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Representative Farm Budgets and Performance Indicators for Integrated Farming Practices in Maine

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CONTENTS

TABLES

FIGURES

ABSTRACT

This report compares the relative profitability and sustainability of Maine farms integrating crops and livestock with comparable non-integrated or conventional farms. Cooperating Maine farmers participating in the project "Re-Integrating Crop and Livestock Enterprises in Three Northern States" sponsored by the Initiative for Future Agriculture and Food Systems (IFAFS) were surveyed. Cooperating farms were considering integration or were already integrated through either diversified on-farm integration or through more prevalent coupled interactions between specialized livestock and crop producers. Potato and dairy systems coupled for only two years (short term) had greater profitability compared to conventional systems. Profitability increased in the short term in two ways. First, potato farms grew more of their primary cash crop. Second, dairy farms expanded cow numbers, increasing profitability assuming increasing returns to scale. Coupled systems integrated for more than ten years (long term) had more favorable profitability and sustainability measures than short-term couplers since greater manure-nutrient credits were taken for potatoes and silage corn. The picture improved even more if potato yields increased in the long term, as suggested by long-term rotation plot studies in Maine. Even if coupling is more profitable than non-integrated systems, it still requires farms to be in close proximity and for farmers to have adequate working relationships. Farmers may have to relocate in order to make coupling feasible. Future research will develop bio-economic models to simulate the long-term impacts of integrated and specialized production.

I. INTRODUCTION

Historically, cash field crops and livestock were integrated in Maine, often being produced on the same farm. Over time, however, farms have become increasingly specialized, focusing exclusively on the production of either crop or livestock products. Recently, some potato, dairy, and beef farms in Maine have experimented with integrating crop and livestock systems by coupled interactions between specialized farms or on-farm integration involving crop diversification. This has generated interest in the potential for integrating crop and livestock systems to improve profitability and to encourage tighter nutrient cycling. Typical integration involves application of manure on cropland used for production of cash field crops, livestock feed, and/or mixed vegetables.

This report documents budgets and economic and sustainability indicators for farms in Maine that integrate crop and livestock systems. Farm budgets and indicators are based on data collected from Maine farmers participating in the project "Re-Integrating Crop and Livestock Enterprises in Three Northern States" sponsored by the Initiative for Future Agriculture and Food Systems (IFAFS). To construct models of integrated crop and livestock systems, participating farms were aggregated to a broadly "representative" level. These participants provided the basis for examining the economic and agronomic tradeoffs in crop and livestock integration.

Interviews with cooperating farms and agronomic results for potato systems amended with manure suggest that integrating livestock with crops may offer agronomic and socio-economic benefits to farmers. Benefits include increased acreage for cash crop production, potential reductions in fertilizer use, increased crop yields and quality, improved soil quality, options for herd expansion, and enhanced management skills by interaction with another producer. However, integrated systems may be more costly during transition to these systems and due to the increased management time spent coordinating integration with another farmer. Additionally, spatial separation of the potato and dairy industries in Maine may limit integration (Files and Smith 2001).

Cooperating farmers were selected based upon a selective sampling structure designed to span the horizon from farms that were considering integration to those that were already integrated through either coupled interactions between livestock and crop producers or through diversified on-farm integration. Coupled farms are specialized crop and livestock operations integrating livestock with crops by swapping land used for cash crops and livestock feed. Livestock feed is exchanged for manure. On-farm integrated farms have both livestock and diversified crop enterprises on farm and are internally integrated. Cash field crops, forages, and/or mixed vegetables are grown. This analysis focuses on coupled farms, which constitute the majority of cooperating producers.

Representative enterprise and whole-farm budgets are compared between models of conventional and coupled potato and dairy farms for central Maine. There are two size classes of representative models, small and medium-large. Two primary cases of coupled interactions are observed in Maine. The more prevalent case involves the coupled dairy farm growing forages on the potato farm's rotational acreage. In the second case, the dairy farm contracts the potato farm to grow all forages. For all coupled cases, it is assumed that the dairy farm provides manure, manure handling equipment, and storage for manure and forages. In this report, conventional potato farms represent potato farms from central Maine, where grain corn is grown as a rotation crop; models of conventional dairy farms are based on a previous cost-of-production study of the dairy industry in Maine (Dalton and Bragg 2003).

Integrators are also classified as short-term and long-term. Short-term integrators have started coupling within the last two years. No reduction in the use of chemical fertilizers for potato and silage corn was observed and increased crop yields from coupling are not likely. Long-term integrators have been coupled for more than ten years and appear to have greater opportunities for increasing profitability. Potatoes and silage corn both receive manure-nutrient credits, and previous field research suggests a higher likelihood of increased potato yields from long-term integration, especially in dry years (Gallandt et al. 1998). Manure-nutrient credits are reductions in fertilizer use from manure only and are not fertilizer reductions from crops grown previously in the rotation.

Economic and sustainability indicators are calculated for coupled and conventional models. Economic indicators include net farm income, return-over-variable costs, profit over revenues, asset-turnover ratio, and operating-expense ratio. Two sustainability indicators of farming value added are used. Other sustainability indicators include energy and machinery use, support for local communities, and feed balance. Coupled farms should have higher profitability, farming value added, and support for local families compared to conventional farms. Energy and machinery use should be lower. Other indicators may be more positive or negative.

Section two of this paper provides a brief background of non-integrated and integrated potato and dairy farms in Maine. A description of the representative models of potato and dairy farms used for this economic analysis is also included in this section. Section three presents the materials and methods used for constructing representative budgets and calculating economic indicators. Section four discusses the results of whole-farm and enterprise budgets for the farm models. Section five compares economic indicators for conventional and coupled model farms. Section six presents the conclusions and the limitations of this study.

II. BACKGROUND

Conventional and Integrated Farms

In Maine, potato farms are concentrated in Aroostook County while the bulk of the dairy industry is in central and south-central Maine (Figure 1). Farm numbers (USDA-NEASS 1997) and estimated crop acreages (Hoshide and Dalton 2003) have decreased for both potato and dairy farms in Maine from 1964 to 1997. Potato production declined during this time (USDA-NEASS 1997), while milk production has been more variable, declining slightly from about 6,600,000 to 6,540,000 cwt from 1965 to 2001 (MSPO 2003). The spatial separation of the Maine potato and dairy industries appears to be a challenge to integration. With the exception of Penobscot County, counties where dairy farms are common have few potato farms and limited potato acreage. In 1997, about 90% of Maine's potato acreage was located in Aroostook County. Dairy farms and milk cows are not common in Aroostook County, but are abundant in Penobscot County. Because of this separation of industries, cooperating farms in Penobscot County account for 65% of the integrated acreage of producers participating in this study.

Integrated farms in Maine are represented by the 26 cooperating producers shown in Figure 2. Extension educators recommended cooperating farmers, and cooperating farms were categorized as on-farm integrated, coupled, and potential integrators. Table 1 describes on-farm and coupled integration. On-farm integrators in this study are diversified dairy operations or a potato farm with a livestock component. Coupled farms are specialized crop and livestock farms that exchange some combination of land, feed, and other inputs as described in Table 1.

Enterprise production operations and asset ownership for these three types of inter-farm coupling are shown in Table 2. The relationship between coupled crop and livestock farms can evolve

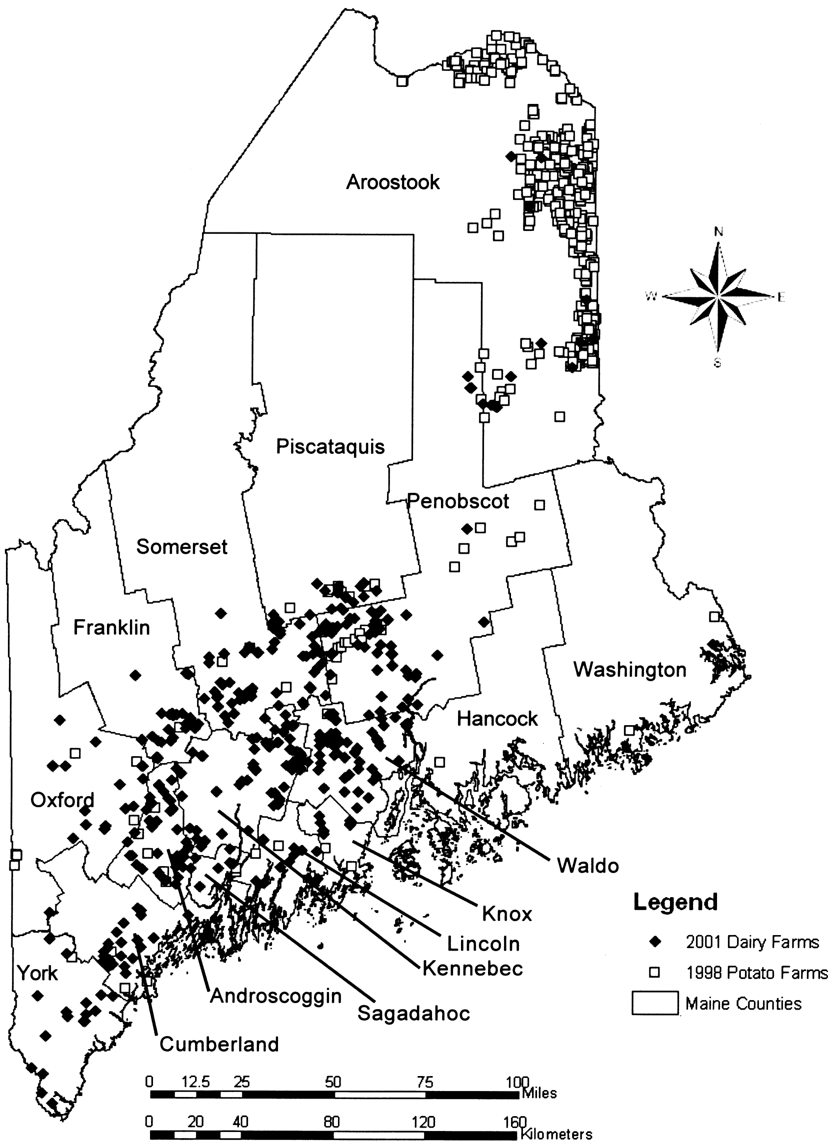

Figure 1. Maine potato farms in 1998 and dairy farms in 2001. Farms are plotted using farmer addresses and may not represent actual farm centers.

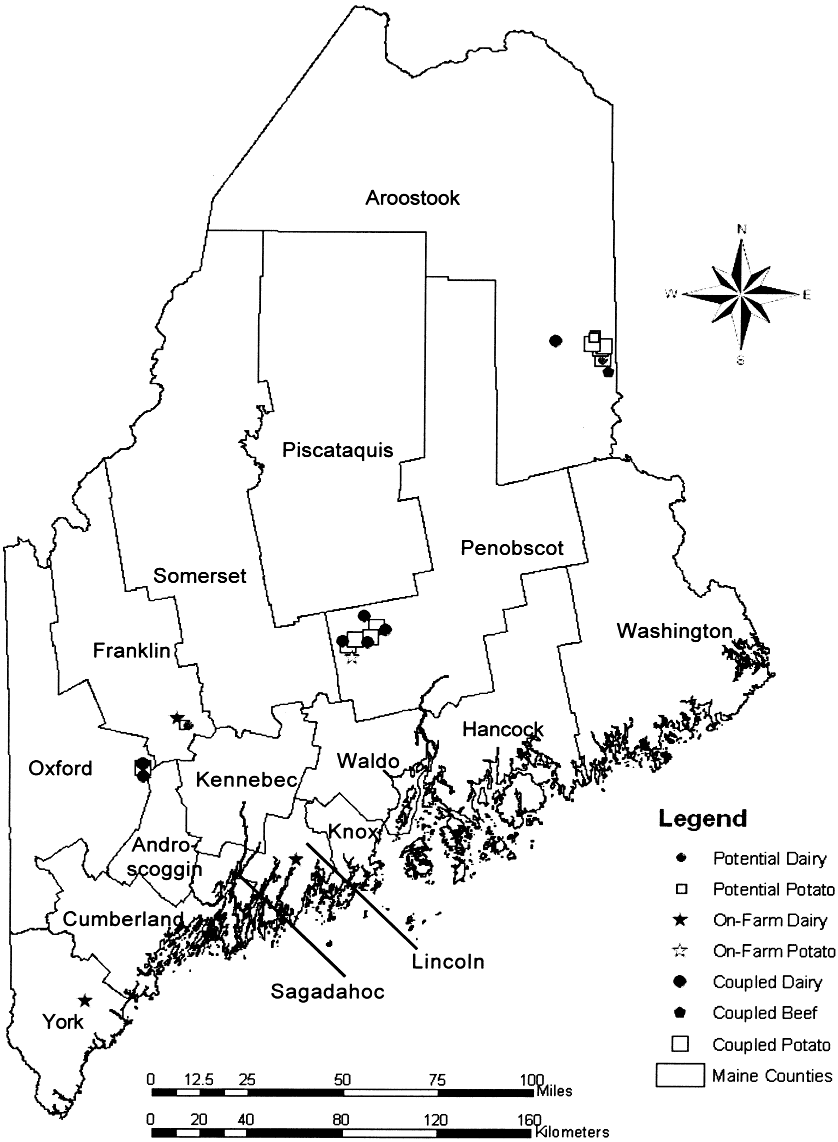

Figure 2. Maine cooperating farms classified as coupled, on-farm integrated, or potentially interested in crop and livestock integration. The on-farm integrated classification represents the farm's dominant enterprise.

from simple trading of cropland (land-coupled) to more complex arrangements where feed is exchanged (land/feed-coupled) or production inputs are shared such as labor, fertilizer, and equipment (land/feed/input-coupled). This analysis focused on land-coupled and land/feed-coupled farm types common in central Maine. Although two pairs of coupled farms in central Maine were land/feed/input-coupled, this case was not analyzed due to the many ways that production inputs can be shared.

The predominant land-coupled (L-coupled) farm model assumed that silage corn grown on potato farmland is managed entirely by the dairy farm in a land swap. Thus the potato farm paid no production costs for silage corn. The dairy farm covered the costs of forage storage and manure-spreading. Land/feed-coupled (LF-coupled) farms also swapped land, and this model assumed that the potato farm grew forages for sale to the coupled dairy farm at typical market prices (Table 3). In this coupling, the dairy farm provided forage and manure storages as well as the manure-spreading equipment; the potato farm paid for all other crop production costs.

This study found some potato and dairy farmers were interested in integration even though their ability to implement it has been limited. These farms were labeled as "potential integrators" and account for four of the 26 cooperating farms. Of the remaining 22 farms, three did not provide enough economic data for representative models. The 19 farms that provided enough data were composed

Table 1. On-farm and coupled integration types.

Integration Type	Farms Involved	Description
On-Farm	1	Livestock and crops raised; Crops raised for livestock feed; Livestock manure applied to crops
Coupled	≥ 2	Specialized crop and livestock farms exchange feed and manure
Land (L)	≥ 2	Livestock farm raises feed on crop farm's land; Crop farm uses livestock land for crops
Land/Feed (LF)	≥ 2	Crop farm contracted by livestock farm to grow feed; Crop farm uses both own land and livestock farm's land
Land/Feed/Input (LFI)	≥ 2	Production operations and ownership as well as land may be shared

Table 2. Division of production responsibilities and asset ownership for coupled farms.

	Coupled Farm Types		
Activities	Land	Land/Feed	Land/Feed/Input
Operations			
Grow and harvest potatoes	Potato	Potato	Potato/Dairy
Grow and harvest forage crops	Dairy	Potato	Potato/Dairy
Grow concentrates[a]	None	None	None
Spreads dairy manure	Dairy	Potato	Potato/Dairy
Purchases concentrates	Dairy	Dairy	Dairy
Manages dairy herd	Dairy	Dairy	Dairy
Ownership			
Potato production equipment	Potato	Potato	Potato
Forage production equipment	Dairy	Potato	Potato/Dairy
Manure spreading equipment	Dairy	Dairy	Potato/Dairy
Manure storages	Dairy	Dairy	Dairy
Livestock feed storages	Dairy	Dairy	Potato/Dairy
Potato and corn cropland	Potato/Dairy	Potato/Dairy	Potato/Dairy

[a]Maine dairy farms do not typically grow crops used for concentrated feed (Dalton and Bragg 2003).

of 15 coupled farms and four on-farm integrators. Production data from the 15 coupled farms were used to construct different scales of representative synthetic budgets. Two pairs of cooperating farms were LF-coupled, selling and purchasing forages slightly below market prices.[1] The remaining cooperating farms were L-coupled.

Representative Conventional and Coupled Models

Models were developed to represent integrated and non-integrated agricultural production. This section describes production information for representative models of conventional (non-integrated) and coupled (integrated) potato and dairy farms in two size classes, small and medium-large (M/L). Both integrated and non-integrated models were constructed using data from previous studies of the Maine potato (Dalton et al. 2003a, 2003b) and dairy (Dalton and Bragg 2003) industries in addition to data from cooperating farms. Information used for all models were based on the 2001 calendar year.

[1]In both instances, the LF-coupled dairy farm conducted some crop production operations.

Crop yields, prices, and acreages for conventional and coupled farm models are listed in Table 3. Silage corn, dry hay, and haylage yields and prices were typical for cooperating producers in central Maine. For small coupled farms, the dry hay price was an average received for a first and second cut of round and square bales, respectively. For medium-large coupled farms, the haylage price was an average of the price received for a first cut of haylage and a second cut consisting of 90% haylage and 10% square bales. Second cut square bales were used to feed calves.

Coupled models represented cooperating farms that were integrated on more than 30% of crop acreage in a two-year potato-silage-corn rotation. This high degree of integration represented the greatest potential for coupled interactions between specialized dairy and potato producers. Coupling occurred on the potato farm's rotational acreage and the dairy farm's silage corn land. Manure was spread in the corn rotation year during spring or fall (our farm models assumed a spring manure application). Models for both potato and dairy farms assumed that 25% of farmland was rented.

Both conventional and coupled potato and dairy farms had common base assumptions of production activities. Production assumptions were based on the most common practices of cooperating farms, were used to derive representative models, and were not necessarily specific to individual cooperating farms. Production assumptions for all crops grown by conventional and coupled potato and dairy farms is summarized in Table 4, while livestock assumptions for dairy farms are listed in Table 5.

Conventional and both types of coupled potato farms raised potatoes and grain corn. LF-coupled potato farms and L-coupled dairy farms grew silage corn and dry hay[2] or haylage[3]. LF-coupled dairy farms did not raise any crops, focusing instead on milk production. Prices are those generally received by cooperating farmers (Table 3). Manure and fertilizer applications are shown in Table 6 for conventional and coupled farm models. The assumptions used for manure and fertilizer applications are the same for L-coupled and LF-coupled farms. Major nutrients, nitrogen (N), phosphorus (P), and potassium (K), applied as manure, fertilizer, and in total are shown for each crop.

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[2]Dry hay is cut, dried, and baled as round bales for first cut and as square bales for second cut. First and second cut yield 2.1 and 1.4 tons, respectively. Round (1000 lb) and square (40 lb) bales use surveyed prices of $22.50 and $1.88/bale, respectively, and may not reflect current market prices.

[3]First and second cut haylage yield 3.6 and 2.4 tons, respectively. It is assumed 10% of second cut is baled as square bales for calves. Haylage is packed into horizontal silos and covered and sold for $30/ton. As with small dairy farms, square bales were sold for $1.88/bale.

Table 3. Enterprise budget crop yields and prices and farm model acreages.

