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Factors Influencing and Steps Leading to the Adoption of Best Management Practices by Louisiana Dairy Farmers

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A logistic regression procedure was used to assess the impact of socioeconomic attributes on the best management practices (BMPs) adoption decision by Louisiana dairy farmers relative to cost-share and fixed incentive payments. Analysis of the steps in the BMP adoption decision process indicated visits between producers and the U.S. Department of Agriculture–Natural Resource Conservation Service significantly increase likelihood of BMP adoption. Producer willingness-to-pay results indicate that marginal increases in dairy BMP adoption and associated improvement in environmental quality require increased technical and financial assistance.

Key Words: best management practices, bootstrap, cost-share, manure, steps in BMP adoption

JEL Classifications: Q16, Q25, Q53

Best management practices (BMPs) are voluntary practices producers adopt or structures they build to manage resources and mitigate environmental pollution from agriculture. In the United States the U.S. Department of Agriculture (USDA)–Natural Resource Conservation Service (NRCS) provides technical and financial assistance to producers interested in implementing certain BMPs (practices or structures) through the Environmental Quality Incentive Program (EQIP). Financial assistance (either cost-sharing construction of structural BMPs or limited annual incentive payments) is provided to qualifying farmers willing to incorporate selected BMPs into their farming operations. Despite the federal government's willingness to underwrite a portion of the cost of implementation, BMP adoption rates for other than waste treatment lagoons and waste storage facilities appear to be low in the dairy sector in Louisiana. For example, 75% of dairy farmers in the region have adopted 5 or fewer of the 18 best management practices recommended for dairy producers, whereas 20% have adopted none of these recommended practices. Inadequate management of dairy manure has been identified as the suspected source of the total fecal coliform that impaired 66 miles of the Tangipahoa River and its tributaries in Louisiana (Louisiana Department of Environmental Quality, pp. 16–17). Further, the Lake Pontchartrain

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basin, which is of great economic and ecological significance in the region, is estimated to be the recipient of about 40% of the nitrogen and 70% of the phosphorus excreted by the dairy cows raised in adjacent parishes. Volatized nitrogen in the amount of 5.79 million pounds per year from dairy waste is estimated to enter Lake Pontchartrain threatening the ecological integrity of the basin (Burkart and James). Significant abatement of nutrient loads from agricultural sources through adoption of BMPs has a potential to improve water quality over the entire basin (Boesch, Brinsfield, and Magnien). Reasons cited by farmers for deciding not to adopt BMPs include ignorance of a specific BMP or of its environmental benefits, reductions in production and profit, inadequate cost-share by the government, and incentive payments that are insufficient to recover lost profits when BMPs are implemented (DeVuyst and Ipe; Kim, Gillespie, and Paudel).

Over time, dairy farming in Louisiana has trended downward both in numbers of dairy farms and in total volumes of milk produced (Rahelizatovo and Gillespie 1999). Primary reasons for the decline include the technologically driven intensity of competition from other regions and the costs of compliance with environmental regulations. Additionally, in the humid South, unique factors adversely affecting production and profits include the difficulty of cooling cows and maintaining quality forage throughout the summers. As a consequence, the Louisiana dairy industry is no longer the hub of economic activity that it once was in areas of the state still largely dependent on agriculture. To maintain that economic activity, Louisiana farmers need to address environmental concerns while maintaining or increasing the profitability of their dairy farms. One way to achieve this is by increasing total milk production at both farm and industry levels so that more milk per cow and more cows per farm occur. This situation potentially creates negative externalities because it increases both the volumes and concentrations of dairy manure within the milkshed and the watershed.

Dairy manure can be both point and nonpoint sources of water pollution. It can adversely affect water quality and potentially harm human health by increasing total fecal coliform in water bodies downstream of dairy farms or on farms applying dairy manure to fields. Manure also can harm the environment when its primary nutrients, nitrogen and phosphorus, concentrate in the soil or subsequently run off or leach into surface and ground waters. Farmers can mitigate the negative externalities associated with manure by implementing BMPs for handling and storing it in more environmentally sensitive ways. Similar to other producers, Louisiana dairy farmers view BMPs as publicly desirable goods, but too costly to implement and maintain privately. This perception results in low adoption rates despite evidence that implementation of many BMPs should theoretically boost profitability (Cooper and Keim).

Some Louisiana dairy farmers have adopted BMPs to better handle and store dairy manure, primarily as a consequence of cost-share and incentive payment programs through EQIP. In addition to the USDA-NRCS EQIP program, the state uses funds from the Lake Pontchartrain Foundation to cost-share expenses for dairy farmers to clean out waste lagoons in the parishes on the northern side of Lake Pontchartrain. These are the same parishes through which the Tangipahoa River flows into Lake Pontchartrain—the only water body in the state with dairies listed as the suspected source of impairment. Although no studies have been conducted to estimate the value residents place on the restoring these water bodies to designated uses (swimmable, boatable, and fishable), historic and anecdotal evidence indicates significant recreational activity occurred on these water bodies prior to impairment.

If dairy farmers adopt waste management BMPs, these practices may help mitigate water quality concerns in the region. Effective policies to reduce water quality can be designed once we identify factors affecting and steps leading to adoption of these BMPs. Further, understanding the real and stated cost-shares farmers need as well as the factors associated with BMP adoption will help to determine an optimal suite of BMPs at a minimal cost to farmers.

The objectives of the study were the following:

(1) Compare hypothetical incentive payments and cost-share percentages, using EQIP benchmark costs, against actual BMP establishment costs and cost-share percentages for producers adopting BMPs against required cost-share percentages for nonadopters to become adopters
(2) Relate sets of variables describing Louisiana dairies and dairy farmers to BMP adoption in terms of BMP costs, EQIP cost-shares as percentages of actual BMP costs to producers, and incentive payments required to entice nonadopters to adopt specific BMPs
(3) Assess selected socioeconomic characteristics of Louisiana dairy farmers that may increase the likelihood of BMP adoption
(4) Identify how sources of information might influence the BMP adoption decision and
(5) Identify crucial steps in the BMP adoption/nonadoption decision-making process.

Conceptual Framework

Many researchers have studied BMP adoption in Louisiana (Henning and Cardona; Rahelizatovo and Gillespie 2004) as well as other areas of the country (Cooper 2003; DeVuyst and Ipe; Dorfman; Houston and Sun; Khanna; Ribaudo and Agapoff; Taylor, Adams, and Miller; Valentin, Bernardo, and Kastens; Wu and Babcock). The primary objective of most studies was to identify variables associated with an increased probability of farmers adopting BMPs. Most of these studies were not concerned necessarily with determining the profitability or lack of it for particular BMPs. Valentin, Bernardo, and Kastens determined that nutrient management BMPs was profitable while herbicide application BMPs were not in wheat and corn systems. On the other hand, Ipe et al. reported that most BMPs were profitable and cost reducing. Gillespie, Kim, and Paudel indicated farmers' perception about the lack of profitability of BMPs was a primary reason for nonadoption. McSweeny and Shortle point out that broad-based BMP adoption may not be cost effective for most farmers. Amacher and Feather emphasized that bundling BMPs essentially created economies of scope and helped reduce cost of adopting BMPs. Thus, Amacher and Feather suggested that policies should emphasize bundling similar BMPs, educate farmers about bundling BMPs, and provide farmers financial support to adopt these practices so that the farming operation remains profitable in the long run. In contrast, our research identifies variables important to the BMP adoption decision by dairy farmers for a given set of practices within the current suite of programs available. Furthermore, our research identifies factors important to the adoption process at various stages or steps farmers encounter when adopting BMPs. This is significant because many dairy farmers may not be adopting BMPs as the process of receiving financial assistance from USDA may be too lengthy and cumbersome.

