On-Farm Demonstrations of Manure Phosphorus Management
Integrated Farm and Livestock Management Demonstration Program
Project No. 05IFLM004 Crop Years 2004-2005

Livestock-intensive farms in eastern Iowa are potential high-environmental impact farms that can profitably use on-farm nutrients. The operators of these farms often do not account for current and past nutrient contributions supplied from on-farm manure applications to their fields. Full rates of commercial nitrogen and phosphorus are applied even where manure applications may be supplying partial or full crop nutrient needs. With excess nutrient applications from on-farm and commercial sources the risk for pollution to the local environment increases. This project sought to establish on-farm demonstrations of nutrient management and utilization from manure and fertilizer sources that reduce pollution risks on eastern Iowa livestock and crop farms. The demonstrations, conducted along with information and educational programs, are locally applicable to a majority of producers throughout eastern Iowa.

The principal goal of the project is to increase producer confidence in manure utilization for crops based on phosphorus and nitrogen content. Emphasis is also placed on refined use of commercial nitrogen and phosphorus on acres not always receiving manure due to the environmental and economic outcomes associated with over-application of commercial nutrients. The more confidence producers have in understanding their soil tests, plant tissue analyses, economic optimum fertility rates and on-farm nutrient resources, the better they can manage nutrient inputs from both a production and a regulatory standpoint. Whatever their source of nutrient and manure management assistance/recommendations, the individual producer ultimately has responsibility to make the right decisions. This is especially true due to the need for constant adjustment of management plans throughout the crop year and annual evaluation in succeeding years depending on weather and other conditions.

Project Objectives:

1) Demonstrate crop response to the application of livestock manure at the P crop removal rate.

2) Demonstrate the economic value of manure nutrients compared to commercial fertilizer when various forms of manure are applied as a crop nutrient source.

3) Demonstrate implementation of the Iowa P index to evaluate P applications by management areas at the field or sub-field level, considering soil types, soil test levels, on-farm nutrients and economic analysis.

4) Promote partnerships/manure exchange opportunities with non-livestock producers in concentrated livestock production areas.

5) Demonstrate refined nitrogen management through the use of performance-based nutrient management evaluation.

This project was carried out by Iowa State University Extension with funding from the Iowa Department of Agriculture and Land Stewardship Integrated Farm and Livestock Management Program, Project No. 05IFLM004. Additional funding was provided by the USDA CREES Water Program, the Iowa Corn Growers Association and the Iowa Farm Bureau Federation

Demonstrate crop response to the application of livestock manure at the P crop removal rate.

Most swine producers or row-crop producers utilizing swine manure may benefit from refined manure management planning based on economics rather than new manure application regulations. To demonstrate manure application nearer to the phosphorus (P) crop removal rate a new approach was attempted this year. The objective was to show producers how to better evaluate their manure management plans through soil and tissue sampling. Cooperators were sought prior to planting using regional media and Extension specialist newsletters. While the goal was to work with 20 producers only 10 producers inquired and signed on with the project.

At each location, manure had been applied in the fall according to the individual producer's manure management plan. Swine finishing manure had been applied at rates between 3000-4000 gallons per acre to supply the corn crop nitrogen needs. Swine nursery and sow unit manure was applied at nearly twice those rates. The dairy manure was fall-applied at 4000 gallons per acre while the poultry layer manure was applied at 2 tons per acre with 50 pounds of nitrogen applied in the spring.

Most of the cooperators had never attempted to evaluate their manure applications with anything other than yield comparisons between manured and non-manured strips. The challenge of this effort was to entice the individuals to initiate an evaluation process by easing them into it with Extension support the first year.

Late spring nitrate test samples were collected in June when the corn crop was 6 to 12 inches tall. The results are shown in Table 1. Producers received the results within a week. Two producers decided to apply additional nitrogen in strips where LSNT values were low. The critical LSNT value when manure is applied is 15 parts per million. On average, the LSNT showed that the manure applications were more than adequate to maximize crop profitability.

Manure source	**LSNT (ppm)**			**Stalk Nitrate (ppm)**		
(# of LSNT samples)	**Avg.**	**Range**		**Avg.**	**Range**	
swine finisher(28)	34	12	62	3104	18	7070
swine nursery(2)	26	24	27	938	877	998
swine sow unit(6)	40	17	79	8065	7890	8240
dairy(2)	21	14	28	516	44	989
poultry(4)	25	20	27	2293	1510	4640

