The Financial Impact of Animal Related Phosphorus Management on Vermont Dairy Farms

Alyssa Dodd, Catherine Halbrendt, Charles F. Nicholson

Department of Community Development and Applied Economics
University of Vermont

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Abstract

Excessive phosphorus loading has been identified as the primary cause of decreasing water quality in Lake Champlain. Dairy farms are the major source of phosphorus pollution to the lake and are targeted to reduce phosphorus run-off. The goal of this research is to determine the farm-level financial impact of phosphorus management on different sizes of Vermont dairy farms. Farm financial performance following implementation of manure management is simulated by farm size (60 cows, 150 cows, and 350 cows) over a ten-year time horizon using the Farm Level Income and Policy Simulation Modeling System (FLIPSim). Results indicate that implementation of Milking Waste Management practices have the smallest financial impact on all three farm sizes. For the small farm (60 cows), a liquid manure storage system, once implemented, may slightly increase average annual net cash farm income and reduce the probability of a cash flow deficit after the initial implementation year.

Background

Phosphorus loading has been identified as the primary cause of decreasing water quality in Lake Champlain. Excessive phosphorus can cause foul odors, increased weed growth and death of fish and other aquatic organisms. Meanwhile, the Lake Champlain Basin is one of the major recreational destinations in New England. Tourism in the Basin generated nearly as much revenue ($2.2 billion) as the manufacturing sector in 1990. Lake Champlain is also a major source of drinking water for approximately 600,000 people living in the Basin (Lake Champlain Management Conference, 1996). Both economically and environmentally, it is necessary to reduce phosphorus loading in Lake Champlain.

Dairy farms are the major source of phosphorus pollution to Lake Champlain (Artuso et al., 1997). The Lake Champlain Management Conference in 1996 targeted dairy farms to reduce their phosphorus runoff in the near future. However, for Vermont, much of which is located in the Lake Champlain Basin, dairy farming plays an important role in its economy. Eighty percent of Vermont’s agricultural outputs are dairy products, with eighty-two percent of these products being exported, bringing a significant amount of money into the state (Pelsue and Finley-Woodruff, 1996). In 1995, dairy farms directly contributed $330.3 million dollars and indirectly contributed $149.5 million dollars to Vermont's economy (Lin, 1999).

There are over 1,700 dairy farms in Vermont with amounts of cropland and pastureland owned, crops grown, number of cows, breed of cows, and management (U.S. Department of Agriculture, 1999). To assist farmers in implementing the appropriate farm practices for sustained profitability, there is a need for information on the farm-level financial impact of phosphorus management practices for different types and sizes of Vermont dairy farms. The goal of this research is to determine the farm-level financial impact of phosphorus management on different types and sizes of Vermont dairy farms.

Studies analysing the impact of phosphorus management on the financial performance of dairy farms are limited (Taylor et al., 1992; Schmit and Knoblauch, 1995; and Hanchar et al., 1998). In general, these studies used simple financial models that are static and deterministic. Second, these studies did not evaluate the impact on different farm sizes. The impact of implementing phosphorus pollution reduction practices on farm returns could be different across various farm sizes due to differing cost structures. Third, the costs assigned to phosphorus management practices are crude approximations rather than detailed farm-level costs.

This research aims to overcome the shortcomings of previous studies. First, this paper utilizes the Farm-level Income and Policy Simulation Modeling System (FLIPSim) developed by Texas A&M University (Richardson, 1986) to model in detail all farm activities and the financial consequences. FLIPSim models the financial performance of dairy farms for a ten-year time horizon and takes into account the effect of stochastic prices, crop yields, and milk productions. Second, three different representative farms are created by farm panels to represent the different typical sizes of dairy farms in Vermont. The three typical sizes are small (≈ 60 cows), medium (≈ 150 cows), and large (≈ 350 cows). Farm characteristics, dairy production, farm management, and financial information is displayed in Table 1. The farm-level implementation of phosphorus management practices, by farm size, is simulated over a ten-year time horizon using the FLIPSim.