Possible reasons why Louisiana dairy farmers have not adopted certain BMPs included being unaware of ongoing efforts to regulate nonpoint source (NPS) pollution in water, ignorance of specific BMPs, and high costs of implementing certain BMPs (Rahelizatovo and Gillespie 2004). Although high costs were one reason some dairy farmers did not adopt dairy waste management BMPs, Rahelizatovo and Gillespie (2004) did not evaluate how the perceptions of cost potentially varied between adopters and nonadopters. Additionally, Rahelizatovo and Gillespie (2004) did not study a sequential adoption process in which producers decide to proceed or not at each juncture. Furthermore, they measured the intensity of BMP adoption by dairy producers using a count data method. In contrast, we identify factors influencing the BMP adoption decisions by Louisiana dairy farmers, estimate the cost-share rates for adopters relative to rates nonadopters would require for each BMP, and identify how BMP adoption rates differ at specific steps in the BMP adoption process. This last issue is significant because it helps us understand how institutional factors such as program implementation may impede adoption of BMPs. Such research may shed light on how encouraging and assisting producers to adopt new practices or structures for mitigating environmental pollution from agriculture may entail more than education and funds.

To test the propositions on how selected variables impact the BMP adoption process, we developed a logistic regression model. We hypothesized that the percentage share of actual costs for implementing EQIP practices (BMPs) was lower than the hypothetical cost-share for the same EQIP practice. Furthermore, we hypothesized that for those same EQIP practices, the cost-share percentage required by nonadopters was higher than that of the hypothetical (or maximum) cost-share that the USDA-NRCS covers. Thus, we hypothesized that this difference in expected or required cost-share was a critical factor impeding the adoption of BMPs by Louisiana dairy farmers. Other factors that we hypothesized influence adoption included years of experience farming (positive effect), farm succession plan (positive effect), education (positive effect), financial factors (farm income [positive effect], debt-to-asset ratio [negative effect]), and opportunity cost of the land (negative effect) (development options for the farm). Last, we hypothesized that steps in the EQIP application process with the USDA-NRCS may critically affect the likelihood of BMPs adoption.

Survey

The survey was constructed and conducted using the tailored design method (Dillman). The survey instrument was designed, pretested by a focus group of dairy farmers and county agents from the three parishes constitutive of Louisiana's principal milkshed, and thoroughly revised using comments from the focus group. The 12-page survey instrument had four distinct sections: dairy manure disposal practices, milk reduction programs, dairy best management practice adoption, and socioeconomic characteristics of the principal operator.

The survey was mailed to all 325 Louisiana dairy farmers registered with the Louisiana Board of Health as a Class "A" dairy. All producers were given the option of completing the survey online, though none did so. Two weeks after the initial mailing, we mailed a postcard reminder to all nonrespondents. We mailed a second survey and return envelope to all remaining nonresponding dairy farmers three weeks after the first contact. To further encourage participation, we offered payments of $10 per survey for the first 50 fully completed surveys along with an opportunity to participate in a $250 cash prize from a lottery drawing. The availability of funds limited the size and number of payments offered to dairy farmers.

In an attempt to increase response rate, we employed a graduate student to contact dairy farmers by phone requesting that they complete the survey. Despite the combination of payments, free lottery prize entry, follow-up post card requests and phone calls, only 49 usable surveys were obtained for a 15% response rate. Although our survey response rate was lower than expected, the set of descriptive statistics of variables identified in this survey were similar to the one done by Rahelizatovo and Gillespie (2004) and overall characteristics of dairy farmers in these three Louisiana parishes. This suggests that responding farmers represent the dairy farming population in Louisiana and their responses are characteristics of that population.

One possible explanation for the low response rate includes a lack of time to complete the survey—an acute problem for all dairy farmers. The length of the survey instrument was probably excessive for some producers. Farmers receive numerous surveys from various sources throughout the year. Farmers had received a BMP adoption survey from Louisiana State University three years before our survey; this may have diminished the response rate. The sensitive nature of this topic (waste management and environmental concerns) to Louisiana dairy farmers could have also contributed to the relatively low response rate. The relatively high rate of Louisiana dairy farmer exits (Rahelizatovo and Gillespie 1999) reduces the likelihood that producers would complete the survey. Compared to their opportunity costs or the value of information, $10 may have been too small a sum to offer for survey completion.

One section of the survey queried farmers about the adoption of BMPs in terms of cost-shares and EQIP incentive payments, sources of information most important in making the BMP adoption/nonadoption decision, and the role of the USDA-NRCS in that decision. In Appendix 18, BMPs recommended by the USDA-NRCS as most appropriate for Louisiana dairy farms are identified and separated according to whether specific EQIP practices or BMPs were eligible for cost-share reimbursement or for an incentive payment. The common format used to elicit responses from producers for each EQIP practice or BMP is presented in the appendix. Each BMP was described in the survey, referenced to its USDA-NRCS practice code, and assigned an estimated cost based on Louisiana benchmark data provided by the USDA-NRCS. The BMP reference cost was an average cost based on each specific EQIP practice (BMP) in Louisiana between 1997 and 2001. This BMP cost was the reference value on which the producer decided to adopt or not to adopt the practice. If not, the question becomes how much more than the reference value would be required to adopt the practice or build the structure. Respondents were asked to report their actual total cost of implementing each BMP. They were also asked to calculate the actual share of the BMP implementation cost reimbursed by the USDA-NRCS for each practice. This provided an estimate of the producer's actual cost share for each BMP.

Producers were asked to identify which of the following reasons best describe the decision not to adopt a specific BMP: expected to retire from dairy farming, BMP was not cost effective regardless of cost-share, and decided not to adopt BMP after discussions with employees of the USDA-NRCS. Producers were asked to rank 11 sources of information about BMPs according to how well a specific source helped improve their understanding of that BMP. Producers were also asked about their interactions with USDA-NRCS personnel, the EQIP application experience, and their views on environmental laws and programs.

Socioeconomic information collected about the principal operator of the dairy farm included length of tenure as the principal farmer, age, educational level, marital status, off-farm employment (either spouse), outside income, and the financial condition of the dairy operation.