					Potato Farm Acres[b]						Dairy Farm Acres[b]		
					Conv.		L-Coup.		LF-Coup.		Conv.& L-Coup.		LF-Coup.
Crop	Yield/Acre[a]	Price ($/unit)	Yield (cwt/acre)	Price ($/cwt)	S	M/L	S	M/L	S	M/L	S	M/L	S & M/L
Potato	240 cwt	$6.88	240	$6.88	160	320	209	480	209	480	-	-	-
Grain Corn	100 bu	$2.50	56	$4.46	160	320	111	160	111	160	-	-	-
Silage Corn	15 tons	$25.00	300	$1.25	-	-	-	-	98	320	98	320	-
Dry Hay[c]	3.5 tons	$64.50	70	$3.23	-	-	-	-	73	-	73	-	-
Haylage[d]	6 tons	$32.55	120	$1.63	-	-	-	-	-	200	-	200	-

[a]Forage yields per acre are shown as harvested tons and not tons of dry matter.
[b]Farm acres are operated crop acres, not owned crop acres.
[c]First cut harvested as round bales and second cut harvested as square bales.
[d]First cut haylage and 90% haylage and 10% square bales for second cut.

Table 4. Base crop production assumptions for potato- and dairy-farm models.

Farm Model Crop	Manure Applied	-- Pesticide Applications - Herbi-cides	Insecti-cides	Fungi-cides	Sprout Inhibit.[a]	Top Kill[b]	Times Har-vested	Lime Applied (t/a)
Potato	No	2	2	8	1	2	1	0.50
Grain Corn	No	1	-	-	-	-	1	0.61
Silage Corn	Yes	1	-	-	-	-	1	0.61
Hay	Yes	-	-	-	-	-	2	0.50
Haylage	Yes	-	-	-	-	-	2	0.50

[a]Applied to 50% of potato acres for late storage varieties.
[b]Applied to 75% of potato acres for storage varieties since 25% of acres are harvested fresh out of field.

Table 5. Base livestock assumptions for dairy-farm models.

Size	Livestock Numbers Milk Cows	Heif-ers	Calves	Bulls	Herd Avg. (cwt)	Manure Type	Bedding	Storage
Small	66	28	26	1	159	Solid	Sawdust	Stack
Medium-large	200	90	90	3	210	Liquid	Sand/ Sawdust	Pit/ Stack

Potato-farm models

Representative potato-farm models assumed a two-year rotation of potatoes and rotation crop. Grain corn was a typical conventional rotation crop in central Maine. Coupled potato farms grew more potatoes and less grain corn than conventional farms with similar acreage since dairy farm crop acreage increased land available for a one-to-one rotation with potatoes. The farm models used an average contract price for chipping potatoes of $6.88/cwt (Table 3). Although most cooperating potato farms used some irrigation, potato-farm models assumed no irrigation. Irrigation was not included in this analysis due to a lack of reliable data for potato yield response to irrigation and amendment for central Maine. Non-irrigated marketable potato yields for all farm models was assumed to be 240 cwt/acre, a typical average for central Maine producers obtained from an agronomist used by many cooperating potato growers (Lauchlin Titus, personal communication).

It was assumed that the L-coupled potato farm grew just potatoes and grain corn, while the LF-coupled potato farm also handled all forage production for the coupled dairy farm. The LF-coupled dairy farm provided manure-spreading equipment as well as feed crop and manure storages. Although small dairy farms generated only solid manure, all small cooperating dairy farms used a combination of both solid dairy and hen[4] manure. Therefore, it was assumed that the same nutrient credit used for liquid manure in the case of medium-large coupled farms was taken for solid manure for small coupled farms. Most input and output quantities and prices were based on cooperating farms in each coupled size class. Both family and hired labor were used in all models. However, family labor was not entered as an explicit cost due to lack of these data for potato farms. Thus returns to family labor were captured in net farm income, and the labor expense shown was only hired labor.

Crop management practices outlined in Table 4 were typical for cooperating farms in central Maine. Two herbicide applications of Sencor 75DF were applied with Matrix for grass. Insecticide applications included Admire in furrow and an early summer Asana XL spray. There was an average of eight fungicide applications of Diathane DF and Curzate. Actual fungicide applications can vary depending on the weather. Half of potato acreage was treated with sprout inhibitor such as Sprout Stop (MH). Potatoes were top killed twice with diquat or other chemical products. Crops required typical amounts of lime. Chemical fertilizer use shown in Table 6 varied depending on duration of integration.

Manure was not applied to conventional potatoes and grain corn or to potatoes on coupled farms. Instead for both coupled potato and dairy farms, manure was typically applied in the spring to silage corn during the coupled rotation year and was also applied to hay/haylage during mid-summer. Farm models took no manure-nutrient credit for potatoes grown by short-term integrators. For long-term coupled potato farms, starter fertilizer on potatoes was reduced by taking manure-nutrient credits amounting to roughly a 61% reduction in nitrogen and a 73% reduction in both phosphorus and potassium compared to conventional applications. Long-term coupled potato farms also reduced the application of 46-0-0 side-dressed fertilizer on potatoes by about 37% compared to conventional and short-term coupled farms (Table 6).

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[4]Poultry were not part of the operation, but hen manure was brought in from large egg facilities.

Table 6. Manure, fertilizer, and nutrient applications and fertilizer cost for conventional and coupled models.

				Manure	Fertilizer			Nutrients Applied as (lb/acre)								
				Applied	Type	Applied	Cost	Manure			Fertilizer			Total		
Model	Type	Size	Crop	per Acre[a]	(Analysis)	(lb/a)	($/ton)	N	P	K	N	P	K	N	P	K
Conventional	Potato	S & M/L	Potato	-	Potato Blend (10-10-10)	1204	$210	-	-	-	178	120	120	178	120	120
					Side Dress (46-0-0)	126	$230									
			Grain Corn	-	Gr. Corn Starter (16-20-0)	270	$220	-	-	-	144	54	78	144	54	78
					Side Dress (46-0-0)	220	$230									
					Muriate of Potash (0-0-60)	130	$160									
	Dairy	Small	Silage Corn	22.5 ton	Side Dress (46-0-0)	125	$230	165	41	148	58	-	-	223	41	148
			Hay	12.5 ton	Top Dress (46-0-0)	100	$230	92	23	82	46	-	-	138	23	82
		M/L	Silage Corn	5500 gal	Side Dress (46-0-0)	125	$230	139	83	113	58	-	-	197	83	113
			Haylage	4000 gal	Top Dress (10-20-10)	200	$220	101	60	82	57	40	20	158	100	102
					Top Dress (46-0-0)	80	$230									
Coupled	Potato	S & M/L	Potato	-	Potato Blend (10-10-10)	1204	$210	-	-	-	178	120	120	178	120	120
Land &					Side Dress (46-0-0)	126	$230									
Land/Feed	Potato	Small	Silage Corn	22.5 ton	Side Dress (46-0-0)	125	$230	165	41	148	58	-	-	223	41	148
(Short-	&	M/L		5500 gal	Side Dress (46-0-0)	125	$230	139	83	113	58	-	-	197	83	113
term)	Dairy	Small	Hay	12.5 ton	Top Dress (46-0-0)	100	$230	92	23	82	46	-	-	138	23	82
		M/L	Haylage	4000 gal	Top Dress (10-20-10)	200	$220	101	60	82	57	40	20	158	100	102
					Top Dress (46-0-0)	80	$230									
Coupled	Potato	S & M/L	Potato	-	Potato Blend (10-10-10)	320	$210	-	-	-	69	32	32	69	32	32
Land &					Side Dress (46-0-0)	80	$230									
Land/Feed	Potato	Small	Silage Corn	22.5 ton	Side Dress (46-0-0)	100	$230	165	41	148	46	-	-	211	41	148
(Long-	&	M/L		5500 gal	Side Dress (46-0-0)	100	$230	139	83	113	46	-	-	185	83	113
term)	Dairy	Small	Hay	12.5 ton	Top Dress (46-0-0)	100	$230	92	23	82	46	-	-	138	23	82
		M/L	Haylage	4000 gal	Top Dress (10-20-10)	200	$220	101	60	82	57	40	20	158	100	102
					Top Dress (46-0-0)	80	$230									

[a]Small models use solid dairy manure (tons/acre) while medium-large (M/L) models use liquid dairy manure (gallons/acre).

Dairy-farm models

In representative models, dairy farms grew silage corn and grass in a long-term rotation for livestock forages. Dairy farms purchased all concentrates.[5] For coupled models, silage corn acreage was integrated with a potato farm. Base livestock assumptions are presented in Table 5. Dairy budgets were based on Dalton and Bragg (2003), where their models of small- and medium-sized dairy farms were aggregated to form the conventional small size class, while the large model was used for the medium-large class. Coupled dairy-farm models were updated with data collected from cooperating dairy farms.

L-coupled dairy farms raised silage corn and hay/haylage on the potato farms' rotation land. The LF-coupled dairy farm purchased all forages from the potato farm at market prices (shown in Table 3) and focused on milk production. Cooperating farms in each coupled size class provided the basis for most input and output quantities and prices. To be consistent with the models of potato farms, family labor on dairy farms was not included due to lack of these data for potato farms. As in potato-farm models, returns to family labor were captured in net farm income and only the cost of hired labor was itemized.

Dairy farms stored and spread manure. In general, small dairy farms generated solid manure bedded with sawdust, while medium-large farms mainly produced liquid manure bedded with sand. Liquid manure was stored in pits and was agitated prior to loading into spreader trucks. Larger dairy facilities also produced some solid manure from young stock, which was bedded with sawdust and was spread with a solid spreader. Some medium-large farms used sand as bedding year round, while others bedded with sawdust during the winter and sand during the remainder of the year.

Typical crop management for silage corn involved one herbicide application with no insecticide or fungicide applications. Hay and haylage received no pesticides and both were cut twice a season. Silage corn, hay, and haylage acreages were limed (Table 4). Forage yields, prices, and acreages grown are shown in Table 3. The price of dry hay used on small farms included labor costs for transporting and storing bales. Larger dairy operations utilized lower-valued haylage, which was packed into horizontal silos with a tractor, covered with plastic and tires, and stored. Manure and fertilizer applications for forages were based on typical rates used by cooperating farms (Table 6).

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[5]Only one cooperating coupled dairy farm grew concentrates.

Dairy farms spread manure on silage corn acreage during the spring before planting or during the fall following harvest. For silage corn fertilization, the farm models used in this report assumed that manure was spring applied. For hay or haylage, conventional fertilizer was top dressed prior to first cut. Manure was then spread during the mid-summer after first cut. Typical manure and fertilizer applications and analysis were used (Table 6). Short-term integrated dairy-farm models had been coupled for about two years and took no more manure-nutrient credits for silage corn than before coupling. Long-term coupled models took the same 20% manure-nutrient credit for silage corn as LF-coupled potato. Conventional and coupled hay fertilization was assumed to be the same.

III. BUDGET ASSUMPTIONS AND ECONOMIC INDICATORS

Enterprise and Whole-Farm Budgets

Representative enterprise and whole-farm budgets for coupled potato and dairy farms were constructed. These integrated budgets were compared to conventional non-integrated budgets derived from previous analyses of the Maine dairy (Dalton and Bragg 2003) and potato (Dalton et al. 2003a, 2003b) industries. Data from cooperating farmers and from these previous studies were used to create budgets for each cooperating farm. Individual budgets were generalized to produce representative budgets for different sizes and types of integrators.

Enterprise budgets indicate the relative profitability of different crop or livestock enterprises that represent one aspect of a farming operation. Enterprise budgets show gross income from the enterprise, production costs, net farm income, and returns-over- variable costs and can be used for break-even analysis. Whole-farm budgets represent all farm crop and/or livestock operations and can be used to compare profitability between different farm plans (Kay 1986). Representative whole-farm budgets are provided in Appendices A-1, A-2, B-1, and B-2. Potato whole-farm budgets included a potato enterprise with a rotation crop or crops. Dairy whole-farm budgets included silage corn and dry hay or haylage enterprises in addition to fluid milk.

Conventional and coupled budget equipment inventories were updated and enterprise budgets for potato rotation crops and dairy forages were added. Budget revenues used typical marketable yields and prices. Most quantities and costs for inputs and outputs were share-weighted based on the extent of integration of farms used to construct a particular model size category. Farm operating costs were itemized as seed, fertilizer, lime, chemicals, labor, fuel and oil, maintenance, supplies, insurance, miscellaneous costs, and interest. To be consistent with potato budgets, dairy budgets were presented using only hired labor. Family labor was included in net farm income. Ownership costs included depreciation, interest, tax and insurance on farm equipment, buildings, and land. Equipment costs shared by two or more crops were weighted based on total seasonal equipment operation time.

Conventional and L-coupled budgets assumed the dairy farm grew silage corn and hay or haylage, while the LF-coupled farm model assumed the potato farm grew these forages. Budgets were checked with 2000 Farm Credit data for dairy (Stafford et al. 2001) and with 2001 data for potatoes (Scott Kenney, Farm Credit of Maine, personal communication). Potato enterprise budgets were also compared with a previous study of potato rotations in Aroostook County (Westra and Boyle 1991). Enterprise budgets for grain corn, silage corn, dry hay, and haylage were checked with Penn State budgets (PSU 2004).

Integrated farms should have lower fertilizer costs if nutrient credits were taken for applied manure. For coupled dairy farms, feed costs may be lower if the coupled potato farm grew concentrates, which replaced purchased grain in the ration. Production costs for coupled dairy farms may be lower if manure spreading is either paid for or conducted by the participating potato farm and not the dairy farm.

Based upon the results of the Maine Potato Ecosystem Project, a positive potato yield response from amended soils is expected in dry years (Porter and McBurnie 1996; Gallandt et al. 1998). Amended soils with higher soil moisture may also encourage tuber diseases such as powdery scab (Porter 2003). Such diseases may reduce marketable potato yield.

Economic and Sustainability Indicators

Economic indicators were used to compare performance of conventional non-integrated systems and coupled integrated systems (Table 7). Most of these were standard indicators used to evaluate the financial performance of farms as proposed by the Farm Financial Standards Council (FFSC). The FFSC has identified 13 measures that are important when evaluating farm performance. The economic indicators listed in Table 7 include four of these measures. Return-over-variable costs is not an FFSC measure (FFSC 1997). Five sustainability indicators were also used.

Table 7. Economic and sustainability performance indicators.

Indicator Type	Indicator	Calculation	Description
Economic			
Profitability	Net Farm Income (NFI)	Revenue – Total Expenses	Return to farmer for unpaid labor, management, and owner equity
	Return over Variable Costs (ROVC)	Revenue – Variable Expenses	Return to farmer after all variable production costs are paid
	Profit over Revenues (POR)	Net Farm Income / Revenue	Proportion of revenues that is farm profit
Efficiency	Asset Turnover Ratio (ATR)	Revenue / Total Farm Assets	Efficiency of farm assets used to generate revenue
	Operating Expense Ratio (OER)	(Total operating expenses – Depreciation expense)/Revenue	Efficiency of adjusted farm operating expenses used to generate revenue
Sustainability			
	Farming Value Added (FVA)	Revenue – Costs Returned to Input Sector	Total systems revenue retained in the farming sector
	FVA as Proportion of Producer's Share (FVA_p)	1 – (Costs Returned to Input Sector / Revenue)	Proportion of total systems revenue retained in the farming sector
	Energy and Machinery Use (NRG)	(Chemicals, Custom Hire, Depreciation, Fertilizers, Lime, Gas, Fuel, Oil, Machinery Rent, Repairs, Utilities) / Revenue	Energy and machinery expenses purchased from non-farm sources as a proportion of farm revenue
	Support for Local Families (SLF)	(Employee Benefits, Labor Hired, Pension and Profit Sharing, Net Farm Income) / Revenue	Proportion of farm revenue returned to farm families and farm workers
	Feed Balance (FB)	(Gross Income from Crops Sold – Feed Purchased)/Revenue	Difference between crops sold and feed purchased as a proportion of farm revenue

Economic indicators were calculated using representative budgets of integrated and conventional farms. Indicators for coupled and conventional farms were compared to each other for two farm size classes, small and medium-large. Indicators were measured on an economic basis for integrated versus non-integrated systems.

Economic indicators

Economic indicators were used to measure comparative profitability and efficiency of integrated and non-integrated representative farms. Net farm income, return-over-variable costs, and profit over revenues were the profitability indicators used in this study. The asset-turnover ratio and the operating-expense ratio were used to measure farm efficiency.

Net farm income (NFI). NFI measures farm profitability in dollars per acre. NFI is total farm revenue minus all expenses including seed, fertilizer, lime, chemicals, labor, gas, fuel and oil, repairs, supplies, insurance, miscellaneous expenses, interest, property taxes, and depreciation. Integrated farms may have higher or lower NFI compared to non-integrated farms depending on how cost savings compare to revenues.

Return-over-variable costs (ROVC). ROVC measures short-run profitability of farms in dollars per acre. ROVC is total farm revenue minus all variable expenses including seed, fertilizer, lime, chemicals, labor, gas, fuel and oil, repairs, supplies, insurance, miscellaneous expenses, and interest on production costs. Integrated farms may have higher ROVC compared to non-integrated farms due to fewer purchased inputs such as fertilizer.

Profit over revenues (POR). POR normalizes farm profitability. A farm may have higher profits but a lower POR ratio. For example, a farm with an NFI of $10,000 and total revenue of $100,000 has a POR ratio of 0.10, whereas a farm with an NFI of $5,000 and a total revenue of $20,000 has a POR of 0.25. A higher POR implies that costs are a lower proportion of farm revenues. Integrated farms may have higher POR due to potentially lower fertilizer and feed costs. However, integrated farms may have higher fixed costs such as equipment depreciation and interest, resulting in a lower POR.

Asset-turnover ratio (ATR). ATR measures the efficiency of the use of farm assets. As taken from the FFSC, ATR uses the farm's average annual total assets. The assets used to calculate ATR in this study included farm inventory at the end of the growing season, not the annual average value of farm inventory. Integrated farms may have higher or lower ATR depending on the value of farm revenues relative to assets.

Operating-expense ratio (OER). OER measures adjusted operating costs per dollar of total farm revenue (FFSC 1997). An integrated farm should have a higher or lower OER compared to a non-integrated farm. This depends on the cost of external variable and fixed inputs relative to farm revenues.

Sustainability indicators

Sustainability indicators include farming value added and farming value added as a proportion of producer's share. The three other sustainability indicators used in this study are found in Levins (1996). These include indicators that capture energy and machinery use, support for local families, and the balance of on-farm feed production and off-farm feed purchases. Data used for these sustainability indicators were from representative farm budgets and IRS Schedule F information collected from cooperating farms.

Farming value added (FVA). FVA is a measure of the contribution to all farm families, hired labor, and owned farmland. It is calculated as total farm revenue minus costs not returned to the farming sector and is measured in dollars per acre. FVA measures the returns to farming distinct from the input and marketing sectors of the agro-food system[6]. Total farm expenses include costs returned to input and farming sectors. Costs not returned to the farming sector include fertilizers, pesticides, equipment, services, and other items that are purchased from input sector firms. Costs returned to the farming sector include all directly paid farm labor and property taxes, plus the proportion of payments that remain in the farming sector that are paid to other farms.