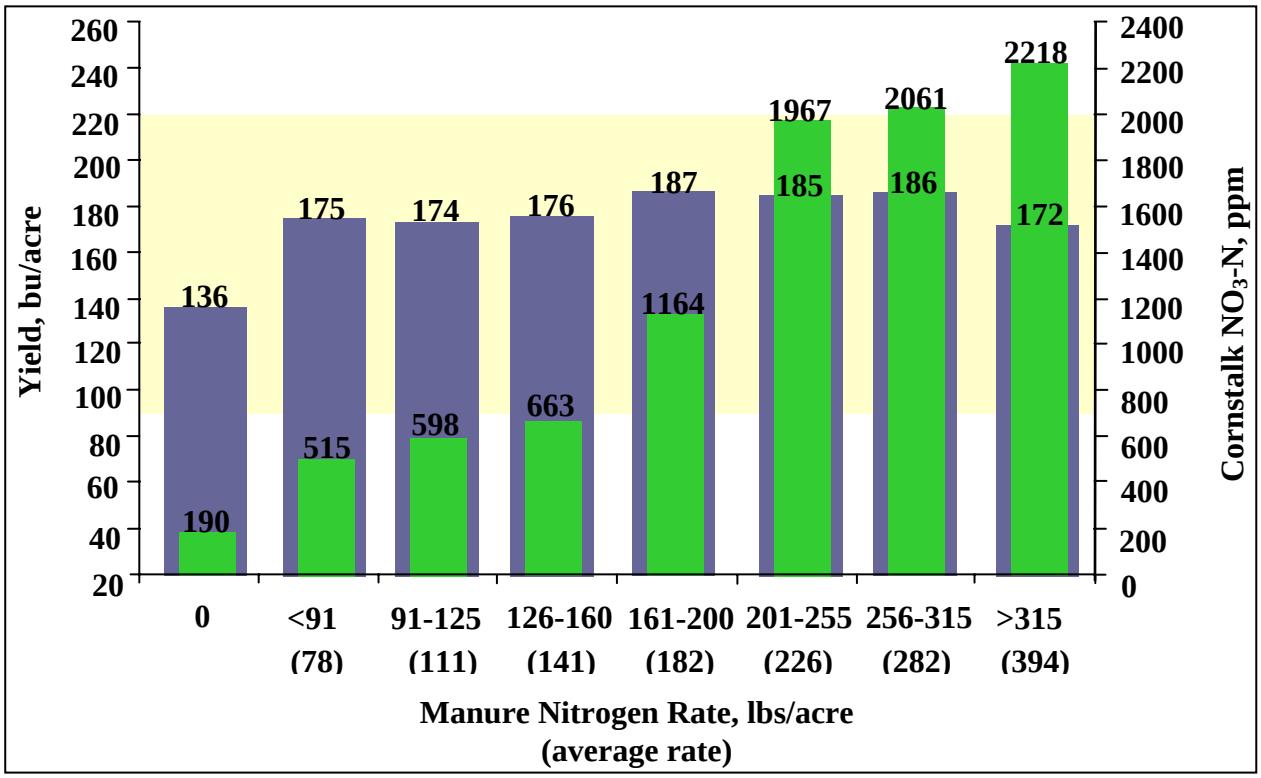
Table 1. Manure management plan evaluation soil nitrate and cornstalk nitrate results.

At harvest corn stalk nitrate samples were collected. Timing of sample collection was dependent on the cooperating producers contacting the project staff when each field was harvested. Not all of the producers followed through with this plan. Seven fewer fields were sampled in the fall than in the spring. Utilizing the stalk nitrate analysis as a gauge, the manure applications more than adequately supplied all the nitrogen needs for the crop. The average results and ranges for each type of manure are listed in Table 1.

On only two farms were the stalk results less than optimum, which is 700 to 2000 parts per million. These were the same two farms that chose to apply additional nitrogen based on their LSNT results. In each instant the manure had been surface applied without much incorporation.

Once the cooperators received their results they were encouraged to compare them against past project results combined with the Hub and Spokes Project and the Maquoketa Watershed Project. Expectations are that the producers will use their evaluation results to refine future manure applications. Past project results from forty swine manure demonstrations are very valuable during individual discussions and group presentations and are continually emphasized, especially now that fertilizer prices are rising dramatically. When these forty field demonstration comparisons are summarized, corn yield was maximized and cornstalk nitrate level optimized at an average rate of 182 pounds manure N per acre. Using a book value of 50 pounds N per 1000 gallons for dry feeder systems, this rate would equate to approximately 3600 gallons per acre. If a wet-dry feeder system was used the application rate could be reduced to 3100 gallons per acre.

Applying manure at higher manure N rates did not result in higher yields, just higher cornstalk nitrate levels. Individual operations may be able to refine their manure application rates even further by collecting stalk samples annually and monitoring cornstalk nitrate levels. Graph 1 shows that yield did not increase once cornstalk nitrate was higher than the optimum range, 700 to 2000 parts per million, shown by the yellow rectangle. An annual stalk sampling effort, in addition to manure sampling, will help to optimize each operation's manure management plan performance.