Methods

Consider a scenario where a dairy farmer would either adopt ($BMP = 1$) or not adopt ($BMP = 0$) a particular EQIP practice or BMP. The adoption literature suggests that the adoption decision is influenced by factors such as experience (years farming), age, education, gender, income from farming or farm size (herd size), and the debt-to-asset ratio—all indicated by X. Then the adoption decision generally can be modeled as

$$\Pr(BMP=1)=F(X\beta),$$
$$\Pr(BMP=0)=1-F(X\beta).$$

Given those probability functions, the logistic distribution function expressing the probability that a particular BMP would be adopted is

$$\Pr(BMP=1)=\frac{e^{\beta' X}}{1+e^{\beta' X}}=\angle\left(\beta' X\right). \quad (1)$$

Here $\angle(.)$ indicates a logistic cumulative distribution function. With the logistic regression, the probability of the logit transformation of the ith observation's event, $\Pr_i$, is modeled as a linear function of the explanatory variables in the vector X_i. For example, take a case of only one explanatory variable, "education," in explaining a BMP adoption. Suppose that the probability of adopting a BMP by a farmer with at least a high school education is $p = 0.7$, then the probability of adoption by a farmer with less than a high school education would be $1 - p = 0.3$. The odds of adopting this BMP by a farmer with at least a high school education would be $p/(1 - p)$ ($0.7/0.3 = 2.33333$), whereas for the less educated farmer, the odds of adopting would be $(1 - p)/p$ (0.3/0.7 = 0.42857). We can compute the odds ratio for BMP adoption as $[p/(1 - p)]^2$. Therefore, in this example for a farmer with a high school education or greater, the odds of adopting a BMP would be 5.44 times larger than the odds for a farmer without a high school diploma adopting the BMP. The method to calculate odds ratio and probability changes if we have more than one explanatory variable in the model. In such a case one wants to use a conditional odds ratio with the effect of all other explanatory variables kept to a certain value. In general, there are 2^{k-j} conditional probabilities, so one has to be careful in interpreting the odds or, in that sense, a conditional odds ratio (Rudas, p. 47). Here j is the total variables in the model, and $k - j$ is the fixed categories of other variables.

The coefficients obtained from the logit model can be used to derive the odds ratio by exponentializing the power of the logit regression coefficient. Because many of the independent variables are discrete or binary, it is easier to interpret the odds ratio than the marginal effects. Further, the odds ratio is a constant that doesn't change with changing values of other independent variables (Gould and Hardin).

Bootstrap Confidence Interval

The validity of the regression results was tested with a bootstrap approach out of a concern for the relatively small number of observations used in the logistics regression. The bootstrap procedure entails drawing repeated samples from the dataset with replacements. These datasets are called bootstrap samples. While actual sample of data may be nonrandomly drawn from the population, the bootstrap datasets are by definition random samples. Because of the small dataset, the concern is that the estimated coefficients from the logistic regression may not fall within the 95% confidence interval for the bootstrap runs. Additionally, the true population coefficients do not exist. Therefore, Efron's bias-corrected accelerated approach (BCa) was applied to the estimated bootstrap empirical confidence interval to center the confidence interval around the point estimate of the coefficients and adjust it for skewness in the empirical distribution, an interpretation analogous to that derived by t-statistics. Bias-corrected and accelerated confidence intervals improve on their bias-corrected counterparts by allowing the variance to depend on true population coefficients (Poi). Specifically, bias-corrected confidence intervals are predicted on the assumption $\left[\phi\left(\widehat{\beta}\right) - \phi(\beta)\right] \xrightarrow{D} N\left(-z_0\tau_\phi, \tau_\varphi^2\right)$. Here $\tau_\phi = 1 + a\varphi\left(\widehat{\beta}\right)$, z_0 is a bias constant, τ is the constant standard error of $\phi\left(\widehat{\beta}\right)$, and a is known as an acceleration parameter. Efron shows that these confidence intervals have better asymptotic properties than a traditional confidence interval based on a normal approximation.[1]

Justification of Explanatory Variables Used in the Regression Analysis

The absence of a guiding theory is a problem in identifying variables that can sufficiently describe the behavior of an agent deciding whether or not to adopt a BMP. The rationale for including selected variables in the survey instrument serves to justify including them in the model to help explain the BMP adoption decision. The rationale for including a specific explanatory variable in the survey and in the model is explained below.

Number of Years as the Principal Dairy Farm Operator (YEARS). Traditionally, researchers have used age to explain why individuals adopt or do not adopt a practice. The argument is that older farmers are more reluctant to adopt new technology than younger farmers (Soule, Tegene, and Wiebe). An alternative to age is the number of years in the profession (Lin). A relatively new entrant to the profession would be more likely to adopt new technology because of a longer time horizon over which to capture returns on

[1] The authors thank the anonymous reviewer who suggested this technique for deriving the bootstrap confidence intervals.

the investment, a stronger desire to use current tools of the trade, and in order to address regulations or other external forces that may challenge the profitability of the enterprise. In addition, under EQIP a first-time farmer qualifies for a higher cost-share rate for implementing eligible practices (BMPs). Therefore, a dairy farmer with longer tenure will be less likely to adopt BMPs (have a negative effect on a BMP adoption decision). In the adoption model *YEARS* is a continuous variable.

EDUCATION. Education is commonly understood to have a positive impact on the adoption of environmentally benign or beneficial farming practices (Fuglie and Bosch; Rahm and Huffman; Thomas, Ladewig, and McIntosh; Traore, Landry, and Amara). Education renders the individual more open to change and appreciative of the need to adopt. A farmer is considered to have implicitly or explicitly recognized the opportunity cost of dairying. As such, training beyond high school tends to enhance awareness of alternative employment opportunities, creating a higher opportunity cost to dairy. The choice to dairy suggests that the dairy farmer seeks to minimize the opportunity cost of dairying by being as profitable as possible. Thus, the dairy farmer is likely to be more aggressive in pursuing practices to make the dairy profitable including the adoption of BMPs. Education is a binary explanatory variable where 0 indicates a farmer with high school or less education and 1 otherwise.

Family Will Continue Dairy (CONTINUE). A farmer with a successor in the family who plans to continue the dairy operation is more likely to adopt BMPs than a farmer without a successor (Kim, Gillespie, and Paudel). *CONTINUE* is a binary variable with 1 indicating a successor and 0 otherwise.

Net Farm Income from Dairying (NETINCOME). A dairy farmer with a positive net cash flow is more likely to adopt a BMP because of the cost-share requirement. Kim, Gillespie, and Paudel have indicated that a profitable operation may provide incentives to incorporate BMPs into the dairy farm. Net farm income is treated as a binary explanatory variable where 0 represents respondent reporting negative farm income while a 1 represents positive net returns.

Debt-to-Asset Ratio (DEBTASSET). A high debt-to-asset ratio suggests that the farmer is less likely to adopt BMPs. Feder, Just, and Zilberman stated that financial conditions of the farm significantly affect technology adoption. Therefore farmers in a poor financial situation, as indicated by high debt-to-asset ratio, would be less likely to adopt BMPs. For this binary explanatory variable, a zero indicates a debt-to-asset ratio of 40% or less and a one indicates a debt-to-asset ratio greater than 40%.

Presence of Nearby Subdivision (WORTH). In Louisiana the Right to Farm Act allows farmers to continue doing what they have been doing for many years. However, a nearby subdivision suggests that the dairy farmer may experience higher cost in maintaining environmental standards. Nearby development also suggests that these alternative uses for the land increase its value and increase the opportunity cost to continue dairy farming. The combination of potentially greater environmental compliance costs and increased opportunity costs to dairy farming implies that the presence of a subdivision would negatively influence the BMP adoption decision. Assigning a one to this binary variable indicates that the dairy farm is worth more in nonagricultural than agricultural uses.

Respondent's Environmental Attitudes (ESCALE). Luzar and Diagne showed that respondents' environmental attitudes had a positive role in voluntary environmental program participation in a Louisiana wetland reserve program. A respondent who doesn't care about the environment is less likely to choose to adopt a BMP (Traore, Landry, and Amara). Lower values in the environmental attitude scale suggest a lower likelihood of BMP adoption. Respondents ranked three environmentally related questions using a Likert scale of one to five. We created a continuous variable indicative of a respondent's environmental attitudes by aggregating the values from three questions about water pollution regulations, soil and water conservation programs, and adoption of environmental practices without government subsidies.