Methodology

FLIPSim, the farm model utilized in this study, is a stochastic dynamic model that simulates annual financial performance of a farm. It simulates the financial performance of a representative farm over a ten-year time horizon. Outcomes one year, such as cash reserves, debts, and animal stocks, are carried into the next year. The researcher specifies farm characteristics and activities, such as resource base, farm size, types of crop and livestock owned, average crop and livestock yields, and operating costs. The model requires extensive data related to stochastic variables such as crop yields, crop prices, livestock production yields, and livestock prices, distinguishing it from other farm-level financial simulation models. The model incorporates multivariate empirical distributions (MVE) for yields and prices from ten years of historical data.

Based on the specified farm characteristics and activities, projected prices and inflation rates, and MVE distribution functions, FLIPSim uses accounting equations to project crop and livestock productions, expenses, sales, and other cash flows of the farm over a ten-year time horizon. The model simulates the financial performance of the representative farm 100 times, generating values for all stochastic variables during each iteration, and calculating net farm income and other measures of financial performance. After 100 iterations, FLIPSim calculates descriptive statistics for farm financial performance during the ten years of simulation, such as average net farm income in the year 2000.

Three types of data are required for the model: price and interest rate projections, detailed farm-level economic data, and cost data associated with the implementation of various phosphorus-reducing farm management practices. Price and interest rate projections are obtained from macroeconomic models utilized at the Food and Agricultural Policy Research Institute, The University of Missouri-Columbia and the Trade and Agricultural Policy Division of the Center for Agricultural and Rural Development (CARD/TAPD) at Iowa State University. Detailed farm-level financial data is collected directly from farmers during a farm panel focus group. Each panel consists of two to four farm managers operating farms of similar type and size. Together, members of each farm panel create a financial profile of one representative farm. Farm-level costs associated with various phosphorus-reducing farm management practices come from an extensive review of scientific literature and key informants at the United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS).

Analysis using FLIPSim first requires the construction of a baseline scenario. The baseline scenario represents the financial performance of representative farms given projected prices and yields, current farm financial information, and existing phosphorus reduction practices. To ensure the simulation is truly representative, baseline simulation results are presented to the farm panel focus group members for review. Several scenarios are developed to represent the financial performance of the representative farms when a new phosphorus-reducing practice is implemented. Comparison of the financial performance results of implementation scenarios to the baseline scenarios reveals the farm-level financial impact of phosphorus management.

Panel Farm Descriptions

The area of study is the Little Otter Creek (LOC) Watershed located within Addison County, Vermont. In 1997 the county was ranked number two in the state for the value of dairy products sold (U.S. Department of Agriculture, 1999). The LOC Watershed was chosen for the following reasons. First, there are various types and sizes of dairy operations in the watershed that are representative of dairy operations found across the state of Vermont. Second, there are several ongoing groundwater and plant science research studies taking place in the watershed that aim to identify effective strategies to reduce phosphorus run-off into Lake Champlain. Combining the results from the latter physical science research projects and this social science study will provide extensive and diverse information for agricultural policy makers in Vermont and elsewhere.

The three representative dairy farms developed depict herd sizes of 60, 150, and 350 cows to portray Vermont's small, medium, and large size dairy farms. The decision to develop the latter three representative farms is based on a farm survey conducted in the study area and discussion with extension specialist at the University of Vermont. The 60 and 150 cow farms are "typical" for today's Vermont dairy farms (USDA, 1999). The 350 cow farm represents a smaller fraction of today's Vermont dairy farms, but may portray the "typical" Vermont dairy farm within the next decade.

General characteristics for the three representative farms are displayed in Table 1. Farm panels provided detailed farm-level information of farm characteristics such as the amount of cropland and pastureland owned and rented; livestock production such as milk production; farm management such as manure spreading, hired labor, custom harvesting; and financial information such as net cash costs, net profit, and cash flow.

The dairy farm characteristics by herd size are different. The small representative farm is a pasture-based dairy farm, while the medium and large representative farms are confinement-based dairy farms. The small farm owns approximately 50% of total cropland farmed and the medium and large farms own over 70% of total cropland farmed. All representative farms grow corn as well as some type of hay or legume and crop yields increase with increasing farm size. Additionally, milk per cow and labor increase with increasing farm size. The medium farm spends the most per cow on manure spreading while the small farm pays the least. All three representative farms own harvesting equipment, but the large farm incurs custom harvesting costs.