Farm production expenses may consist of costs that produce proportionate returns to both the non-farming and farming sectors. Therefore, each itemized expense is adjusted by an appropriate FVA factor to determine the percentage of that expense that is returned to the farming sector. For example, labor and property tax expenses directly paid by the farmer return all of their cost to the farming

[6]The agro-food system consists of farming, input, and marketing sectors. The farming sector includes all on-farm activities generating farm production. Input sector firms produce fertilizers, pesticides, and farm machinery and provide credit and other services to farmers. Marketing sector firms take commodities or other products from the farming sector and transform them into consumer purchases (Smith 1992).

sector by definition. Thus labor and property taxes are direct impacts of FVA.

Indirect impacts of FVA, on the other hand, only contribute a proportion of their value to the farming sector. For example, repairs and maintenance to equipment and buildings, with an FVA factor of 20%, means that 20% of those costs are returned to the farming sector and 80% to the non-farm sector. Included in this indirect contribution to FVA are the returns to other farm profits, labor, and property taxes from the purchase of inputs and services from these other farms. FVA factors used in this report are listed in Table 8; further explanation of FVA calculations can be found in Files (1999) and Hoshide (2002).

Farming value added as a proportion of producer's share (FVA_p). FVA_p measures the returns to the farming sector as a proportion of farm revenues. FVA_p equals FVA divided by total farm revenue. Since FVA equals total farm revenue minus costs returned to the

Table 8. FVA factors for integrated and non-integrated Maine farms (Files 1999).

Budget Line Items	FVA Factors (%)	Source
Direct impacts paid by farmer		
Labor	100	From definition of FVA
Property Taxes	100	From definition of FVA
Indirect impacts from purchases from other farmers		
Potato Seed	43	Based on average FVA ratio for conventional treatment of the MPEP[a]
Grain and Forage Seed	22	Barley and alfalfa seed used as proxy for grains and forages
Repairs and Maintenance (Equipment & Buildings)	20	Percentage of repairs and maintenance costs which are labor, as estimated by Langille Construction, Inc.
Miscellaneous:		
Rent or Lease:		
Vehicle/Mach./Equip.	20	Barley custom combine rental used as proxy
Land	100	If rented from other farmers
Custom Hire	20	Barley custom combine rental used as proxy
Feed Purchased	22	Seed used for grain and forage feed used as proxy

[a]The Maine Potato Ecosystem Project (MPEP) at the University of Maine has analyzed the agronomic and economic effects of conventional and alternative pest and soil management systems on potato production since 1991 (Marra 1996).

input sector, FVA_p is equal to 1 minus costs returned to the input sector divided by total farm revenue. Thus an FVA_p value of 0 indicates that no farm revenue is retained in the farming sector, while an FVA_p of 1 means that all farm revenue is retained in the farming sector. Negative FVA indicators mean that costs returned to input and marketing sectors exceed farm revenues.

Earlier research contrasted hypothetical integrated and non-integrated livestock and potato operations (Files 1999). Files (1999) found that FVA_p was 7% greater for integrated dairy and potato operations using rotational grazing than for those using confined feeding. Large integrated dairy and potato operations using rotational grazing had 18% higher FVA_p than large non-integrated dairy and potato farms using confined feeding. Integrated farms should have higher FVA and FVA_p than non-integrated farms due to their reduced use of chemical fertilizers, which are not purchased from the farming sector.

Energy and machinery use (NRG). NRG measures energy and machinery use purchased from non-farm sources as a proportion of total farm revenue. NRG ratios are higher with greater farm dependence on non-farm generated inputs (Levins 1996). Integrated farms should have lower NRG indicators because they purchase fewer inputs such as fertilizer. NRG is approximately equal to costs returned to the input sector divided by total farm revenues as used in the FVA_p calculation above.

Support for local families (SLF). SLF measures the amount of farm income retained by local farmers and farm workers. The more a farm supports the local families that are employed by the farm (including the farm family itself), the closer the SLF value is to 1 (Levins 1996). Because of higher labor costs, SLF should be higher for integrated farms; however, depending on the size of net farm income, this indicator may be lower for integrated farms. SLF is roughly equal to direct costs returned to the farming sector divided by total farm revenues as described in previous sections on FVA measures.

Feed balance (FB). The feed balance between crops produced on-farm and purchased feed is equal to 1 if a farm only sells crops and has no livestock. A livestock farm that does not sell crops and buys all of its feed has a negative FB. The closer crop sales are to the value of feed purchases, the closer FB is to zero (Levins 1996). The FB for an integrated farm should be closer to 0 than that of a non-integrated farm due to less purchased feed and/or increased crop sales. Potato farms have FB of +1 and are not compared. Freyenberger et al. (2001) demonstrated these trends for sustainability indicator values for conventional and sustainable farms in Kansas during 1995 and 1996.

IV. WHOLE-FARM AND ENTERPRISE BUDGET RESULTS

Coupled enterprise budgets shown in this section (Tables 12, 14, 19, and 21) and whole-farm budgets shown in Appendices A-1, A-2, B-1, and B-2 represent integration lasting more than ten years (long term) where fertilizer use was reduced. Although the budgets are not shown in this report, farms coupled for only two years (short term) took less manure-nutrient credits. Models of conventional and coupled farms had similar crop equipment inventories. The relative profitability of potato yield response from integration is analyzed in this section. In addition to enterprise and whole-farm budgets, conventional and coupled agricultural systems are also compared.

Potato-Farm Models

Whole-farm and enterprise budgets were compared for small and medium-large conventional and coupled potato farms. Table 9 shows return-over-variable costs and net farm income per acre of owned cropland for conventional and coupled models. For LF-coupled potato farms, profits are attributed to the farm that owns the land, regardless of which farm is operating it. Whole-farm budget comparisons are in Appendices A-1 and A-2. Revenues, costs, and returns for potato and rotation crops are summarized in Table 10. Potato enterprise budgets are shown in Tables 11 to 14. Enterprise budgets for grain corn, hay, and haylage are in Appendices C-1 and C-2.

In general, profitability improved as the number of years spent coupling increased. The scenarios outlined in Table 9 assumed that the dairy farm portion of the couple remained the same size. The larger coupled cropland base allowed the potato farm to increase potato acreage while maintaining the same rotation and current silage corn production by reducing the acreage devoted to grain corn. Assuming a two-year potato-corn rotation was maintained, profitability increased from the expanded production of a cash crop (potato) and the reduced acreage of a less lucrative rotation crop (grain corn). Both ROVC and NFI increased from short-term coupling even if there was no increase in potato yields from integration and no manure-nutrient credits were taken.

Table 9. Relative profitability of conventional and coupled potato-farm models.

Profit Measure	Size	Conventional[b]	Short Term L-Coupled[c]	Short Term LF-Coupled[d]	Long Term L-Coupled[c]	Long Term LF-Coupled[d]
ROVC[a]	S	$200	$262	$335	$327	$402
	M/L	$225	$334	$443	$409	$520
NFI[a]	S	-$51	$12	$57	$76	$124
	M/L	$18	$127	$208	$203	$285

[a]Return over variable costs (ROVC) and net farm income (NFI) are in $/acre of owned cropland.
[b]Small (S) conventional farms grew 160 acres of potatoes and 160 acres of grain corn for a total of 320 owned crop acres. Medium-large (M/L) crop acreages were doubled.
[c]Small L-coupled raised 209 acres of potatoes and 111 acres of grain corn, while M/L grew 480 acres of potatoes and 160 acres of grain corn. Owned crop acreages are the same as conventional farms.
[d]LF-coupled owned crop acreages are the same as L-coupled. Additional crops raised were 98 acres of silage corn and 73 acres of hay for small and 320 acres of silage corn and 200 acres of haylage for M/L.

Potato enterprises were identical for conventional and short-term coupling. Potatoes were more profitable in the short term than grain corn, which had negative NFI per acre. Grain corn was also less profitable than dairy forages such as silage corn and hay/haylage (Table 10). However, grain corn profitability may be more competitive than indicated in this study for four reasons. First, the grain corn yields assumed for this study were typical for central Maine, but were low (100 bu/acre) compared to other areas in Maine further south. Second, grain corn prices may be higher. Third, budgets did not account for commodity payments. Fourth, grain corn leaves plant residues that are incorporated into the soil after harvest. While the organic matter in such residues has value, this value was not recognized in potato farm models.

It was assumed that potato farmers would increase potato acreage in a coupled relationship if the dairy farmer chose not to fully expand forage production and herd size. However, one cooperating coupled potato farmer increased the length of potato rotation to three years by growing more forages with the expanding dairy farm. Even if coupled potato acreage is not increased, profitability can still be improved. For example, NFI for a short-term L-coupled potato farm was greater than conventional even with no increase in potato production due to dairy farm expansion. Here NFI per acre of owned

Table 10. Crop enterprise budget summary for conventional and coupled potato farms.

			Potato[b]						Rotation[bc]					
Farm Size	Coup. Hist.[a]	Model	Acres	Rev.	Oper. Costs	Own. Costs	ROVC	NFI	Acres	Rev.	Oper. Costs	Own. Costs	ROVC	NFI
Small	None	Conv.	160	$1,650	$1,247	$340	$403	$63	160	$250	$253	$163	-$3	-$166
	ST	L-Coup.	209	$1,650	$1,247	$289	$403	$114	111	$250	$255	$179	-$5	-$184
		LF-Coup.	209	$1,650	$1,247	$252	$403	$151	111	$250	$251	$151	-$1	-$152
									98	$375	$211	$113	$164	$51
									73	$226	$130	$114	$96	-$18
	LT	L-Coup.	209	$1,650	$1,146	$289	$504	$215	111	$250	$255	$179	-$5	-$184
		LF-Coup.	209	$1,650	$1,146	$252	$504	$252	111	$250	$251	$151	-$1	-$152
									98	$375	$208	$113	$167	$54
									73	$226	$130	$114	$96	-$18
M/L	None	Conv.	320	$1,650	$1,206	$300	$444	$144	320	$250	$244	$114	$6	-$108
	ST	L-Coup.	480	$1,650	$1,206	$229	$444	$215	160	$250	$247	$138	$3	-$135
		LF-Coup.	480	$1,650	$1,206	$196	$444	$248	160	$250	$243	$115	$7	-$108
									320	$375	$195	$75	$180	$105
									200	$195	$137	$71	$58	-$13
	LT	L-Coup.	480	$1,650	$1,105	$229	$545	$316	160	$250	$247	$138	$3	-$135
		LF-Coup.	480	$1,650	$1,105	$196	$545	$349	160	$250	$243	$115	$7	-$108
									320	$375	$192	$75	$183	$108
									200	$195	$137	$71	$58	-$13

[a]Coupling history, Short-term (ST) and long-term (LT) coupled.
[b]Revenue, costs, and returns are in $/acre.
[c]Conventional and L-coupled potato rotation is grain corn. LF-coupled potato rotations are grain and silage corn. LF-coupled also raises hay or haylage.

Table 11. Potato enterprise budget for a small conventional farm.[a]

	Total	Per Acre	Per Cwt
Number of Acres	160	-	-
Potato Yield (cwt)	38,400	240	-
Price ($/cwt)	$6.88	-	-
Annual Revenue	**$264,107**	**$1,650.67**	**$6.88**
Annual Operating Expenses			
Seed	$37,368	$233.55	$0.97
Fertilizer	$22,546	$140.91	$0.59
Lime	$1,600	$10.00	$0.04
Chemicals	$26,336	$164.60	$0.69
Labor	$36,688	$229.30	$0.96
Diesel Fuel and Oil	$12,058	$75.36	$0.31
Maintenance and Upkeep	$17,754	$110.96	$0.46
Supplies	$9,215	$57.59	$0.24
Insurance	$8,865	$55.40	$0.23
Miscellaneous			
Utilities	$6,101	$38.13	$0.16
Custom Hire	$0	$0	$0
Rent or Lease	$10,000	$62.50	$0.26
Freight and Trucking	$2,849	$17.81	$0.07
Storage and Warehousing	$1,879	$11.75	$0.05
Other Expenses	$960	$6.00	$0.03
Interest	$5,364	$33.52	$0.14
Total Operating Expenses	**$199,581**	**$1,247.38**	**$5.20**
Annual Ownership Expenses			
Depreciation and Interest	$51,305	$320.66	$1.34
Tax and Insurance	$3,133	$19.58	$0.08
Total Ownership Expenses	**$54,438**	**$340.24**	**$1.42**
Total Annual Cost	**$254,019**	**$1,587.62**	**$6.62**
Net Farm Income (NFI)	**$10,088**	**$63.05**	**$0.26**
Return over Variable Cost (ROVC)	**$64,526**	**$403.29**	**$1.68**
Performance Measures			
Breakeven Revenue		$/acre	$/cwt
Long-run to Cover All Costs		$1,587.62	$6.62
Short-run to Cover Operating Costs		$1,247.38	$5.20

[a]Numbers may not sum due to rounding.

cropland increased to -$14 and $43 for the small and medium-large size classes, respectively (data not presented), from conventional NFI of -$51 and $18 per acre (Table 9). Even though this was an unlikely scenario, it highlighted how unprofitable growing grain corn was compared to growing forages for the dairy farm.

Table 12. Potato enterprise budget for a small long-term land-coupled farm.[a]

	Total	Per Acre	Per Cwt
Number of Acres	209	-	-
Potato Yield (cwt)	50,160	240	-
Price ($/cwt)	$6.88	-	-
Annual Revenue	**$344,990**	**$1,650.67**	**$6.88**
Annual Operating Expenses			
Seed	$48,812	$233.55	$0.97
Fertilizer	$8,945	$42.80	$0.18
Lime	$2,090	$10.00	$0.04
Chemicals	$34,401	$164.60	$0.69
Labor	$47,924	$229.30	$0.96
Diesel Fuel and Oil	$15,750	$75.36	$0.31
Maintenance and Upkeep	$23,191	$110.96	$0.46
Supplies	$12,037	$57.59	$0.24
Insurance	$11,580	$55.40	$0.23
Miscellaneous			
Utilities	$7,969	$38.13	$0.16
Custom Hire	$0	$0	$0
Rent or Lease	$13,063	$62.50	$0.26
Freight and Trucking	$3,721	$17.81	$0.07
Storage and Warehousing	$2,455	$11.75	$0.05
Other Expenses	$1,254	$6.00	$0.03
Interest	$6,440	$30.81	$0.13
Total Operating Expenses	**$239,631**	**$1,146.56**	**$4.78**
Annual Ownership Expenses			
Depreciation and Interest	$56,921	$272.35	$1.13
Tax and Insurance	$3,584	$17.15	$0.07
Total Ownership Expenses	**$60,506**	**$289.50**	**$1.21**
Total Annual Cost	**$300,137**	**$1,436.06**	**$5.98**
Net Farm Income (NFI)	**$44,853**	**$214.61**	**$0.89**
Return over Variable Cost (ROVC)	**$105,358**	**$504.11**	**$2.10**
Performance Measures			
Breakeven Revenue		$/acre	$/cwt
Long-run to Cover All Costs		$1,436.06	$5.98
Short-run to Cover Operating Costs		$1,146.56	$4.78

[a]Numbers may not sum due to rounding.

Table 13. Potato enterprise budget for a medium-large conventional farm.[a]

	Total	Per Acre	Per Cwt
Number of Acres	320	-	-
Potato Yield (cwt)	76,800	240	-
Price ($/cwt)	$6.88	-	-
Annual Revenue	**$528,214**	**$1,650.67**	**$6.88**
Annual Operating Expenses			
Seed	$74,736	$233.55	$0.97
Fertilizer	$45,091	$140.91	$0.59
Lime	$3,200	$10.00	$0.04
Chemicals	$52,672	$164.60	$0.69
Labor	$64,925	$202.89	$0.85
Diesel Fuel and Oil	$21,878	$68.37	$0.28
Maintenance and Upkeep	$35,507	$110.96	$0.46
Supplies	$18,430	$57.59	$0.24
Insurance	$17,729	$55.40	$0.23
Miscellaneous			
Utilities	$12,202	$38.13	$0.16
Custom Hire	$0	$0	$0
Rent or Lease	$18,000	$56.25	$0.23
Freight and Trucking	$5,698	$17.81	$0.07
Storage and Warehousing	$3,759	$11.75	$0.05
Other Expenses	$1,920	$6.00	$0.03
Interest	$10,377	$32.43	$0.14
Total Operating Expenses	**$386,123**	**$1,206.64**	**$5.03**
Annual Ownership Expenses			
Depreciation and Interest	$90,345	$282.33	$1.18
Tax and Insurance	$5,603	$17.51	$0.07
Total Ownership Expenses	**$95,947**	**$299.84**	**$1.25**
Total Annual Cost	**$482,071**	**$1,506.47**	**$6.28**
Net Farm Income (NFI)	**$46,143**	**$144.20**	**$0.60**
Return over Variable Cost (ROVC)	**$142,090**	**$444.03**	**$1.85**
Performance Measures			
Breakeven Revenue		$/acre	$/cwt
Long-run to Cover All Costs		$1,506.47	$6.28
Short-run to Cover Operating Costs		$1,206.64	$5.03

[a]Numbers may not sum due to rounding.

Table 14. Potato enterprise budget for a medium-large long-term land-coupled farm.[a]

	Total	Per Acre	Per Cwt
Number of Acres	480	-	-
Potato Yield (cwt)	115,200	240	-
Price ($/cwt)	$6.88	-	-
Annual Revenue	**$792,320**	**$1,650.67**	**$6.88**
Annual Operating Expenses			
Seed	$112,104	$233.55	$0.97
Fertilizer	$20,544	$42.80	$0.18
Lime	$4,800	$10.00	$0.04
Chemicals	$79,008	$164.60	$0.69
Labor	$97,387	$202.89	$0.85
Diesel Fuel and Oil	$32,818	$68.37	$0.28
Maintenance and Upkeep	$53,261	$110.96	$0.46
Supplies	$27,645	$57.59	$0.24
Insurance	$26,594	$55.40	$0.23
Miscellaneous			
Utilities	$18,303	$38.13	$0.16
Custom Hire	$0	$0	$0
Rent or Lease	$27,000	$56.25	$0.23
Freight and Trucking	$8,546	$17.81	$0.07
Storage and Warehousing	$5,638	$11.75	$0.05
Other Expenses	$2,880	$6.00	$0.03
Interest	$14,264	$29.72	$0.12
Total Operating Expenses	**$530,792**	**$1,105.82**	**$4.61**
Annual Ownership Expenses			
Depreciation and Interest	$103,238	$215.08	$0.90
Tax and Insurance	$6,684	$13.92	$0.06
Total Ownership Expenses	**$109,922**	**$229.00**	**$0.95**
Total Annual Cost	**$640,714**	**$1,334.82**	**$5.56**
Net Farm Income (NFI)	**$151,606**	**$315.85**	**$1.32**
Return over Variable Cost (ROVC)	**$261,529**	**$544.85**	**$2.27**
Performance Measures			
Breakeven Revenue		$/acre	$/cwt
Long-run to Cover All Costs		$1,334.82	$5.56
Short-run to Cover Operating Costs		$1,105.82	$4.61

[a]Numbers may not sum due to rounding.

In Table 9, LF-coupled potato farms had higher NFI per acre of owned cropland than L-coupled farms due to the added revenue from growing dairy forages in addition to potatoes and grain corn. LF-coupled potato farms were even more profitable if they grew dairy forages exclusively and not grain corn since grain corn was a less profitable enterprise than dairy forages. For short-term LF-coupled potato farms growing just silage corn and hay/haylage, ROVC per acre of owned cropland increased to $394 for small and $487 for medium-large farm models, while NFI per acre of owned cropland increased to $136 for small and $265 for medium-large (data not presented). This scenario assumed expansion of the coupled dairy farm to utilize the additional forages.