Results

BMP Adoption Rates, Costs of Adoption, and Incentive Payment Levels

The BMP is the focal point of our analysis and synthesis. In Table 1 BMPs are listed according to the rank order of BMP adoption. Results in Table 1 suggest that the respondents were only fully responsive to 6 of the 18 BMPs as demonstrated by values for average cost of adoption, average cost-share percentage, and willingness to pay for only a few of the BMPs. The response rate among the 49 survey respondents to the 18 BMPs ranged from 78% to 94%. Of these, the highest response was associated with the waste treatment lagoon BMP, and the lowest response corresponded to the waste storage facility and critical area planting BMPs. Of the seven BMPs with the highest rates of adoption, average cost of adoption rates and cost-share percentages are reported for six.

Adoption rates of BMPs varied considerably among the 49 respondents, ranging from 2.5% for roof runoff management to 67% for waste treatment lagoon. To help interpret our findings, we will illustrate using the waste treatment lagoon BMP. For this particular BMP, the average cost of adopting or constructing this structural BMP by respondents was $12,886, and the average cost-share was 39% of actual construction costs. For nonadopters (33% of dairy farmers who responded to the survey), 28% indicated they would adopt this BMP if their share of constructing a waste treatment lagoon never exceeded 20%. Thus, nonadopters require a minimum cost-share of 80% to adopt this BMP, whereas adopters of this BMP were only provided with a 39% cost share.

The waste treatment lagoon BMP had the highest percentage of adoption among the 18 BMPs, 67%. Waste storage facility was the second highest ranked BMP in terms of adoption rate (37%), and it featured a cost-share under EQIP. The average cost for producers to build a waste storage facility was $11,800 with a cost-share rate of 33% (percentage of total costs reimbursed by the USDA-NRCS). Of the nonadopters, 30% indicated they would be willing to adopt this BMP. However, they did not provide the information needed to determine the minimum cost-share they required to adopt.

The two BMPs with the highest rates of adoption also had the highest average cost of adoption, and they were practices with cost-share incentive under EQIP. Anecdotal evidence suggests these practices were advocated as an initial response to high levels of *E. coli* that caused the water body to be listed for nonattainment of designated uses (swimmable, boatable, and fishable). Public concern led state environmental authorities to encourage and help support efforts by dairy farmers to reduce the *E. coli* levels. Dairy farmers avoided possible revocation of permits from the state department of health by implementing BMPs that reduced the potential for *E. coli* runoff into affected water bodies. However, one third of all survey respondents had not adopted these practices.

For fixed incentive payment practices under EQIP, the highest ranked BMP was waste utilization at 41%. The fixed incentive for this practice was $10 per acre with a 100-acre limit or a maximum payment of $1,000 for two or three years. Fifty-nine percent of producers had yet to adopt the waste utilization BMP, but over one half (55%) of nonadopters indicated a willingness to adopt this BMP. Unfortunately there was insufficient information to determine the incentive payment required by these producers for adoption.

The rate of adoption reported in Table 1 identifies the most popular BMPs among the 18 practices available under EQIP for Louisiana dairies. Similarly, the least popular BMPs among Louisiana dairy farmers can be identified by the percentage of nonadopters and the cost-share percentages they require to adopt those BMPs. There appears to be a strong, though nonlinear, correlation between

Table 1. Information Related to BMP Adopters and Nonadopters among Louisiana Dairy Producers

	Respondents		Adopters						
Cost-Share BMPs	Number	%	Number	%	Average Cost of Adoption ($)	Average Cost-Share (%)	% Nonadopters	% Nonadopters Who Said They Would Adopt	Cost-Share WTP[a]
Waste treatment lagoon	46	94	31	67	12,886	39	33	28	1.67
Waste storage facility	38	78	14	37	11,800	33	63	30	
Sediment basin	40	82	14	35	4,550	39	65	21	
Watering facility	41	84	12	29			71	19	2.57
Field borders and filter strips	41	84	10	24	533	12	76	16	
Fence	43	88	9	21	1,000	35	79	21	2.46
Grassed waterways	41	84	8	19	2,000	50	81	15	
Cover and green manure crop	42	86	7	17			83	20	
Heavy use area protection	39	80	6	15			85	12	
Critical area planting	38	78	4	11			89	18	
Streambank and shoreline protection	41	84	4	10			90	17	
Riparian forest buffer	41	84	3	7			93	22	
Roof runoff management	40	82	1	2.5			97.5	19	2.27
Incentive payment BMPs									
Residue management or CTP	41	84	12	29		3	71		
Nutrient management	41	84	14	34			66		52
Pest management	40	82	9	22			78		48
Prescribed grazing	40	82	12	30			70		54
Waste utilization	41	84	17	41			59		55

[a] Cost-share willingness-to-pay (WTP) values are asked in a Likert scale for cost-share best management practices (BMPs). The coding is 1, 2, 3, 4, and 5 for WTP values 0–9.9%, 10–19.9%, 20–29.9%, 30–40%, and 40% and higher, respectively.

Table 2. Logistic Regression Coefficients (Odds Ratio) at a 95% Bootstrap Confidence Interval (CI) for Coefficients from 1,000 Replications for Selected Best Management Practices in Louisiana

	Waste Treatment Lagoon			Streambank Shoreline			Field Border and Filter Strips			Riparian Forest Buffer		
		Bootstrap CI			Bootstrap CI			Bootstrap CI			Bootstrap CI	
Variable	Coeff. (Odds Ratio)	Lower Limit	Upper Limit	Coeff. (Odds Ratio)	Lower Limit	Upper Limit	Coeff. (Odds Ratio)	Lower Limit	Upper Limit	Coeff. (Odds Ratio)	Lower Limit	Upper Limit
YEARS	0.001 (1.00)	−0.10	0.20	−0.01 (0.99)	−0.18	0.11	0.03 (1.03)	−41.75	0.27	−0.01 (0.99)	−0.13	0.16
EDUCATION	0.63 (1.89)	−3.07	2.79	1.39 (4.03)	−6.38	3.86	1.69 (5.43)	−607.36	6.67	−0.19 (0.82)	−3.22	3.27
ESCALE	0.051 (1.05)	−0.78	0.83	0.13 (1.13)	−0.79	1.07	0.39 (1.48)	−0.651	1.69	0.08 (1.00)	−1.05	0.82
CONTINUE	−0.47 (0.63)	−6.22	2.50	−1.00 (0.36)	−3.68	2.66	−1.57 (0.21)	−98.53	1.76	0.18 (1.20)	−3.64	3.88
WORTH	1.21 (3.34)	−2.22	3.53	−0.06 (0.94)	−3.41	2.72	−1.18 (0.31)	−4.21	505.4	−0.28 (0.75)	−3.43	2.43
NETINCOME	0.33 (1.39)	−3.57	3.89	0.78 (2.17)	−2.85	18.88	1.18 (3.27)	−217.22	6.40	0.31 (1.36)	−3.22	4.64
DEBTASSET	−0.53 (0.59)	−3.40	2.01	0.75 (2.11)	−2.70	3.41	−1.04 (0.35)	−30.49	17.39	0.79 (2.22)	−5.77	3.43

