Lake Erie Protection Fund

Small Grant SG-327-07

Final Technical Report

Soil phosphorus stratification with reduced tillage

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May 5, 2009

Abstract.

As a result of National Center for Water Quality Research monitoring efforts, concern has risen in recent years over the ever increasing dissolved reactive phosphorus levels in tributaries to Lake Erie and the impacts of those levels on over enrichment of the Lake. Increasing soil test phosphorus levels (phosphorus stratification) in the surface soil layers of fields under conservation tillage are a suspected cause. This project gathered stratified soil test data from fields in the Rock Creek watershed and evaluated the extent and degree of stratification by tillage type and manure history. Fields with less tillage had more phosphorus stratification. None of the stratified values exceeded the Ohio 300 lbs/ac Bray P1 value, above which excessive phosphorus enrichment of agricultural runoff is a concern. However, for many fields, phosphorus soil test levels did exceed those required for optimal economic growth of corn and soybean (30 lbs/ac Bray P1), and are at levels accompanied by increased dissolved phosphorus runoff concentrations. It appears then that while phosphorus stratification can measurably increase runoff DRP, other factors such as annual management of commercial and manure phosphorus fertilizers also play important roles in DRP losses.

Note: Much of the content of this report is supported by sets of graphs and tables used in power point presentations related to this project. Those slides and tables are included in Appendix A to this report, where they are numbered consecutively. The particular presentation and slide number within the presentation are identified in the caption for each power point slide. Copies of the Power Point presentations are available from the Heidelberg University National Center for Water Quality Research.

Introduction

Since the mid 1990's, monitoring data gathered by the National Center for Water Quality Research at Heidelberg University has shown steadily increasing levels of dissolved reactive phosphorus (DRP) in streams tributary to Lake Erie. This dissolved form of phosphorus is readily available for uptake by algae and typically controls the rate and amount of algal growth in freshwater streams and lakes. Thus, it was not that surprising that lake water users plus those government and university individuals charged with evaluating Lake water quality observed increasing growth and abundance of blue green algae at about the same time, especially within the Western Lake Erie basin. With the regulation of major municipal point sources of phosphorus already in effect, a closer evaluation of nonpoint sources of DRP was warranted.

In North Central and North Western Ohio watersheds, where agricultural land use predominates, there are three major sources of phosphorus which can contribute to degraded water quality through over enrichment: commercial fertilizers, animal manures and elevated soil test phosphorus levels. For North Central and North Western Ohio, National Agricultural Statistic Service and USDA-Economic Research Service data show the use of commercial fertilizers to be essentially level since 1995 (ppt Slide 1). While the same data sources show some upturns in the generation of manure phosphorus after 2005, the increases were a small fraction of commercial fertilizer usage. Analysis of soil test data from the Great Lakes A&L Laboratory in Ft. Wayne, IN showed that standard 0 to 8 inch soil test values from NW Ohio were nearly three times the level required for optimal economic growth of corn and soybeans (30 lbs/ac Bray P1 soil test) (ppt Slide 2). A similar analysis of NW Ohio soil test data provided by Mike Hall of Spectrum Analytic Laboratory, Washington Court House, OH (ppt Slide 2). showed standard soil test values to be more than twice those needed for optimal economic corn and soybean growth. Research by several mid western universities (ppt Slide 3) plus preliminary local testing (ppt Slide 4) also indicates that phosphorus soil test levels can be elevated at the soil surface as a result of conservation tillage adoption. USDA-Natural Resources Conservation Service data shows a significant increase in the adoption of conservation tillage in North Western and North Central Ohio since 1995 (ppt Slide 5). In all of Ohio and based on USDA-Agricultural Research Service information, the established soil test phosphorus threshold, above which unacceptable phosphorus enrichment of agricultural runoff occurs, is 300 lbs/ac Bray P1 (ppt Slide 6).

The purpose of this project then was to document the extent and degree of soil phosphorus stratification in a watershed dominated by row crop agriculture under conservation tillage and with minimal influence from urban areas or livestock operations. The watershed selected was the 34 square mile Rock Creek watershed in North Central Ohio (ppt Slide 7). The stream is a tributary to the Sandusky River (Lake Erie watershed) and has had daily water quality monitoring as part of a USDA Conservation Effects Assessment Project (CEAP) grant the

Heidelberg University and, more recently, as part of a Great Lakes Protection Fund Grant to the Heidelberg. Project results were to help determine if elevated phosphorus levels in the soil surface might explain the increasing levels of DRP recorded in the monitoring of Rock Creek and other Ohio tributaries to Lake Erie. Results were also intended to give new perspectives on ways to manage fertilizer and manure phosphorus for more efficient crop production and enhanced water quality.

Approach and Methods

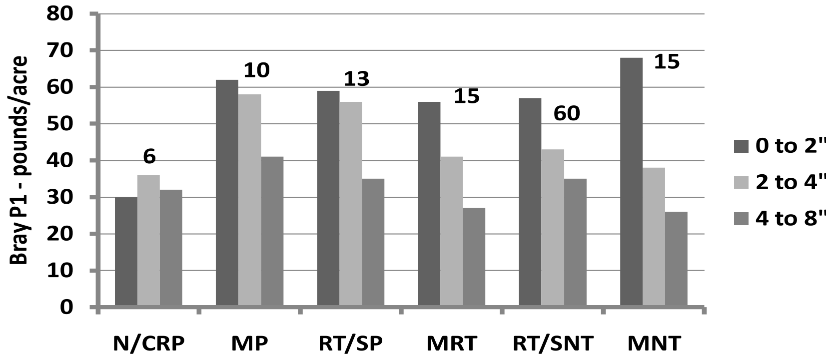
From the beginning, project data collection activities were designed and planned to utilize the existing process for the collection and analysis of on farm soil test data. Specifically, there was an initial meeting with agronomy staff personnel from three farm service centers covering respective portions of the Rock Creek watershed. At this meeting, Heidelberg staff gave an overview of why the stratified testing was needed and asked for the advice and assistance of service center personnel. The plan was to collect separate samples from the 0 to 2 inch, 2 to 4 inch and 4 to 8 inch depths for each field sampled and send samples to laboratories used by the respective service centers for analysis. For these same fields, service center staff would also complete a data collection form that would record both laboratory soil test results and information about tillage and manure history that would help with soil test data interpretation (Appendix B). To help encourage farmer participation, these data sheets did not identify the farmer by name and recorded field location by Township and Section number only. Based on this approach, staff from the three service centers estimated the number of fields that would likely be sampled in the summer and fall of 2007 and the spring of 2008. In these 300 plus fields, service center staff agreed to perform all required work by charging $10 for the 2 to 4 inch sample and another $10 for the 4 to 8 inch sample. They would cover cost of the 0 to 2 inch sample and their time to complete the data collection form as part of the grant match. Upon receipt of the data collection forms, Heidelberg would reimburse the service centers (Appendix C) and provide them periodic summaries of soil testing results. Those farm service center assisting this project were: Tiffin Farmers Co-op and Cal-Mar Soil Testing Laboratory, Worthington, OH; Republic Elevator and Sure Tech Lab, Indianapolis, IN; Sunrise Cooperative, Inc. - Attica Branch and Sure Tech Lab, Indianapolis, IN.