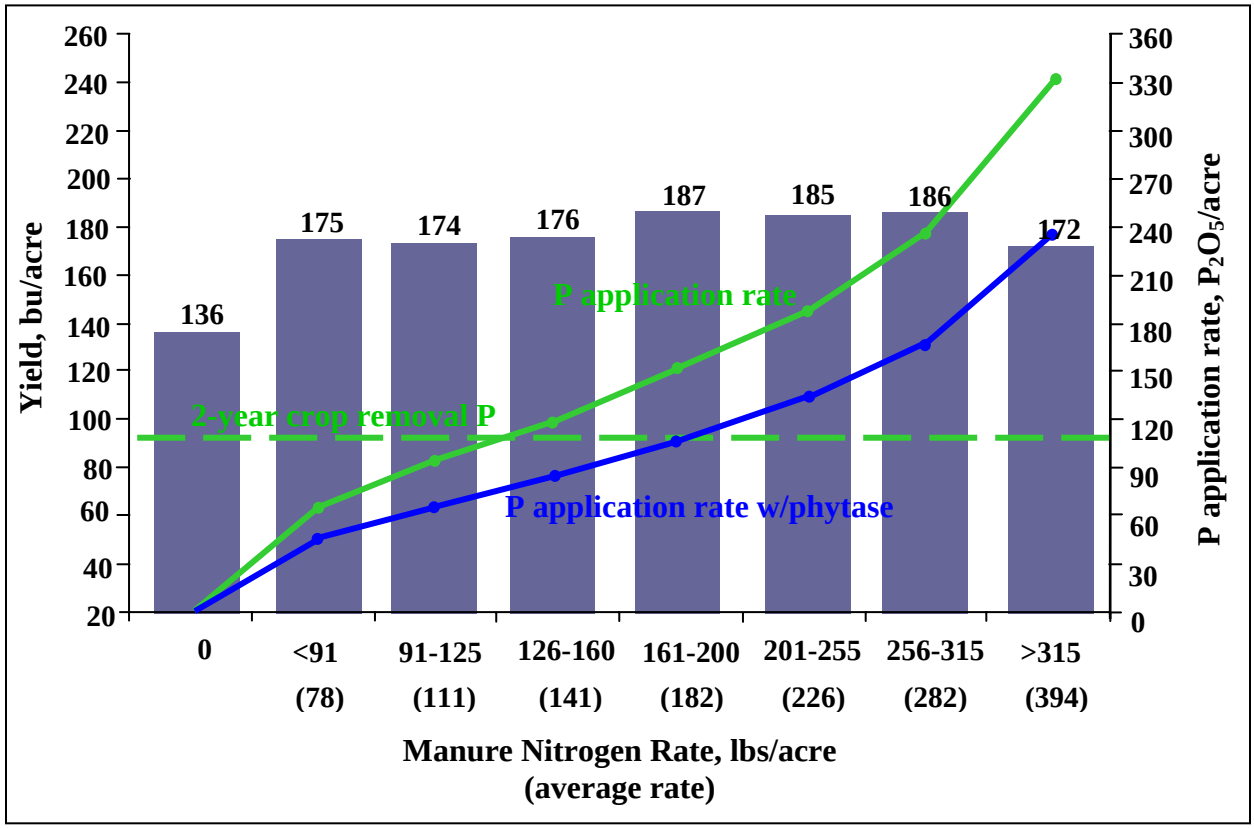


Graph 1. Corn yield and cornstalk nitrate for 40 swine manure management demonstrations, crop years 2002-04. Hub and Spokes Project, Maquoketa Watershed Project and Manure Phosphorus Management Project.

Phosphorus application was also compared to corn yield, shown in Graph 2. A two-year crop removal of phosphorus in a corn/soybean rotation would be approximately 110 pounds P_2O_5 per acre when corn yield is 185 bushels per acre and soybean yield is 50 bushels per acre. When manure was applied at the highest yielding manure nitrogen rate, 161-200 pounds N per acre, excess manure phosphorus was applied when a conventional feed ration was fed to swine.

Including phytase in the swine ration enables pork producers to reduce the amount of di-calcium phosphate in the ration, resulting in a 25-40 percent reduction of phosphorus in the manure. The blue line in graph 2 shows the manure P application rate when using phytase. In this scenario the manure P application rate at the highest yielding manure nitrogen application rate provides an equal amount of phosphorus removed by a corn/soybean crop rotation.

Livestock farmers can reduce the environmental impact of increasing soil phosphorus levels due to over application of manure P by using phytase, while at the same time applying sufficient manure nitrogen to maximize crop yield.



Graph 2. Corn yield, normal P application rate and estimate P application rate when using phytase in the swine ration for 40 swine manure management demonstrations, crop years 2002-04. Hub and Spokes Project, Maquoketa Watershed Project and Manure Phosphorus Management Project.

