration of processes and cell numbers within the creeks are important, especially at the local levels, how they impact the river as a source is less clear. This subdivision of sources is critical if we are to implement watershed level management as source reduction is expensive and needs to be targeted. For example, our analysis shows that the two year average volume of water moving past our West Lafayette gauge is 219,306,395,808 ft^3/year. The average volume of water moving past our gauges on the Little Wea and Little Pine creeks are 800,792,100 and 808,109,100 ft^3/year, respectfully. As an average contribution of water to the river, the creeks contribute 0.36 and 0.37 % respectfully. The stability of the signal created by the *E. coli* from the creeks as part of the river biology and their zone of influence is unknown.

Publications: None to date

Grant Submissions: Preliminary data used as part of successful 319 grant "Region of the Great Bend of the Wabash River Implementation Project". 05/13/2012 to 05/12/2015. Total funding (including cost sharing): $1,332,900

Students: Megan Heller Hass, MS student. Laura Trice, Undergraduate student.

Information Transfer Program Introduction

None.

Pollution Prevention Through Better Management of Fertilizers, Pesticides, and Salts In Tanks and On Trailers

Basic Information

Title:	Pollution Prevention Through Better Management of Fertilizers, Pesticides, and Salts In Tanks and On Trailers
Project Number:	2011IN317B
Start Date:	3/1/2011
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	IN-004
Research Category:	Ground-water Flow and Transport
Focus Category:	Agriculture, Climatological Processes, Floods
Descriptors:	
Principal Investigators:	Fred Whitford

Publications

1. Keep the Trailer Connected to the Truck—Understanding the Hitch System (PPP-92) 2011. Whitford, F., S. Hawkins, D. Ess, P. Walker, J. Meganck, J. Obermeyer, & K. Smith.
2. Fiberglass Tanks for Storage, Transport and Application: Designing Your Customized Tank. (PPP-93) 2011. Whitford, F., K. Baalmann, S. Hawkins, J. Flanders, & K. Smith.

Titles: Pollution Prevention Through Better Management of Fertilizers, Pesticides, and Salts In Tanks and On Trailers

Project Title 1A: Keeping the Trailer Connected to the Truck

Project Title 1B: Fiberglass Tanks for Storage, Transport, and Application

Project Type: Outreach

Start Date: 3/01/2011 End Date: 2/28/2012

Congressional District: Indiana 4th Congressional District

Focus Categories: AG, CP, FL, M&P, NPP, SED, SW, TS, WQL

Key Words: spills, tank location, pollution prevention, trailers, fiberglass tank

Principal Investigator: Fred Whitford, Ph.D., Coordinator, Purdue Pesticide Programs, Purdue University, 915 West State Street, West Lafayette, IN 47907-2054; Phone: 765-494-1284; Fax: 765-494-1556; Email: fwhitford@purdue.edu

Principal Deliverables for Project 1A: Keeping the Trailer Connected to the Truck

• *Extension Publication*

Keep the Trailer Connected to the Truck—Understanding the Hitch System (PPP-92) by **Whitford, F**., S. Hawkins, D. Ess, P. Walker, J. Meganck, J. Obermeyer, & K. Smith. 2011. A total of 10,000 copies were printed. An additional 5,000 copies were printed as the first printing was exhausted by demand.

• *Publication Mailing*

Printed copies were mailed to all pesticide application businesses registered with the Office of Indiana State Chemist. In addition, copies were handed out at instate and regional recertification programs. Each Indiana county extension educator received a copy of the publication, and a complimentary copy was sent to each state's pesticide coordinator at the land-grant schools across the United States.

> "...the information was on point and will enable our members to transport equipment more safely and make more effective applications. The publications were an added bonus that will serve as excellent resources." Alabama Vegetation Management Association

• *Online Posting* at http://www.ppp.purdue.edu/Pubs/PPP-92.pdf. There were about 800 hits to this page.

• *Purdue School of Agriculture Press Release*

New Purdue Extension guide teaches hitch system safety.
http://www.purdue.edu/newsroom/general/2011/110627WhitfordHitch.html

• *Trade Journal (examples)*

Keep the Trailer Connected to the Truck. AgWeb from Farm Journal.
http://www.agweb.com/article/keep_the_trailer_connected_to_the_truck/

A Weak Link. February 11, 2012. AgWeb on the iPhone from Farm Journal.