	Pest Management			Prescribed Grazing			Waste Utilization		
		Bootstrap CI			Bootstrap CI			Bootstrap CI	
Variable	Coeff. (Odds Ratio)	Lower Limit	Upper Limit	Coeff. (Odds Ratio)	Lower Limit	Upper Limit	Coeff. (Odds Ratio)	Lower Limit	Upper Limit
YEARS	0.001 (0.90)	−0.29	62.44	−0.10 (0.90)	−0.29	60.03	−0.02 (0.98)	−0.32	7,025.00
EDUCATION	1.81 (6.11)	−103.71	6.24	0.24 (1.79)	−1.76	5.04	0.14 (1.15)	−316.63	5.75
ESCALE	−0.06 (0.94)	−48.87	1.39	−0.17 (0.83)	−44.18	1.27	−0.26 (0.76)	−19.93	2.38
CONTINUE	0.43 (1.53)	−19.17	121.39	−1.14 (0.32)	−27.94	11.79	−2.22 (0.11)	−56.30	8.61
WORTH	−1.22 (0.30)	−112.82	10.96	0.41 (1.51)	−40.32	5.40	−0.73 (0.48)	−107.26	4.12
NETINCOME	0.26 (1.30)	−18.47	20.92	0.17 (1.19)	−21.76	17.65	−0.15 (0.85)	−22.81	19.79
DEBTASSET	3.40 (29.97)	0.46	153.73	0.29 (11.34)	0.75	172.54	−0.27 (0.77)	0.53	74.59

Table 2. (Continued)

Variable	Roof Runoff Management			Waste Storage Facility			Residue Management or Conservation Tillage Practices			Nutrient Management		
		Bootstrap CI			Bootstrap CI			Bootstrap CI			Bootstrap CI	
	Coeff. (Odds Ratio)	Lower Limit	Upper Limit	Coeff. (Odds Ratio)	Lower Limit	Upper Limit	Coeff. (Odds Ratio)	Lower Limit	Upper Limit	Coeff. (Odds Ratio)	Lower Limit	Upper Limit
YEARS	−0.03 (0.97)	−0.16	5.90	−0.02 (0.97)	−0.15	0.29	−0.03 (0.97)	−0.13	0.13	−0.06 (0.94)	−0.17	0.72
EDUCATION	0.96 (2.60)	−9.60	4.10	1.17 (3.23)	−11.12	18.03	0.91 (2.49)	−1.95	3.39	0.58 (1.79)	−2.36	4.81
ESCALE	−0.01 (0.98)	−1.59	1.10	−0.49 (0.60)	−27.54	−0.19	0.31 (1.36)	−0.47	0.75	−0.11 (0.90)	−0.65	1.02
CONTINUE	−1.1 (0.34)	−4.16	3.30	−1.25 (0.28)	−48.45	3.30	−1.30 (0.27)	−25.8	0.76	−0.02 (0.98)	−4.12	3.91
WORTH	−1.00 (0.36)	−3.52	2.50	−2.00 (0.13)	−0.83	22.75	−0.24 (0.78)	−2.65	2.13	−0.82 (0.44)	−4.63	1.92
NETINCOME	−0.24 (0.78)	−4.55	7.10	1.73 (5.68)	−21.22	0.48	0.45 (1.57)	−1.89	3.60	0.37 (1.45)	−4.11	4.06
DEBTASSET	−0.22 (0.80)	−7.76	2.70	−1.64 (0.19)	−10.71	460.73	−0.22 (0.80)	−2.73	2.43	0.21 (1.23)	−3.17	3.23

Notes: Coefficients shown are from logistic regression. The value inside the parentheses is the odds ratio. The confidence interval shown is bootstrap confidence interval at 95% level for the parameters obtained from 1,000 replications.

the relatively high rates of nonadoption and the relatively low rates of nonadopters among the cost-share payment group who would adopt if their cost-share levels were to be met. For example, the roof runoff management BMP had the highest nonadoption rate (97.5%), and the lowest percentage of nonadopters who would adopt (19%). As a group, BMPs with fixed incentive payments had the highest percentages of nonadopters willing to adopt. Respondents were asked to identify the sources of information that had the greatest influence on their decision to adopt a specific BMP. From 11 sources of information, the LSU Agricultural Center, USDA-NRCS, and *Hoard's Dairyman* or other dairy publication were identified as the most important to the BMP adoption decision (regardless of whether the practice had a cost-share or fixed incentive payment). Last, the majority of nonadopters indicated retirement was the most frequent reason for not adopting a BMP—more so even than cost.

Likelihood of BMP Adoption

We estimated a logit model to assess the impact of selected explanatory variables on the BMP adoption decisions of Louisiana dairy farmers. Matrix singularity resulted in estimation of the model for 14 of the 18 BMPs. The majority of the regression results suggest that the independent variables were not significant in explaining the BMP adoption decision. Those variables that significantly increased the likelihood of adopting some BMPs were *EDUCATION* and *DEBTASSET.* Independent variables used in the regression were *ESCALE, WORTH, DEBTASSET, NETINCOME, CONTINUE, EDUCATION,* and *YEARS.*

A change in the probability of adopting a specific BMP given a one-unit increase in the value of an independent variable varies according to the decision maker's reference point as determined by the values of the independent variables unique to that decision maker. This is because a logit model assumes a nonlinear relation between the probability of adoption and the relationships between the explanatory variables. Interpretation is simplified somewhat if the adoption of a specific BMP is expressed in terms of odds rather than in terms of probabilities. For these reasons, identifications and interpretations of the odds ratio that the independent variables contributed to the BMP adoption decisions are presented. The interpretation of the odds of BMP adoption is similar for the binary variables of education, continue, worth, net income, and debt. The interpretation of the odds ratio of BMP adoption differs between quantitative variables such as *ESCALE* and *YEARS* and qualitative variables like the remaining independent variables.

The odds ratios identifying the contributions of independent variables to adoption of a specific BMP for 11 of the 18 BMPs are presented in Table 2. *EDUCATION,* a binary variable, takes the value of one when a farmer has more than a high school diploma. For 10 of the 11 BMPs, we consistently found that the odds of BMP adoptions by farmers with more than a high school diploma were greater than the odds of adoption by farmers with a high school education or less. For the pest management BMP, farmers with more than a high school education were 6.11 times more likely to adopt this BMP than dairy farmers with no more than a high school education. In the cases of the waste treatment lagoon, waste storage facility, and waste utilization BMPs, the odds of adoption by farmers with more than a high school diploma were respectively 1.89, 3.23, and 1.15 times higher than dairy farmers with no more than high school education. Educational attainment was least effective for adoption of the Riparian Forest Buffer BMP.

The variable *CONTINUE* represents a dairy farmer with an identified heir-apparent who will continue the dairy farming operation beyond their planning horizon. The odds that an heir-apparent would increase the likelihood of adopting a BMP were uniformly low for all but two BMPs—riparian forest buffer and pest management. These two BMPs represent dairy management practices recommended by extension service specialists throughout the country. Additionally, neither of these BMPs requires a major capital investment. Thus, there is no asset fixity associated with these BMPS that would preclude or diminish their prospects for adoption by most producers. The overall counterintuitive finding, that successors appear to have no impact on BMP adoption, suggests that current Louisiana dairy farmers are neither expecting nor encouraging too many of their children to continue dairy farming. Consequently these farmers are not investing in BMPs with a useful life beyond their own farming time horizon.