Long-term coupling improved profitability even further compared to short-term coupling (Table 9). As for short-term couplers, potato enterprise budget NFI per acre was greater for long-term coupled farms because of reduced fixed costs per acre from more potatoes grown. Potato enterprise ROVC was greater for long-term coupled farms than for conventional farms from decreased fertilizer costs due to increases in the manure-nutrient credits taken for potatoes and silage corn and the subsequent reduction of purchased chemical fertilizer (Tables 11 to 14).

Short-term coupled farms took no manure-nutrient credit for potatoes and had the same enterprise fertilizer cost of $141/acre as conventional farms (Table 11 and 13). Fertilizer costs for potato were about 70% less for long-term coupled farms, at $43/acre. Similarly, fertilizer costs for rotation crops were less for silage corn grown on long-term coupled farms, $12/acre, than for both grain corn grown on conventional farms, $65/acre, and silage corn grown on short-term coupled farms, $14/acre (Tables 18 to 21, Appendix C-1).

Some cooperating potato farms that had been coupled long term (over ten years) believe that their potato yields have increased from improved soil quality. However, they did not have records to establish the amount of potato yield increase. Also, no experimental field data comparing yield differences between integrated and non-integrated potato and corn systems in Maine could be found. Researchers with the Maine Potato Ecosystem Project indicated that while it is likely that potato yields would increase from integration because of increased soil quality, especially in dry years, there was some evidence that increased disease pressure could suppress yields.

To test the impact of potential yield variability, NFI was estimated for coupled potato models at various yields ranging between -25% and +25% from the base yield of 240 cwt/acre. These yield differences were assumed to be from soil quality changes as a result of integration and not from additional fertilizer. Harvest labor, truck fuel, and storage costs were adjusted in proportion to yield changes.

Table 15 shows gains of up to about $451 per acre for long-term integrators over conventional if potato yields increase by 15%. On the other hand, larger sized long-term integrators would be no worse off than equivalent sized conventional farms with yield losses of 15% to 20%. Table 15 shows the differences in NFI for coupled potato farm models at various yields from conventional potato farm base yields of 240 cwt/acre that produce an NFI/acre of -$51 for small farms and $18 for medium/large farms. The shaded areas in Table 15 show where NFI of integrators is superior to the conventional base cases at various differences and demonstrate that long-term integrators can withstand yield losses of up to 20% and be as well off as conventional farms (Table 15).

Dairy-Farm Models

Whole-farm and enterprise budgets were compared for conventional and coupled small- and medium-large-sized dairy-farm models. Table 16 compares ROVC and NFI for coupled and conventional dairy-farm models. Whole-farm conventional and coupled budgets are in shown Appendices B-1 and B-2. Revenues, costs, and returns for rotation crops are summarized in Table 17. Crop enterprise budgets for silage corn are shown in Tables 18 to 21. Enterprise budgets for hay or haylage are shown in Appendix C-2.

If potato farms expanded potato acreage during coupling and the dairy farm did not increase herd size, then benefits were minimal for L-coupled dairy farms. In the short-term, ROVC and NFI were identical to conventional farms. Long-term coupled farms had slightly greater profitability measures due to the small manure-nutrient credit assumed for silage corn on farms that had been integrated for more than ten years (Table 16). Silage corn enterprise budgets confirmed greater ROVC and NFI for long-term coupled dairy farms from this slight manure-nutrient credit for silage corn (Tables 17 to 21). Fertilizer costs for silage corn for long-term coupled dairy farms, $12/acre, was about 15% less than for conventional dairy farms, $14/acre (Tables 18 to 21).

LF-coupled dairy farms had lower profitability than conventional or L-coupled farms. Although there were no crop production expenses for LF-coupled dairy farms, the dairy farm did not eliminate all of the fixed costs allocated to forage crops. Profitability for LF-coupled dairy farms can be improved if prices paid to the potato

Table 15. Net farm income for whole-farm models of coupled potato farms with yield response for potatoes ranging from -25% to 25%.

			NFI ($/acre)[b]							
	Market Yield		Short-Term Integration				Long-Term Integration			
Potato	%	cwt/	Small		Medium-Large		Small		Medium-Large	
Model	Increase	acre	Land	LF	Land	LF	Land	LF	Land	LF
Coupled[a]	-25%	180	-$257	-$209	-$179	-$98	-$191	-$143	-$103	-$21
	-20%	192	-$203	-$156	-$117	-$37	-$137	-$89	-$42	$40
	-15%	204	-$150	-$103	-$56	$24	-$84	-$36	$19	$101
	-10%	216	-$97	-$50	$5	$85	-$31	$17	$81	$162
	-5%	228	-$43	$4	$66	$147	$23	$71	$142	$224
	0%	240	$12	$57	$127	$208	$76	$124	$203	$285
	5%	252	$63	$110	$189	$269	$129	$177	$264	$346
	10%	264	$117	$164	$250	$330	$183	$230	$326	$407
	15%	276	$170	$217	$311	$391	$236	$284	$387	$469
	20%	288	$223	$270	$372	$453	$289	$337	$448	$530
	25%	300	$277	$324	$434	$514	$343	$390	$509	$591

[a]Coupled ROVC is shaded if greater than or equal to conventional.
[b]Acreage in denominator includes just owned crop acres.

farm for forages were reduced. Increased profitability from coupling in both the short term and long term may be limited for dairy farms unless they expand or unless management can be redirected from crop production to improve livestock productivity. Such potential increased profitability of the livestock enterprise was not reflected in this model. Assuming increasing returns to scale, profitability should be greater if coupled dairy farms were able to expand herd size. However, dairy farm budgets were difficult to scale up to exact herd and farm sizes for hypothetical dairy farm expansions.

A hypothetical dairy farm expansion is demonstrated by transition from the model of a small LF-coupled dairy farm to the model of a medium-large LF-coupled dairy farm. In this demonstration, the acreage of silage corn grown by the coupled potato farm increased from 98 to 258 acres to take advantage of all rotational acreage available from coupling. This scenario assumed the expanding dairy farm purchased the equivalent of an additional 62 acres of silage corn and 127 acres of haylage for increased feed needs. ROVC and NFI under this scenario increased by $39/acre and $136/acre, respectively, compared to both the conventional and short-term L-coupled small dairy farm (Table 16). This analysis identified alternative scenarios where the dairy farm could expand herd size while the potato farm increased potato acreage. Thus, both potato and dairy farms may benefit from coupling.

Table 16. Relative profitability of conventional and coupled dairy-farm models.

Profit Measures	Size	Conventional[b]	Short Term: L-Coupled[c]	Short Term: LF-Coupled[d]	Long Term: L-Coupled[c]	Long Term: LF-Coupled[d]
ROVC[a]	S	$148	$148	$44	$150	$44
	M/L	$319	$319	$187	$321	$187
NFI[a]	S	-$245	-$245	-$295	-$243	-$295
	M/L	-$9	-$9	-$109	-$7	-$109

[a]ROVC and NFI in $/acre of owned cropland. Crop acreage did not include pasture.
[b]Small (S) conventional dairy farms grew 98 acres of silage corn and 73 acres of hay for a total of 171 owned crop acres. Medium-large (M/L) conventional dairy farms grew 320 acres of silage corn and 200 acres of haylage for a total of 520 owned crop acres. The 29 and 43 acres of pasture for S and M/L dairy farms, respectively, were not included as crop acres.
[c]L-coupled farms raised the same crop acreages as conventional farms.
[d]LF-coupled dairy farms did not raise forages since the LF-coupled potato farms grew these. However, returns were calculated using the same owned crop acres as conventional and L-coupled farms.

Table 17. Crop enterprise budget summary for conventional and coupled dairy farms.

			Silage Corn[b]						Hay/Haylage[bc]					
Dairy Size	Coup. History[a]	Model	Acres	Rev.	Oper. Costs	Own. Costs	ROVC	NFI	Acres	Rev.	Oper. Costs	Own. Costs	ROVC	NFI
Small	None	Conv.	98	$375	$220	$181	$155	-$26	73	$226	$139	$165	$87	-$78
	ST	L-Coup.	98	$375	$220	$181	$155	-$26	73	$226	$139	$165	$87	-$78
		LF-Coup.	0	-	-	-	-	-	0	-	-	-	-	-
	LT	L-Coup.	98	$375	$217	$181	$158	-$23	73	$226	$139	$165	$87	-$78
		LF-Coup.	0	-	-	-	-	-	0	-	-	-	-	-
M/L	None	Conv.	320	$375	$202	$137	$173	$36	200	$195	$140	$96	$55	-$41
	ST	L-Coup.	320	$375	$202	$137	$173	$36	200	$195	$140	$96	$55	-$41
		LF-Coup.	0	-	-	-	-	-	0	-	-	-	-	-
	LT	L-Coup.	320	$375	$199	$137	$176	$39	200	$195	$140	$96	$55	-$41
		LF-Coup.	0	-	-	-	-	-	0	-	-	-	-	-

[a]Short-term (ST) and long-term (LT) coupled.
[b]Revenue, costs, and returns are in $/acre.
[c]The small model grows dry hay, while the medium-large (M/L) model raises primarily haylage.

Table 18. Silage corn enterprise budget for a small conventional dairy farm.[a]

	Total	Per Acre	Per Ton
Number of Acres	98	-	-
Silage Corn Yield (tons)	1,470	15	-
Price ($/ton)	$25	-	-
Annual Revenue	**$36,750**	**$375.00**	**$25.00**
Annual Operating Expenses			
Seed	$3,234	$33.00	$2.20
Fertilizer	$1,409	$14.38	$0.96
Lime	$1,189	$12.13	$0.81
Chemicals	$2,390	$24.39	$1.63
Labor	$5,675	$57.90	$3.86
Diesel Fuel and Oil	$1,558	$15.90	$1.06
Maintenance and Upkeep	$2,618	$26.71	$1.78
Supplies	$980	$10.00	$0.67
Insurance	$32	$0.33	$0.02
Miscellaneous			
Rent or Lease	$1,225	$12.50	$0.83
Storage and Warehousing	$196	$2.00	$0.13
Other Expenses	$490	$5.00	$0.33
Interest	$580	$5.92	$0.39
Total Operating Expenses	**$21,575**	**$220.16**	**$14.68**
Annual Ownership Expenses			
Depreciation and Interest	$16,480	$168.17	$11.21
Tax and Insurance	$1,233	$12.59	$0.84
Total Ownership Expenses	**$17,714**	**$180.75**	**$12.05**
Total Annual Cost	**$39,289**	**$400.91**	**$26.73**
Net Farm Income (NFI)	**-$2,539**	**-$25.91**	**-$1.73**
Return over Variable Cost (ROVC)	**$15,175**	**$154.84**	**$10.32**
Performance Measures			
Breakeven Revenue		$/acre	$/ton
Long-run to Cover All Costs		$400.91	$26.73
Short-run to Cover Operating Costs		$220.16	$14.68

[a]Numbers may not sum due to rounding.

Whole-Farm Potato and Dairy System Analysis

Coupled and conventional comparisons in previous sections focused on the potato or dairy side of the coupled relationship. This section compares conventional and coupled budgets as agricultural systems including both potato and dairy components. Acreages, revenues, and costs from conventional and coupled model budgets

Table 19. Silage corn enterprise budget for a small long-term land-coupled dairy farm.[a]

	Total	Per Acre	Per Ton
Number of Acres	98	-	-
Silage Corn Yield (tons)	1,470	15	-
Price ($/ton)	$25	-	-
Annual Revenue	**$36,750**	**$375.00**	**$25.00**
Annual Operating Expenses			
Seed	$3,234	$33.00	$2.20
Fertilizer	$1,127	$11.50	$0.77
Lime	$1,189	$12.13	$0.81
Chemicals	$2,390	$24.39	$1.63
Labor	$5,675	$57.90	$3.86
Diesel Fuel and Oil	$1,558	$15.90	$1.06
Maintenance and Upkeep	$2,618	$26.71	$1.78
Supplies	$980	$10.00	$0.67
Insurance	$32	$0.33	$0.02
Miscellaneous			
Rent or Lease	$1,225	$12.50	$0.83
Storage and Warehousing	$196	$2.00	$0.13
Other Expenses	$490	$5.00	$0.33
Interest	$572	$5.84	$0.39
Total Operating Expenses	**$21,286**	**$217.20**	**$14.48**
Annual Ownership Expenses			
Depreciation and Interest	$16,480	$168.17	$11.21
Tax and Insurance	$1,233	$12.59	$0.84
Total Ownership Expenses	**$17,714**	**$180.75**	**$12.05**
Total Annual Cost	**$39,000**	**$397.96**	**$26.53**
Net Farm Income (NFI)	**-$2,250**	**-$22.96**	**-$1.53**
Return over Variable Cost (ROVC)	**$15,464**	**$157.80**	**$10.52**
Performance Measures			
Breakeven Revenue		$/acre	$/ton
Long-run to Cover All Costs		$397.96	$26.53
Short-run to Cover Operating Costs		$217.20	$14.48

[a]Numbers may not sum due to rounding.

were aggregated to the farm-level. Silage corn acreage grown by the coupled dairy farm was less than potato rotational acreage since dairy farm acreages were based on models in Dalton and Bragg (2003). To compare segregated to integrated systems, an artificial combination of conventional systems was simulated. Results are compared in Table 22.

Table 20. Silage corn enterprise budget for a medium-large conventional dairy farm.[a]

	Total	Per Acre	Per Ton
Number of Acres	320	-	-
Silage Corn Yield (tons)	4,800	15	-
Price ($/ton)	$25	-	-
Annual Revenue	**$120,000**	**$375.00**	**$25.00**
Annual Operating Expenses			
Seed	$10,560	$33.00	$2.20
Fertilizer	$4,600	$14.38	$0.96
Lime	$3,882	$12.13	$0.81
Chemicals	$7,805	$24.39	$1.63
Labor	$15,366	$48.02	$3.20
Diesel Fuel and Oil	$5,088	$15.90	$1.06
Maintenance and Upkeep	$6,196	$19.36	$1.29
Supplies	$3,200	$10.00	$0.67
Insurance	$106	$0.33	$0.02
Miscellaneous			
Rent or Lease	$4,000	$12.50	$0.83
Storage and Warehousing	$640	$2.00	$0.13
Other Expenses	$1,600	$5.00	$0.33
Interest	$1,741	$5.44	$0.36
Total Operating Expenses	**$64,783**	**$202.45**	**$13.50**
Annual Ownership Expenses			
Depreciation and Interest	$40,841	$127.63	$8.51
Tax and Insurance	$3,044	$9.51	$0.63
Total Ownership Expenses	**$43,885**	**$137.14**	**$9.14**
Total Annual Cost	**$108,667**	**$339.59**	**$22.64**
Net Farm Income (NFI)	**$11,333**	**$35.41**	**$2.36**
Return over Variable Cost (ROVC)	**$55,217**	**$172.55**	**$11.50**
Performance Measures			
Breakeven Revenue		$/acre	$/ton
Long-run to Cover All Costs		$339.59	$22.64
Short-run to Cover Operating Costs		$202.45	$13.50

[a]Numbers may not sum due to rounding.

For short-term integrated systems, ROVC and NFI were higher for L-coupled and LF-coupled compared to conventional farm systems (Table 22). This was mainly due to the increased profitability of coupled potato farms from an increase in potato acreage. For long-term integrated systems, ROVC and NFI were greater than for conventional systems for all coupled cases and sizes due to reduc-

Table 21. Silage corn enterprise budget for a medium-large long-term land-coupled dairy farm.[a]

	Total	Per Acre	Per Ton
Number of Acres	320	-	-
Silage Corn Yield (tons)	4,800	15	-
Price ($/ton)	$25	-	-
Annual Revenue	**$120,000**	**$375.00**	**$25.00**
Annual Operating Expenses			
Seed	$10,560	$33.00	$2.20
Fertilizer	$3,680	$11.50	$0.77
Lime	$3,882	$12.13	$0.81
Chemicals	$7,805	$24.39	$1.63
Labor	$15,366	$48.02	$3.20
Diesel Fuel and Oil	$5,088	$15.90	$1.06
Maintenance and Upkeep	$6,196	$19.36	$1.29
Supplies	$3,200	$10.00	$0.67
Insurance	$106	$0.33	$0.02
Miscellaneous			
Rent or Lease	$4,000	$12.50	$0.83
Storage and Warehousing	$640	$2.00	$0.13
Other Expenses	$1,600	$5.00	$0.33
Interest	$1,716	$5.36	$0.36
Total Operating Expenses	**$63,837**	**$199.49**	**$13.30**
Annual Ownership Expenses			
Depreciation and Interest	$40,841	$127.63	$8.51
Tax and Insurance	$3,044	$9.51	$0.63
Total Ownership Expenses	**$43,885**	**$137.14**	**$9.14**
Total Annual Cost	**$107,722**	**$336.63**	**$22.44**
Net Farm Income (NFI)	**$12,278**	**$38.37**	**$2.56**
Return over Variable Cost (ROVC)	**$56,163**	**$175.51**	**$11.70**
Performance Measures			
Breakeven Revenue		$/acre	$/ton
Long-run to Cover All Costs		$336.63	$22.44
Short-run to Cover Operating Costs		$199.49	$13.30

[a]Numbers may not sum due to rounding.

tions in fertilizer use for both potato and corn in coupled systems. Differences in ownership and operating costs for L-coupled and LF-coupled cases were due to different machinery, equipment storages, and maintenance costs for potato- compared to dairy-farm models. Thus profitability for L-coupled and LF-coupled systems are similar, though not identical when comparing the same size and coupling history.

Table 22. Whole-farm budget summary for conventional and coupled farm systems.

			Crop Acres					System Budget[a]				
System Size	Coup. History	Model	Potato	Grain Corn	Silage Corn	Hay/ Haylage	Total	Rev.	Oper. Costs	Own. Costs	ROVC	NFI
Small	None	Conv.	160	160	98	73	491	$967	$769	$317	$198	-$119
	ST	L-Coup.	209	111	98	73	491	$1,107	$868	$317	$239	-$78
		LF-Coup.	209	111	98	73	491	$1,215	$965	$316	$250	-$66
	LT	L-Coup.	209	111	98	73	491	$1,107	$825	$317	$282	-$35
		LF-Coup.	209	111	98	73	491	$1,215	$922	$316	$294	-$22
M/L	None	Conv.	320	320	320	200	1160	$1,088	$805	$277	$283	$6
	ST	L-Coup.	480	160	320	200	1160	$1,281	$938	$277	$343	$66
		LF-Coup.	480	160	320	200	1160	$1,418	$1,073	$279	$345	$66
	LT	L-Coup.	480	160	320	200	1160	$1,281	$895	$277	$386	$109
		LF-Coup.	480	160	320	200	1160	$1,418	$1,030	$279	$388	$109

[a]Revenue, costs, and returns are in $/acre of total potato and dairy farm cropland, not including pasture.

V. ECONOMIC INDICATORS

Coupled and Conventional Indicator Comparisons

Economic and sustainability indicators for models of coupled and conventional potato and dairy farms were calculated. Conventional and coupled indicators were not tested for statistically significant differences since they were based on representative budgets constructed from a limited number of cooperating producers. Thus, results should be viewed with caution. NFI, ROVC, and FVA were calculated in dollars per acre of crops. Conventional and coupled indicators in this section were based on the same coupling type (L-coupled and LF-coupled), duration (short-term and long-term), and size classifications (small and medium-large) as representative farm budgets. Similarly, medium and large cooperating farms were aggregated into the medium-large group due to low sample size.