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
Livestock			
Cow, (number)	60	150	350
Milk production, (lbs/cow/yr)	16,000	19,800	20,500
Crop Yields (tons per acre)			
Corn	12	13.5	14.0
Alfalfa hay	2	-	
Grass hay	1.9	2.4	
Mix Legume	-	4.65	5.0
Legume	-	-	5.0
Resident Labor[1]	0	3	4
Manure Spreading ($/cow/yr)	44	75	67
Custom Harvest, ($ per acre)	-	-	58
Total Cash Cost[2] ($ per cow)	1,524	2,280	2,385
Net Profit[2] ($ per cow)	891	639	802
Net Cash Flow[2] ($/cow)	147	393	352

[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.

Source: LOC Watershed Farm Panel Participants, 1999.

Net cash costs per cow increase with increasing farm size. The small farm earns the largest net profit per cow ($891/cow), followed by the large farm ($802/cow), with the medium farm earning the least ($639/cow). However, the small farm has the lowest net cash flow per cow ($147/cow). The medium and large farms have comparable net cash flows ($393/cow, $352/cow) that are twice as large as the small farm's per cow cash flow.

Baseline Farm Manure and Wastewater Management

Manure and milking wastes are two primary sources of potential P pollution. Manure related P losses may occur from farmstead areas, including the barn and barnyard, or fields where manure is utilized as fertilizer for crop production. Milking waste is an additional source of P that can be captured and contained to reduce potential runoff. Farmers may choose to implement a number of best management practices (BMPs) at the farm (barn, barnyard, milkhouse) and the field-level to reduce potential P losses by managing manure and wastewater in a "closed system". A "closed system" aims to collect, transfer, store, and utilize all manure produced on the farm while simultaneously diverting clean water away from manure. The costs associated with BMP implementation are tied to the current manure management and milking system, which are related to herd housing (Overcash et al., 1983). Therefore, it is necessary to first examine the herd housing, manure, and wastewater management practices on the three baseline panel farms. Due to the limited time offered by farm panel participants to provide farm-level economic and management data, the following descriptions are based on conversations with key NRCS and University Extension informants familiar with the farm operations rather than panel participants.

Small Baseline Panel Farm

The small farm's milking herd is housed in a traditional tie-stall barn where the cows are confined to individual stalls with hay bedding (Table 2). There is a paved alley in front of the stalls for feeding and behind the stalls where manure is collected by a mechanical scraper system (gutter cleaners, alley scrapers, or elevator stacker) or by tractor (a small tractor with a front-end loader or a skid steer). The herd has access to a dirt barnyard area year round. The herd is let out to pasture five months out of the year, during which pasture provides the primary source of forage. A tractor (or skid steer) is used to collect manure deposited in the barn. The manure is transferred to the field using a box spreader where it is immediately spread on cropland or stored in stacks. Manure deposited in the barnyard area is not collected.

Table 2:

Herd Housing, Manure Management, and Wastewater Management Characteristics for Baseline Panel Farms

Characteristic	Small farm	Medium farm	Large farm
# Milking Cows	60	150	350
Herd Housing Bedding	Tie-Stall Hay	Free-Stall Sawdust	Free-Stall Sawdust
Manure Collection in Barn	Tractor Scraper Mechanical Scraper system	Tractor Scraper	Slated Alleys
Type of Barnyard	Outside Dirt Barnyard	Outside Dirt Barnyard	Roofed holding area part of the free-stall barn
Manure Collection in Barnyard	NONE	NONE	Tractor Scraper
Milking System	Pipeline	Parlor	Parlor
Milking Wastewater Management System	Mechanical scraper system	NONE	NONE

Source: NRCS personnel and University of Vermont Extension Agents working within the LOC watershed, 1999.

The farm has a pipeline milking system, typical for operations with tie-stall barns, where the cows are milked in their stalls (Overcash et al., 1983). The milk is transferred to a bulk storage tank located in a separate location. There is no system in place to specifically capture milking waste (consisting of water, dilute milk, and cleaning products that typically are high in P). However, waste deposited in the barn alleys is collected by the mechanical scraper system (gutter cleaners, alley scrapers, or elevator stacker).