Project Results

Due to the illness of one service center staff representative and a workload demand that shifted a second service center staff individual to soil sampling priorities outside the Rock Creek watershed, only 119 fields were sampled. In an attempt to increase sample numbers, a grant revision was requested and approved in the fall of 2007 which added the adjacent Morrison Creek and Honey Creek watersheds to the sampling area. This change could not overcome absences or constraints on service center personnel and only a few additional samples were obtained.

Figure 1 shows the extent and degree of soil test stratification by tillage categories defined by the data collection form. Stratification at the 0 to 2 inch depth is only apparent when moldboard plowing is removed

Figure 1. Phosphorus soil test stratification by tillage type in the Rock Creek watershed (119 fields). Calculated average soil test value for all samples is 42 lbs/ac Bray P1.

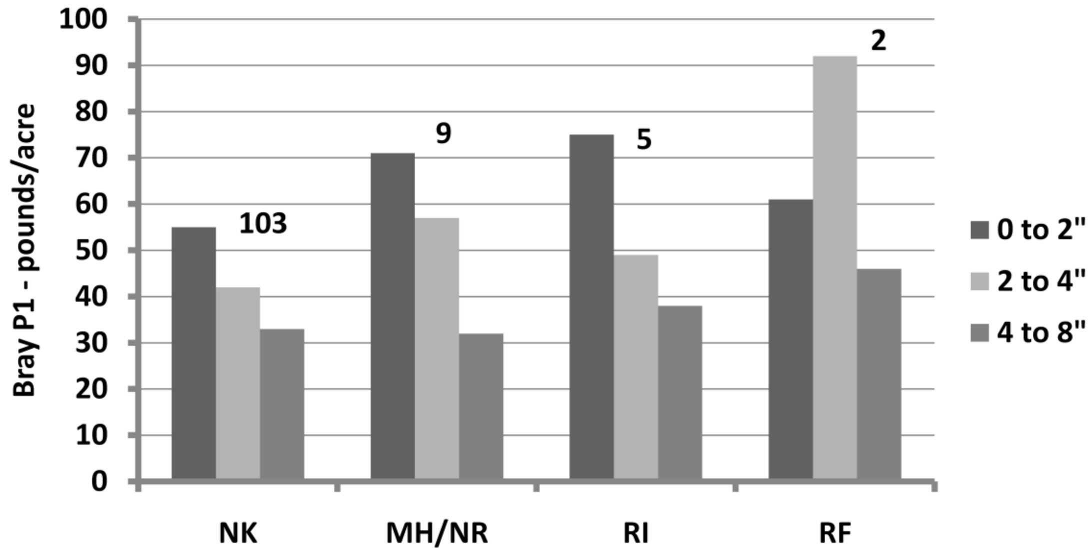


N/CRP	**None, Long Term CRP**
MP	**Mostly Moldboard Plowing**
RT/SP	**Reduced Tillage with Some Plowing**
MRT	**Mostly Reduced Tillage**
RT/SNT	**Reduced Tillage with Some No-till**
MNT	**Mostly No-till**

from a given category. When moldboard plowing remains in a category, little stratification occurs in the upper 0 to 4 inch soil layer. The greatest degree of 0 to 2 inch stratification occurs in the "Mostly No-till" category. When an average 0 to 2 inch soil test value is compared to a calculated average 0 to 8 inch value for fields in this category, the 1.72 ratio is less than reported in university research where ratios for strictly no-till systems range from two or three to one (ppt Slide 3). This difference seemingly results from the fact that the project tillage categories were not mutually exclusive. For example, one field was reported as "Mostly No-till" when in fact, the field was no-tilled for three years and moldboard plowed every fourth year. The degree of stratification can in some cases be altered as well when upper portions of the subsoil are included in the 4 to 8 inch fraction of the sample. Little stratification occurred in fields that had been planted to grass and enrolled within the Conservation Reserve Program for 10 years or more.

Figure 2 shows the extent and degree of soil test stratification by manure history categories defined by the data collection form. As would be expected by the selection of this watershed, only 7 fields had manures that were "recently" applied. Cattle manures were applied to 6 of these fields. In the 5 fields with "Recent but infrequent manure applications", most were under reduced or no-tillage systems, thus the stratification shown. In the two fields having "Recent and frequent manure applications", moldboard plowing dominated. This form of manure incorporation resulted in a "de-stratification" of phosphorus within the soil profile and caused greater soil test values in the 2 to 4 inch layer of soil. The "No known manure applications" category (103 fields) essentially represents all tillage categories within the watershed and therefore an estimated average soil test stratification condition for the entire watershed.

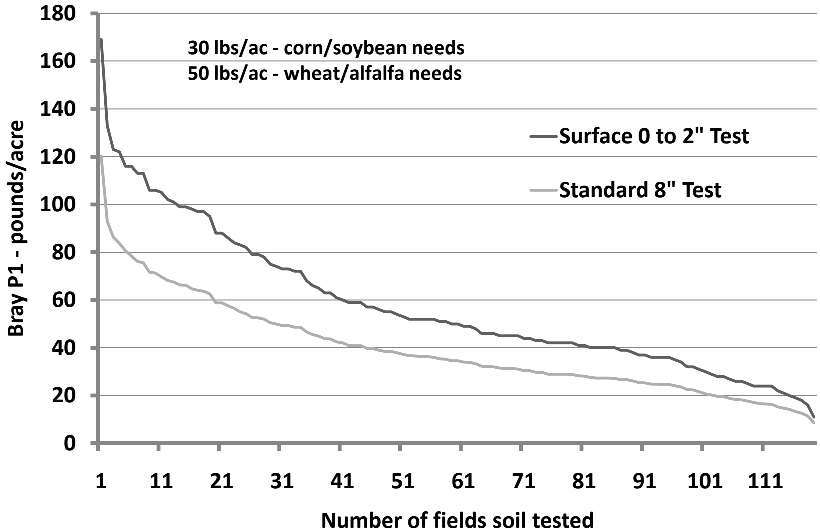
Figure 2. Phophorus soil test stratification by manure history in the Rock Creek watershed (119 fields).