Potato-farm model indicators

Indicators for conventional and coupled potato-farm models are provided in Table 23. Indicators were compared relative to conventional models for both short-term (Appendix D-1) and long-term (Appendix D-2) coupled models. Crops included potato plus rotation crops. Typical expected values for indicators were based on the literature.

Economic indicators. Profitability indicators (NFI, ROVC, and POR) were greater for the models of coupled potato farms for both coupled cases and both size classes in the short term because more potatoes were grown. For the model of LF-coupled potato farms, per acre fixed costs were lower from equipment used for potatoes, grain corn, and forages. There was an increase in profitability from short-term to long-term coupled models from manure-nutrient credits taken for potatoes and silage corn. POR for LF-coupled potato farms was higher than for L-coupled farms due to the addition of more profitable forage enterprises to complement potatoes. A typical value for POR is 0.10 with an expected range of -0.25 to 0.25. In this study, POR values for models of potato farms ranged between -0.054 and 0.184.

The asset turnover ratio (ATR), which measures the efficiency of asset use, was greater for coupled potato farms than for conventional primarily because the farm produced more potatoes on more acres without having to purchase more land assets. The ATR was lower for LF-coupled than L-coupled potato farms because the LF-coupled farm purchased more feed-crop producing equipment with a relatively modest boost in feed-crop revenues (Table 23). As seen in

Table 23. Economic and sustainability indicators for coupled and conventional potato- and dairy-farm models.

					Economic					Sustainability				
					Profitability			Efficiency						
Farm Type	Size	Coup. Hist.[a]	Model	Crop Acres[b]	NFI[c]	ROVC[c]	POR	ATR	OER	FVA[c]	FVA_p	NRG	SLF	FB[d]
Potato	S	None	Conv.	320	-$51	$200	-0.054	0.306	0.541	$126	0.132	0.633	0.086	-
		ST	L-Coup.	320	$12	$262	0.010	0.416	0.571	$225	0.193	0.576	0.150	-
			LF-Coup.	320	$57	$335	0.043	0.373	0.559	$304	0.228	0.549	0.187	-
		LT	L-Coup.	320	$76	$327	0.065	0.416	0.516	$289	0.248	0.521	0.205	-
			LF-Coup.	320	$124	$402	0.093	0.373	0.509	$370	0.278	0.501	0.237	-
	M/L	None	Conv.	640	$18	$225	0.019	0.348	0.559	$179	0.188	0.577	0.145	-
		ST	L-Coup.	640	$127	$334	0.098	0.507	0.595	$341	0.262	0.508	0.222	-
			LF-Coup.	640	$208	$443	0.134	0.451	0.572	$464	0.300	0.481	0.261	-
		LT	L-Coup.	640	$203	$409	0.156	0.507	0.536	$417	0.321	0.451	0.280	-
			LF-Coup.	640	$285	$520	0.184	0.451	0.522	$541	0.349	0.433	0.311	-
Dairy	S	None	Conv.	171	-$245	$148	-0.245	0.210	0.235	-$131	-0.132	0.574	-0.182	-0.224
		ST	L-Coup.	171	-$245	$148	-0.245	0.210	0.235	-$131	-0.132	0.574	-0.182	-0.224
			LF-Coup.	171	-$295	$44	-0.296	0.235	0.398	-$240	-0.240	0.442	-0.286	-0.512
		LT	L-Coup.	171	-$243	$150	-0.244	0.210	0.234	-$130	-0.130	0.572	-0.180	-0.224
			LF-Coup.	171	-$295	$44	-0.296	0.235	0.398	-$240	-0.240	0.442	-0.286	-0.512
	M/L	None	Conv.	520	-$9	$319	-0.007	0.319	0.340	$92	0.073	0.405	0.041	-0.279
		ST	L-Coup.	520	-$9	$319	-0.007	0.319	0.340	$92	0.073	0.405	0.041	-0.279
			LF-Coup.	520	-$109	$187	-0.086	0.346	0.474	-$56	-0.045	0.316	-0.073	-0.523
		LT	L-Coup.	520	-$7	$321	-0.006	0.319	0.339	$94	0.075	0.404	0.043	-0.279
			LF-Coup.	520	-$109	$187	-0.086	0.346	0.474	-$56	-0.045	0.316	-0.073	-0.523

[a]Short-term (ST) and long-term (LT) coupled.

[b]Crop acreage includes just owned cropland. Crop acreage for LF-coupled potato farms does not include forages grown for sale to dairy farm. Dairy farm crop acreage does not include pasture.

[c]NFI, ROVC, and FVA are in $/acre of just owned cropland. Owned and operated cropland includes potato plus rotation(s) for potato models and silage corn and hay/haylage for dairy models.

[d]Feed balance comparison not applicable for potato farms since no feed is purchased and indicator values are equal to +1.

Table 23, ATR values for potato farms ranged from 0.306 for smaller conventional farms to 0.507 for larger L-coupled farms. Expected values for ATR range from 0.20 to 0.60.

The operating expense ratio (OER) measures the efficient use of production expenses. OER values were somewhat lower (preferred) for long-term coupled potato farms than conventional farms because of their more efficient use of purchased fertilizers. On the other hand, short-term coupled farms had slightly worse OER than conventional farms because potatoes comprised a larger proportion of the crop mix. Potatoes had a higher (less preferred) OER since a higher percentage of its costs constituted operating expenses relative to grain corn. OER values ranged from 0.516 for small, long-term LF-coupled potato farms to 0.595 for medium-large, short-term L-coupled farms. OER values were within an expected range of 0.20 to 0.80.

Sustainability indicators. FVA and FVA_p were more favorable for coupled farms than for conventional farms for both short- and long-term integration due to greater farm profits and paid labor from growing more potatoes. Models of coupled farms appeared to return more to the farming sector than models of conventional farms. There was also an increase in FVA_p from L-coupled to LF-coupled models, due higher labor costs per dollar of total revenue for more diversified crop enterprises and thus greater returns to the farming sector. The measures of FVA were also greater for long-term integration than for short-term integration due to reductions in purchased fertilizer. FVA_p was within an expected range of -0.20 to 0.50, ranging between 0.132 and 0.349.

Other sustainability indicators were more favorable for coupled than conventional farm models. NRG was lower (preferred) for coupled models than for conventional models for both size classes and both couple types. Long-term integrators had lower NRG than short-term ones since they used less purchased fertilizer. L-coupled had lower NRG than conventional due to efficiencies in equipment use when growing more profitable potatoes. LF-coupled models had lower NRG than L-coupled because the increase in energy and machinery costs was proportionally less than the increase in total revenues due to equipment inventory efficiencies. NRG values for potato models were between 0.433 and 0.633; the expected NRG range was 0.30 to 0.70.

SLF was higher and thus more favorable for all coupled potato models relative to conventional models. SLF was higher for long-term than short-term integration because NFI was higher for long-term integrators. SLF was also greater for LF-coupled farms than for L-coupled farms due to higher NFI and labor expenses for growing dairy forages. SLF for models were between 0.086 and 0.311; the expected SLF range was -0.05 to 0.30. FB was not compared for potato farms since no feed is used and since values for total revenue and crop sales are the same.

Dairy-farm model indicators

All indicators in Table 23 for dairy farms were based on 2001 data, except for ATR, which was based on 2000 Farm Credit data (Stafford et al. 2001). Since fluid milk prices were below break-even in 2001, several indicators were negative (Dalton and Bragg 2003). Since no feed crops were grown and no manure-nutrient credits were taken, indicators for short- and long-term LF-coupled models were identical. Dairy cropland used for calculating returns and FVA per acre included silage corn and hay/haylage, but not pasture. Indicators are ranked in Appendices D-1 and D-2.

Economic indicators. In general, profitability indicators (NFI, ROVC, and POR) were the same for short-term L-coupled dairy-farm models compared to conventional models since their enterprise budgets were the same. For long-term L-coupled models, profitability indicators were slightly better because of the small manure-nutrient credit taken for silage corn. LF-coupled dairy-farm models had lower values for NFI, ROVC, and POR because the production savings from not having to grow forages were less than the cost of purchasing forages from the coupled potato farm since stranded fixed costs from previously used feed crop equipment remained. Coupled dairy farms appeared to be better off if they grew their own forages. Values for POR were between -0.296 and -0.006, which were lower than a typical value of 0.10, due to low fluid milk prices in 2001.

Financial efficiency measures were similar for L-coupled and conventional models. Comparisons of LF-coupled models with conventional models were mixed. ATR values for L-coupled and conventional models were the same since farm revenues and total assets were identical. Models of LF-coupled farms had slightly higher ATR than conventional farms because fewer machinery assets were needed since forage crops were not grown. In this study, values for ATR for dairy farms were between 0.210 and 0.346, while a typical ATR is 0.30.

OER for LF-coupled dairy farms was higher (less favorable) than for conventional farms due to higher operating expenses since new purchased feed costs exceeded savings in forage production. For L-coupled dairy-farm models, there was a slight decrease in OER going from short- to long-term coupling because of the small fertilizer reduction for silage corn. OER values ranged from 0.234 to 0.474. A typical value for OER is 0.66. OER for dairy farms was lower than typical values since family labor was not included explicitly.

Sustainability indicators. Models of short-term L-coupled dairy farms had FVA measures that were the same as conventional models since crop production techniques were the same and there was no change in cropped acres. Indicators for LF-coupled dairy farms were the same for both short- and long-term coupling. Long-term L-coupled farms had slightly higher FVA measures than conventional farms due to small reductions in purchased fertilizer from the manure-nutrient credit taken for silage corn. There was also a decrease in FVA and FVA_p from L-coupled to LF-coupled farms, which did not grow forages and required less labor than L-coupled dairy farms. FVA measures were lower even though a proportion of forages purchased from the coupled potato farm were returned to the farming sector. FVA_p ranged from -0.240 to 0.075.

Other comparisons of sustainability indicators were mixed for coupled and conventional dairy-farm models. NRG, SLF, and FB were identical for short-term L-coupled and conventional models. Since forages were purchased from another farm rather than produced on-farm, LF-coupled models had lower and thus more favorable NRG values because of lower machinery and energy costs. NRG improved slightly for L-coupled models going from short-term to long-term due to less purchased fertilizer for silage corn. NRG values were between 0.316 and 0.574.

LF-coupled models had lower SLF values due to lower labor expenditures and lower NFI. For all L-coupled dairy models, SLF increased slightly from the short- to long-term because of higher NFI. SLF ranged from -0.286 to 0.043.

For both short- and long-term models, FB for L-coupled dairy farms was the same as for conventional farms since production and feeding regiments were the same. LF-coupled farms have more negative (less preferred) FB because forages were purchased and were not grown on-farm. FB values ranged between -0.523 and -0.224.

System indicators

While individual farm indicators are of interest to the farmer, this analysis is ultimately interested in the workings of the agricultural system, a combination of crop and livestock enterprises. Indicators for conventional and integrated potato and dairy systems are provided in Table 24. Conventional systems were based on

Table 24. Economic indicators for coupled and conventional potato- and dairy-farm systems.

					Economic					Sustainability			
					Profitability			Efficiency					
System Type	Size	Coup. Hist.[a]	Model	Crop Acres[b]	NFI[c]	ROVC[c]	POR	ATR	OER	FVA[c]	FVA_p	NRG	SLF
Potato & Dairy	S	None	Conv.	491	-$119	$198	-0.123	0.263	0.495	$36	0.037	0.612	-0.010
		ST	L-Coup.	491	-$78	$239	-0.070	0.318	0.521	$101	0.091	0.575	0.046
			LF-Coup.	491	-$66	$250	-0.054	0.320	0.557	$137	0.112	0.519	0.051
		LT	L-Coup.	491	-$35	$282	-0.032	0.318	0.483	$143	0.130	0.537	0.084
			LF-Coup.	491	-$22	$294	-0.018	0.320	0.521	$180	0.148	0.484	0.087
	M/L	None	Conv.	1160	$6	$283	0.006	0.332	0.506	$140	0.129	0.488	0.091
		ST	L-Coup.	1160	$66	$343	0.052	0.402	0.534	$230	0.179	0.463	0.142
			LF-Coup.	1160	$66	$345	0.047	0.402	0.578	$254	0.179	0.416	0.128
		LT	L-Coup.	1160	$109	$386	0.085	0.402	0.501	$272	0.212	0.430	0.176
			LF-Coup.	1160	$109	$388	0.077	0.402	0.548	$297	0.209	0.387	0.158

[a]Short-term (ST) and long-term (LT) coupled.
[b]Crop acres include total potato plus dairy cropland.
[c]NFI, ROVC, and FVA are in $/acre.

separate potato- and dairy-farm models whose whole-farm budgets were combined. Like separate potato and dairy comparisons, indicators were calculated for small and medium-large, short- and long-term coupling, and for L-coupled and LF-coupled farm model types. For system models, acres of crops grown were aggregated from potato and dairy farm cropland.

Economic indicators. Across each farm size, profitability indicators (NFI, ROVC, and POR) for coupled systems were greater than for conventional systems. L-coupled systems were more profitable than conventional due to increased profitability from growing more potatoes. LF-coupled systems showed equal or better profitability measures than L-coupled systems due to efficiencies in equipment use for crops. Profitability improved going from short- to long-term integration since greater manure-nutrient credits were taken for potatoes and silage corn after ten years of integration.

System comparisons were mixed for economic efficiency. Coupled systems had higher and thus more favorable values for ATR than conventional systems due to higher revenues from growing more potatoes. For LF-coupled systems, equipment savings also contributed to greater ATR than conventional. ATR was similar for L-coupled and LF-coupled models since lower ATR for LF-coupled potato farm models offset higher ATR for LF-coupled dairy farm models.

OER was generally higher (less preferred) for coupled compared to conventional models. L-coupled systems had higher OER than conventional since more potatoes were grown, a crop with a higher OER than grain corn. LF-coupled OER was slightly higher due to additional dairy forage expenses. However, higher OER for LF-coupled may be dependent on how forage transactions between LF-coupled potato and dairy farms were accounted for when calculating OER. Differences in OER between L-coupled and LF-coupled may also be due to slight differences in equipment inventories between potato and dairy farms. OER was lower (better) going from the short term to long term due to fertilizer costs that were lowered by manure-nutrient credits.

Sustainability indicators. Models of coupled systems had higher FVA measures than models of conventional systems because coupled systems grew more potatoes and less grain corn. Potatoes were more profitable and more labor intensive than grain corn. FVA also improved from short- to long-term coupling due to reduction in purchased fertilizer inputs. The NRG indicator was lower (more favorable) for coupled than for conventional systems since crop revenues were higher relative to NRG expenses for coupled farm models due to equipment energy use efficiencies when increasing potato acreage relative to grain corn and when adding forages enterprises. NRG was more favorable for long-term than short-term integrators due to reduced purchased fertilizer use in the system from greater manure-nutrient credits taken after several years of coupling. SLF was greater for coupled systems, especially in the long-term, due to greater profitability of these systems. FB was not compared between agricultural systems since this indicator was not compared for potato farm models.

Indicator Diagram Comparisons

Radial diagrams are increasingly used to display outcomes containing differing metrics. By observing outcome values on rays extending from a vertex, the reader can visually grasp how well the displayed options compare across a number of objectives. Radial diagrams used here display the relative desirability of eight coupled farming models compared to equivalent sized conventional models.

Six economic (POR, ATR, and OER) and sustainability (FVA_p, NRG, and SLF) indicators were compared with ray diagrams for coupled and conventional potato and dairy systems (Figures 3 to 6). All selected indicators used in this analysis had possible ranges of -1 to +1. Indicators were graphed as rays on radial diagrams. Minimum and maximum values for the expected range of each indicator were used as lower and upper bounds. Minimum indicator values correspond to the ray diagram origin, while maximum indicator values correspond to the outer bound of the diagram. Thus, more favorable indicator ratios are found further from the origin. Lower OER and NRG indicator values are preferred. These two rays were reversed so the preferred lower ratios are located further away from the origin.

With the exception of OER, coupled system models were favored over conventional system models for all indicators. This was true for both size classes, small and medium-large, and for both farm model types, L-coupled (Figures 3 and 4) and LF-coupled (Figures 5 and 6). Medium-large-sized models generally had higher indicator values than small ones regardless of farm type. Diagrams of small farm systems were contained within comparable diagrams of medium-large systems. Size generally dominated integration, where the best small farm systems were usually worse than the worst medium-large farm systems. Indicators were well within expected ranges.

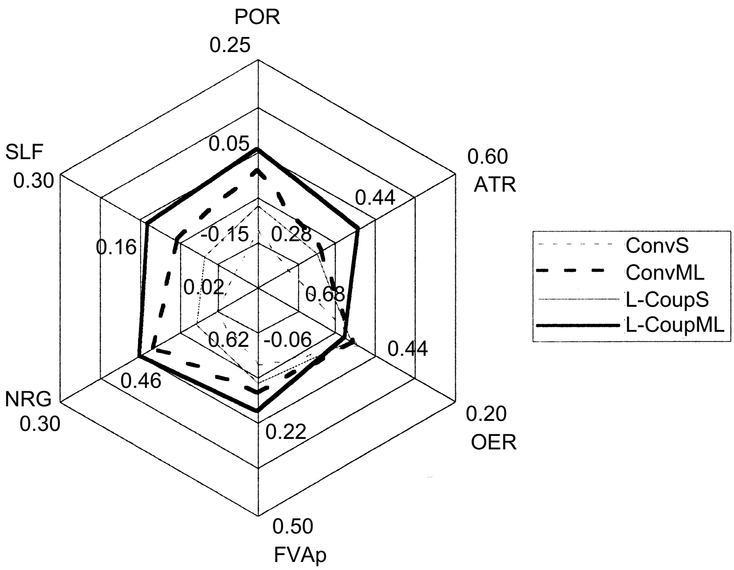

Figure 3. Comparison of conventional and short-term land-coupled indicators.

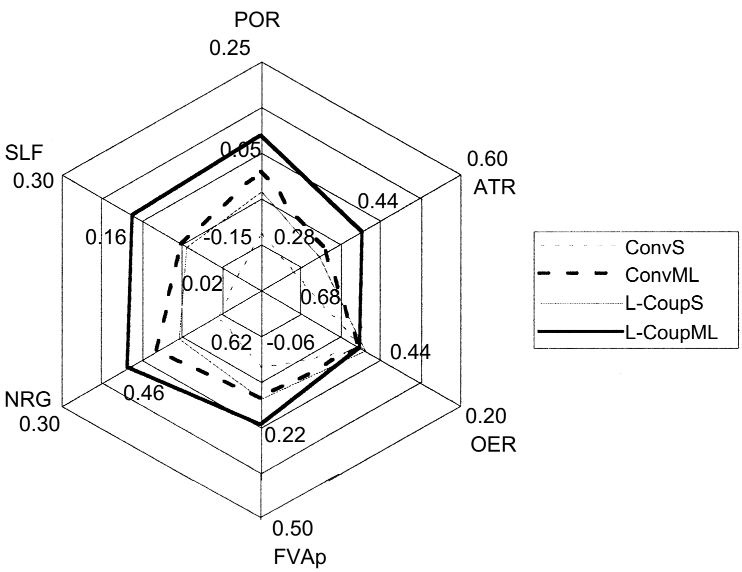

Figure 4. Comparison of conventional and long-term land-coupled indicators.