Demonstrate the economic value of manure nutrients compared to commercial fertilizer when various forms of manure are applied as a crop nutrient source.
A simple economic evaluation comparing the value of manure nutrients to a similar rate of commercial nutrients has been utilized with cooperators and during group presentations to answer the inevitable question, "What is manure worth?." Livestock manure, regardless of the source, provides significant levels of crop available nutrients. However, the value of manure nutrients will vary from farm to farm depending on the crop nutrient requirements of the growing crops based on yield, soil test levels and the cost to haul manure from the farmstead to the field.

Graph 3 shows an example of the potential value of swine manure. Considerations for the example include the cost of hauling ($.009/gallon), the value of commercial nitrogen, phosphorus and potassium ($.20, $.23 and $.13 per unit), corn yield and the value of the corn ($2.40 /bushel). The cost of application, shown by the red line, increased steadily as the volume of manure applied per acre increased.

If phosphorus and potassium soil test levels are greater than optimum, greater than 20 and 150 parts per million, the value of the manure is maximized at approximately $25 per acre, shown by the blue line. However, if phosphorus and potassium soils tests are optimum or lower, the value of the manure increases to nearly $80 per acre when manure nitrogen applications near 200 pounds N per acre. The cost to apply manure at this rate is near $50 per acre.

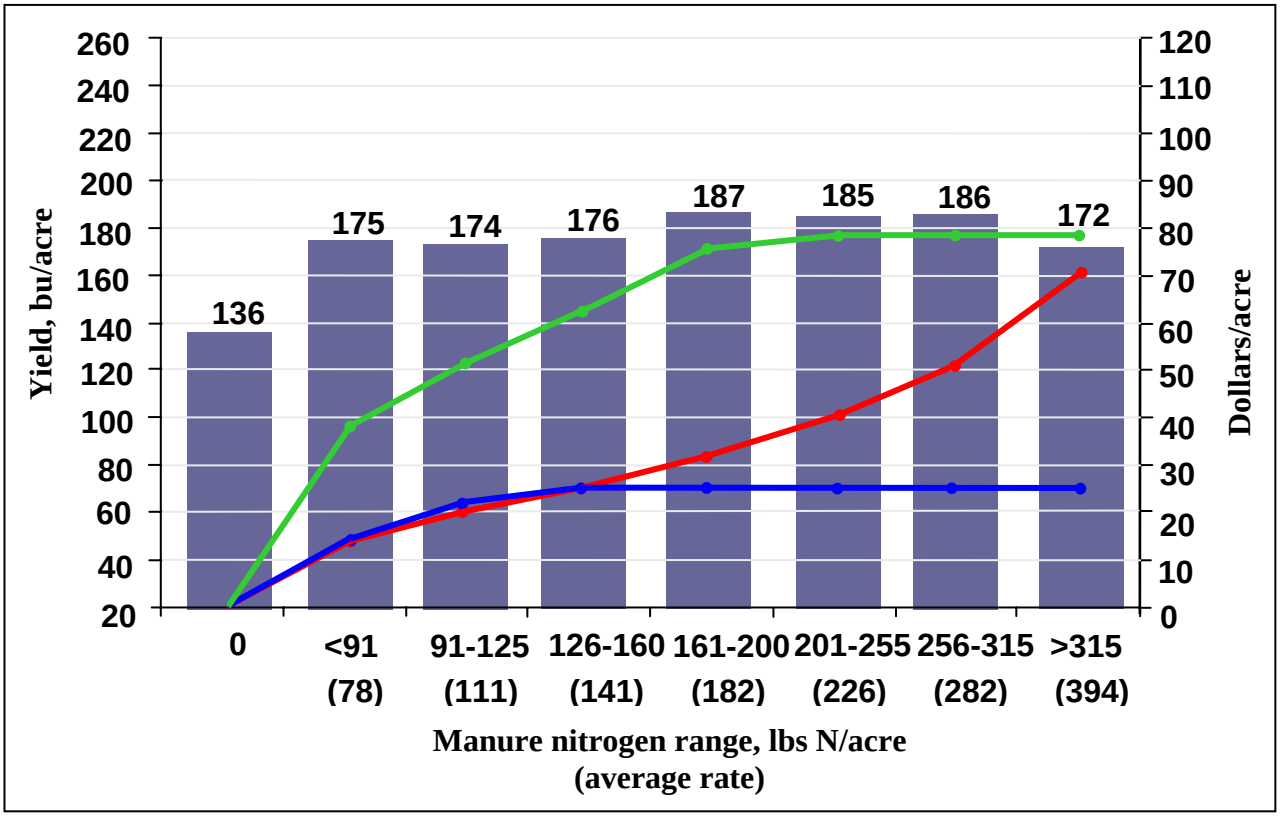


Figure 3. Corn yield, cost to apply manure, manure value when applied to fields with high soil P and K, manure values when applied to fields with optimum or lower soil P and K. Forty swine manure management demonstrations, crop years 2002-04. Hub and Spokes Project, Maquoketa Watershed Project and Manure Phosphorus Management Project.