Medium Baseline Panel Farm

The medium farm's milking herd is housed in a free stall barn, composed of a resting area, feeding area, milking parlor, and outside dirt barnyard area (Table 2). The free stall area is composed of adjoining stalls with rows separated by an alleyway. The alley floors, where most manure and urine is deposited, are paved, covered with sawdust bedding and a tractor-mounted scraper is used to collect manure. Typically, the manure deposited in the barn contains more moisture than the traditional tie-stall because less bedding is used. Barn waste is moved to one or more collection points and transferred via pump to a liquid storage system. The farm contracts for custom manure spreading in which a tank spreader is used to spread liquid manure on the fields. Manure deposited in the barnyard area is not collected.

This farm has a separate elevated stall milking parlor. Cows enter the parlor in small groups and are placed in stalls where they are milked. Milk is transferred to a bulk tank located in a separate location. Milking parlor cleanup and manure management is typically high for a parlor system (Overcash et al., 1983). The parlor floor must be scraped to collect solids and liquids must be captured and stored (Overcash et al., 1983). This farm does not have a milking wastewater management.

Large Baseline Panel Farm

The large farm's milking herd is housed in a free-stall barn, composed of a resting area, feeding area, milking parlor, and holding area, and minimal amounts of sawdust are used for bedding (Table 2). Manure is deposited in slatted alleys into a manure pit located underneath the barn so no tractor scraping is required in the barn. Manure is pumped from a collection channel to an earthen pit or lagoon. There is no adjacent outdoor barnyard area, but the barn has an enclosed loafing area. Custom manure spreading is contracted, and a tank spreader is utilized to spread manure on the fields.

Similar to the medium farm the large farm has a separate elevated stall milking parlors. Cows are usually brought in large groups to a holding area where they await milking. They usually enter the parlor in small groups and are placed in stalls where they are milked. Milk is transferred to a bulk tank located in a separate location. Milking parlor cleanup and manure management is high for a parlor system (Overcash et al., 1983). The parlor floor must be scraped to collect solids and liquids must be captured and stored. Additionally, manure from the holding must be collected to reduce the amount entering the parlor (Overcash et al., 1983). This farm does not have a milking wastewater management system.

Animal Related BMP Scenarios

Implementation of three types of animal related BMPs are examined in this paper: manure management, barnyard waste management, and milking waste management. This study quantifies the financial impact of implementing specific BMPs from a designated baseline management situation. Therefore, because existing BMPs make up the baseline management situation certain BMPs are applicable to all panel farms while others are applicable to only one size of baseline panel farm. This paper does not analyze the impacts of BMPs already in use on panel farms.

Manure Management

Two levels of manure management are defined due to differences in capital investment, annual ownership costs, annual operation costs and manure value. The first level, *Manure Management I*, assumes the farm complies with the Vermont Department of Agriculture, Food, and Markets Acceptable Agricultural Practices (AAPs) with respect to avoiding winter spreading, and stores manure in a central stacking facility (CSF) specifically designed to minimize runoff losses.

The second level, *Manure Management II*, assumes the farm complies with the Vermont Agency of Agriculture, Food, and Markets' Acceptable Agricultural Practices (AAPs) with respect to avoiding winter spreading. Manure is stored in an earthen pond (EP) liquid storage system with an earthen floor, and a nutrient management plan that eliminates winter spreading, requires prompt incorporation of waste applied to tilled land, specifies maximum application rates, and avoids applications near water courses is created.

Manure Management I (CSF) and II (EP) are only applicable to the small panel farm because the medium and large panel farms are currently managing manure at the *Manure Management II (EP)* level. Therefore, no manure management scenario is analyzed for the medium and large panel farms.

The Small Farm *Manure Management I (CSF)* scenario simulates the financial impact associated with converting the small representative farm's current field stacking manure storage system to a central stacking system located near the barn assuming no milking or barnyard wastewater is stored in the central stacking facility. An NRCS key informant who has worked with farmers in the study area to implement this BMP constructed the following representative capital cost estimate (Hartline, 1999).

To implement the scenario, the small farm is assumed to initially spend $33,131.62, in cash, to build a central stacking facility that will provide 180 days of manure storage based on a 60 milk cow/18 young stock herd producing 1,059 tons of manure annually when confined (Table 3). Annual depreciation of the storage facility is calculated using the Internal Revenue Service's accelerated cost recovery system. Implementing a central stacking facility does not require the purchase of additional equipment. Therefore, no insurance cost is included. Tax implications associated with implementing the facility will vary widely from farm to farm so no attempt was made to include them in the cost estimate (Martin and Matthews, 1984).