Reducing Hitch-related Truck and Trailer Accidents. West Farm Press. June 28, 2011.

Trailer Accident Caused by Faulty Hitches Are Not Supposed to Happen. July 3, 2011 blog at http://www.philadelphiainjuryattorneyblog.com/auto_accident/large_trucks

• *Train-the Trainer Programs*

Powerpoint presentation was shared with many safety and risk coordinators across the country.

> "Just wanted to let you know that I used your wonderful trailer safety presentation in my safety meeting yesterday. Thanks so much for allowing me to have it."

> "I have just looked over several of your publications including "Keep the Trailer Connected to the Truck" and another "Securing the Load" dealing with tie downs and chaining equipment to trailers. Let me just say you have excellent illustrations and great up-close photography. My question is this, do you have PowerPoint presentations available on these subjects? I work in the public sector and would love to share this information during some of my training exercises with my public works and parks employees."

• *Personal Impacts*

> "I went to the hauling/towing training last week and let me tell you it was awesome. What an eye opener...I want to invite him back and give a training to the county agents. Farmers are hauling things all of the place not knowing the limits of their stuff. Thanks for having that training available."

> "Those in attendance will be more thoughtful every time they hook up a trailer and/or haul something....As a result of this meeting, Facilities Management will be taking a serious look at our trailers, hitches, and vehicle towing/hauling capacities. I'm sure accidents will be prevented as a result of your efforts."

• *Indiana Presentations* (56)

Synergistic Solutions Spray and Safety School

Indiana Farm Bureau Spring Conference

Wabash County Soil and Water Conservation District Annual Meeting

Northwestern Indiana Nursery and Landscaping Association Annual Educational Seminar

Crop Production Services Grower Meeting

Midwest Mint Growers Annual Meeting

Hybrids Seed Salespersons Training

Green Crop Services Winter Agronomy Meeting

Union County Private Applicator Recertification Program

Indiana Arborist Association Annual Conference

Aquatic Control Applicator Workshop

Vincennes Tractor Farm Profit Preview

Howard County Private Applicator Recertification Program

Stuben/Dekalb County Private Applicator Recertification Program

Carroll/Cass County Private Applicator Recertification Program

Henry County Private Applicator Recertification Program

Purdue University Preharvet Workshop

Purdue University Forest Pesticide Training Program

Tri-County Private Applicator Recertification Program

Miami County Private Applicator Recertification Program

Sullivan County Private Applicator Recertification Program

Animal Sciences Research and Education Center

Purdue University Agronomy Club

Indiana Flower Growers Association

Pinney Purdue Field Day

Anderson Agricultural Field Day

Purdue University Northeast Purdue Ag Center Seed Treatment Workshop

Boone County Private Applicator Recertification Program

TenBarge Seed and Turfgrass Supplies Education and Trade Show

Beck's Hybrids Chauffeur and CDL Driver Training School

Crop Production Services Farmer Safety Meeting

Fayette County Private Applicator Recertification Program

Northern Indiana Soil Management Seminar

Moss Fertilizer Services Grower Meeting

Tipton County Private Applicator Recertification Program

Wilson Fertilizer Annual Grower Meeting

Professional Landscape Management School

Purdue University Crop Management Statewide Workshops (5)

Indiana Green Expo

Crop Production Services Annual Certified Crop Advisors Workshop

Purdue Agricultural Centers Superintendents Meeting

Pioneer Seed Treatment Seminar

Jay County Private Applicator Recertification Program

Randolph County Private Applicator Recertification Program

Jennings County Private Applicator Recertification Program

County Private Applicator Recertification Program

Fayette County Private Applicator Recertification Program

Ohio and Dearborn Private Applicator Recertification Program

Hoosier Energy Herbicide Seminar

Indiana Cooperative Risk Coordinators Group

United States Department of Agriculture Field Transportation Workshop

Madison County Private Applicator Recertification Program

National Presentations (16)

Hitch the trailer safely. Alabama Vegetation Management Seminar. **Tuscaloosa, Alabama**.

Pesticide safety—loading and transportation of pesticides. Green Industry Professional Seminar. **Annandale, Virginia**.

Keep the trailer connected to the truck. Iowa Turfgrass Conference and Trade Show. **Des Moines, Iowa.**

A classroom and field demonstration of keeping the trailer connected to the truck. University of Kentucky College of Agriculture workshop. **Lexington, Kentucky**.