As producers learn to evaluate manure applications based on economics they will quickly move to adopt new strategies to move manure applications to low testing fields, typically further from the farmstead and applying manure at the P crop removal rate. The new strategies will reduce manure applications on fields near the livestock production units while also reducing or eliminating commercial nutrient applications on fields that do not historically receive manure.

Farm profitability should increase as commercial nutrient applications are reduced and on-farm nutrients are used more efficiently. As on-farm and commercial nutrients are used more efficiently the environmental risks posed by over-application of nutrients should lessen.

Presentations have been made with partnering watersheds to promote the value of manure and best management practices associated with targeting manure applications to fields that may be less environmentally sensitive. A copy of the presentation can be found with the attachments and is titled *Maquoketa manure.*

Demonstrate implementation of the Iowa Phosphorus Index to evaluate P applications by management areas at the field or sub-field level, considering soil types, soil test levels, on-farm nutrients and economic analysis.

New manure planning and application regulations are causing livestock farmers to consider the impact of manure phosphorus applications for the first time. Most producers do not understand what the Iowa P Index is and how it might affect their operations. To demonstrate how the Iowa P Index is calculated a simple example was prepared using ArcView GIS, RUSLE2, the Iowa P Index and Microsoft Powerpoint. The sample can be found as an electronic attachment titled *P Index*.

Another avenue to demonstrate the P Index and also the Soil Conditioning Index was made available as three eastern Iowa watersheds, Hewitt Creek, Lime Creek and Coldwater-Palmer Creek, initiated a performance-based incentive program to improve water quality in their watersheds. The indices were added as prominent components in the incentive outlines. To demonstrate to the participants how the process might work, thirteen farmers cooperated by providing the background information, including soil test results, needed to calculate soil loss and the P Index. Calculations were completed for 102 fields, separated by P Index categories and summarized for the Hewitt Creek watershed. The results can be found as an attachment titled *Hewitt P_N info*. Stalk nitrate results from several farms are also ranked by value on page 3 of the attachment.

With their own results, the watershed council was comfortable discussing the incentive outline and developed a comprehensive incentive design based on their own information. As a result nearly 35 producers are currently enrolling into a performance-based incentive program for Hewitt Creek watershed. The performance-based approach is outlined in an attached presentation titled *Performance-based presentation*. Included are a description of the incentive structure and some detail of the primary components.

An important item learned by staff was that as new watersheds come on line it is critical to do examples based on one or two farms in each particular watershed so the local residents get a feel for the indices and how the results might look in their watershed program.

Individual meetings also have been held with producers wishing to learn more about the P Index or wanting to complete the P Index on their own farm. Through these meetings many producers realize that they do not have the time or desire to learn how to use RUSLE2 and the P Index on their own. However, they will have a greater understanding of what information they need to complete the P Index for their next manure management plan.

Promote partnerships/manure exchange opportunities with non-livestock producers in concentrated livestock production areas.

A partnership with the South Fork Maquoketa watershed project was developed to create a manure directory to promote manure exchanges and increase producer knowledge about the potential of manure use in crop production. The development of the directory was truly a team effort with the inclusion of a great deal of northeast Iowa manure management demonstration information. A copy of the directory is attached and is titled *Nutrient_trading_directory*.

While the number of producers willing to step up and to openly offer their manure was small the development of the directory has created discussion within the community. Through project outreach more crop producers are recognizing the potential value of manure to their farming operations. This recognition may help livestock producers in finding neighboring crop farmers willing to provide manure easements on their cropland, but measuring actual achievement or success in this objective is difficult.

Demonstrate refined nitrogen management through the use of performance-based nutrient management evaluation.

Eastern Iowa crop producers using a corn-soybean rotation do not always have livestock associated with their operations, but they still may be applying excess crop nutrients. Producers with past manure application history on their fields or a history of applying high nitrogen (N) rates may benefit from evaluating their nitrogen applications through performance-based tools such as the cornstalk nitrate test.

