Economics of Precision Conservation: The Case of Dairy Manure Management In Delaware County, Ohio

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ABSTRACT

The trend towards fewer but more concentrated livestock production in the U.S. has brought greater attention to manure production and its management in recent decades. Appropriate manure nutrient utilization is a key conservation practice for minimizing nutrient loss to downstream waters. However, the environmental impact and the farm-level economic implications of manure management can vary significantly depending upon various field attributes such as soil type and chemical properties, topography, and weather.

Previous studies have more confirmed the environmental implications of such precision farming methods. By evaluating the economic impacts of phosphorus-based dairy manure application restrictions as compared to nitrogen-based rates, this study enhances the economic impacts of precision conservation for the case of manure nutrient management on corn fields in Ohio.

Introduction

Manure production and its management have been documented as having significant impacts on surface water quality. Nutrient pollution from improperly managed manure application has been listed as a leading cause of impairments in rivers and streams.

Previous studies have linked high manure application rates with increased nutrient loss in runoff, and confirmed the environmental impacts of precision conservation for manure nutrient management. However, the economic implications are far from certain due in part to the cost involved.

This study indicates that precision manure nutrient management can be a source of environmental relief. Environmental impacts differ based on soil type and other biophysical attributes. Costs are also variable and could be significant.

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Review of Literature

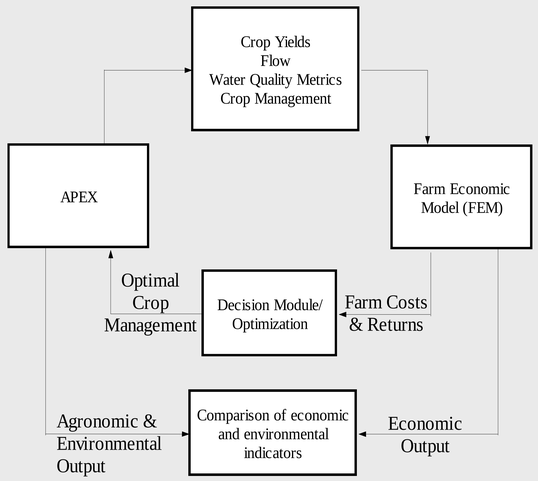
Manure management has been shown to impact downstream water qualtiy (Sharpley et al., 1994). In general eutrophication in inland waters or hypoxia in coastal zones could result from over-application of manure nutrients. However, judicious management of manure can entail significant cost, particularly when manure has to be hauled long distances (Osei et al., 2008).

In general, farms with significant land area stand to gain from judicious manure use. However, with increasing concentration of livestock, many farms have limited land area for proper manure utilization (Osei and Keplinger, 2008).

Various studies show that manure application at nitrogen uptake rates tends to result in over application of phosphorus for crop needs (e.g., Pratt et al., 1997; Osei et al., 2000b; Gassman et al., 2006). This study shows how manure applications at phosphorus based rates can have variable environmental effects due to soil type variability and other biophysical attributes. Economic impacts can also differ significantly if precision management of manure is the goal. The integrated modeling system was used to evaluate

Methodology

- To determine the economic impact of precision dairy manure nutrient management, a coupled dynamic biophysical-economic modeling system was used for the simulations.
- The Agricultural Policy Environmental eXtender (APEX) model (Williams et al., 2000) was used to simulate the agronomic and biophysical impacts on a daily time step. For P rate scenario, average soil attributes from the APEX model were used to determine current year crop yields as well as the manure application rate for the subsequent year.
- FEM (Osei et al., 2000), an annual economic simulation model, simulates entire farms holistically to determine the resulting economic impacts.



Model Calibration

- APEX and FEM were calibrated to measured data in the study area.
- Comparison of calibrated model output and custom rates for selected field operations are shown in Table 1.

Table 1. Comparison of custom rates and FEM model output ($/acre).

		FEM Model Output	
Field operation	*Custom rate*	*Fixed Cost*	*Total*
Moldboard plow	18.68	13.37	19.79
Tandem Disk	13.46	7.36	15.13
Chisel Plow	14.32	7.35	16.33
Field Cultivator	11.36	2.88	11.76
Offset Disk	14.4	5.96	16.23
Rotary Hoe	7.56	4.89	8.06
Row Crop Cultivator	10.42	4.99	11.68
Bulk Fertilizer Spreader	6.61	1.14	5.69

Simulation Procedure

For each unique soil map unit-weather combination, two scenarios were simulated as follows:

Baseline Scenario: it is assumed to be manure application at the N rate of the corn crop. The N uptake rate was calculated using a fixed coefficient per yield unit, multiplied by the potential yield for the soil. The potential yield for the soil was determined using a prior APEX simulation for all map unit-weather combinations.

Static Uniform P Rate Scenario: it is represented a constant manure application rate across all map unit-weather combinations, using the average rate derived from the dynamic precision P rate scenario for each year.

Long-term simulations were performed using APEX and FEM to account for the impacts of variable weather patterns over time.

Data Sources

- The USDA Cropland Data Layer (CDL) at a 30-m grid
- The USDA-NRCS Soil Survey Geographic Database (SSURGO)
- USDA-NRCS PRISM Weather Data
- USDA Agricultural Prices Survey
- National Research Council database on dairy nutrient requirements
- Dairy manure nutrient characteristics from ASABE standards

Summary of Results

Results of the simulations highlight the variability in manure management due to biophysical attributes of fields.

Variability in weather patterns can also result in significant differences in impacts over time

Impacts of P Rate manure application versus baseline

Environmental impacts

	Baseline	P Rate	% Change Average	% Change Range
Sediment (t/ac)	0.41	0.32	-23	-17 to -30
Total N (lb/ac)	8.65	7.61	-12	-4 to -26
Total P (lb/ac)	0.58	0.44	-24	-20 to -33

Economic impacts

	Baseline	P Rate	Difference
Net income ($/ac)	217.32	188.19	-29.13
Manure Hauled Off (%)	39.0	69.5	30.48

Discussion

Nutrient pollution from improperly managed manure applications is key source of concern in manure production and its management. Due to various field attributes, both the environmental and economic impacts of manure management can vary significantly.

Conclusions and Implications

Research confirms the intuition that improved environmental outcomes can result from precise targeting based on each field's spatial variability. Precision manure P applications would result in lower nutrient losses.

The economic implications of such precision farming methods are far from certain due in part to the cost of information associated. In some cases additional costs to farmers could be significant, while in other cases cost reductions would be experienced.

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