Truck hitches—understanding the system. Vegetation Management Association. **Franklin, Tennessee**.

Keeping the trailer connected to the truck. Chemical Weed Control-R.O.W Managers Meeting. **Brownwood, Texas**.

Keeping spray trailers hitched to the truck. Oklahoma Vegetation Management Association. **Catoosa, Oklahoma**.

Truck hitches: understand the system. Farm Journal Corn College Consultant and Farmer Sessions. **Heyworth, Illinois**.

Keeping spray trailers hitched to the truck. Florida Vegetation Management Association Annual Conference. **Daytona Beach, Florida**.

Just hook it up and go. West Virginia Vegetation Management Association. **Roanoke, West Virginia**.

Truck hitches—understanding the system. Colorado Pest Control Association Spring Conference. **Denver, Colorado**.

Under how trailers are hitched to trucks. Syngenta National Biological Research and Development Meeting. **Greensboro, North Carolina**.

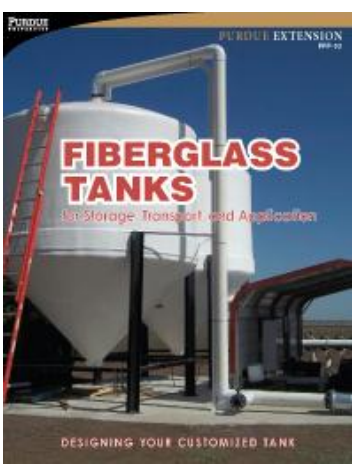
Hitch and trailer safety. Texas Vegetation Management Association Annual Conference. **College Station, Texas**.

Safe pesticide transportation: the truck hitch influence. University of Florida Aquatic Weed Control Short Course. **Coral Springs, Florida**.

Keeping the truck and trailer connected. Ohio State University West Ohio Agronomy Day. **Ft. Loramie, Ohio**.

Staying hitched and road safe—safety tips for trailers, equipment and pesticide handling for all businesses. Ohio Turfgrass Foundation. **Columbus, Ohio.**

Principal Deliverables for Project Title 1B: Fiberglass Tanks for Storage, Transport, and Application



• *Extension Publication*

Fiberglass Tanks for Storage, Transport and Application: Designing Your Customized Tank. (PPP-93) by **Whitford, F**., K. Baalmann, S. Hawkins, J. Flanders, & K. Smith. 2011. Purdue Pesticide Programs printed 7,500 copies with current inventory at 2,700.

• *Publication Mailing*

Printed copies were mailed to all pesticide application businesses registered with the Office of Indiana State Chemist. In addition, copies were handed out at instate and regional recertification programs. Each Indiana county extension educator received a copy of the publication, and a complimentary copy was sent to each state's pesticide coordinator at the land-grant schools across the United States.

"I just received your newest bulletin on 'Fiberglass Tanks'. Thanks so much for sharing with me. Your materials are amazing and once again, you have produced a very informative product that is easy to understand. That's very important to people like me." University Extension Coordinator

• *Online Posting* at http://www.ppp.purdue.edu/Pubs/PPP-93.pdf. There were ca. 100 hits to this page.

• *Indiana Presentations by Group* (2)

Consideration of poly and fiberglass tanks for storage and transportation. 2011. Dearborn County Soil and Water Conservation Service Conservation Tillage Breakfast and Pesticide Recertification. Lawrenceburg, Indiana.

Spray tanks: fiberglass or poly? 2012. Indiana Green Expo. Indianapolis, Indiana.

• *National Presentations* (2)

Poly vs. fiberglass tanks. West Virginia Vegetation Management Association Meeting. **Roanoke, West Virginia**.

Plastic poly and fiberglass tank safety. Ohio No-Till Field Day. **West Manchester, Ohio**.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	9	4	0	2	15
Masters	8	0	0	0	8
Ph.D.	0	2	0	2	4
Post-Doc.	0	0	0	0	0
Total	17	6	0	4	27

Notable Awards and Achievements

Dr. Ronald Turco received the Outstanding Achievement Award -- Academic Sector -- from the Indiana Water Resources Association at the Spring 2011 meeting.

One of his noted activities was working with the State Department of Natural Resources and for his work with the Indiana Water Resources Research Center.

Publications from Prior Years