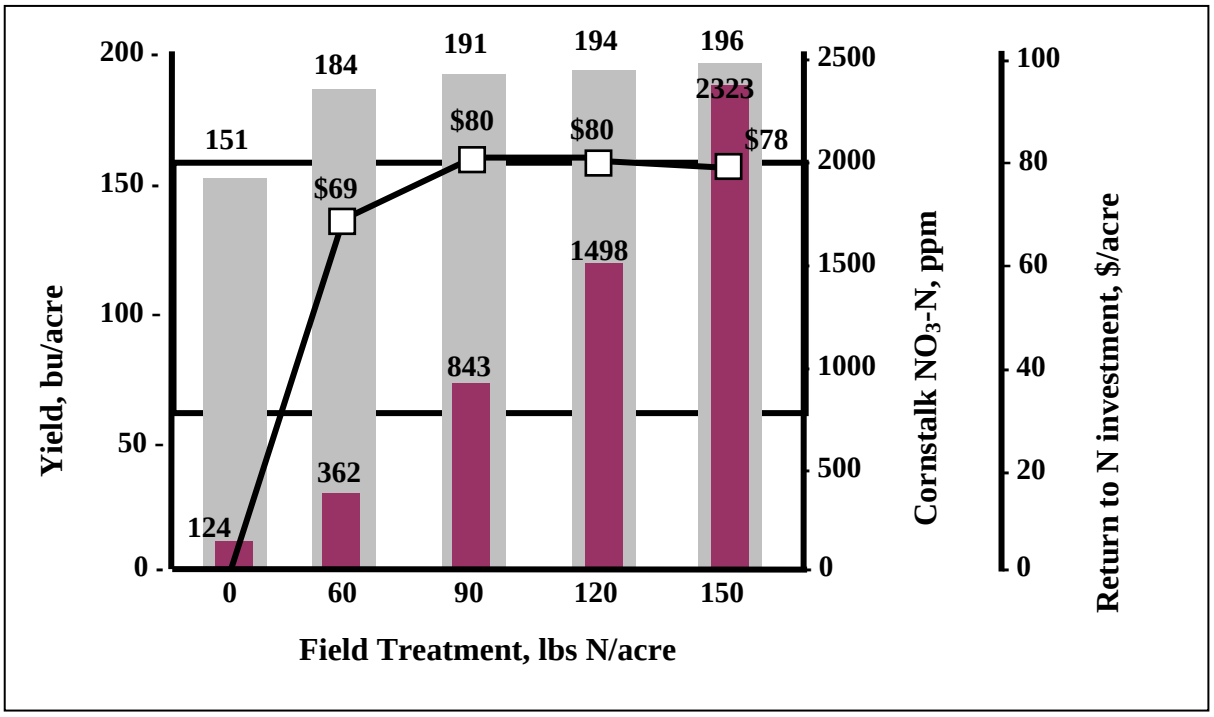
Iowa State University recommends applying 100-150 pounds N per acre for corn following soybeans versus applying 150-200 pounds N per acre for continuous corn. Higher corn yields, lower N application rates and potentially less environmental impact from N associated with a corn-soybean rotation encouraged producers in the eastern Iowa watersheds to explore ways to further refine University recommendations. These corn-following-soybean demonstrations show that N use is optimized when applied at rates between 90 and 120 pounds N per acre.

Eastern Iowa demonstration results from 18 field-scale N demonstrations are shown in Graph 4. The gray bars show the average yield for each of the five N treatments, ranging from 151 to 196 bushels per acre.

Residual nitrate-N in the cornstalks following corn maturity was measured for all N treatments, shown as the red bars in the graph. To measure the residual nitrate-N in the cornstalks, fifteen 8-inch segments of the lower stalk were collected from each N treatment and sent to a certified laboratory.

The zero check and 60 pounds N per acre treatments did not have enough N available to optimize corn production. Both the 90 and 120 pounds N per acre rates were within the optimum range of 700 to 2,000 parts per million (ppm), while the 150 pounds N per acre rate showed excess N remaining in the corn plant after maturity.

The optimum range for cornstalk nitrate-N of 700-2,000 ppm is marked by the rectangle in the background indicating a high probability that the appropriate N rate was applied to the crop to provide the most profitable return on the N investment.



Graph 4. Corn yield, end-of-season cornstalk nitrate-N results and return to N investment from 18 field-scale N rate demonstrations, 2002-04.

The average return to dollars spent for N fertilizer, priced at 20 cents per pound and corn at $2.40 per bushel, is shown as the black line on the graph. The best return to N fertilizer, $80 per acre, was at the 90 and 120 pounds N per acre rates. Application of N at rates higher than 120 pounds N per acre showed a reduction in net return to the N investment.

Producers have found that many times they can refine their nitrogen rate further than University recommendations, reduce input costs, maintain crop yield and improve farm profitability. More efficient use of nitrogen should enable producers to reduce the environmental impact of each cropping operation.

Cooperators in partnering watersheds are continually referring to these demonstration results as targets to guide possible nitrogen management changes in their communities. Farmers are encouraged to compare lower rates to their historic practices. Stalk sampling is encouraged so that each producer may have some additional evaluation measure to guide nitrogen management decisions. An example of how the Hewitt Creek watershed is "publicizing" their results can be seen in the attachment title *Hewitt P_N info*.

Project Outreach
The dissemination of project information is ongoing and being accomplished in several ways. These methods included publications, new releases, field days, educational programs and conference reports.

The primary method of outreach was the creation of the project Summary of Demonstration Results. This document is included in the attachments. The summary is a compilation of field demonstration results derived across a wide area of eastern Iowa. Multiple types of demonstrations are detailed in the summary along with specific information on topics such as the Iowa P Index, the cornstalk nitrate-nitrogen test and phosphorus application recommendations.