Table 3:

Capital Investment, Annual Ownership and Operation Costs, Nutrient Value of Manure, and Net Annual Cost for Manure Management I (Central Stacking Facility) and II (Earthen Pond) for the Small Farm

Item	Manure Management I (Central Stacking Facility)	Manure Management II (Earthen Pond)
1. Capital investment	$33,131.62	$24,422.30
2. Annual ownership costs		
a. Depreciation[a]	$3,975.79	$2,442.23
b. Tax Implications	-	-
c. Insurance costs	$0.00	$0.00
3. Annual operation costs		
a. Fuel and lubrication	$0.00	$0.00
b. Maintenance	$60.00	$244.42
c. Electricity	$0.00	$300.00
d. Labor	$0.00	-$3,000.00 (net gain)
e. Custom Manure Spreading	$0.00	$1,843.00
4. Nutrient value of manure	$0.00	-$503.00 (net gain)
5. Net Annual Cost	$37,167.41	$25,748.95

[a]Depreciation in implementation year (1999)

Annual operation costs of the facility include maintenance, machinery, fuel and lubrication, electricity, labor, and manure nutrient value. Maintenance costs are assumed to be $60.00 per year. The cost is low since the facility only requires maintenance of the fence structure and access road. The scenario assumes no change in the type of machinery utilized because manure waste is collected and transferred from the barn and barnyard areas in the same manor as the baseline scenario. The central stacking facility does not change the amount of labor needed to collect manure from the barn. Labor associated with transporting and stacking the manure is reduced on a daily basis during the winter months because the facility is located closer to the barn. However, larger blocks of time will ultimately be required in early spring to transport manure to the field for spreading. Implementation of a central stacking facility does not change the type of manure, it is still "semi-solid". Therefore, no change in manure nutrient value is assumed.

The small farm *Manure Management II (EP)* scenario simulates the financial impact associated with converting a field stacking manure storage system to a liquid manure (earthen pit) storage system. The facility is sized to hold barnyard runoff and milking wastewater. Eliminating the need for separate milking and barnyard waste systems is one of the primary economic advantages of implementing this system. An NRCS key informant who has worked with farmers in the study area to implement this BMP constructed the following representative capital cost estimate (Hartline, 1999).

To implement this scenario, the small farm must build a facility with the storage capacity of 180 days based on a 60 milk cow and 18 young stock cow herd producing 1,059 tons of manure annually. The amount of manure storage necessary is 37,679 cubic feet (25,571 cubic feet for manure, 5,076 cubic feet for bedding, 4,813 for milking wastewater, and 2,219 cubic feet for barnyard wastewater). The small farm must spend $24,422.37 to build an earthen pit or lagoon manure facility that is 10 feet deep covering an area of 10,000 square feet and to pump manure from the barn to the new facility (Table 3). No insurance costs are included because the small farm is assumed to custom hire liquid manure spreading rather than purchase the spreading equipment. Tax implications associated with implementing the facility are not included in the cost estimate.

The cost of maintaining the facility is assumed to be $244.22, one percent of the initial capital implementation cost. Agitation of the earthen pond with a hollow piston pump costs

$300 per year assuming the pump requires 3000 KW/Year valued at $.10/KW. There is no change in the type of machinery utilized to collect manure from the barn and barnyard areas. However, moving from a solid to liquid storage system requires the use of different machinery to spread the manure in the field. It is unlikely the farm will purchase this expensive equipment. Therefore, the scenario assumes the small farm custom hires manure application at a cost of $75 per cow, totaling $4,500 annually. It is important to note that the small farm will no longer be spending $2,657.00 to spread field-stacked manure. Therefore, the manure spreading cost is $1,843.00. Lower labor requirements are cited as an economic benefit of implementing a liquid manure storage system (Casler and LaDue, 1972, Holmes and Klemm,1989). This scenario assumes implementation of the liquid manure storage system reduces labor 25%. This benefit reduces hired-labor costs by $3,000.

The nutrient value (nitrogen, phosphorus, and potassium) of the manure is assumed to increase slightly when switching from a field stacking to liquid manure storage system. Nitrogen is assumed to increase 0.7 pounds per ton, phosphorus 0.3 pounds and potassium 1.3 pounds. Valuing nitrogen at $0.27/lb, phosphate at $0.26/lb, and potash at $0.16/lb the farm saves $503.00. Therefore, commercial fertilizer purchases are reduced to reflect this savings.