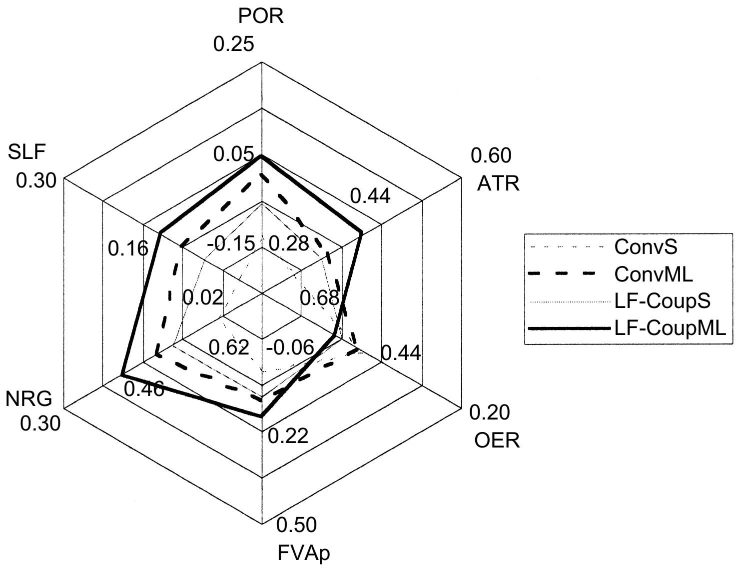

Figure 5. Comparison of conventional and short-term land/feed-coupled indicators.

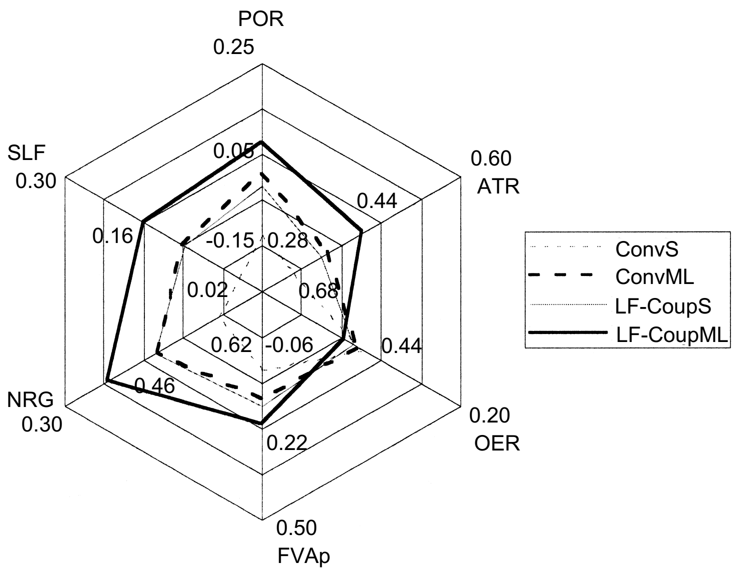

Figure 6. Comparison of conventional and long-term land/feed-coupled indicators.

VI. SUMMARY AND CONCLUSIONS

Integrating crops and livestock can introduce technical and economic efficiencies that may increase productivity and profitability and that may reduce soil-nutrient loading and non-point source pollution. Benefits from coupling potato and dairy farms were less direct than originally expected because farmers did not capture all of the potential gains during early transition years. For example, short-term couplers did not take manure-nutrient credits for potatoes and silage corn while long-term couplers took these credits. Surveyed farmers were hesitant to expose themselves to the risk of taking manure-nutrient credits for uncertain yield increases in high-value crops, such as potatoes, especially when chemical fertilizer was relatively inexpensive. These risks are greater in the short term when organic matter levels are low from less manure applications.

Analyses of budgets and economic indicators suggest that potato and dairy systems coupled for only two years (short term) had greater profitability and sustainability indicator values than conventional non-coupled systems. Profitability increased in the short term in two ways. Because the land base expanded from coupling, potato farms were able to grow more potatoes, a more profitable cash crop, and less grain corn, a less profitable rotation crop while keeping the same rotation. This was possible because silage corn was added as a rotation crop during coupling with the dairy farm. For land-coupled potato farms, NFI and ROVC were about $62 to $109/acre higher than for conventional farms, assuming equal potato yields and no reductions in chemical fertilizer in the short-term. Results might be different if average market prices and assumed yields for cash and rotation crops changed. Also, the profitability of silage corn as a potato rotation assumed that the coupled dairy farm was close enough for manure to be applied to the silage corn acreage. Silage corn production without manure applications would lead to soil quality deterioration, may require additional chemical fertilizer, and may not be as profitable.

A second way that profitability improved from coupling in the short term was that dairy farms expanded the size of their herds to take advantage of the potential for more silage corn produced in the rotation. Greater profitability from livestock expansion assumed increasing returns to scale. Hypothetical expansion for a small LF-coupled dairy farm increased NFI by $136/acre and ROVC by $39/acre compared to a conventional dairy farm. Instead of expanding herd size, coupled systems could grow barley and soybeans in rotation to reduce purchased concentrated feed. Profitability and sustainability may also be improved if dairy farmers distributed manure nutrients over a greater land base. Integrating crops and livestock may be encouraged where livestock farms have expanded or desire to expand and crop farms are close enough for coupling.

Potato and dairy systems coupled for more than ten years (long term) had more favorable profitability and sustainability measures than short-term coupled systems as farmers maintained an integrated agricultural system over many years. Due to greater manure-nutrient credits taken in the long term for potatoes and silage corn, long-term coupled potato farms could have withstood a 10% to 20% loss in marketable potato yield and still have been as profitable as conventional farms. The picture improved even more if potato yields increased following several years of manure application, as suggested by long-term rotation plot studies in Maine. Assuming marketable potato yields increased 10%, NFI for long-term coupled potato farms was about $234 to $389/acre higher than for conventional potato farms.

In addition to economic benefits, other benefits to integrated systems, such as improved soil quality, may be more difficult to quantify. Cooperating coupled farms mentioned that integration provided more land base to dairy farms and greater opportunities for disposal of livestock waste. Thus, integrating crops and livestock in Maine may be encouraged where dairy farms are rapidly expanding their herds and crop farms are close enough to couple. Land swapping may also reduce land rental costs for farms. Some coupled farms stated that their managerial skills improved from interaction with another specialized producer. Shared equipment and labor were also cited as benefits.

There are several challenges to integrating potato and dairy systems in Maine despite short-term and long-term benefits. Coupling between cooperating farms usually occurs within ten miles of the dairy farm. The current potential for integration may be limited given the spatial separation of the two industries. In addition to a proximity requirement, coupled sets of farms need to be of similar scale to reduce the transaction costs of the relationship and make integration feasible. Furthermore, the added management time required to integrate may not be appealing to certain farmers. Long-term integrators stressed that successful integration required both couplers to worry less about which farmer was currently making out better and instead to focus on potential future benefits.

This analysis suggests three areas for future research. First, the profitability of hypothetical coupled potato and dairy operations in northern Maine should be explored. Second, the profitability of on-farm integration should be analyzed, in particular cases where concentrates and mixed vegetables are raised. Third, simulation models can be used to model coupled and conventional potato yields to estimate the long-run productivity and profitability of integrated and non-integrated agricultural production.

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APPENDIX A-1—SMALL POTATO WHOLE-FARM BUDGETS

Conventional Small[a]

	Acres	Yield/Acre	Unit Price
Potato	160	240 cwt	$6.88
Grain Corn	160	100 bu	$2.50

	Total	Per Acre	Per Cwt
Annual Revenue	**$304,107**	**$950.33**	**$6.42**
Annual Operating Expenses			
Seed	$41,658	$130.18	$0.88
Fertilizer	$33,010	$103.16	$0.70
Lime	$3,541	$11.07	$0.07
Chemicals	$30,238	$94.49	$0.64
Labor	$42,575	$133.05	$0.90
Diesel Fuel and Oil	$14,126	$44.14	$0.30
Maintenance and Upkeep	$21,538	$67.31	$0.45
Supplies	$10,815	$33.80	$0.23
Insurance	$8,917	$27.87	$0.19
Miscellaneous			
Utilities	$6,421	$20.07	$0.14
Custom Hire	$0	$0	$0
Rent or Lease	$12,000	$37.50	$0.25
Freight and Trucking	$2,849	$8.90	$0.06
Storage and Warehousing	$4,971	$15.53	$0.10
Other Expenses	$960	$3.00	$0.02
Interest	$6,452	$20.16	$0.14
Total Operating Expenses	**$240,070**	**$750.22**	**$5.07**
Annual Ownership Expenses			
Depreciation and Interest	$75,586	$236.21	$1.60
Tax and Insurance	$4,906	$15.33	$0.10
Total Ownership Expenses	**$80,492**	**$251.54**	**$1.70**
Total Annual Cost	**$320,562**	**$1,001.76**	**$6.77**
Net Farm Income (NFI)	**-$16,455**	**-$51.42**	**-$0.35**
Return over Variable Cost (ROVC)	**$64,036**	**$200.11**	**$1.35**
Performance Measures			
Breakeven Revenue		$/acre	$/cwt
Long-run to Cover All Costs		$1,001.76	$6.77
Short-run to Cover Operating Costs		$750.22	$5.07

[a]Numbers may not sum due to rounding.

Long-Term Coupled Small[a]
Land-Coupled

	Acres	Yield/Acre	Unit Price
Potato	209	240 cwt	$6.88
Grain Corn	111	100 bu	$2.50
	Total	**Per Acre**	**Per Cwt**
Annual Revenue	**$372,740**	**$1,164.81**	**$6.61**
Annual Operating Expenses			
Seed	$51,788	$161.84	$0.92
Fertilizer	$16,205	$50.64	$0.29
Lime	$3,436	$10.74	$0.06
Chemicals	$37,109	$115.96	$0.66
Labor	$52,008	$162.53	$0.92
Diesel Fuel and Oil	$17,185	$53.70	$0.30
Maintenance and Upkeep	$26,046	$81.39	$0.46
Supplies	$13,147	$41.08	$0.23
Insurance	$11,616	$36.30	$0.21
Miscellaneous			
Utilities	$8,191	$25.60	$0.15
Custom Hire	$0	$0	$0
Rent or Lease	$14,450	$45.16	$0.26
Freight and Trucking	$3,721	$11.63	$0.07
Storage and Warehousing	$4,600	$14.37	$0.08
Other Expenses	$1,254	$3.92	$0.02
Interest	$7,201	$22.50	$0.13
Total Operating Expenses	**$267,957**	**$837.37**	**$4.75**
Annual Ownership Expenses			
Depreciation and Interest	$75,586	$236.21	$1.34
Tax and Insurance	$4,906	$15.33	$0.09
Total Ownership Expenses	**$80,492**	**$251.54**	**$1.43**
Total Annual Cost	**$348,449**	**$1,088.90**	**$6.18**
Net Farm Income (NFI)	**$24,291**	**$75.91**	**$0.43**
Return over Variable Cost (ROVC)	**$104,782**	**$327.44**	**$1.86**
Performance Measures			
Breakeven Revenue		$/acre	$/cwt
Long-run to Cover All Costs		$1,088.90	$6.18
Short-run to Cover Operating Costs		$837.37	$4.75

[a]Numbers may not sum due to rounding.

Long-Term Coupled Small[a]
Land/Feed-Coupled

	Acres	Yield/Acre	Unit Price
Potato	209	240 cwt	$6.88
Grain Corn	111	100 bu	$2.50
Silage Corn	98	15 tons	$25.00
Hay	73	3.5 tons	$64.50

	Total	Per Acre[b]	Per Cwt
Annual Revenue	**$425,969**	**$867.55**	**$4.69**
Annual Operating Expenses			
Seed	$55,022	$112.06	$0.61
Fertilizer	$18,171	$37.01	$0.20
Lime	$5,355	$10.91	$0.06
Chemicals	$39,499	$80.45	$0.43
Labor	$61,210	$124.66	$0.67
Diesel Fuel and Oil	$19,507	$39.73	$0.21
Maintenance and Upkeep	$28,582	$58.21	$0.31
Supplies	$14,857	$30.26	$0.16
Insurance	$11,673	$23.77	$0.13
Miscellaneous			
Utilities	$8,191	$16.68	$0.09
Custom Hire	$0	$0	$0
Rent or Lease	$16,588	$33.78	$0.18
Freight and Trucking	$3,721	$7.58	$0.04
Storage and Warehousing	$4,869	$9.92	$0.05
Other Expenses	$2,109	$4.30	$0.02
Interest	$7,947	$16.19	$0.09
Total Operating Expenses	**$297,302**	**$605.50**	**$3.27**
Annual Ownership Expenses			
Depreciation and Interest	$83,459	$169.98	$0.92
Tax and Insurance	$5,585	$11.37	$0.06
Total Ownership Expenses	**$89,043**	**$181.35**	**$0.98**
Total Annual Cost	**$386,345**	**$786.85**	**$4.25**
Net Farm Income (NFI)	**$39,624**	**$80.70**	**$0.44**
Return over Variable Cost (ROVC)	**$128,667**	**$262.05**	**$1.42**
Performance Measures			
Breakeven Revenue		$/acre	$/cwt
Long-run to Cover All Costs		$786.85	$4.25
Short-run to Cover Operating Costs		$605.50	$3.27

[a]Numbers may not sum due to rounding.
[b]Acreage in denominator includes both owned and operated crop acres.

APPENDIX A-2—MEDIUM-LARGE POTATO WHOLE-FARM BUDGETS

Conventional Medium-Large[a]

	Acres	Yield/Acre	Unit Price
Potato	320	240 cwt	$6.88
Grain Corn	320	100 bu	$2.50
	Total	**Per Acre**	**Per Cwt**
Annual Revenue	**$608,214**	**$950.33**	**$6.42**
Annual Operating Expenses			
Seed	$83,316	$130.18	$0.88
Fertilizer	$66,019	$103.16	$0.70
Lime	$7,082	$11.07	$0.07
Chemicals	$60,477	$94.49	$0.64
Labor	$76,243	$119.13	$0.80
Diesel Fuel and Oil	$26,014	$40.65	$0.27
Maintenance and Upkeep	$40,677	$63.56	$0.43
Supplies	$21,630	$33.80	$0.23
Insurance	$17,835	$27.87	$0.19
Miscellaneous			
Utilities	$12,842	$20.07	$0.14
Custom Hire	$0	$0	$0
Rent or Lease	$22,000	$34.38	$0.23
Freight and Trucking	$5,698	$8.90	$0.06
Storage and Warehousing	$9,941	$15.53	$0.10
Other Expenses	$1,920	$3.00	$0.02
Interest	$12,474	$19.49	$0.13
Total Operating Expenses	**$464,167**	**$725.26**	**$4.90**
Annual Ownership Expenses			
Depreciation and Interest	$124,128	$193.95	$1.31
Tax and Insurance	$8,178	$12.78	$0.09
Total Ownership Expenses	**$132,305**	**$206.73**	**$1.40**
Total Annual Cost	**$596,472**	**$931.99**	**$6.30**
Net Farm Income (NFI)	**$11,741**	**$18.35**	**$0.12**
Return over Variable Cost (ROVC)	**$144,047**	**$225.07**	**$1.52**
Performance Measures			
Breakeven Revenue		*$/acre*	*$/cwt*
Long-run to Cover All Costs		$931.99	$6.30
Short-run to Cover Operating Costs		$725.26	$4.90

[a]Numbers may not sum due to rounding.

Long-Term Coupled Medium-Large[a]
Land-Coupled

	Acres	Yield/Acre	Unit Price
Potato	480	240 cwt	$6.88
Grain Corn	160	100 bu	$2.50

	Total	Per Acre	Per Cwt
Annual Revenue	**$832,320**	**$1,300.50**	**$6.70**
Annual Operating Expenses			
Seed	$116,394	$181.87	$0.94
Fertilizer	$31,008	$48.45	$0.25
Lime	$6,741	$10.53	$0.05
Chemicals	$82,910	$129.55	$0.67
Labor	$103,046	$161.01	$0.83
Diesel Fuel and Oil	$34,886	$54.51	$0.28
Maintenance and Upkeep	$56,324	$88.01	$0.45
Supplies	$29,245	$45.69	$0.24
Insurance	$26,647	$41.64	$0.21
Miscellaneous			
Utilities	$18,623	$29.10	$0.15
Custom Hire	$0	$0	$0
Rent or Lease	$29,000	$45.31	$0.23
Freight and Trucking	$8,546	$13.35	$0.07
Storage and Warehousing	$8,730	$13.64	$0.07
Other Expenses	$2,880	$4.50	$0.02
Interest	$15,326	$23.95	$0.12
Total Operating Expenses	**$570,306**	**$891.10**	**$4.59**
Annual Ownership Expenses			
Depreciation and Interest	$123,872	$193.55	$1.00
Tax and Insurance	$8,178	12.78	$0.07
Total Ownership Expenses	**$132,049**	**$206.33**	**$1.06**
Total Annual Cost	**$702,355**	**$1,097.43**	**$5.66**
Net Farm Income (NFI)	**$129,965**	**$203.07**	**$1.05**
Return over Variable Cost (ROVC)	**$262,015**	**$409.40**	**$2.11**
Performance Measures			
Breakeven Revenue		$/acre	$/cwt
Long-run to Cover All Costs		$1,097.43	$5.66
Short-run to Cover Operating Costs		$891.10	$4.59

[a]Numbers may not sum due to rounding.

Long-Term Coupled Medium-Large[a]
Land/Feed-Coupled

	Acres	Yield/Acre	Unit Price
Potato	480	240 cwt	$6.88
Grain Corn	160	100 bu	$2.50
Silage Corn	320	15 tons	$25.00
Haylage	200	6 tons	$32.55

	Total	Per Acre[b]	Per Cwt
Annual Revenue	**$991,380**	**$854.64**	**$4.06**
Annual Operating Expenses			
Seed	$126,954	$109.44	$0.52
Fertilizer	$40,928	$35.28	$0.17
Lime	$12,622	$10.88	$0.05
Chemicals	$90,715	$78.20	$0.37
Labor	$126,137	$108.74	$0.52
Diesel Fuel and Oil	$42,883	$36.97	$0.18
Maintenance and Upkeep	$61,741	$53.22	$0.25
Supplies	$34,445	$29.69	$0.14
Insurance	$26,820	$23.12	$0.11
Miscellaneous			
Utilities	$18,623	$16.05	$0.08
Custom Hire	$0	$0	$0
Rent or Lease	$35,500	$30.60	$0.15
Freight and Trucking	$8,546	$7.37	$0.04
Storage and Warehousing	$9,570	$8.25	$0.04
Other Expenses	$5,480	$4.72	$0.02
Interest	$17,473	$15.06	$0.07
Total Operating Expenses	**$658,437**	**$567.62**	**$2.70**
Annual Ownership Expenses			
Depreciation and Interest	$140,720	$121.31	$0.58
Tax and Insurance	$9,898	$8.53	$0.04
Total Ownership Expenses	**$150,618**	**$129.84**	**$0.62**
Total Annual Cost	**$809,055**	**$697.46**	**$3.31**
Net Farm Income (NFI)	**$182,325**	**$157.18**	**$0.75**
Return over Variable Cost (ROVC)	**$332,943**	**$287.02**	**$1.36**
Performance Measures			
Breakeven Revenue		$/acre	$/cwt
Long-run to Cover All Costs		$697.46	$3.31
Short-run to Cover Operating Costs		$567.62	$2.70

[a]Numbers may not sum due to rounding.
[b]Acreage in denominator includes both owned and operated crop acres.