Three hundred fifty copies of the summary were printed and distributed. The summaries were printed on an office printer and provided to current and past cooperating producers, meeting attendees and other interested produces. Copies were also provided to local and state Extension staff and local and state agency staff. The summary has been a very popular means of receiving project information but it is a time consuming task to prepare, print and bind the publication.

News releases have been prepared to promote field demonstration results, field day events, cornstalk nitrate test sampling and soil sampling. Outreach via news releases could be enhanced with additional resources and communications assistance. Project results are applicable to a wide audience of eastern Iowa and need to be disseminated further to achieve greater project success.

Field days provided an opportunity for small group discussions of project activities during the growing season. Two events were held, one in the Hewitt Creek watershed and a second near West Union. Approximately 60 people attend each of the two events. The Hewitt Creek event focused on their watershed priorities and water monitoring while the West Union field day focused on no-till farming. At each event agency specialists along with local farmers highlighted their experiences on each of the topics. Participating producers were encouraged to comment on their personal observations and expectations.

Several educational programs have provided opportunities to reach producers in 9 eastern Iowa watersheds. Activities have included presentations, field demonstrations, manure spreader calibrations, P Index calculations and other one-on-one discussions. These watershed partnerships have included the Upper Maquoketa, South Fork Maquoketa, Hewitt Creek, Mineral Creek, Mud Creek, Lime Creek, Coldwater-Palmer Creek, Coffee Creek and Bear Creek. Presentations and project activities have also taken place in Howard, Fayette and Cedar counties and at the Northeast Research Farm at Nashua.

Demonstration information is also used by Extension area crop specialists Brian Lang, George Cummins, Virgil Schmitt and Jim Fawcett and area ag engineers Dan Meyer and Greg Brenneman during educational programs they offer to producers. These specialists cover 33 counties in eastern Iowa. Regional manure management information has been utilized during confinement site applicator training sessions held in 17 counties of northeast Iowa.

John Sawyer, ISU Agronomy, has used project results from eastern Iowa nitrogen management demonstrations during Ag Chem Dealer update meetings, Crop Advantage Conference meetings and the Integrated Crop Management Conference. Most recently this data has been used to develop the Nitrogen Rate Calculator which is used to determine optimal nitrogen application rates.

Project information was presented at the Integrated Crop Management Conference and the Agriculture and Environment Conference. The presentation titled, *Performance-based management to improve water quality,* can be found in the attachment in the presentations folder under *Performance-based presentation.*

Additional Partners

A primary partner involved with this project is the Iowa Corn Growers Association. Through the ICGA production and environment committee the ICGA provided $5000 to cost share cooperator yield loss from no or low nitrogen application treatments. The ICGA funding also went toward paying for over $1500 of cornstalk nitrate-nitrogen analyses. The ICGA is a significant partner in this project lending credibility to activities hosted by the producer cooperators involved in the project.

The Iowa Farm Bureau Federation has been a critical partner in the Hewitt Creek watershed. Without Farm Bureau involvement the performance-based incentive outline would not have been developed and the need for P Index and Soil Conditioning Index calculations and model development would not be needed. Through the incentive program development the Hewitt Creek watershed residents are understanding the significance of both indices and their place in water quality programming.

The project has sought partnerships with local and regional water quality protection projects and local soil and water conservation districts. Field demonstration activities have been targeted in the following watersheds: Upper Maquoketa, South Fork Maquoketa, Bear Creek, Hewitt Creek Mud Creek, Elk Creek and Mineral Creek. Project coordinators in these watersheds provide initial producer contacts and a local presence for in-season contacts.

The Cedar County Cooperative in Tipton has also been a valuable partner. Their agronomist has provided valuable local contacts in Cedar County. The cooperative's involvement interests their members because they see the cooperative as striving to improve their bottom line rather than just selling products.

The Hub and Spokes IFLM project provided valuable manure management demonstration information that was summarized with Maquoketa Watershed Project and Manure Phosphorus Management Project results. This project seeks to spread use the combined information as a valuable education tool across a wide area of eastern Iowa.