NK	**No known manure applications**
MH/NR	**Manured historically but not recently**
RI	**Recent but infrequent manure applications**
RF	**Recent and frequent manure applications**

Figure 3 shows the distribution of Rock Creek soil test data from both the 0 to 2 inch and calculated 0 to 8 inch depths for the 119 fields sampled. Of key interest is the fact that 0 to 2 inch soil test values are typically greater than those indicated by a 0 to 8 inch sample. When this is the case, the potential for DRP losses from a given field would be underestimated by a standard soil test sample. Of equal interest is the fact that 71 of the field soil test values from the calculated 0 to 8 inch depth exceed the "critical soil test level" required for optimal economic growth of corn and soybean crops (30 lbs/ac Bray P1). Similarly, 31 of the fields exceed the "critical soil test level" required for optimal economic growth of wheat and alfalfa crops (50 lbs/ac Bray P1). This means that in many instances, the soil is over enriched with phosphorus for the planned crop, especially for the most common crops of corn and soybeans. In all instances, however, the phosphorus soil test values of both the 0 to 2 inch and calculated 0 to 8 inch depths are far below the 300 lbs/ac Bray P1 level used in Ohio as an upper limit of environmentally acceptable phosphorus soil test levels. At issue is the fact that losses of DRP in runoff from soils between the "critical level" and the "environmental level" are not well understood for Ohio soils.

Figure 3. Distribution of Rock Creek soil test data from 119 fields.



Discussion

Do elevated phosphorus soil test values at the surface of a field really contribute significantly to increased DRP levels in runoff? They do at some degree but is the impact significant or are there other factors to consider? Research by Sharpley and others (ppt Slide 8) has shown that in the absence of recently applied manures or commercial fertilizers, the concentration of DRP in runoff does increase as soil test values increase. However, the soil test values recorded in the Rock Creek watershed are at the lower end of the response range where DRP increases are small relative to increases in soil test values. In contrast, research in Wisconsin by Andraski and Bundy has shown substantial increases in DRP runoff concentrations from fields with similar soil test values as those found in Rock Creek, particularly for poorly drained soils (ppt Slide 9)

The Phosphorus Index (PI), a tool used by many states to assess the risk of individual fields to contribute phosphorus in runoff, is used as a means to integrate all of the factors that contribute to phosphorus runoff from fields. A USDA-Agricultural Research Service publication (10) describing PI development indicates that field applications of manures and fertilizers have 5 times the impact on DRP runoff concentrations compared to an equivalent increase in soil test value. Recent information compiled by Vadas and others (ppt Slides 10-14) shows that nearly half of phosphorus fertilizer applied can be lost to runoff when large storm events occur within a day of application. DRP losses in subsequent storms can also be substantial with losses being even greater from crop residues and grasses where applied fertilizers have less opportunity to interact and bind with exposed soil. USDA-Economic Research Service data for Ohio (ppt Slide 15) show that from 1996 to 2005, about 25 percent of phosphorus fertilizers applied to corn acres was not incorporated but left on the surface. For soybeans nearly 60 percent of phosphorus fertilizers applied was not incorporated; for wheat, it was nearly 80 percent not incorporated. In context of the Vadas research, these figures suggest ample opportunity for DRP runoff losses when storms occur even several weeks after fertilizer application. An example of this condition would be when phosphorus fertilizers are applied in fall on soybean residues prior to no-till wheat planting. At this time of year, there is also greater opportunity for runoff with increasing soil moisture levels and limited opportunity for nutrient uptake by the wheat crop after dormancy. All this heightens the chances for DRP losses to streams in fall and winter when it is most commonly observed (ppt Slide 16).

<u>Summary</u>

So what is the added value of collecting stratified phosphorus soil test data? Results summarized by this project suggest that stratified data provides another dimension to the interpretation of both phosphorus needs for crop production and the levels of phosphorus available for surface runoff. This concept is best understood when soil test phosphorus values are viewed as an integration of past phosphorus fertilizer and manure management practices as modified by crop yields, form of tillage, erosion and leaching. If standard 0 to 8 inch soil test values are high relative to crop production needs, then past fertility programs have typically supplied more phosphorus than crops require, crop yields have been lower than expected or both may have occurred. Under these conditions, farmers could expect increased profits by limiting additional inputs of phosphorus. If 0 to 2 inch soil test values are high and stratification is indicated, then past crop rotations and tillage systems have afforded fewer opportunities for the incorporation of phosphorus fertilizers or manures into the soil profile where they can be most effectively used by plants. This condition increases the amount of time phosphorus fertilizers or manure are lying unincorporated on the soil surface and exposed to rainfall events and subsequent runoff as DRP. From a farmers standpoint, phosphorus fertilizers or manures expected to aid crop growth and production are literally washed away where they can only cause over enrichment of freshwater streams and lakes (ppt Slide 17).

It might then be concluded that while elevated soil test levels on a field surface can measurably increase runoff DRP, this analysis suggests that annual management of commercial and manure phosphorus fertilizers may play a more important role in DRP losses. When phosphorus is managed from this new dimension, however, the opportunities for improved on farm profits and reduced off site costs abound.

<u>On Farm DRP Management</u>

Following are a number of practices farmers might employ to improve profits and reduce losses of DRP in agricultural runoff:

1. SOIL TEST!!! Include 0 to 2 inch depth samples in no-till or minimum tillage situations.
2. Read and study the phosphorus section of the Tri-State Fertility Guide. See Figure 1 in the Guide and understand "critical level" and "maintenance limit" as well as soil test buildup, maintenance and drawdown ranges.
3. Where soil test phosphorus values are above the "maintenance limit" for crop yield goals, follow the "drawdown" recommendations for phosphorus fertilizer needs, if any.
4. Avoid surface broadcast applications of phosphorus fertilizers and manures unless incorporated by some form of tillage. Other options are injection and banding.
5. Avoid fertilizer or manure applications on frozen/snow covered soils or before intense rain storm events.

6. Manure test to quantify phosphorus nutrient value; then match manure application rate with crop needs.
7. Add phytase enzymes to feed to enhance phosphorus nutrient utilization by hogs and chickens.
8. Use manure or soil amendments like aluminum or ferrous sulfate to stabilize dissolved phosphorus.
9. Use upland grass or tree buffers to permit greater infiltration of dissolved phosphorus in runoff.
10. Establish winter cover where growing roots can retain dissolved phosphorus in fields.
11. Where 0 to 2 inch soil test phosphorus levels are high (two times the "maintenance limit" for corn or soybeans or 120 lbs/ac Bray P1), consider a onetime inversion of the soil profile; then resume conservation tillage methods.

Main Activities and Outcomes

This grant project was very timely and provided important insight to many related projects to follow.