APPENDIX B-1—SMALL DAIRY WHOLE-FARM BUDGETS

Conventional Small[a]

	Total	Per Cow	Per Cwt
Number of Cows	66	-	-
Annual Milk Shipment (cwt)	10,413	159	-
Annual Revenue			
Milk Receipts	$157,878	$2,407.52	$15.16
Crop and Hay Revenue	$4,059	$61.90	$0.39
Livestock Revenue	$8,730	$133.13	$0.84
"Other" Revenue	$0	$0	$0
Total Revenue	**$170,668**	**$2,602.56**	**$16.39**
Annual Operating Expenses			
Labor Expenses			
Family	$0	$0	$0
Hired	$10,824	$165.07	$1.04
Subtotal	*$10,824*	*$165.07*	*$1.04*
Purchased Feed Expenses			
Dairy Forage	$0	$0	$0
Dairy Concentrate	$42,344	$645.72	$4.07
Subtotal	*$42,344*	*$645.72*	*$4.07*
Livestock Expenses			
Breeding Fees	$1,971	$30.06	$0.19
Veterinary and Medicine	$4,201	$64.06	$0.40
Bedding	$2,362	$36.02	$0.23
DHIA Expenses	$729	$11.12	$0.07
Livestock Insurance	$1,486	$22.66	$0.14
Subtotal	*$10,749*	*$163.91*	*$1.03*
Crop and Pasture Expenses			
Seeds	$3,234	$49.32	$0.31
Chemicals	$2,390	$36.45	$0.23
Fertilizer	$2,248	$34.28	$0.22
Lime	$1,919	$29.26	$0.18
Other	$5,028	$76.67	$0.48
Subtotal	*$14,819*	*$225.98*	*$1.42*
Maintenance and Equipment Expenses			
Fuel and Oil	$5,902	$90.00	$0.57
Machinery Repairs	$11,986	$182.78	$1.15
Subtotal	*$17,888*	*$272.78*	*$1.72*

	Total	Per Cow	Per Cwt
Deduction Expenses			
Milk Marketing	$1,446	$22.05	$0.14
Hauling and Trucking	$6,404	$97.66	$0.62
Subtotal	*$7,850*	*$119.70*	*$0.75*
Interest (5.4% on 1/2 of total operating expense)	$2,821	$43.02	$0.27
Total Operating Expenses	**$107,296**	**$1,636.18**	**$10.30**
Annual Overhead Expenses			
Property Tax	$7,869	$120.00	$0.76
Farm Insurance	$7,883	$120.21	$0.76
Dues and Professional Fees	$1,018	$15.52	$0.10
Utilities	$6,362	$97.01	$0.61
Miscellaneous	$14,946	$227.91	$1.44
Total Overhead Expenses	**$38,078**	**$580.66**	**$3.66**
Annual Depreciation and Interest Expenses			
Land	$8,081	$123.23	$0.78
Buildings	$25,738	$392.48	$2.47
Machinery and Equipment	$16,750	$255.42	$1.61
Subtotal	*$50,569*	*$771.13*	*$4.86*
Livestock Herd Expenses			
Cows (Milking and Dry)	$10,444	$159.26	$1.00
Heifers	$4,407	$67.21	$0.42
Calves	$1,658	$25.28	$0.16
Dairy Bulls	$75	$1.15	$0.01
Subtotal	*$16,584*	*$252.90*	*$1.59*
Total Ownership Expenses	**$67,153**	**$1,024.03**	**$6.45**
Total Annual Cost	**$212,526**	**$3,240.87**	**$20.41**
Net Farm Income (NFI)	**-$41,859**	**-$638.31**	**-$4.02**
Return over Variable Cost (ROVC)	**$25,294**	**$385.72**	**$2.43**
Performance Measures			
Breakeven Revenue		$/cow	$/cwt
Long-run to Cover All Costs		$3,045.83	$19.18
Short-run to Cover Operating Costs		$2,021.80	$12.73

[a]Numbers may not sum due to rounding.

Long-Term Coupled Small[a]
Land-Coupled

	Total	Per Cow	Per Cwt
Number of Cows	66	-	-
Annual Milk Shipment (cwt)	10,413	159	-
Annual Revenue			
Milk Receipts	$157,878	$2,407.52	$15.16
Crop and Hay Revenue	$4,059	$61.90	$0.39
Livestock Revenue	$8,730	$133.13	$0.84
"Other" Revenue	$0	$0	$0
Total Revenue	**$170,668**	**$2,602.56**	**$16.39**
Annual Operating Expenses			
Labor Expenses			
Family	$0	$0	$0
Hired	$10,824	$165.07	$1.04
Subtotal	*$10,824*	*$165.07*	*$1.04*
Purchased Feed Expenses			
Dairy Forage	$0	$0	$0
Dairy Concentrate	$42,344	$645.72	$4.07
Subtotal	*$42,344*	*$645.72*	*$4.07*
Livestock Expenses			
Breeding Fees	$1,971	$30.06	$0.19
Veterinary and Medicine	$4,201	$64.06	$0.40
Bedding	$2,362	$36.02	$0.23
DHIA Expenses	$729	$11.12	$0.07
Livestock Insurance	$1,486	$22.66	$0.14
Subtotal	*$10,749*	*$163.91*	*$1.03*
Crop and Pasture Expenses			
Seeds	$3,234	$49.32	$0.31
Chemicals	$2,390	$36.45	$0.23
Fertilizer	$1,967	$29.99	$0.19
Lime	$1,919	$29.26	$0.18
Other	$5,028	$76.67	$0.48
Subtotal	*$14,537*	*$221.69*	*$1.40*
Maintenance and Equipment Expenses			
Fuel and Oil	$5,902	$90.00	$0.57
Machinery Repairs	$11,986	$182.78	$1.15
Subtotal	*$17,888*	*$272.78*	*$1.72*

	Total	Per Cow	Per Cwt
Deduction Expenses			
Milk Marketing	$1,446	$22.05	$0.14
Hauling and Trucking	$6,404	$97.66	$0.62
Subtotal	*$7,850*	*$119.70*	*$0.75*
Interest (5.4% on 1/2 of total operating expense)	$2,813	$42.90	$0.27
Total Operating Expenses	**$107,006**	**$1,631.77**	**$10.28**
Annual Overhead Expenses			
Property Tax	$7,869	$120.00	$0.76
Farm Insurance	$7,883	$120.21	$0.76
Dues and Professional Fees	$1,018	$15.52	$0.10
Utilities	$6,362	$97.01	$0.61
Miscellaneous	$14,946	$227.91	$1.44
Total Overhead Expenses	**$38,078**	**$580.66**	**$3.66**
Annual Depreciation and Interest Expenses			
Land	$8,081	$123.23	$0.78
Buildings	$25,738	$392.48	$2.47
Machinery and Equipment	$16,750	$255.42	$1.61
Subtotal	*$50,569*	*$771.13*	*$4.86*
Livestock Herd Expenses			
Cows (Milking and Dry)	$10,444	$159.26	$1.00
Heifers	$4,407	$67.21	$0.42
Calves	$1,658	$25.28	$0.16
Dairy Bulls	$75	$1.15	$0.01
Subtotal	*$16,584*	*$252.90*	*$1.59*
Total Ownership Expenses	**$67,153**	**$1,024.03**	**$6.45**
Total Annual Cost	**$212,237**	**$3,236.46**	**$20.38**
Net Farm Income (NFI)	**-$41,569**	**-$633.90**	**-$3.99**
Return over Variable Cost (ROVC)	**$25,584**	**$390.13**	**$2.46**
Performance Measures			
Breakeven Revenue		$/cow	$/cwt
Long-run to Cover All Costs		$3,041.42	$19.15
Short-run to Cover Operating Costs		$2,017.39	$12.70

[a]Numbers may not sum due to rounding.

Long-Term Coupled Small[a]
Land/Feed-Coupled

	Total	Per Cow	Per Cwt
Number of Cows	66	-	-
Annual Milk Shipment (cwt)	10,413	159	-
Annual Revenue			
Milk Receipts	$157,878	$2,407.52	$15.16
Crop and Hay Revenue	$4,059	$61.90	$0.39
Livestock Revenue	$8,730	$133.13	$0.84
"Other" Revenue	$0	$0	$0
Total Revenue	**$170,668**	**$2,602.56**	**$16.39**
Annual Operating Expenses			
Labor Expenses			
Family	$0	$0	$0
Hired	$1,622	$24.74	$0.16
Subtotal	*$1,622*	*$24.74*	*$0.16*
Purchased Feed Expenses			
Dairy Forage	$49,170	$749.81	$4.72
Dairy Concentrate	$42,344	$645.72	$4.07
Subtotal	*$91,515*	*$1,395.53*	*$8.79*
Livestock Expenses			
Breeding Fees	$1,971	$30.06	$0.19
Veterinary and Medicine	$4,201	$64.06	$0.40
Bedding	$2,362	$36.02	$0.23
DHIA Expenses	$729	$11.12	$0.07
Livestock Insurance	$1,486	$22.66	$0.14
Subtotal	*$10,749*	*$163.91*	*$1.03*
Crop and Pasture Expenses			
Seeds	$0	$0	$0
Chemicals	$0	$0	$0
Fertilizer	$0	$0	$0
Lime	$0	$0	$0
Other	$0	$0	$0
Subtotal	*$0*	*$0*	*$0*
Maintenance and Equipment Expenses			
Fuel and Oil	$3,580	$54.59	$0.34
Machinery Repairs	$7,426	$113.25	$0.71
Subtotal	*$11,006*	*$167.84*	*$1.06*

	Total	Per Cow	Per Cwt
Deduction Expenses			
Milk Marketing	$1,446	$22.05	$0.14
Hauling and Trucking	$6,404	$97.66	$0.62
Subtotal	*$7,850*	*$119.70*	*$0.75*
Interest (5.4% on 1/2 of total operating expense)	$3,314	$50.54	$0.32
Total Operating Expenses	**$126,056**	**$1,922.26**	**$12.11**
Annual Overhead Expenses			
Property Tax	$7,869	$120.00	$0.76
Farm Insurance	$6,810	$103.84	$0.65
Dues and Professional Fees	$1,018	$15.52	$0.10
Utilities	$6,362	$97.01	$0.61
Miscellaneous	$14,946	$227.91	$1.44
Total Overhead Expenses	**$37,004**	**$564.29**	**$3.55**
Annual Depreciation and Interest Expenses			
Land	$8,081	$123.23	$0.78
Buildings	$25,738	$392.48	$2.47
Machinery and Equipment	$7,658	$116.78	$0.74
Subtotal	*$41,477*	*$632.49*	*$3.98*
Livestock Herd Expenses			
Cows (Milking and Dry)	$10,444	$159.26	$1.00
Heifers	$4,407	$67.21	$0.42
Calves	$1,658	$25.28	$0.16
Dairy Bulls	$75	$1.15	$0.01
Subtotal	*$16,584*	*$252.90*	*$1.59*
Total Ownership Expenses	**$58,061**	**$885.39**	**$5.58**
Total Annual Cost	**$221,122**	**$3,371.94**	**$21.24**
Net Farm Income (NFI)	**-$50,454**	**-$769.39**	**-$4.85**
Return over Variable Cost (ROVC)	**$7,607**	**$116.01**	**$0.73**
Performance Measures			
Breakeven Revenue		$/cow	$/cwt
Long-run to Cover All Costs		$3,176.91	$20.01
Short-run to Cover Operating Costs		$2,291.51	$14.43

[a]Numbers may not sum due to rounding.

APPENDIX B-2—MEDIUM-LARGE DAIRY WHOLE-FARM BUDGETS

Conventional Medium-Large[a]

	Total	Per Cow	Per Cwt
Number of Cows	200	-	-
Annual Milk Shipment (cwt)	41,916	210	-
Annual Revenue			
Milk Receipts	$635,516	$3,177.58	$15.16
Crop and Hay Revenue	$0	$0	$0
Livestock Revenue	$17,875	$89.38	$0.43
"Other" Revenue	$0	$0	$0
Total Revenue	**$653,391**	**$3,266.95**	**$15.59**
Annual Operating Expenses			
Labor Expenses			
Family	$0	$0	$0
Hired	$31,616	$158.08	$0.75
Subtotal	*$31,616*	*$158.08*	*$0.75*
Purchased Feed Expenses			
Dairy Forage	$0	$0	$0
Dairy Concentrate	$182,400	$912.00	$4.35
Subtotal	*$182,400*	*$912.00*	*$4.35*
Livestock Expenses			
Breeding Fees	$9,527	$47.64	$0.23
Veterinary and Medicine	$15,319	$76.60	$0.37
Bedding	$5,704	$28.52	$0.14
DHIA Expenses	$2,934	$14.67	$0.07
Livestock Insurance	$4,841	$24.21	$0.12
Subtotal	*$38,325*	*$191.63*	*$0.91*
Crop and Pasture Expenses			
Seeds	$10,560	$52.80	$0.25
Chemicals	$7,805	$38.02	$0.19
Fertilizer	$10,840	$54.20	$0.26
Lime	$5,882	$29.41	$0.14
Other	$15,312	$76.56	$0.37
Subtotal	*$50,398*	*$251.99*	*$1.20*
Maintenance and Equipment Expenses			
Fuel and Oil	$22,823	$114.11	$0.54
Machinery Repairs	$32,000	$160.00	$0.76
Subtotal	*$54,823*	*$274.11*	*$1.31*

	Total	Per Cow	Per Cwt
Deduction Expenses			
Milk Marketing	$4,192	$20.96	$0.10
Hauling and Trucking	$20,958	$104.79	$0.50
Subtotal	*$25,150*	*$125.75*	*$0.60*
Interest (5.4% on 1/2 of total operating expense)	$10,333	$51.67	$0.25
Total Operating Expenses	**$393,044**	**$1,965.22**	**$9.38**
Annual Overhead Expenses			
Property Tax	$18,751	$93.75	$0.45
Farm Insurance	$18,022	$90.11	$0.43
Dues and Professional Fees	$4,200	$21.00	$0.10
Utilities	$15,000	$75.00	$0.36
Miscellaneous	$38,519	$192.59	$0.92
Total Overhead Expenses	**$94,492**	**$472.46**	**$2.25**
Annual Depreciation and Interest Expenses			
Land	$17,274	$86.37	$0.41
Buildings	$61,646	$308.23	$1.47
Machinery and Equipment	$36,306	$181.53	$0.87
Subtotal	*$115,227*	*$576.13*	*$2.75*
Livestock Herd Expenses			
Cows (Milking and Dry)	$37,301	$186.51	$0.89
Heifers	$15,144	$75.72	$0.36
Calves	$2,761	$13.80	$0.07
Dairy Bulls	$159	$0.79	$0.004
Subtotal	*$55,364*	*$276.82*	*$1.32*
Total Ownership Expenses	**$170,591**	**$852.96**	**$4.07**
Total Annual Cost	**$658,128**	**$3,290.64**	**$15.70**
Net Farm Income (NFI)	**-$4,737**	**-$23.68**	**-$0.11**
Return over Variable Cost (ROVC)	**$165,854**	**$829.27**	**$3.96**
Performance Measures			
Breakeven Revenue		$/cow	$/cwt
Long-run to Cover All Costs		$3,201.26	$15.27
Short-run to Cover Operating Costs		$2,348.31	$11.20

[a]Numbers may not sum due to rounding.

Long-Term Coupled Medium-Large[a]
Land-Coupled

	Total	Per Cow	Per Cwt
Number of Cows	200	-	-
Annual Milk Shipment (cwt)	41,916	210	-
Annual Revenue			
Milk Receipts	$635,516	$3,177.58	$15.16
Crop and Hay Revenue	$0	$0	$0
Livestock Revenue	$17,875	$89.38	$0.43
"Other" Revenue	$0	$0	$0
Total Revenue	**$653,391**	**$3,266.95**	**$15.59**
Annual Operating Expenses			
Labor Expenses			
Family	$0	$0	$0
Hired	$31,616	$158.08	$0.75
Subtotal	*$31,616*	*$158.08*	*$0.75*
Purchased Feed Expenses			
Dairy Forage	$0	$0	$0
Dairy Concentrate	$182,400	$912.00	$4.35
Subtotal	*$182,400*	*$912.00*	*$4.35*
Livestock Expenses			
Breeding Fees	$9,527	$47.64	$0.23
Veterinary and Medicine	$15,319	$76.60	$0.37
Bedding	$5,704	$28.52	$0.14
DHIA Expenses	$2,934	$14.67	$0.07
Livestock Insurance	$4,841	$24.21	$0.12
Subtotal	*$38,325*	*$191.63*	*$0.91*
Crop and Pasture Expenses			
Seeds	$10,560	$52.80	$0.25
Chemicals	$7,805	$39.02	$0.19
Fertilizer	$9,920	$49.60	$0.24
Lime	$5,882	$29.41	$0.14
Other	$15,312	$76.56	$0.37
Subtotal	*$49,478*	*$247.39*	*$1.18*
Maintenance and Equipment Expenses			
Fuel and Oil	$22,823	$114.11	$0.54
Machinery Repairs	$32,000	$160.00	$0.76
Subtotal	*$54,823*	*$274.11*	*$1.31*

	Total	Per Cow	Per Cwt
Deduction Expenses			
Milk Marketing	$4,192	$20.96	$0.10
Hauling and Trucking	$20,958	$104.79	$0.50
Subtotal	*$25,150*	*$125.75*	*$0.60*
Interest (5.4% on 1/2 of total operating expense)	$10,308	$51.54	$0.25
Total Operating Expenses	**$392,100**	**$1,960.50**	**$9.35**
Annual Overhead Expenses			
Property Tax	$18,751	$93.75	$0.45
Farm Insurance	$18,022	$90.11	$0.43
Dues and Professional Fees	$4,200	$21.00	$0.10
Utilities	$15,000	$75.00	$0.36
Miscellaneous	$38,519	$192.59	$0.92
Total Overhead Expenses	**$94,492**	**$472.46**	**$2.25**
Annual Depreciation and Interest Expenses			
Land	$17,274	$86.37	$0.41
Buildings	$61,646	$308.23	$1.47
Machinery and Equipment	$36,306	$181.53	$0.87
Subtotal	*$115,227*	*$576.13*	*$2.75*
Livestock Herd Expenses			
Cows (Milking and Dry)	$37,301	$186.51	$0.89
Heifers	$15,144	$75.72	$0.36
Calves	$2,761	$13.80	$0.07
Dairy Bulls	$159	$0.79	$0.004
Subtotal	*$55,364*	*$276.82*	*$1.32*
Total Ownership Expenses	**$170,591**	**$852.96**	**$4.07**
Total Annual Cost	**$657,183**	**$3,285.91**	**$15.68**
Net Farm Income (NFI)	**-$3,792**	**-$18.96**	**-$0.09**
Return over Variable Cost (ROVC)	**$166,799**	**$834.00**	**$3.98**
Performance Measures			
Breakeven Revenue		$/cow	$/cwt
Long-run to Cover All Costs		$3,196.54	$15.25
Short-run to Cover Operating Costs		$2,343.58	$11.18

[a]Numbers may not sum due to rounding.