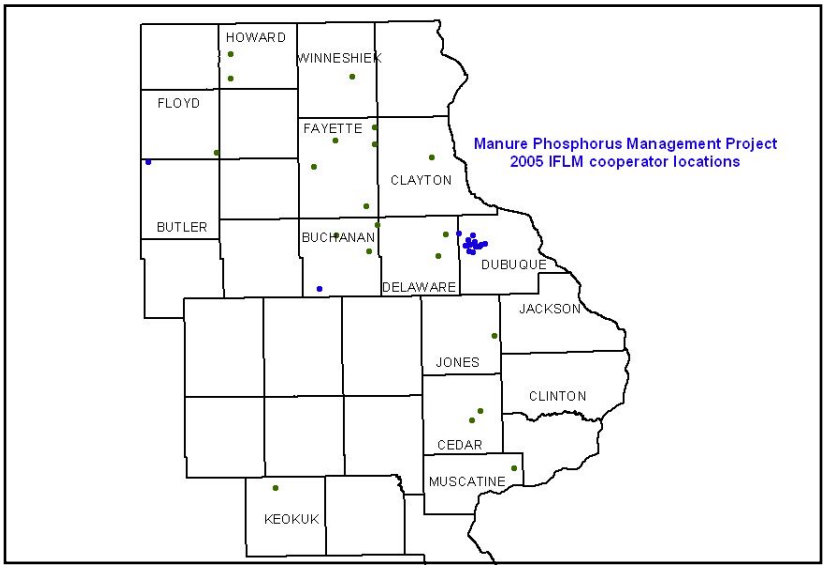
The Iowa DNR through EPA 319 funding was an essential partner in developing past field demonstration information. Without IDNR support a valuable database of demonstration information would not be available to build upon for further dissemination through this project.

This report was prepared by Chad Ingels, ISU manure and nutrient management specialist. Please call 563-425-3233 or email ingels@iastate.edu with questions or comments about the Manure Phosphorus Management Project.

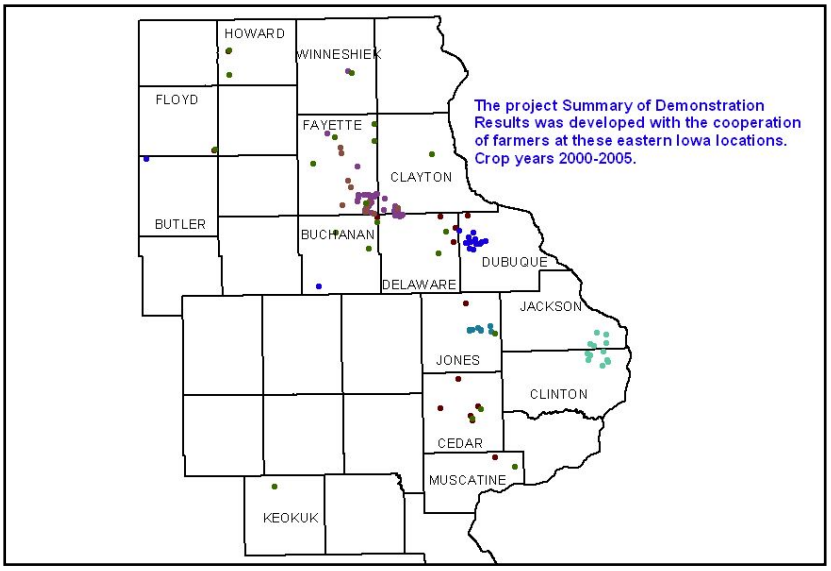
The following attachments are available electronically:

Summary of Demonstration Results	**04_newSOR.pdf**
Attachments referred to in the report	**Maquoketa manure** **P Index** **Hewitt P_N info** **Performance-based presentation** **Nutrient_trading_directory**

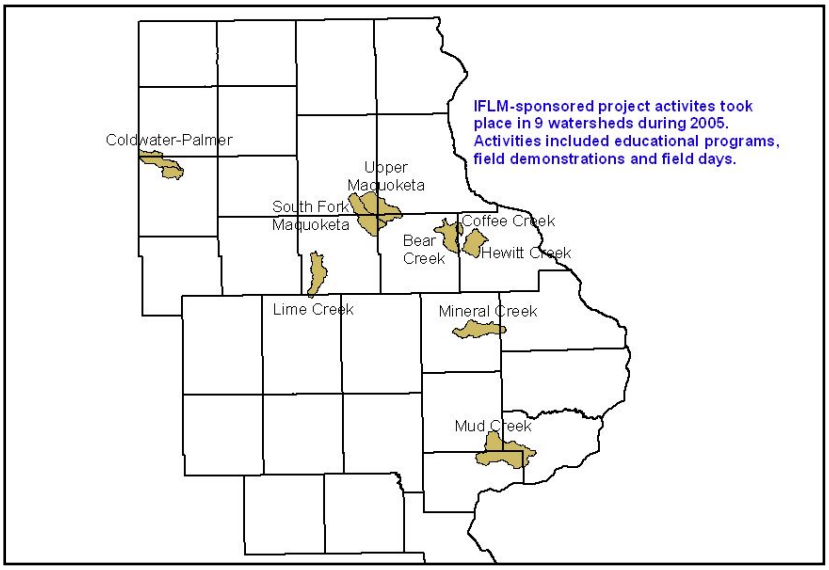
Project Map Appendix



Map 1. Locations of crop year 2005 eastern Iowa demonstration cooperators.



Map 2. Locations of cooperators who have participated in demonstration activities during crop years 2000-2005.



Map 3. Nine watersheds where project activities took place during 2005.