1. Assisted with work planning details for the USEPA Targeted Watershed Grant ($900,000) for the Honey Creek watershed located immediately south of the Rock Creek watershed.
2. Provided important background information and preliminary data for the Great Lakes Protection Fund grant ($940,000) approved to develop a "soil test metric" for determining on a larger scale what impact stratification of phosphorus within the soil profile might have on DRP runoff to the Great Lakes ecosystem. The entire Sandusky River watershed was selected for this grant initiative.
3. Helped guide efforts of the Ohio EPA Phosphorus Task Force to evaluate DRP impacts on Lake Erie by providing current stratified phosphorus soil test data for a watershed, Rock Creek, within the Lake Erie basin.

In addition to these contributions, the grant project produced several multi state level presentations on the topic of phosphorus soil test stratification with respect to water quality concerns and improved nutrient management practices.

1. Soil test phosphorus trends and stratification in Northwest Ohio soils. Crumrine, J.P., Baker, D.B. and Richards, R.P. (National Center for Water Quality Research, Heidelberg University). Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.
2. Elevated soil test phosphorus levels may explain increasing dissolved reactive phosphorus in Western Lake Erie tributaries. Crumrine, J.P., Baker, D.B. and Richards, R.P. (National Center for Water Quality Research, Heidelberg University). 7th Annual Tri-State Conservation Farming Expo, February 27, 2008. Auburn, IN.
3. Elevated soil test phosphorus levels may explain increasing dissolved reactive phosphorus in Western Lake Erie tributaries. Crumrine, J.P., Baker, D.B. and Richards, R.P. (National Center for Water Quality Research, Heidelberg University). 2008 Annual Meeting - The Ohio Academy of Science, April 12, 2008. University of Toledo.

Locally, many activities were accomplished, as well, to raise awareness of the grant project goals and purpose. Some of these were: presentation to local Farm Bureau representatives, news releases in the local Advertiser-Tribune paper, mailing to watershed farmers, article in Seneca Soil and Water Conservation District newsletter, periodic meetings with participating farm service representatives to assess project progress, stratified phosphorus soil test data summaries for use by farm service representatives, sharing project progress and status with members of the Sandusky River Watershed Steering Committee and involving the local OSU Extension Agent and the local Soil and Water Conservation District Manure Management Specialist with interpretation of project data.

References used in Power Point Presentations and Technical Report:

Mallarino, Antonio. 1999. Soil phosphorus testing for crop production and environmental purposes. Proceedings of the Integrated Crop Management Conference, p 185-192. Iowa State University Extension. Ames, Iowa.

Minor, Harry C., John Stecker and J. R. Brown. 2006. Fertilizer Management for No-till Corn and Sorghum in Missouri. University of Missouri Extension Publication G9176.

Johnson, Jay and Mark Loux. 1995. Best Management Practices: Managing Fertility in No-till. Ohio State University Extension Publication AGF-209-95.

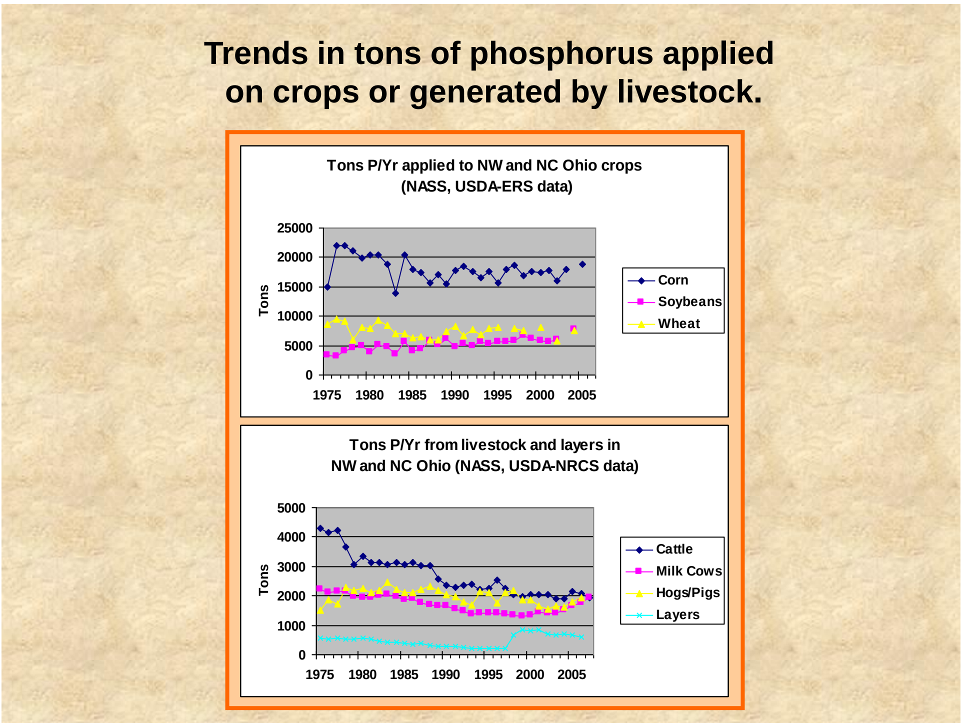
Sharpley, A. N., T. Daniel, T. Sims, J. Lemunyon, R. Stevens and R. Parry. 2003. Agricultural Phosphorus and Eutrophication, 2nd edition. U.S. Department of Agriculture, Agricultural Research Service, ARS-149, 44 pp.

Vadas, P.A., L.B. Owens, and A.N. Sharply. 2008. An Empirical Model for Dissolved Phosphorus Runoff From Surface-Applied Fertilizers. (draft for submission).

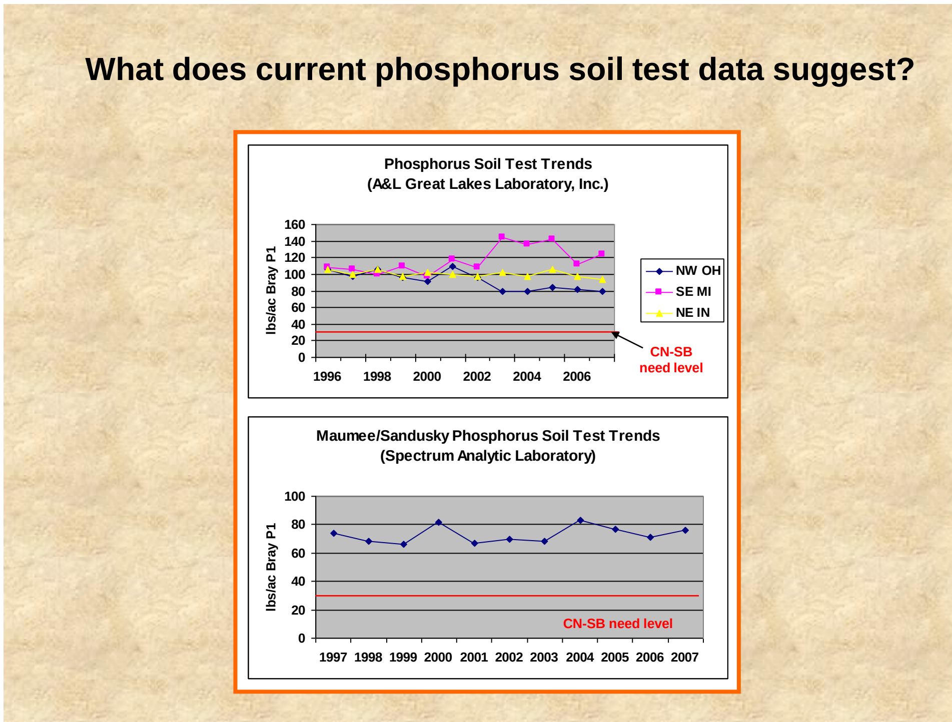
Vitosh, M.L., J.W. Johnson, and D.B.Mengel. 1995. Tri-State Fertilizer Recommendations for Carn, Soybeans, Wheat and Alfalfa. Extension BulletinE-2567. Michigan State University, The Ohio State Universtiy, and Purdue University.