Barnyard Waste Management

Similar to manure management, improved barnyard waste management is defined as two levels based on expected differences in costs. Both scenarios assume the barnyard provides 50 square feet per cow, but are differentiated by their runoff transfer and collection systems. An NRCS key informant who has worked with farmers in the study area to implement this BMP constructed the following representative capital cost estimate (Hartline, 1999).

Barnyard Waste Management I assumes barnyard runoff is conveyed to a settling basin where solids are removed and then periodically (every 2-5 days) discharged onto a designated vegetative filter strip (VFS). The scenario is only applicable to the small and medium farms. The large farm has a freestall barn and no outside barnyard area for the cows. *Barnyard Waste Management II (EP)* assumes barnyard runoff is captured and conveyed to the liquid manure storage system. This scenario is applicable to the medium baseline farm since it currently operates a liquid manure management system. The scenario is only applicable to the small farm if Manure Management II is implemented (i.e. a liquid manure storage facility is implemented). The scenario is not applicable to the large farm since it is rare for this size operation to utilize a barnyard in this geographical area (Hartline, 1999).

To implement *Barnyard Management I (to VFS)* the small farm must spend $11,765.08 to pave the barnyard and establish a vegetative filter strip. Implementation of *Barnyard Waste Management II (to EP)* for the small farm costs $9,425.98 (in addition to implementing *Manure Management II (EP)*). The medium farm must spend $24,568.03 to implement *Barnyard Waste Management II (to EP).* Annual maintenance costs of the both systems are assumed to be 1% of the initial implementation cost.

Milking Waste Management

In this analysis, Milking Waste Management is defined at two levels, differentiated by wastewater collection and transfer systems. *Milking Waste Management I* assumes the wastewater is collected in a settling basin and periodically (every 2-5 days) transferred and discharged onto a designated vegetative filter strip (VFS). This scenario is only applied to the small farm. This milking waste management system is not recommended by NRCS personnel for the large farm due to expected large quantities of wastewater (Hartline, 1999). The medium farm could implement this BMP, but transferring milking waste to the farm's current liquid manure storage system is less expensive.

Milking Waste Management II (to EP) assumes the wastewater is collected and transferred to a liquid manure storage system. This scenario is applicable to the medium and large baseline panel farms because they currently operate a liquid manure storage system. The scenario is only applicable to the small panel farm if *Manure Management II (EP)* is implemented (i.e. a liquid manure storage facility is implemented).

Both scenarios assume the small farm pipeline milking system results in 200 gallons (3.33 gallons/cow) of wastewater discharged a day. The medium and large farms milking parlors are assumed to discharge 500 (3.33 gallons/cow) and 1000 gallons (2.86 gallons/cow) of wastewater a day. The amount of wastewater decrease with increasing herd size because the water needed to wash down the milking equipment and/parlor does not increase proportionally.

Capital costs estimates for the milking management scenarios for each panel farm were constructed by an NRCS key informant who has worked with farmers in the study area to implement these BMPs (Hartline, 1999). The initial capital cost to implement *Milking Waste Management I (to VFS)* for the small farm is equal to $3, 217.13. Implementation of *Milking Waste Management II (to EP)* for the small farm is equal to $2,532.03 (in addition to implementing *Manure Management II (EP)*). Since the medium and large farms currently operate a liquid manure storage system the capital costs of implementing *Milking Waste Management II (to EP)* are relatively low, $4,843.80. Annual maintenance costs of the both systems are assumed to be 1% of the initial implementation cost.

Results and Discussions

Numerous financial indicators may be used as criteria to quantify the financial impact of BMP implementation. This section summarizes the change in average annual net cash farm income and the probability of a cash flow deficit during a given year over the ten year time horizon. Net cash farm income equals total cash receipts minus all cash expenses. Net cash farm income is used to pay family living expenses, principal payments on loans, income and self employment taxes, and machinery replacement. The probability of a cash flow deficit is the number of iterations (out of the 100 that FLIPSIM runs before summarizing the financial situation in any given year) that result in cash requirements for family living, principal payments, taxes, and machinery greater than the annual net cash farm income earned.

