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Financial and Environmental Tradeoffs of Phosphorus Management Practices on Vermont Dairy Farms

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Abstract

FLIPSim is combined with GISPLM to provide policymakers and dairy farmers estimated farm financial impacts on the implementation of 8 Best Management Practices (BMP) designed to reduce phosphorus loading in Lake Champlain. Financial performance indicators are derived for three Vermont dairy farms (60, 150, and 350 cows). Results indicate that feed reformulation and nutrient management are the least cost BMPs but that a combination of 4 BMPs cannot meet the 8% reduction goal. Additional, less effective but more costly BMPs will have to be implemented to meet the goal. None of the individual BMPs cause any of the farms to go out of business. However, the initial declining financial position of the small farm is hastened by the implementation of all BMP's except the row crop field buffer and feed reformulation. The medium farm is also threatened by several costly BMPs. Achieving the desired goal will have an adverse financial impact on watershed farms.

Introduction

Animal and crop management practices on Vermont dairy farms are the major focus of efforts to reduce phosphorus loading in Lake Champlain. Programs aimed to reduce phosphorus loading in Lake Champlain raises the concern that voluntary efforts may have to become required management practices on the region's dairy farms, causing financial strains on the region's dairy farms that account for 85% of Vermont's agricultural production (Pelsue and Finley-Woodruff). In contrast, the environmental health of Lake Champlain is of major concern to bordering Vermont, New York, and Canada's Province of Quebec. The lake is of key importance to the $880 million to the regional tourist economy for supplying drinking water for approximately 180,000 people or 34 percent of the Basin population (Lake Champlain Basin Program).

Current cleanup efforts are focusing on reducing the lake's phosphorus content which has been responsible for algae growth that contributes to foul odors, reduced oxygen content that results in the death of fish and other aquatic organisms, and degraded esthetic conditions (Carpenter et al.). Concerted efforts to improve water quality in Lake Champlain date to the 1960's and have produced excellent results from point sources in (Schnitkey and Miranda). Primary efforts are now aiming to reduce phosphorus contamination from the region's dairy farms which are strongly believed to be one of the largest non-point phosphorus contributors to the lake (LCMC, USEPA, USDA-ERS). Dairy farms use large amounts of fertilizer on hay and corn silage and produce phosphorus-laded manure that erodes off of cropland and animal areas into surface waters flowing into Lake Champlain (Heimlich and Stachowski, Holmes et al., Hegman et al.).

Farm leaders and public officials are apprehensive that efforts to reduce phosphorus runoff will impose economic hardship on the region's dairy farms. Profitability on dairy farms has declined nationally and regionally in recent years, resulting in 20 percent loss of dairy farms over the past five years (USDA-Census of Agriculture). Fewer farm has not resulted in fewer cows as the remaining farms have concentrated more cows per farm (Frink). The dilemma facing policymakers and the regions' dairy farmers is that almost all efforts to reduce phosphorus runoff are expected to require investments or higher operational costs. With declining profitability, there is no surprise that Vermont dairy farmers are reluctant to embrace phosphorus reducing Best Management Practices (BMP). To balance the financial and environmental impacts of alternative strategies, the question facing policymakers is: "How to reduce the agricultural non-point phosphorus pollution to Lake Champlain without mandating undue financial burdens that could threaten the survivability of the region's dairy farms?"

Study Overview

The goal of this study is to examine the costs associated of alternative phosphorus reducing BMPs on Vermont dairy farms. Specifically, the objectives are:

1. To quantify the implementation cost of selected BMPs on different size Vermont dairy farms.
2. Quantify the financial impact of selected BMPs on farm survival of a 9-year period.

Previous studies that examined the financial impacts of alternative phosphorus management practices are limited (Taylor et al., Schmit and Knoblauch, Hanchar et al., Heimlich and Stachowski, Osei et al., and Parsons). In most cases, the studies utilized static and deterministic models and did not

examine the impacts on alternative farm sizes. This study employs the Farm Level Income and Policy Simulation Modeling System (FLIPSim), a financial simulation model, to simulate the economic impacts associated with selected phosphorus BMPs. The model incorporates environmental impacts from a watershed phosphorus loading model, the Geographic Information System Phosphorus Loading Model (GISPLM). The coupling of these two models enables comparison of the financial as well as the environmental impacts from alternative phosphorus management practices in the Little Otter Creek watershed (LOCW) of Lake Champlain. This study will specifically focus on the farm-level financial impacts on 3 farm sizes.