Voss, Regis and Bill Griffith. 1998. Phosphorus and Surface Water. Illinois Fertilizer and Chemical Association. St. Anne, Illinois.

Appendix A: Selected Power Point Slides



Ppt Slide 1. Slide 9 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.



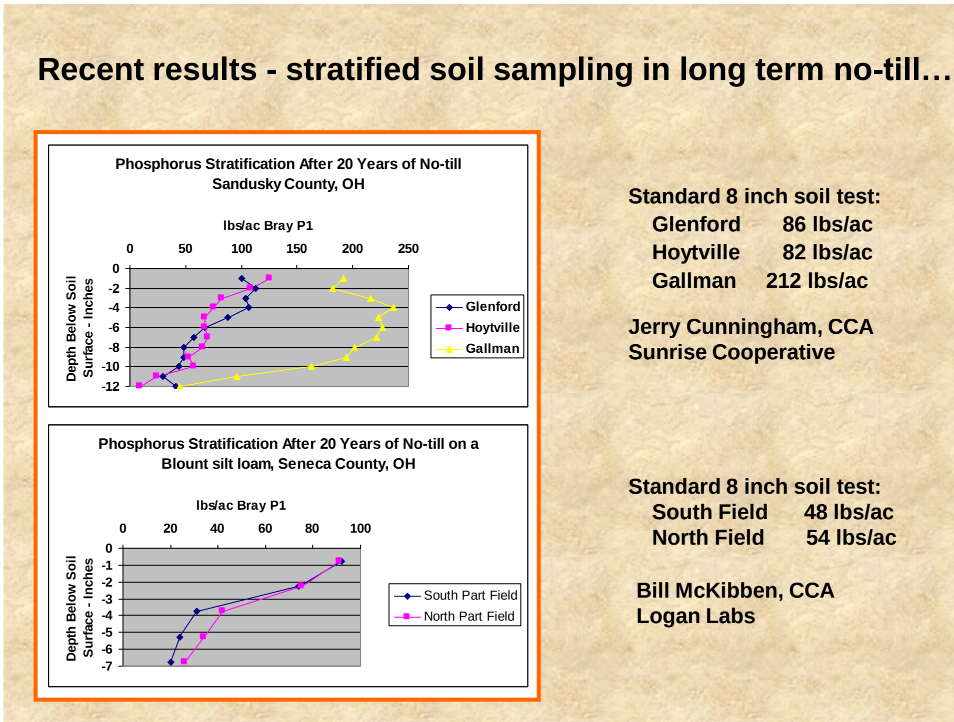
Ppt Slide 2. Slide 17 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.

Conservation tillage (lack of moldboard plowing) can result in the stratification of P near soil surface . . .

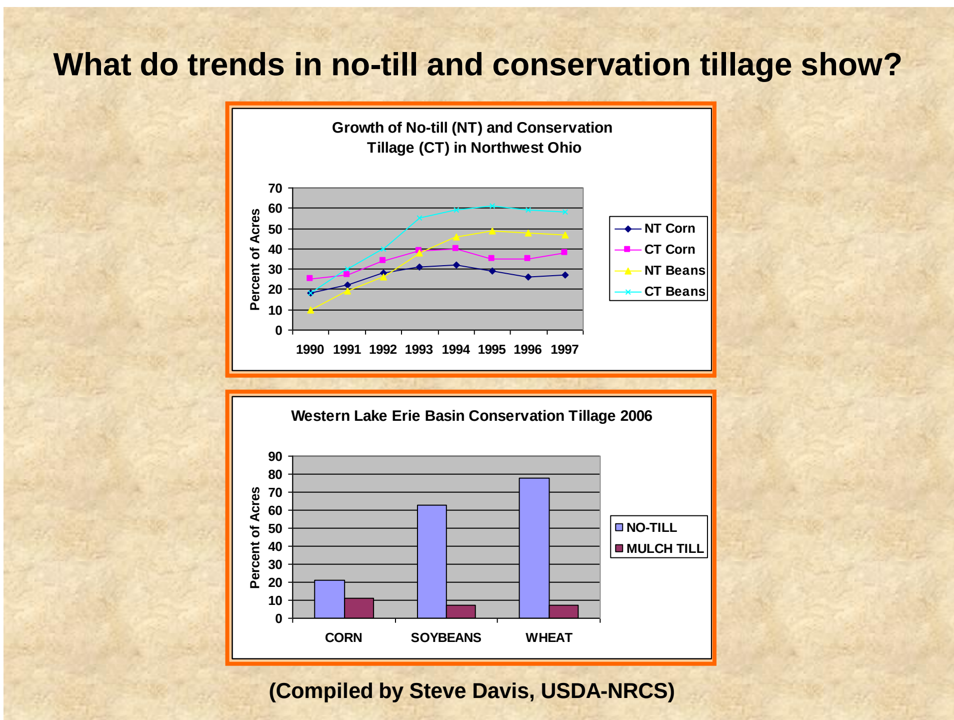
Percent increase in soil test P (Bray P-1, lbs/ac) in the upper 2 to 3 inches of the soil profile after long term (7 to 20 years) tillage studies:

Long Term Study	Plow	Chisel	(% Incr.)	No-till	(%Incr.)
U of Missouri	49	121	(247)	168	(343)
Ohio State U	74	170	(230)	180	(243)
Iowa State 1	58	101	(174)	141	(243)
Iowa State 2	66	124	(188)	132	(200)
Miss. State	78	172	(221)	182	(233)
Average Long Term Increases:			(212%)		(253%)