The variable *WORTH* identifies a situation where there is an increasing opportunity cost to dairy farm because of the pressure on land parcels for suburban development. Suburban development may also be placing upward pressure on labor costs as it offers an alternative to dairy production employment. This combination discourages the adoption of any BMP other than those enhancing the scenery and environment surrounding the dairy farm. Under this variable the odds that any BMP would be adopted, other than the waste treatment lagoon (3.34) and prescribed grazing (1.51), are quite low. The high odds of adopting the waste treatment lagoon may reflect heighten environmental or aesthetic sensitivities of the farmer by activities on neighboring properties, and thus increase the farm's potential value for nonagricultural purposes. Prescribed grazing is a BMP that can improve the aesthetics of country landscapes as well as enhance milk production. Most other BMPs evaluated entail some capital investment that would increase the value of the dairy farm as a dairy, but that increased value is dwarfed by the appreciated value of the dairy farm for nonagricultural purposes. Thus, farmers may be less motivated to increase a farm's value as a future dairy operation by adopting many BMPs when its nonagricultural use values are substantially larger.

NETINCOME is a binary variable in which a one indicates annual net income from dairying is $50,000 or more. With the exception of the roof runoff management and waste utilization BMPs, a net income of $50,000 or more increases the odds of adopting the BMP. The majority of the remaining BMPs are usually capital investments that potentially increase future milk production and profitability while simultaneously having potential tax advantages for higher-income producers. Thus, the combination of cost-share and fixed incentive payments and tax relief increases the odds of BMPs adoptions.

The waste utilization BMP minimizes manure runoffs and makes manure available as a substitute for commercial fertilizer. However, the relatively lower cost of commercial fertilizers and potentially increased cost of applying manure limits any savings from the use of manure as a fertilizer. Similarly, roof runoff management entails capital investments, though perhaps it is not as labor intensive. The incentive payment for this practice probably is insufficient to cover the additional labor costs.

The variable *DEBTASSET* describes farmers whose debt-to-asset ratio is less than 20%. These farmers are more likely to adopt BMPs like streambank and shoreline, riparian forest buffer, nutrient management, pest management, and prescribed grazing than farmers with greater debt loads. The relatively low debt level suggests that these operators are more financially secure. As a consequence, they have debt capacity and financial management skills necessary to implement these BMPs.

Using a 15-point scale based on the summation of responses to three questions in the survey, *ESCALE* measures the farmer's affinity for the environment. The coefficient in Table 2 expresses the percentage change in the odds of adopting a specific BMP for each one-unit increase in *ESCALE.* In this study a one-unit increase in the *ESCALE* increases the odds of the producer adopting a waste treatment lagoon and using streambank and shoreline protection, field borders and filter strips, a riparian forest buffer, and residue management BMPs. For *ESCALE,* the highest percentage increase in the odds of BMP adoption rests in field borders and filter strips. This BMP entails the planting of strips of grass around the boundaries of fields and along drainage ditches and other water bodies to retard and retain sediments, organic materials, and chemicals in the runoff that would otherwise enter into the water bodies. This BMP is visibly pleasing and effective at minimizing pollution.

The number of years a farmer has been dairying (*YEARS*) only increases the odds that the farmer will adopt a waste treatment lagoon or field borders and filter strips BMPs. The odds of adopting these BMPs increases by 0.4 and 3.0, respectively, for every year spent in dairying. A possible reason for this is that these BMPs are capital intensive and dairy farmers close to retirement are not very interested in making major capital investments. Instead they are interested in extracting rent from their existing capital assets. It is also possible that producers of more advanced age are not as motivated to implement new practices that require adjustment to existing systems.

Bootstrapping the Adoption Results

In this study 1,000 replications (bootstrap samples) from the main dataset were drawn to determine if the estimated logistic regression coefficients from our model fell within the estimated bootstrap 95% confidence interval. Bootstrap results for all BMPs for which logistic models were estimated are shown in Table 2. Most of the parameters fell within the bootstrap identified confidence interval, suggesting that the estimated parameters were derived from a random sample. The confidence interval is calculated using Effron's bias-corrected method.

Within the 95% bootstrap confidence interval, the logistic regression (bootstrap) procedure identified two coefficients associated with the *NETINCOME* and *WORTH* variables from logistic regression for the waste storage facility, and the coefficient associated with the *DEBTASSET* variable for waste utilization fell outside of the confidence interval. The coefficients of the remaining independent variables in the logistic regression model for BMPs fell within the simulated bootstrap confidence interval.

Table 3. Association between Farmers' Visits with USDA-NRCS Staff to Discuss BMP and Submissions of Application to the USDA-NRCS (Values in %)

	Application Submission for EQIP Funds		
Visit	No	Yes	Yes but Withdrew Later
No	35.71	2.38	0.00
Yes	23.81	33.33	4.76

Notes: Chi Square = 12.6 (df = 2), Likelihood Ratio Chi Square = 14.8 (df = 2), Mantel-Haenszel Chi Square = 11.1 (df = 1), Number of observations (N) = 42.

Table 4. Association between Farmers' Visit to USDA-NRCS Staff to Discuss BMP and Their Application Being Ranked by the USDA-NRCS (Value in %)

	Rank Status of Application	
Visit	Application Not Ranked	Application Ranked
No	37.9	2.7
Yes	29.7	29.7

Notes: Chi Square = 7.6 (df =1), Likelihood Ratio Chi Square = 8.8 (df = 1), Mantel Haenszel Chi Square = 7.4 (df = 1), Contingency Coefficient = 0.4138, Number of observations (N) = 37.

Steps in the BMP Adoption Decision

The steps involved in the interactions between the dairy farmers and the NRCS are themselves significant in the adoption/nonadoption decision for the EQIP practice or BMP. For all results in Tables 3–7, the limited number of observations resulted in the use of tests of association to assess the relationships between the steps in the BMP adoption process and the adoption/nonadoption decision. Limitations on the number of observations caused us to use tests of association in evaluating relationships between the steps in the BMP adoption process and factors like visits with USDA-NRCS staff. Tests statistics include the chi square, likelihood ratio chi square, Mantel-Haenszel chi square, phi coefficient, contingency coefficient, and Cramer's V. The first three test statistics are based on the chi square value, whereas the last three values are examined based on their nearness to one. If the latter three values are close to one, a high level of association between any two steps in the BMP adoption process is indicated.

Between producer awareness of a BMP and adoption, there are a series of steps the producer must take. For BMPs that feature cost share or fixed incentive payments, the producer must first submit an EQIP application package. That submission may or may not be preceded by a visit to the USDA-NRCS office. Table 3 suggests a visit is important to the submission of an application for EQIP funds. A greater proportion of producers who actually visited with NRCS staff submitted applications for EQIP funding (33.3% versus 23.8%). Producers who visited were nearly 14 times more likely to apply for EQIP financial assistance than those who did not visit NRCS staff (33.3% versus 2.4%). Producers who visited with the NRCS staff receive some technical assistance regarding assessments of the most appropriate BMPs for their unique dairy farm. This information may benefit producers because NRCS staff identi-

Table 5. Association between Farmers' Visit to USDA-NRCS Staff to Discuss BMP and Application Acceptance by the USDA-NRCS (%)

	Acceptance Status			
Visit	Not Accepted	Accepted	Accepted but Withdrew Afterward	Accepted but Declared Ineligible after Farm Visit
No	38.9	0	0	0
Yes	22.2	33.3	2.8	2.8

Notes: Chi Square = 14.5 (df = 3), Likelihood Ratio Chi Square = 19.2 (df = 3), Mantel-Haenszel Chi Square =10.5 (df = 1), Phi Coefficient = 0.63, Contingency Coefficient = 0.53, Cramer's V = 0.63, Number of observations (N) = 36.