The farm models were developed by procedures recommended by Richardson and Nixon. FLIPSim simulates the annual production, farm policy, marketing, financial management, growth, and income tax aspects of a farm over a multiple-year planning horizon with risk and uncertainty incorporated through probability distribution functions based on historical prices and yields (Richardson and Nixon). A baseline scenario for each representative farm was developed for FLIPSim that included all receipts, expenses, principal repayments, family living, and taxes. Initial baseline simulation results for year 1 were presented to the farm panel for review and final approval to ensure the model reflects expected financial performance of the respective representative farm. Alternative models for each farm were then developed for each BMP incorporating all financial impacts specified by BMP experts consisting of farmers, NRCS, and extension specialists.

A panel of area farmers was assembled to define each farm's specification and baseline structure including crop acreage, production level, feed rations, debt level, cost structure and family living costs. The three farm sizes specified by the farm panels were: 1) small pasture-based (60 cows);

2) medium confinement (150 cows), and 3) large confinement farm (350 cows). The 350-cow farm represents a smaller but growing sector of Vermont dairy farms that commands specific attention because of their proportional share of dairy cows and milk production (Dodd). The specifications for the three representative farms are shown in Table 1. Please note that milk and crop production were highest for the largest dairy farm.

Table 1. Representative Farm Characteristics and Financial Performance by Farm Size

Characteristics	**Small**	**Medium**	**Large**
Cropland (acres)	88	350	870
Pastureland (acres)	110	70	50
Cows (number)	60	150	350
Milk production, (lbs/cow/yr)	16,000	19,800	20,500
Crop Yields (tons per acre)			
Corn	12	13.5	14
Grass hay	1.9	2.2	-
Mix Legume	3.5	4.4	4.4
Legume	-	-	4.4
Resident Labor[1]		3	4
Manure Spreading ($/cow/yr)	44	75	67
Total Cash Cost[2] ($ per cow)	1,512	2,280	2,414
Net Cash Profit[2] ($ per cow)	951	863	752

[1] Full-time workers, does not include the owner/operator
[2] Total cash costs in 1998 including crop production costs, dairy costs, dairy feed costs, cash rent for land, hired labor costs, property taxes, accountant and legal fees, unallocated maintenance, utilities, fuel and lube, insurance, and interest on long-term, intermediate, operation, and carryover debt. Does not include income taxes or depreciation.
[3] Source: Dodd (2000).

Examined Best Management Practices

The identified BMPs were identified by our panel of experts who specified implementation steps, procedures, and associated costs. A specific scenario was then developed from the base farm

model that reflected the farm's financial performance following the implementation of the specified phosphorus management practice.

The 8 BMPs analyzed in this study are:

1) Manure Storage

Each farm is required to implement manure storage structures. The large farm is assumed to have a manure structure on site. The small farm must install a stacking pad while the medium farm implement a storage unit. There are added costs related to the manure structure while the farm has manure of higher nutrient value that can reduce fertilizer costs on certain fields. The small and medium farms contract with custom haulers to empty manure storage structures.

2) Feed Reformulation

Rations are reformulated to reduce phosphorus content, thus reducing manure phosphorus content. Rations for each farm size are set by a university dairy nutritional specialist. The results indicate that each farm has a feed savings feeding the reduced phosphorus feed. It is assumed that the dairy cows incur no adverse health or breeding affects.

3) Manure Export

All farms are assumed to have excessive high soil phosphorus rates so that 20% of the manure must be transported to sites an average of 5 miles from the farm. Each farm has to pay hauling fees to have the manure moved. For several fields, the farm has to purchase additional fertilizer to account for lost nutrients from the manure.

4) Conservation cropping

Farmers would be required to incorporate strip cropping on all corn and hay acreage. The strips would be laid out at no cost by NRCS. Yields would remain the same but the farmer's would incur 3 percent higher tillage, harvesting, and manure handling costs because of more turning, harvesting time, and greater hauling distances.

5) Nutrient management

All farms contract with a crop management association to advise on nutrient applications that are limited to crop phosphorus removal rates for corn silage, hay, and pasture. Crop management association membership will increase costs while fertilizer costs depend on the difference between current and recommended applications. It was assumed that nutrient management recommendations are based on crop agronomic requirements and nutrient applications would not reduce yields.