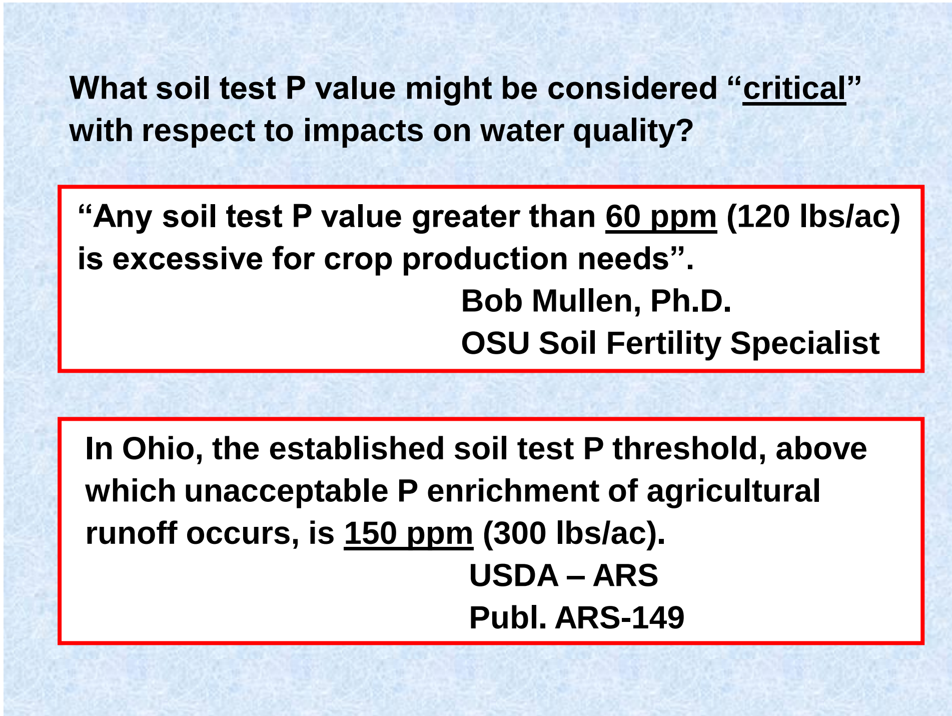
Ppt Slide 3. Slide 13 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.



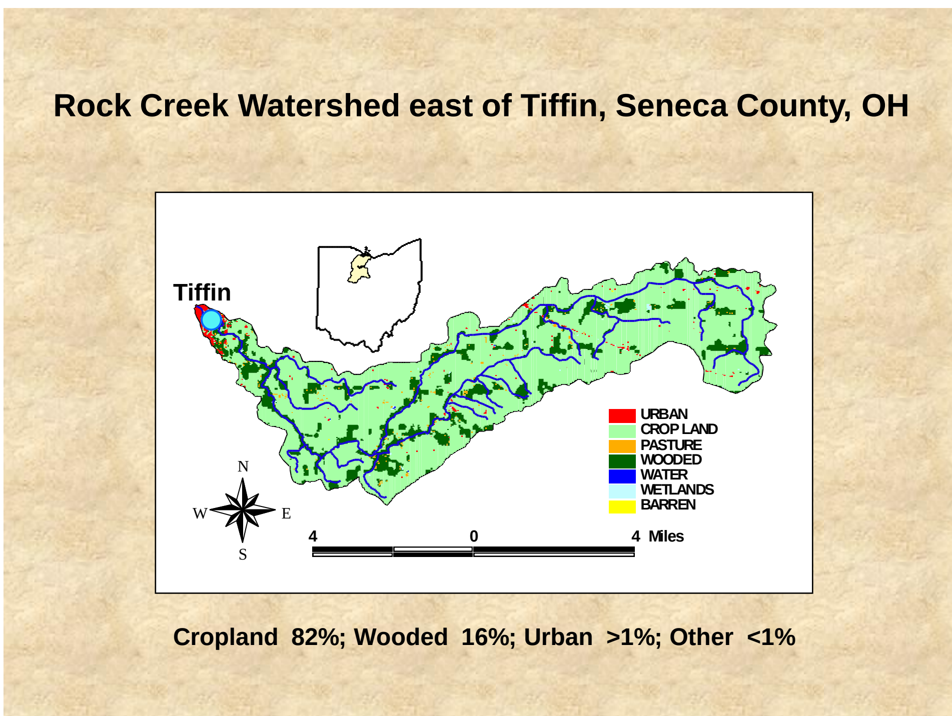
Ppt Slide 4. Slide 19 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.



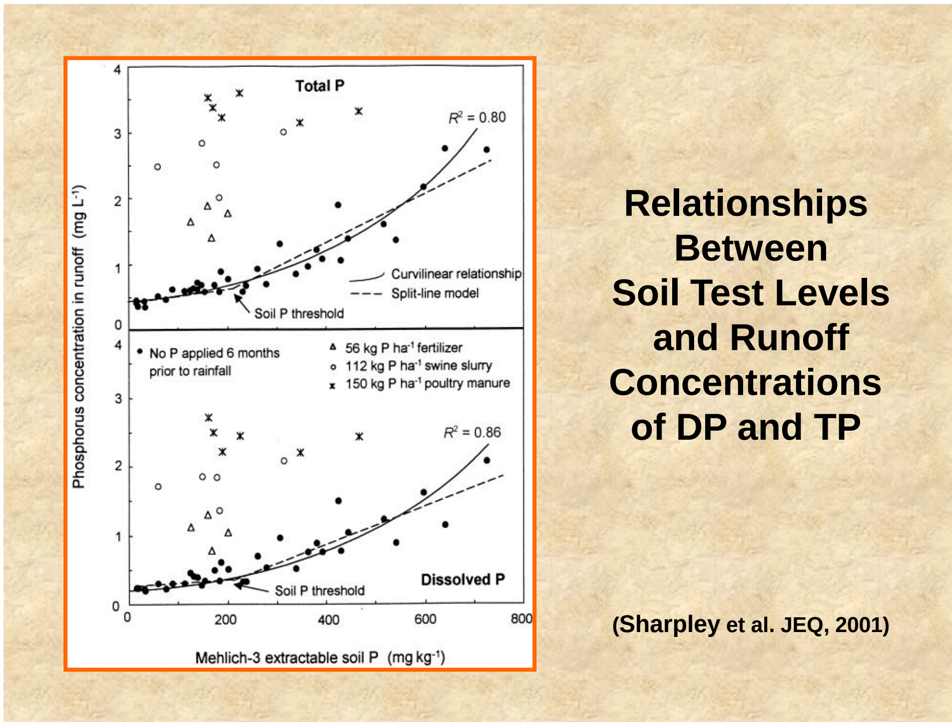
Ppt Slide 5. Slide 22 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.