<u>Small Farm</u>

As expected, the impact on average annual net cash farm income in year 1999 (the implementation year) corresponds with the magnitude of the initial one-time implementation cost (Table 4). Implementing only *Manure Management I (to CSF)*, *Manure Management II (to EP)* or combination systems such as *Manure Management II (to EP) & Barnyard (to storage)*, *Manure Management II (to EP) & Milking Waste (to storage)*, and *Manure Management II (to EP) plus Barnyard & Milking Waste (to storage)* require the largest capital investments resulting in the largest impact on average annual net cash farm income.

Average annual net cash farm income is reduced 67% in 1999 when the farm implements *Manure Management I (to CSF)*. The large capital investment increases the probability of a cash flow deficit at the end of the implementation year by 85% (Table 5). However, the farm secures an operating loan to cover this deficit and on average adds a small amount to cash reserves the following year. It is important to note that in the case of a cash flow deficit, annual family withdrawals are forced to be minimal (approximately $25,000). Implementation of *Manure Management II (to EP)* reduces average annual net cash farm income by 47% in the implementation year (Table 4). However, benefits associated with the system, such as decreased labor and increased nutrient value (decreased commercial fertilizer purchases) increase the average annual net cash farm income slightly over the remaining time horizon. Similarly the probability of a cash flow deficit is increased 63% in the implementation year, but decreases slightly over the remaining years (Table 5). Benefits of Manure Management II are reflected in all systems that contain this type of storage.

Table 4:

Net Cash Farm Income (% Change from Baseline Scenario)

BMP	1999	2000	2001	2002-2007
SMALL Farm				
Manure Management I (to CSF[a])	-67%	-1%	-1%	-1 to -3%
Barnyard Waste Management I (to VFS[b])	-24%	Decreases 1% or less in remaining yrs		
Milking Waste Management I (to VFS)	-7%	Decreases 1% or less in remaining yrs		
Manure Management II (to EP[c])	-47%	+3%	+4%	+4 to +5%
Barnyard Waste Management II (to EP)	-66%	+3%	+3%	+3 to +4%
Milking Waste Management II (to EP)	-57%	+3%	+3%	+3 to +5%
Barnyard & Milking Management (to EP)	-76%	+2%	+2%	+2 to +3%
MEDIUM Farm				
Barnyard Waste Management II (to EP)	-24%	Decreases 1% or less in remaining yrs		
Milking Waste Management II (to EP)	-5%	Decreases 1% or less in remaining yrs		
Barnyard & Milking Management (to EP)	-28%	Decreases 1% or less in remaining yrs		
LARGE Farm				
Milking Waste Management II (to EP)	-2%	Decreases 1% or less in remaining yrs		

[a]CSF=Central Stacking Facility
[b]VFS = Vegetative Filter Strip
[c]EP=Earthen Pond

Table 5:

Probability of a Cash Flow Deficit (Percentage Change from Baseline Scenario)

BMP	1999	2000	2001	2002-2007
SMALL Farm				
Manure Management I (to CSF)	+85%	+9%	+7%	+9 to +23%
Barnyard Waste Management I (to VFS)	+24%	+1%	+1%	+1 to +4%
Milking Waste Management I (to VFS)	+4%	+1%	0%	0 to +1%
Manure Management II (to EP)	+63%	-4%	-4%	-8 to 0%
Barnyard Waste Management II (to EP)	+85%	+6%	+2%	+3 to +11%
Milking Waste Management II (to EP)	+73%	+2%	-1%	-1 to +5%
Barnyard & Milking Management (to EP)	+94%	+16%	+8%	+8 to +22%
MEDIUM Farm				
Barnyard Waste Management II (to EP)	+29%	+28%	+41%	+31 to +54%
Milking Waste Management II (to EP)	+12%	+32%	+41%	+32 to +53%
Barnyard & Milking Management (to EP)	+34%	+27%	+41%	+31 to +55%
LARGE Farm				
Milking Waste Management II (to EP)	0%	0%	0%	0%

A combination system that includes *Manure Management II (to EP)* & *Barnyard and Milking Waste Management II (to EP)* reduces net cash farm income by 76% (Table 4). The probability of a cash flow deficit at the end of the implementation year is 94% (Table 5). However, the farm secures an operating loan to cover this deficit and on average adds a small amount to cash reserves the following year. Annual family withdrawals during the implementation year are minimal, approximately $25,000.