Table 6. Association between Drawn-Up BMP Plan and Final Signing of the BMP Contract by Dairy Farmers in Louisiana

	Contract Signing		
Plan Drawn Up	Did Not Sign Because of Cost Requirement	Did Not Sign for Reason Other than Cost	Signed the Contract
No	47.6	4.8	0
Yes	0	0	47.6

Notes: Chi Square = 21.0 (df = 2), Likelihood Ratio Chi Square = 29.1 (df = 2), Mantel-Haenszel Chi Square = 19.1 (df = 1), Phi Coefficient = 1.0, Contingency Coefficient = 0.7, Cramer's V = 1.0, Number of observations (N) = 21.

fies practices and structures that would be eligible for funding under EQIP and that could potentially increase the environmental benefits score associated with the application. Even if a producer decides not to proceed with the application for EQIP funding, the NRCS site visit offers the positive externality of information regarding which BMPs or resource-conserving practices could be implemented on the dairy farm to minimize environmental problems. Chi square test statistics were found to be significant using all three criteria (chi square, likelihood chi square, and Mantel-Haenszel chi square test). These significant test statistics suggest that increases in one variable (visits by NRCS staff) are associated with increase in the other variable (submitting an EQIP application) that are greater than would be expected by chance.

One half of producers who visited with NRCS staff had their application scored and ranked by the NRCS. Through this process the NRCS determined whether the producer and the proposed practices met the eligibility criteria for potential EQIP financial assistance and additional technical assistance. Table 4 indicates that producers who visited the USDA-NRCS office were 11 times more likely to have their applications ranked than producers who had not visited with NRCS staff. Although this transaction is an intangible action step, it is critical to the producer seeking to minimize the private cost of BMP implementation and to the society seeking to minimize the environmental degradation from practices critical to the production of food and fiber and to the maintenance of economic activity in the rural areas.

Once ranked, the application is either accepted or rejected by the NRCS. Survey respondents identified one of four BMP application outcomes: 1) application rejected, 2) application accepted, 3) application accepted but withdrawn before the required USDA-NRCS visits to the farm, and 4) application accepted but farm declared ineligible. The majority of respondents (61%) had their applications rejected by the NRCS. Of the 39% of respondents who had their applications accepted, nearly 3% withdrew their application before the NRCS visit. Another 3% indicated that though their application was acceptable initially, it was later declared

Table 7. Association between USDA-NRCS Staff Visit by Farmers and Final Contract Signing by Dairy Farmers in Louisiana

	Signing		
Visit	Did Not Sign Because of Cost Requirement	Did Not Sign for Other than Cost Reason	Signed the Contract
No	36.4	0	0
Yes	9.1	4.5	50

Notes: Chi Square = 15.08 (df = 2), Likelihood Ratio Chi Square = 18.8 (df = 2), Mantel-Haenszel Chi Square = 13.8 (df = 1), Phi Coefficient = 0.82, Contingency Coefficient = 0.63, Cramer's V = 0.82, Number of observations (N) = 21.

ineligible and rejected by the NRCS. The importance of visiting with NRCS staff in the adoption decision process (or EQIP financial assistance application process) is underscored by the fact that no producers were successful in having their application accepted unless they had worked with NRCS staff (Table 5). Of all responding producers, only one third had their applications accepted, and all of those dairy farmers had visited with NRCS staff prior to submitting their EQIP application. The test statistics reported in Table 5 establish a significant association between NRCS visits and application acceptance.

Next, a plan is developed for implementing the specific EQIP practices or BMPs for application accepted by the NRCS. The plan requires the farmers and NRCS to provide more detailed cost estimates for BMP implementation at the farmer's dairy site. The farmer remains free to withdraw the application. Table 6 indicates that the overwhelming majority of farmers not adopting at this stage did so because of the implementation costs. Nonadoption for reason of costs corresponds to findings in the literature (Cattaneo). The chi square–related tests, phi coefficient, contingency coefficient, and Cramer's V-values close to or equal to one indicate a strong association between a developed BMP adoption plan and contract signing.

Table 7 once more illustrates the importance of NRCS visits to the adoption process. For those farmers who visited with NRCS staff, one half signed a contract with NRCS. Such farmers received financial assistance and additional technical assistance to implement specific BMPs on their dairy farms. On the other hand, results indicate that farmers who never visited NRCS staff about BMPs or EQIP practices were not likely to successfully participate in EQIP or adopt BMPs.

From these findings it could be argued that farmers visiting the NRCS office are more strongly motivated to adopt BMPs in the first place. Our findings also suggested positive correlations between a farmer's visit to the NRCS office, making an application, and getting the application accepted and implemented with NRCS cost sharing. However, even if a farmer wishes to adopt a BMP, there are several other variables that affect the adoption decision. These variables include NRCS budget constraints, NRCS emphasis of a particular water quality problem in that location, and perceptions by NRCS of the producer's land to address particular resource concerns like water quality. These administrative issues may limit the number of farmers practicing particular BMPs in a given location.

Farmers formally adopt a BMP when they sign the USDA contract. After signing, farmers begin constructing or implementing the EQIP practices or BMPs and receive the financial assistance (cost-share or fixed incentive payments) specified in the contract. NRCS monitors construction and implementation of BMPs for a specified term that varies by practice. The consequences of BMP adoption are then experienced directly by the farmer and indirectly by society.

Summary and Conclusions

In this paper we described 18 BMPs particularly relevant to dairy farmers in Louisiana but also applicable to most dairy farmers in the southern United States. We report findings from a survey designed to identify which BMPs were being adopted by dairy farmers in Louisiana and how much it was costing them to actually implement those practices, to identify the associated cost-share and incentive payments producers received for BMP implementations, and to determine how much nonadopting producers needed to receive to adopt those BMPs. We identified, by BMP, the percentage of nonadopters willing to become adopters given specific increases in cost-share incentive payments. The likelihood of adoption of a specific BMP was related to a set of socioeconomic and financial variables including years of experience dairy farming, education, presence of a successor to continue the dairy operation, net farm incomes, debt-to-asset ratios, nonagricultural value of the farm, and the farmer's environmental ethos.

Data constraints limited our ability to document and estimate average costs of adopting BMPs for all 18 practices. Additionally the paucity of data precluded us from determining the survey respondents' willingness to pay for all but eight of the 18 BMPs. These same data constraints required us to develop the validity of the regression coefficients using a bootstrap approach. Bootstrapping of data indicated only a few coefficients from the logistic regression fell outside of the 95% confidence interval, indicating that the data came from a random sample.

Survey respondents identified the LSU Agricultural Center, USDA-NRCS, *Hoard's Dairyman,* and similar dairy-specific publications as being the most important sources of information influencing their attitudes about BMPs. If more widespread adoption of BMPs benefits the public and the environment, then this implies that these sources trusted by dairy farmers will have to be in the vanguard in delivering reliable information on the benefits and costs of adopting BMPs. Additionally, these sources will have to increase outreach efforts designed to educate producers about programs like EQIP that address resource concerns and provide both technical and financial assistance to help farmers address these concerns.