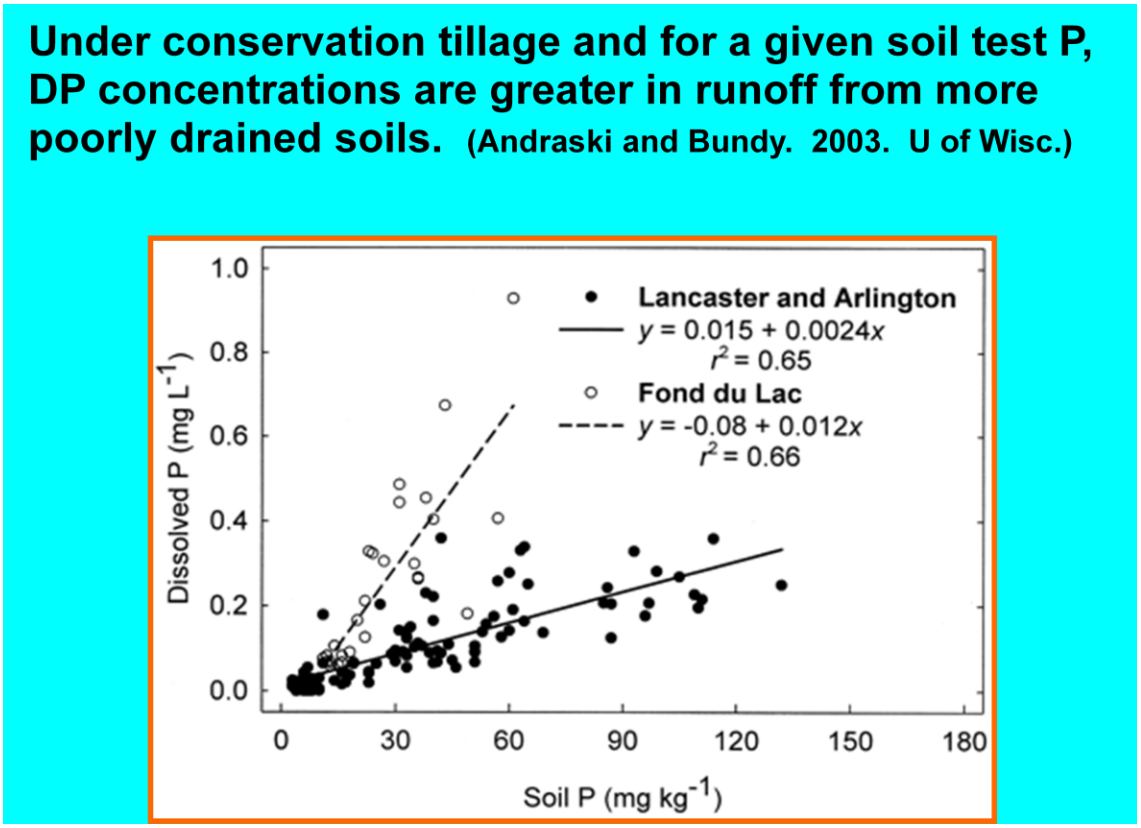
Ppt Slide 6. Slide 5 of power point presentation at the 2008 Annual Meeting - The Ohio **Academy of Science, April 12, 2008. University of Toledo.**



Ppt Slide 7. **Slide 4 of power point presentation at Heidelberg University Site Review Visit by** Lake Erie Protection Fund staff and advisors. November 27, 2008.



Ppt Slide 8. Slide 11 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.



Ppt. Slide 9. Slide 15, 7th Annual Tri-State Conservation Farming Expo,Auburn, IN February 27, 2008

An empirical model for dissolved phosphorus (DP) in runoff from surface applied fertilizers. Vadas, Owens and Sharpley. 2007.

… helps explain soil test P stratification and DP transport mechanisms!

1. **Fertilizer P fixation into the soil prior to first storm event and for differing soil cover conditions.**
2. **DP release to runoff and/or leaching by storm sequence following fertilizer P application.**
3. **Impact of storm intensity on the distribution of DP for either runoff and/or leaching.**

Ppt. Slide 10. Slide 24 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.

Percent applied fertilizer P remaining on the soil surface after application and before the first rain event (Vadas etal. 2007).

Days after Application	Soil Cover Condition: Bare	Soil Cover Condition: Crop Residues	Soil Cover Condition: Grass
0	100	100	100
1	65	75	85
4	48	58	68
12	35	45	55
25	27	37	47

Ppt. Slide 11. Slide 25 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.

Potential for DP release from surface fertilizer P application by storm number (Vadas etal. 2007).

Storm No.	Percent DP release to runoff or leaching
First	75% of available fertilizer
Second	40% of available fertilizer
Third	7.5% of available fertilizer
Others	7.5% of available fertilizer

Ppt. Slide 12. Slide 26 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.

Storms of different sizes produce different amounts of DP for runoff and leaching (Vadas etal. 2007).

	Distribution of Available Fertilizer P	
Storm Type	For Runoff	For Leaching*
Low runoff	5%	95%
Med runoff	20%	80%
High runoff	60%	40%

*** Note: Leached DP typically binds to clays or organic colloids at or near the soil surface.**

Ppt. Slide 13 Slide 27 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.

Percent DP released to runoff – immediate storm:

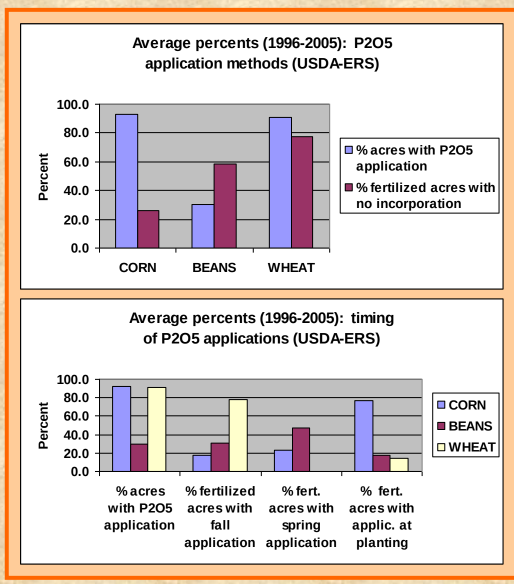
Storm type	Bare	Crop Residues	Grassed
		Soil Cover Condition	
Lo runoff	4	4	4
Med runoff	15	15	15
Hi runoff	45	45	45

Percent DP released to runoff – rain after 4 days:

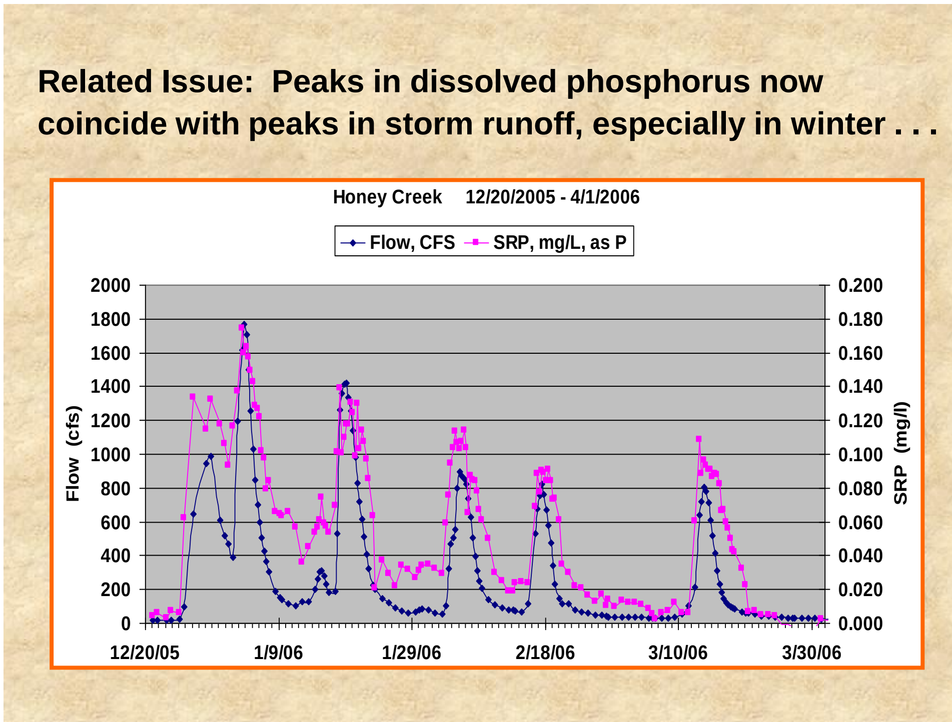
Storm type	Bare	Crop Residues	Grassed
		Soil Cover Condition	
Lo runoff	2	2	3
Med runoff	7	9	10
Hi runoff	22	26	31

Ppt. Slide 14. Slide 28 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.

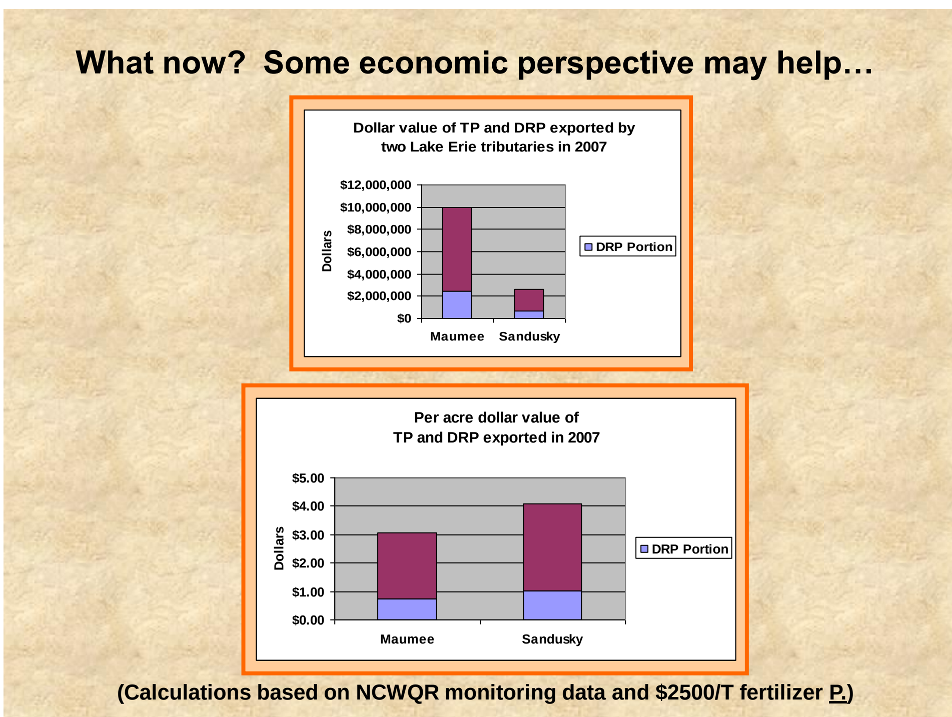
What about method and timing of P2O5 fertilizer application for corn, soybeans and wheat in Ohio?



Ppt Slide 15. Slide 23 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.



Ppt Slide 16. Slide 6 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.



Ppt Slide 17. Slide 29 of power point presentation at the Conservation Tillage and Technology Conference, February 21 and 22, 2008. Ohio Northern University, Ada, OH.

Appendix B.

DATA COLLECTION SHEET
ROCK/HONEY CREEK STRATIFIED SOIL TESTING FOR PHOSPHORUS

SAMPLE DATE: Month_____________ Day___________ Year__________

LOCATION: Township_____________________________ Section__________

FIELD TILLAGE HISTORY (circle one):

1. Mostly moldboard plow
2. Reduced tillage with some moldboard plowing
3. Mostly reduced tillage
4. Reduced tillage with some no-till or strip till
5. Mostly no-till or strip till

FIELD MANURE HISTORY (circle one):

1. Manured historically but no recent applications
2. No known manure applications
3. Recent but infrequent manure applications
4. Recent and frequent or routine manure applications

TYPES OF MANURE RECENTLY APPLIED (circle one or more):

1. Dairy   2. Cattle   3. Hogs   4. Poultry   5. Sheep

PHOSPHORUS SOIL TEST DATA:

	0 to 2 inch	2 to 4 inch	4 to 8 inch
P lbs/ac	________	________	________

INTERPRETIVE SOIL TEST DATA:

	0 to 2 inch	2 to 4 inch	4 to 8 inch
CEC meq/100g	________	________	________
pH	________	________	________
OM%	________	________	________
K lbs/ac	________	________	________
Ca lbs/ac	________	________	________
Mg lbs/ac	________	________	________

SOILS LAB ID NO. ________ ________ ________

FIELD REPRESENTATIVE
REPORTING____

Appendix C

(Month, Day, Year)

TO: John Crumrine
Agricultural Project Coordinator
National Center for Water Quality Research
Heidelberg College
310 East Market Street
Tiffin, OH 44883

RE: Lake Erie Protection Fund Grant
Rock/Honey Creek Stratified Soil Testing for Phosphorus
BILLING FOR COMPLETED SOIL TESTING

Please find enclosed copies of soil test reports and related interpretive sheets for soil tests taken from ______________ locations (fields, portions of fields, grids).

The following number of samples were processed and tested by our laboratory from the above locations:

________ samples at the 2 to 4 inch depth @ $10.00 per sample or $____________

________ samples at the 4 to 8 inch depth @ $10.00 per sample or $____________

Please reimburse us for a total amount of $_______________.

Name of Company Representative
(Signature of Company Representative)