Milking Waste (to VFS) and *Barnyard Waste (to VFS*) have the smallest impact on average annual net cash farm income and probability of a cash flow deficit (Table 4, Table 5). Both scenarios have relatively low capital investment costs and extremely low annual operation and maintenance costs. Therefore, implementation of either BMP is an attractive option for the small farm that is not ready to make the large capital investment needed to change the current manure storage system.

Medium Farm

The medium farm currently operates a liquid manure storage system. Therefore, only three BMP implementation scenarios were modeled: *Barnyard Waste Management II (to EP), Milking Waste Management II (to EP)*, and a combination of *Barnyard and Milking Waste II (to EP)*.

As expected, the impact on average annual net cash farm income in year 1999 (the implementation year) corresponds with the magnitude of the initial one-time implementation cost (Table 4). The combination system of *Barnyard and Milking Waste II (to EP)* has the largest impact on average annual net cash farm income, reducing it by 28% in 1999. The probability of a cash flow deficit at the end of the implementation year is increased 34% and is increased from a range of 27% to 55% over the remaining years (Table 5). *Barnyard Waste Management II (to EP)* as a similar effect on average annual net cash farm income and probability of a cash flow deficit. *Milking Waste Management II (to EP)* has the smallest financial impact because capital and annual operation and maintenance cost are relatively low.

It is important to note that no matter what BMP is implemented, the medium farm has a larger percentage change in the probability of a cash flow deficit over the time horizon as compared to the small farm. This occurs because the baseline medium farm has a very small probability of a cash deficit in any year over the time horizon while the small baseline farm has a high probability of a cash flow deficit.

Large Farm

The large farm has a free-stall barn and currently operates a liquid manure storage system. Therefore, no manure management or barnyard BMP implementation scenarios are analyzed. The only additional P management examined is Milking Waste Management. Implementing *Milking Waste Management II (to EP)* has minimal effect of average annual net cash farm income, reducing it by 2% in the implementation year, because the initial investment and average annual operation and maintenance costs are extremely low. Implementation of the BMP does not effect the probability of a cash flow deficit.

Conclusion

The primary pollutant of Lake Champlain is phosphorus and dairy farms have been identified as a major contributor. To reduce the threat of phosphorus, farmers may choose to implement management strategies that minimize the amount of clean water contacting animal manure. The goal of this study is to determine the farm-level financial impact of alternative phosphorus management practices on different sizes and types of Vermont dairy farms.

Future financial performance of three representative farms (60 cows, 150 cows, 350 cows) were modeled under current manure management farm practices and under several new phosphorus-reducing manure management regimes using the Farm-level Income and Policy Simulator (FLIPSim). All simulation scenarios were run with milk price projections assuming no Northeast Dairy Compact.

Results indicate that implementation of milking waste management practices have the smallest financial impact on all three farm sizes. For the small farm, BMPs requiring large capital investments in manure storage structures have the largest financial impact in terms of reducing average annual net cash farm income. However, a liquid manure storage system, once implemented, may slightly increase average annual net cash farm income and reduce the probability of a cash flow deficit after the initial implementation year. It is important to note that the benefits of reduced labor and manure nutrient value are "potential" and must be recognized by the individual farm operator. Milking waste management has a relatively small financial impact on the medium farm and virtually no impact on the large farm. Both barnyard waste management or a combination barnyard & milking waste management system have the largest financial impact on the medium farm primarily because the paving of a barnyard to hold 150 cows requires a large capital investment.

It is important to note several limitations of this study. First, changes in yields that may result from implementing manure management are not included. Second, the herd size for each representative farm is held constant over the ten-year time horizon. Third, the scenarios are representative of three well-managed Vermont dairy farms and do not necessarily represent the financial impact of manure management for similar sizes of dairy farms located in other areas of the country.

This analysis assumes the farm pays the full (cash) cost of implementation. Cost-sharing or loan subsidies may facilitate the adoption of BMPs by reducing the large financial impacts in the implementation year. While most BMPs have a large capital investment, once implemented, operation and maintenance costs are low and in some cases benefits, such as reduced labor and increased manure nutrient value, may slightly increase net cash farm income decreasing the probability of a cash flow deficit over time.

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