The BMP adoption decision entails a number of intermediate action steps between awareness and implementation of the BMP. Our results indicate that at every step in that adoption decision process, visiting with NRCS staff is the first and most critical action step taken by farmers who eventually adopt BMPs. First, producers who did not visit with NRCS staff were much less likely to submit an EQIP application, and conversely the majority of producers who actually visited with NRCS staff were much more likely to apply for EQIP funds. Second, producers who visited with NRCS staff received some technical assistance with BMPs, even if they did not apply for EQIP funds. At a minimum, conversations between producers and NRCS staff helped producers identify which practice-based and structural BMPs might work on their farm to address environmental problems. This process itself potentially creates positive externalities (environmental education, improved farm management practices) that may mitigate some of the potential negative externalities of dairy farming.

For those farmers who visited with NRCS staff, one half signed a contract with NRCS; none of the farmers who stayed away from the NRCS were successfully awarded an EQIP contract. For farmers who signed a contract with USDA to develop the BMPs on that dairy farm, NRCS followed through and monitored construction and implementation of BMPs for several years after the contract was signed. This implementation of EQIP by the NRCS insures genuine adoption of the BMPs. If sufficient funds were available to NRCS staff for encouraging BMP adoption in programs like EQIP, more widespread adoption of more BMPs by more farmers may occur.

The results obtained and presented here have some caveats. First, the response rate (15%) was relatively low, despite extensive efforts to collect the data following Dillman's tailored design method. Potential limitations on this small sample in terms of interpretation and extension should be considered by readers. Methodologically speaking, bivariate models can advance the sequential adoption portion of the results further than contingency tables provided the number of observations is higher. Even with these caveats our results provide three important findings. First, adoption rates for BMPs increase significantly when producers interact with NRCS staff, especially regarding EQIP practices. Second, responses by producers indicated that the relatively low cost-share percentage offered for EQIP practices may be a significant hindrance to producer adoption of BMPs. Third, emphasis should be placed on educating young farmers about BMPs. This suggestion echoes that of McCann and Easter, who indicated that education is the second best alternative to reduce phosphorus pollution in the Minnesota River watershed. Bundling and efficient targeting of BMPs may help to improve water quality in an impaired watershed more efficiently (Amacher and Feather;

Johansson et al.). Information like that collected from this study can help inform that effort. Furthermore, the cost information obtained from this research can be used to help design future policy regarding BMP adoption, in a vein similar to that of Cooper (1997).

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Appendix A. Dairy BMPs Suggested for Louisiana

Sample Format of the Question Asked on Each Cost-Share BMP

1. Waste Treatment Lagoon (NRCS code 359): *An impoundment made by excavation or earth fill for the temporary storage and biological treatment of animal or other agricultural waste.*

Estimated Reference cost = $11,750 each

Has this BMP been adopted on your farm?

[ ] YES → **If YES, in which year? If stopped, in what year? _______ Total cost from all sources to install BMP $ *Your* cost-share %**

[ ] NO → **If NO, would you adopt this BMP on your farm?**

[ ] YES

[ ] NO

[ ] Not suitable for my farm

If YES, what is the maximum percentage of total cost you would pay to adopt this BMP?

[ ] 0–9.9% [ ] 10–19.9% [ ] 20–29.9% [ ] 30–40% [ ] more than 40%

2. Cover and Green Manure Crop (NRCS code 340): *A crop of close growing grasses, legumes, or small grains primarily for seasonal protection and soil improvement. Estimated Reference Cost = $12 per acre*

3. Critical Area Planting (NRCS code 342): *A planting of vegetation such as trees, shrubs, vines, grasses, or legumes on highly erodible areas. Estimated Reference Cost = $415 per acre*

4. Fence (NRCS code 382): *A constructed barrier to livestock, wildlife, or people to facilitate the implementation of conservation practices. Estimated Reference Cost = $1 per foot*

5. Field Borders and Filter Strips (NRCS code 386 and 393): *Strips of grasses planted around fields and along drainage ways and other water bodies to* *reduce sediment, organic materials, and chemicals carried in runoff. Estimated Reference Cost = $0.10 per foot for Field Borders and $210 per acre for Filter Strips*

6. Grassed Waterways (NRCS code 422): *A channel, shaped or graded to required dimensions and established in suitable vegetation to convey runoff from terraces, diversion, or other water concentration. Estimated Reference Cost = $1 per foot*

7. Heavy Use Area Protection (NRCS code 561): *Protecting areas by establishing vegetative cover. Estimated Reference Cost = $1 per acre*

8. Riparian Forest Buffer (NRCS code 391): *An area of trees, shrubs, and other vegetation located adjacent to water courses or water bodies. Estimated Reference Cost = $1 per acre*

9. Roof Runoff Management (NRCS code 558): *A facility for collecting, controlling, and disposing of roof runoff water. Estimated Reference Cost = $75 each*

10. Sediment Basin (NRCS code 350): *A basin to collect and store debris or sediment (sand trap). Estimated Reference Cost = $4,100 for each basin*

11. Streambank and Shoreline Protection (NRCS code 580): *Use of vegetation or structures to stabilize and protect banks or streams and lakes against scouring and erosion. Estimated Reference Cost = $4,100/acre*

12. Watering Facility (NRCS code 614): *A trough or tank with needed devices for water control and waste disposal installed to provide drinking water for livestock. Estimated Reference Cost = $780 for each*

13. Waste Storage Facility (NRCS code 313): *An impoundment to temporarily store manure, wastewater, and contaminated runoff. Estimated Reference Cost = $90,000 for each facility*

Incentive Payment BMPs

14. Residue Management or Conservation Tillage Practices (NRCS code 329A,B,C): *A system designed to manage the amount, orientation, and distribution of crop and other plant residues on the soil surface year round (such as No-till, Strip-till, Ridge-till, and Mulch-till systems). Incentive payment = $10–15 per acre, 100 acre limit, 2–3 years*

Have you adopted this BMP on your farm?

[ ] YES → **If YES, in which year? If stopped, in what year_______?**
Total Incentive Payment received for this BMP $______ per acre

[ ] NO → **If NO, would you adopt this BMP on your farm?**
[ ] YES
[ ] NO
[ ] Not suitable for my farm

If YES, what is the minimum additional incentive payment you need to receive to adopt this BMP? [ ] 20% [ ] 40% [ ] 60% [ ] 80% [ ] 100%

15. Nutrient Management: *Management of the amount, form, placement, and timing of application of plant nutrients (fertilizers) for optimum forage and crop yields. Also includes soil samples and comprehensive nutrient management plans. Incentive payment = $5 per acre, 50–100 acre limit, 1–2 years*

16. Pest Management (NRCS code 595): *A pest control program consistent with crop production goals and environmental standards. Incentive payment = $5 per acre, 50 –100 acre limit, 1–2 years*

17. Prescribed Grazing (NRCS code 528A): *Controlled harvest of vegetation with grazing animals. Incentive payment = $5 per acre, 50–100 acre limit, 1–2 years*

18. Waste Utilization: *Use of agricultural wastes on land in an environmentally acceptable manner to fertilize crops and to improve/ maintain soils. Incentive payment = $10 per acre, 100 acre limit, 2–3 years*