6) Residual management

To reduce soil erosion, farmers would be required to maintain a rye cover crop on corn silage acreage over winter months. Farmers will incur the cost of fall planting and seed without any additional tillage costs. The rye is not harvested for forage so there are no positive cash benefits for the farmer. Planting costs reflect the assumption that rye could not be planted in one year out of four due to fall weather conditions.

7) Row crop field buffer

Farmers are required to maintain an unfertilized grass hay buffer strip along the edge of corn silage cropland. The buffer is a minimum 25 feet wide along fields adjoining riparian zones. The buffer

strip is seeded to grass and harvested for hay. The farmer loses corn silage production from the buffer strip but saves the cost of corn seed, fertilizer, and chemical costs.

8) Other field buffer

Farmers are required to maintain an unharvested grass hay buffer strip along the edge of legume, mixed legume, grass hay, and pasture acreage. The buffer is a minimum 25 feet wide along riparian zones. The farmer loses hay and pasture production but saves from lower seed, fertilizer, and chemical costs on the buffer strip. Implementing buffer strips around pastures requires building additional fences, building stream crossings, and providing pasture water sources.

FLIPSim Results

Each farm model was simulated for 9 years. The financial measures used in this study were the change in net cash farm income and cash reserve after the 9 year periods. Net cash farm income equals total cash receipts minus total cash expenses. The cash reserve equals the net cash the farm has remaining after principal payments, income taxes, family living withdraw, and scheduled machinery repayments. If the farm ends with a deficit, then it must borrow to meet minimum cash requirements.

The percentage changes from baseline scenario in net cash farm income and cash reserve after the 9-year simulation are presented in Table 2. Positive numbers indicate net gains or savings from the implementation of the BMP while negative numbers indicate that the net cash farm income and cash reserve decline.

Table 2. Net cash farm income and cash reserve (percentage change from baseline scenario after 9 years).

BMP	*Small Farm*		*Medium Farm*		*Large Farm*	
	Net Cash Farm Income	**Cash Reserve**	**Net Cash Farm Income**	**Cash Reserve**	**Net Cash Farm Income**	**Cash Reserve**
Manure Storage	-8.6%	-156.0%	-5.1%	-34.4%	0.0%	0.0%
Feed Reformulation	1.0%	0.5%	1.5%	3.4%	1.98%	3.66%
Manure Export	-8.0%	-150.2	-11.5%	-23.8%	-17.3%	-32.8%
Conservation Cropping	-0.9%	-5.6%	-1.9%	-4.2%	-4.0%	-7.5%
Nutrient Mgmt	-0.3%	-3.2%	0.3%	0.6%	1.3%	2.3%
Residual Mgmt	-2.5%	-15.1%-	-5.7%	-11.5%	-5.6%	-10.4%
Row-Crop Field Buffer	0.4%	2.3%	-0.3%	-0.8%	1.0%	1.9%
Other Field Buffer	-1.4%	–2.4%	-1.9%	-4.93%	2.3%	3.5%

The results indicate that feed reformulation is the only BMP that has positive returns for all farms. The row crop field buffer improves the financial situation of the small and large farms while nutrient management leaves the large and medium farms in stronger financial position. The large farm also benefits financially from the other field buffer BMP. The manure storage and manure transport have the greatest detrimental impacts on the farms. These BMPs require a high initial cost in the case of

the manure storage and a high annual cost in the case of manure transport. Both of these practices severely impact the small farm. While the small farm is not likely to be forced out of business due to its equity base, it would be difficult for these operators to stay in business without any bright perspective change on the horizon. The small farm starts out in a precarious position as its cash surplus is used up before the end of the 9-year baseline simulation. In reality, the small farm would have to consider selling out, expanding the dairy herd, or obtaining off-farm income to remain business. Adding any BMPs that have any cost would only hasten the day of decision for the small farm.

These results would indicate farmers would most likely to embrace feed reformulation and the row crop field buffer to reduce phosphorus losses because of their minimal costs. The feed reformulation raises the question of why producers are not currently reducing feed phosphorus content. Conversations with nutritionists indicate that at the relatively low cost of phosphorus, farmers would likely feed additional phosphorus to assure protection against metabolic and breeding problems that have been associated with low phosphorus content. However, while current research indicates phosphorus levels can be reduced in many cases without any risk, the farmer would rather feed the higher levels as a risk reducing practice. Most farmers have enough breeding problems to take on additional risk.