Long-Term Coupled Medium-Large[a]
Land/Feed-Coupled

	Total	Per Cow	Per Cwt
Number of Cows	200	-	-
Annual Milk Shipment (cwt)	41,916	210	-
Annual Revenue			
Milk Receipts	$635,516	$3,177.58	$15.16
Crop and Hay Revenue	$0	$0	$0
Livestock Revenue	$17,875	$89.38	$0.43
"Other" Revenue	$0	$0	$0
Total Revenue	**$653,391**	**$3,266.95**	**$15.59**
Annual Operating Expenses			
Labor Expenses			
Family	$0	$0	$0
Hired	$8,524	$42.62	$0.20
Subtotal	*$8,524*	*$42.62*	*$0.20*
Purchased Feed Expenses			
Dairy Forage	$159,060	$795.30	$3.79
Dairy Concentrate	$182,400	$912.00	$4.35
Subtotal	*$341,460*	*$1,707.30*	*$8.15*
Livestock Expenses			
Breeding Fees	$9,527	$47.64	$0.23
Veterinary and Medicine	$15,319	$76.60	$0.37
Bedding	$5,704	$28.52	$0.14
DHIA Expenses	$2,934	$14.67	$0.07
Livestock Insurance	$4,841	$24.21	$0.12
Subtotal	*$38,325*	*$191.63*	*$0.91*
Crop and Pasture Expenses			
Seeds	$0	$0	$0
Chemicals	$0	$0	$0
Fertilizer	$0	$0	$0
Lime	$0	$0	$0
Other	$0	$0	$0
Subtotal	*$0*	*$0*	*$0*
Maintenance and Equipment Expenses			
Fuel and Oil	$14,825	$74.13	$0.35
Machinery Repairs	$22,859	$114.30	$0.55
Subtotal	*$37,685*	*$188.42*	*$0.90*

	Total	Per Cow	Per Cwt
Deduction Expenses			
Milk Marketing	$4,192	$20.96	$0.10
Hauling and Trucking	$20,958	$104.79	$0.50
Subtotal	*$25,150*	*$125.75*	*$0.60*
Interest (5.4% on 1/2 of total operating expense)	$12,181	$60.90	$0.29
Total Operating Expenses	**$463,325**	**$2,316.62**	**$11.05**
Annual Overhead Expenses			
Property Tax	$18,751	$93.75	$0.45
Farm Insurance	$16,102	$80.51	$0.38
Dues and Professional Fees	$4,200	$21.00	$0.10
Utilities	$15,000	$75.00	$0.36
Miscellaneous	$38,519	$192.59	$0.92
Total Overhead Expenses	**$92,572**	**$462.86**	**$2.21**
Annual Depreciation and Interest Expenses			
Land	$17,274	$86.37	$0.41
Buildings	$61,646	$308.23	$1.47
Machinery and Equipment	$19,650	$98.25	$0.47
Subtotal	*$98,570*	*$492.85*	*$2.35*
Livestock Herd Expenses			
Cows (Milking and Dry)	$37,301	$186.51	$0.89
Heifers	$15,144	$75.72	$0.36
Calves	$2,761	$13.80	$0.07
Dairy Bulls	$159	$0.79	$0.004
Subtotal	*$55,364*	*$276.82*	*$1.32*
Total Ownership Expenses	**$153,934**	**$769.67**	**$3.67**
Total Annual Cost	**$709,831**	**$3,549.16**	**$16.93**
Net Farm Income (NFI)	**-$56,440**	**-$282.20**	**-$1.35**
Return over Variable Cost (ROVC)	**$97,494**	**$487.47**	**$2.33**
Performance Measures			
Breakeven Revenue		$/cow	$/cwt
Long-run to Cover All Costs		$3,459.78	$16.51
Short-run to Cover Operating Costs		$2,690.11	$12.84

[a]Numbers may not sum due to rounding.

APPENDIX C-1—ADDITIONAL POTATO CROP ENTERPRISE BUDGETS

Conventional Small Grain Corn[a]

	Total	Per Acre	Per Bu
Number of Acres	160	-	-
Grain Corn Yield (bu)	16,000	100	-
Price ($/bu)	$2.50	-	-
Annual Revenue	**$40,000**	**$250.00**	**$2.50**
Annual Operating Expenses			
Seed	$4,290	$26.81	$0.27
Fertilizer	$10,464	$65.40	$0.65
Lime	$1,941	$12.13	$0.12
Chemicals	$3,902	$24.39	$0.24
Labor	$5,887	$36.80	$0.37
Diesel Fuel and Oil	$2,068	$12.92	$0.13
Maintenance and Upkeep	$3,785	$23.65	$0.24
Supplies	$1,600	$10.00	$0.10
Insurance	$53	$0.33	$0.003
Miscellaneous			
Utilities	$320	$2.00	$0.02
Rent or Lease	$2,000	$12.50	$0.13
Drying	$3,091	$19.32	$0.19
Interest	$1,088	$6.80	$0.07
Total Operating Expenses	**$40,489**	**$253.06**	**$2.53**
Annual Ownership Expenses			
Depreciation and Interest	$24,281	$151.76	$1.52
Tax and Insurance	$1,772	$11.08	$0.11
Total Ownership Expenses	**$26,054**	**$162.83**	**$1.63**
Total Annual Cost	**$66,543**	**$415.89**	**$4.16**
Net Farm Income (NFI)	**-$26,543**	**-$165.89**	**-$1.66**
Return over Variable Cost (ROVC)	**-$489**	**-$3.06**	**-$0.03**
Performance Measures			
Breakeven Revenue		$/acre	$/bu
Long-run to Cover All Costs		$415.89	$4.16
Short-run to Cover Operating Costs		$253.06	$2.53

[a]Numbers may not sum due to rounding.

Conventional Medium-Large Grain Corn[a]

	Total	Per Acre	Per Bu
Number of Acres	320	-	-
Grain Corn Yield (bu)	32,000	100	-
Price ($/bu)	$2.50	-	-
Annual Revenue	**$80,000**	**$250.00**	**$2.50**
Annual Operating Expenses			
Seed	$8,580	$26.81	$0.27
Fertilizer	$20,928	$65.40	$0.65
Lime	$3,882	$12.13	$0.12
Chemicals	$7,805	$24.39	$0.24
Labor	$11,318	$35.37	$0.35
Diesel Fuel and Oil	$4,136	$12.92	$0.13
Maintenance and Upkeep	$5,169	$16.15	$0.16
Supplies	$3,200	$10.00	$0.10
Insurance	$106	$0.33	$0.003
Miscellaneous			
Utilities	$640	$2.00	$0.02
Rent or Lease	$4,000	$12.50	$0.13
Drying	$6,182	$19.32	$0.19
Interest	$2,097	$6.55	$0.07
Total Operating Expenses	**$78,044**	**$243.89**	**$2.44**
Annual Ownership Expenses			
Depreciation and Interest	$33,783	$105.57	$1.06
Tax and Insurance	$2,575	$8.05	$0.08
Total Ownership Expenses	**$36,358**	**$113.62**	**$1.14**
Total Annual Cost	**$114,401**	**$357.50**	**$3.58**
Net Farm Income (NFI)	**-$34,401**	**-$107.50**	**-$1.08**
Return over Variable Cost (ROVC)	**$1,956**	**$6.11**	**$0.06**
Performance Measures			
Breakeven Revenue		$/acre	$/bu
Long-run to Cover All Costs		$357.50	$3.58
Short-run to Cover Operating Costs		$243.89	$2.44

[a]Numbers may not sum due to rounding.

APPENDIX C-2—ADDITIONAL DAIRY CROP ENTERPRISE BUDGETS

Conventional and Coupled Small Dry Hay[a]

	Total	Per Acre	Per Ton
Number of Acres	73	-	-
Hay Yield (tons)	256	3.5	-
Price ($/ton)	$64.50	-	-
Annual Revenue	**$16,480**	**$225.75**	**$64.50**
Annual Operating Expenses			
Seed[b]	$0	$0	$0
Fertilizer	$840	$11.50	$3.29
Lime	$730	$10.00	$2.86
Chemicals	$0	$0	$0
Labor	$3,528	$48.32	$13.81
Diesel Fuel and Oil	$764	$10.46	$2.99
Maintenance and Upkeep	$1,942	$26.60	$7.60
Supplies	$730	$10.00	$2.86
Insurance	$24	$0.33	$0.09
Miscellaneous			
Rent or Lease	$913	$12.50	$3.57
Storage and Warehousing	$73	$1.00	$0.29
Other Expenses	$365	$5.00	$1.43
Interest	$230	$3.15	$0.90
Total Operating Expenses	**$10,138**	**$138.88**	**$39.68**
Annual Ownership Expenses			
Depreciation and Interest	$11,179	$153.14	$43.75
Tax and Insurance	$857	$11.74	$3.35
Total Ownership Expenses	**$12,036**	**$164.88**	**$47.11**
Total Annual Cost	**$22,174**	**$303.75**	**$86.79**
Net Farm Income (NFI)	**-$5,694**	**-$78.00**	**-$22.29**
Return over Variable Cost (ROVC)	**$6,342**	**$86.87**	**$24.82**
Performance Measures			
Breakeven Revenue		$/acre	$/ton
Long-run to Cover All Costs		$303.75	$86.79
Short-run to Cover Operating Costs		$138.88	$39.68

[a]Numbers may not sum due to rounding.
[b]Establishment costs not included for acreage in silage corn the previous year.

Conventional and Coupled Medium-Large Haylage[a]

	Total	Per Acre	Per Ton
Number of Acres	200	-	-
Haylage Yield (tons)	1,200	6	-
Price ($/ton)	$32.55	-	-
Annual Revenue	**$39,060**	**$195.30**	**$32.55**
Annual Operating Expenses			
Seed[b]	$0	$0	$0
Fertilizer	$6,240	$31.20	$5.20
Lime	$2,000	$10.00	$1.67
Chemicals	$0	$0	$0
Labor	$7,725	$38.63	$6.44
Diesel Fuel and Oil	$2,910	$14.55	$2.42
Maintenance and Upkeep	$2,945	$14.72	$2.45
Supplies	$2,000	$10.00	$1.67
Insurance	$66	$0.33	$0.06
Miscellaneous			
Rent or Lease	$2,500	$12.50	$2.08
Storage and Warehousing	$200	$1.00	$0.17
Other Expenses	$1,000	$5.00	$0.83
Interest	$534	$2.67	$0.45
Total Operating Expenses	**$28,120**	**$140.60**	**$23.43**
Annual Ownership Expenses			
Depreciation and Interest	$17,696	$88.48	$14.75
Tax and Insurance	$1,409	$7.04	$1.17
Total Ownership Expenses	**$19,105**	**$95.52**	**$15.92**
Total Annual Cost	**$47,225**	**$236.12**	**$39.35**
Net Farm Income (NFI)	**-$8,165**	**-$40.82**	**-$6.80**
Return over Variable Cost (ROVC)	**$10,940**	**$54.70**	**$9.12**
Performance Measures			
Breakeven Revenue		$/acre	$/ton
Long-run to Cover All Costs		$236.12	$39.35
Short-run to Cover Operating Costs		$140.60	$23.43

[a]Numbers may not sum due to rounding.
[b]Establishment costs not included for acreage in silage corn the previous year.

APPENDIX D-1—SHORT-TERM ECONOMIC AND SUSTAINABILITY INDICATOR RANKINGS[a]

Economic

Profitability						Efficiency			
NFI	Model	ROVC	Model	POR	Model	ATR	Model	OER	Model
$208	LF-CoupPotML	$443	LF-CoupPotML	0.134	LF-CoupPotML	0.507	L-CoupPotML	0.541	ConvPotS
$127	L-CoupPotML	$335	LF-CoupPotS	0.098	L-CoupPotML	0.451	LF-CoupPotML	0.559	LF-CoupPotS
$57	LF-CoupPotS	$334	L-CoupPotML	0.043	LF-CoupPotS	0.416	L-CoupPotS	0.559	ConvPotML
$18	ConvPotML	$262	L-CoupPotS	0.019	ConvPotML	0.373	LF-CoupPotS	0.571	L-CoupPotS
$12	L-CoupPotS	$225	ConvPotML	0.010	L-CoupPotS	0.348	ConvPotML	0.572	LF-CoupPotML
-$51	ConvPotS	$200	ConvPotS	-0.054	ConvPotS	0.306	ConvPotS	0.595	L-CoupPotML
-$9	L-CoupDairyML	$319	L-CoupDairyML	-0.007	L-CoupDairyML	0.346	LF-CoupDairyML	0.235	L-CoupDairyS
-$9	ConvDairyML	$319	ConvDairyML	-0.007	ConvDairyML	0.319	L-CoupDairyML	0.235	ConvDairyS
-$109	LF-CoupDairyML	$187	LF-CoupDairyML	-0.086	LF-CoupDairyML	0.319	ConvDairyML	0.340	L-CoupDairyML
-$245	L-CoupDairyS	$148	L-CoupDairyS	-0.245	L-CoupDairyS	0.235	LF-CoupDairyS	0.340	ConvDairyML
-$245	ConvDairyS	$148	ConvDairyS	-0.245	ConvDairyS	0.210	L-CoupDairyS	0.398	LF-CoupDairyS
-$295	LF-CoupDairyS	$44	LF-CoupDairyS	-0.296	LF-CoupDairyS	0.210	ConvDairyS	0.474	LF-CoupDairyML

Sustainability

FVA	Model	FVAp	Model	NRG	Model	SLF	Model	FB	Model
$464	LF-CoupPotML	0.300	LF-CoupPotML	0.481	LF-CoupPotML	0.261	LF-CoupPotML	-	L-CoupPotS
$341	L-CoupPotML	0.262	L-CoupPotML	0.508	L-CoupPotML	0.222	L-CoupPotML	-	LF-CoupPotS
$304	LF-CoupPotS	0.228	LF-CoupPotS	0.549	LF-CoupPotS	0.187	LF-CoupPotS	-	L-CoupPotML
$225	L-CoupPotS	0.193	L-CoupPotS	0.576	L-CoupPotS	0.150	L-CoupPotS	-	LF-CoupPotML
$179	ConvPotML	0.188	ConvPotML	0.577	ConvPotML	0.145	ConvPotML	-	ConvPotS
$126	ConvPotS	0.132	ConvPotS	0.633	ConvPotS	0.086	ConvPotS	-	ConvPotML
$92	L-CoupDairyML	0.073	L-CoupDairyML	0.316	LF-CoupDairyML	0.041	L-CoupDairyML	-0.224	L-CoupDairyS
$92	ConvDairyML	0.073	ConvDairyML	0.405	L-CoupDairyML	0.041	ConvDairyML	-0.224	ConvDairyS
-$56	LF-CoupDairyML	-0.045	LF-CoupDairyML	0.405	ConvDairyML	-0.073	LF-CoupDairyML	-0.279	L-CoupDairyML
-$131	L-CoupDairyS	-0.132	L-CoupDairyS	0.442	LF-CoupDairyS	-0.182	L-CoupDairyS	-0.279	ConvDairyML
-$131	ConvDairyS	-0.132	ConvDairyS	0.574	L-CoupDairyS	-0.182	ConvDairyS	-0.512	LF-CoupDairyS
-$240	LF-CoupDairyS	-0.240	LF-CoupDairyS	0.574	ConvDairyS	-0.286	LF-CoupDairyS	-0.523	LF-CoupDairyML

[a]NFI, ROVC, and FVA are in $/acre. Acreage in denominator includes just owned acres and not operated acres. For dairy farms, crop acreage includes just silage corn and hay/haylage, not pasture.

APPENDIX D-2—LONG-TERM ECONOMIC AND SUSTAINABILITY INDICATOR RANKINGS[a]

Economic

Profitability						Efficiency			
NFI	Model	ROVC	Model	POR	Model	ATR	Model	OER	Model
$285	LF-CoupPotML	$520	LF-CoupPotML	0.184	LF-CoupPotML	0.507	L-CoupPotML	0.509	LF-CoupPotS
$203	L-CoupPotML	$409	L-CoupPotML	0.156	L-CoupPotML	0.451	LF-CoupPotML	0.516	L-CoupPotS
$124	LF-CoupPotS	$402	LF-CoupPotS	0.093	LF-CoupPotS	0.416	L-CoupPotS	0.522	LF-CoupPotML
$76	L-CoupPotS	$327	L-CoupPotS	0.065	L-CoupPotS	0.373	LF-CoupPotS	0.536	L-CoupPotML
$18	ConvPotML	$225	ConvPotML	0.019	ConvPotML	0.348	ConvPotML	0.541	ConvPotS
-$51	ConvPotS	$200	ConvPotS	-0.054	ConvPotS	0.306	ConvPotS	0.559	ConvPotML
-$7	L-CoupDairyML	$321	L-CoupDairyML	-0.006	L-CoupDairyML	0.346	LF-CoupDairyML	0.234	L-CoupDairyS
-$9	ConvDairyML	$319	ConvDairyML	-0.007	ConvDairyML	0.319	L-CoupDairyML	0.235	ConvDairyS
-$109	LF-CoupDairyML	$187	LF-CoupDairyML	-0.086	LF-CoupDairyML	0.319	ConvDairyML	0.339	L-CoupDairyML
-$243	L-CoupDairyS	$150	L-CoupDairyS	-0.244	L-CoupDairyS	0.235	LF-CoupDairyS	0.340	ConvDairyML
-$245	ConvDairyS	$148	ConvDairyS	-0.245	ConvDairyS	0.210	L-CoupDairyS	0.398	LF-CoupDairyS
-$295	LF-CoupDairyS	$44	LF-CoupDairyS	-0.296	LF-CoupDairyS	0.210	ConvDairyS	0.474	LF-CoupDairyML

Sustainability

FVA	Model	FVAp	Model	NRG	Model	SLF	Model	FB	Model
$541	LF-CoupPotML	0.349	LF-CoupPotML	0.433	LF-CoupPotML	0.311	LF-CoupPotML	-	L-CoupPotS
$417	L-CoupPotML	0.321	L-CoupPotML	0.451	L-CoupPotML	0.280	L-CoupPotML	-	LF-CoupPotS
$370	LF-CoupPotS	0.278	LF-CoupPotS	0.501	LF-CoupPotS	0.237	LF-CoupPotS	-	L-CoupPotML
$289	L-CoupPotS	0.248	L-CoupPotS	0.521	L-CoupPotS	0.205	L-CoupPotS	-	LF-CoupPotML
$179	ConvPotML	0.188	ConvPotML	0.577	ConvPotML	0.145	ConvPotML	-	ConvPotS
$126	ConvPotS	0.132	ConvPotS	0.633	ConvPotS	0.086	ConvPotS	-	ConvPotML
$94	L-CoupDairyML	0.075	L-CoupDairyML	0.316	LF-CoupDairyML	0.043	L-CoupDairyML	-0.224	L-CoupDairyS
$92	ConvDairyML	0.073	ConvDairyML	0.404	L-CoupDairyML	0.041	ConvDairyML	-0.224	ConvDairyS
-$56	LF-CoupDairyML	-0.045	LF-CoupDairyML	0.405	ConvDairyML	-0.073	LF-CoupDairyML	-0.279	L-CoupDairyML
-$130	L-CoupDairyS	-0.130	L-CoupDairyS	0.442	LF-CoupDairyS	-0.180	L-CoupDairyS	-0.279	ConvDairyML
-$131	ConvDairyS	-0.132	ConvDairyS	0.572	L-CoupDairyS	-0.182	ConvDairyS	-0.512	LF-CoupDairyS
-$240	LF-CoupDairyS	-0.240	LF-CoupDairyS	0.574	ConvDairyS	-0.286	LF-CoupDairyS	-0.523	LF-CoupDairyML

[a]NFI, ROVC, and FVA are in $/acre. Acreage in denominator includes just owned crop acres and not operated crop acres. For dairy farms, crop acreage includes just silage corn and hay/haylage, not pasture.

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