Estimating Phosphorus Losses

Watershed phosphorus losses were simulated with the Geographic Information System Phosphorus Loading Model (GISPLM). The watershed model simulates the change in phosphorus losses as a result of BMP's being incorporated on all farms in the watershed. It is important to point

out that since we are looking at the change in losses so that we need to have a base measure of current practices in the watershed. This was accomplished by way of a detailed personal survey that identified current nutrient practices in use on the watershed's dairy farms. The survey data was then used to set the base GISPLM model. When individual BMPs were examined, the model assumed that the practice was implemented 100% and the change in phosphorus losses were the change resulting from adopting the BMP where had previously not been in use.

The "target" reduction in nutrient losses was 8%, a goal that was established by the Lake Champlain Commission in the early 90% as a goal for phosphorus loss reduction in Lake Champlain by 2005. The full description of GISPLM is beyond the scope of this paper and results will be published in a latter report. For this study, we will concentrate on the financial results.

The GISPLM results for this study indicated that none of the individual BMPs were capable on their own of reaching the 8% reduction threshold. Individually the most effective BMPs (in order) were conservation cropping, nutrient management, row crop field buffer, and feed reformulation. Therefore, the solution was to examine combinations of BMP's to reach the desired goal. Logically, farmers when faced with the above information, would be expected to vote for the combination of BMPs that would cost them the least.

Combination BMPs

Two combinations of BMP's were examined to calculate the change in phosphorus losses. We examine RCFB/NM/CC and RCFB/NM/CC/FR. A joint model was formulated for combination of BMPs. These BMPS presented very little duplication in practices or costs so the financial impacts were generally cumulative. The results are presented in Table 3.

Table 3. Table 2. Net cash farm income and cash reserve (percentage change from baseline scenario after 9 years).

BMP	*Small Farm*		*Medium Farm*		*Large Farm*	
	Net Cash Farm Income	**Cash Reserve**	**Net Cash Farm Income**	**Cash Reserve**	**Net Cash Farm Income**	**Cash Reserve**
RCFB NM CC[1]	-3.3%	-10.0%	-7.6%	-15.6%	-7.2%	-13.7%
RCFB NM CC FR[2]	-0.81%	-5.0%	-1.9%	-4.5%	-1.7%	-3.3%

[1] Row crop field buffer/ nutrient management/ conservation cropping.
[2] Row crop filed buffer/ nutrient management/ conservation cropping/ feed reformulation.

The results indicate that the RCFB/NM/CC/FR option has the smallest financial impact on the farms. As would be expected, the addition of feed reformulation lessens the impact due to its positive impact on net farm income. The real measure of the BMPs is their impact on phosphorus losses. Under RCFB/NM/CC/FR, GISPLM estimates that phosphorus losses approach an average of 8% over a 3-year simulation period. The impact is that the 8% goal cannot be reached with any other lower cost combination of BMPs. To achieve the minimum 8% goal, another, more costly but less effective, BMP must be adopted.

Conclusion

These findings confirm that many recommended phosphorus management practices are not a win-win situation for the farm and the environment. Only feed reformulation provides financial benefits for all farms. The real problem is that a combination of the 4 most effective BMPs cannot reach the 8% goal in reduced phosphorus losses. To meet the goal, a more costly set of BMPs must be adopted by watershed farmers. The situation becomes more complex if a higher goal, 10% for example, becomes the target. There is a distinct possibility that the goal may be beyond reach with the current combination of BMPs.

When the BMP's are implemented on financially stressed farms, the impact is reduced feasibility and survivability. The dilemma for policymakers is that small farms constitute the largest number of farms in the Lower Otter Creek Watershed, representing sizable contribution toward potential environmental contamination of Lake Champlain as well as sizeable economic losses. It is worth noting that this study assumes farmers pay the cost of adopting phosphorus reduction BMPs in full by themselves without taking into account any cost sharing or subsidies that may facilitate the adoption from the government. This conservative method is believed to provide more space for future policy making.

When making recommendations on BMP adoptions, policymakers need to consider both economic and environmental efficiencies. Thus, a phosphorus reduction cost efficiency indicator should be used in the future study to provide information containing both economic and environmental impacts. This will be a second part of this study that will examine in detail the related GISPLM estimated change in phosphorus losses as compared to the estimated farm costs attributed to each BMP.

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