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Factors Influencing the Adoption of Water Quality Best Management Practices by Texas Beef Cattle Producers

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Abstract

The management of agricultural nonpoint source pollution is complex. Rather than rely on direct regulation, Texas natural resource agencies utilize a watershed approach to encourage the voluntary adoption of best management practices (BMPs) to improve water quality and control nonpoint source pollution. Policy tools used to encourage voluntary adoption include educational programming as well as technical and financial assistance opportunities. Despite the known water quality benefits of BMPs and the availability of policy tools to encourage adoption, some landowners and livestock producers choose not to adopt conservation practices. A statewide survey of Texas beef cattle producers was conducted to examine adoption behavior and to investigate how factors related to capacity, attitudes, environmental awareness, and farm characteristics influence the adoption of BMPs known to reduce levels of bacteria and other contaminants in runoff. Results suggested producers are adopting and maintaining water quality BMPs despite a significant lack of knowledge concerning common water quality terms and the availability of financial assistance programs to aid in practice implementation. The most significant predictors of adoption among survey respondents included interactions with Extension, prior participation in a government cost-share program, crop diversity, annual income, and percent income from the operation. The results suggested the need to address information gaps among beef cattle producers as well as demonstrate a significant opportunity for the Natural Resources Conservation Service and the Extension Service to forge a strategic long-term partnership to promote increased and sustained adoption of water quality BMPs.

Keywords: Best management practices (BMPs)—conservation—agricultural nonpoint source pollution—water quality—beef cattle—univariateprobit

Excessive Levels of Fecal Indicator Bacteria (e.g. E. coli) Remain a Major Cause of Water Quality Impairment throughout Texas

Although watersheds can be affected by microbial pollution from a wide variety of sources, livestock are increasingly under scrutiny (McAllister and Topp 2012). The Texas beef cattle industry is an important agricultural industry in the state, impacting the economy and lives of its citizens.

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As of January 2014, Texas had 10.9 million head of cattle and calves (NASS 2014) and ranks first in the nation accounting for 12% of the total U.S. cattle inventory (NASS 2014). Texas also ranks first in the nation in total number of beef cattle operations and fed cattle. The total economic value added by meat animals in Texas is estimated to be more than $7 billion dollars. One mechanism for reducing bacterial contamination from livestock species, precluding potential regulatory implications, and protecting human health is promoting greater adoption, implementation, and maintenance of best management practices (BMPs) by livestock producers and landowners across the state (Hoorman and McCutcheon 2005). Despite the existence of financial assistance programs and the known water quality benefits of BMPs, many livestock producers and landowners are not adopting practices for a variety of reasons (Gillespie et al. 2007). The objectives of this study were to assess the extent of current BMP adoption in the Texas beef cattle industry; to determine how variables related to capacity, attitudes, environmental awareness, and farm characteristics influence producer adoption decisions, and to make policy recommendations based on the empirical results.

Previous Research

Although BMP adoption studies are numerous in the literature, there are few studies specifically examining the adoption of livestock management BMPs (Prokopy et al. 2008) and none known evaluating BMP adoption in the Texas beef cattle industry. Previous research has shown a variety of factors can influence BMP adoption rates,including information (Feather and Amacher 1994, Saltiel et al. 1994), education (Gould et al. 1989, Caswell et al. 2001), operator age (Harper et al. 1990, Featherstone and Goodwin 1993), income (Norris and Batie 1987, Gould et al. 1989), farming experience (Caswell et al. 2001), perceived profitability (Cary and Wilkinson 2008, Prokopy et al. 2008, Gedikoglu et al. 2011), perceived risk (Feder 1980, Cary et al. 2001), attitudes (McCann et al. 1997, Kaiser et al. 1999), awareness (Korsching and Nowak 1983, Napier and Bridges2002, Rahelizatovo 2002), farm size (Belknap and Saupe 1988, Caswell et al. 2001, Prokopy et al. 2008), land tenure (Caswell et al. 2001, Khanna 2001, Kim et al. 2005), and operator gender (Zelezney et al. 2000, Ghazalian et al. 2009). In their meta-analysis, Prokopy et al. (2008) succinctly categorized these various factors into four broad constructs: capacity, environmental attitudes, awareness, and farm characteristics. Capacity includes variables related to age, diversity of operation, education, farming experience, income, information, labor, and networking. Attitude includes variables related to adoption payments, profitability of practice, heritage, and risk. Environmental awareness includes variables related to environmental attitude, causes of pollution, quality of environment, consequences of degraded ecosystems, knowledge of nonpoint source programs, and general terms related to environmental quality. Finally, farm characteristic includes variables related to total acres, applicability/compatibility of practice, capital, land tenure, operator gender, ownership type, and proximity of water body to operation. This study used these categorizations as the framework for evaluating how variables comprising these constructs specifically influence the adoption decisions of Texas beef cattle producers. A better understanding of the BMP adoption behavior of this population will enable state water quality and natural resource agencies to improve the design of practices and programs that encourage and secure participation, facilitate sustained adoption of practices, and meet water quality goals in the most cost-effective manner.

Materials and Methods

Data

A mixed-mode data collection approach employing mail and electronic survey instruments was utilized to conduct a statewide survey of Texas beef cattle producers in fall 2013. Survey questions focused on production characteristics, environmental awareness and attitudes, adoption of 18 water quality BMPs (table 1), barriers to adoption, and producer characteristics. Survey questions comprised a combination of five-point Likert-scale, dichotomous (Yes/No), and multiple choice items designed to directly address the awareness, capacity, environmental attitude, and farm characteristics constructs discussed in the meta-analysis by Prokopy et al. (2008). The BMPs comprise erosion and sediment control; grazing management; and mortality, nutrient, and pesticide management practices and are all applicable to beef cattle operations in Texas. In addition, all practices have been shown to minimize contaminants originating from agricultural nonpoint sources of pollution, although the impact of each particular BMP on water quality would depend upon various factors such as soil type and erodability, land use, slope, degree of implementation, and practice maintenance. The paper version of the survey instrument was guided by that of Rahelizatovo and Gillespie (2004). An electronic version of the paper questionnaire was created using Qualtrics™ (www.qualtrics.com). Both versions of the survey instrument were pilot tested with beef cattle producers in spring and summer 2012.There were a total of 36 questions in the paper survey and 44 questions in the online survey.

Advanced programming capabilities in Qualtrics™ (i.e., JavaScript, skip logic, displaylogic) allowed researchers to separate some questions in the online version (i.e., If–Yes questions) that were combined in the paper version. Other than the different number of questions, the electronic version and paper version of the survey instrument were essentially identical. The sampling frame for this study was derived from a list of all beef cattle producers in Texas maintained by the Southern Plains Regional Field Office of the National Agricultural Statistics Service (NASS) in Austin, Texas.This list was sorted by county and herd sizeand a stratified random sample of 1,700 beef cattle producers was drawn. Herd size was determined by the number of cattle reported by the operation on the 2012 United States Department of Agriculture(USDA) Census of Agriculture survey. Within each county, the population was subdivided into three size groups: small, medium, and large. Size group boundaries were identified in each county so records in the small group were below the 25thpercentile cattle, the medium group between the 25th and 75th percentile, and the large group above the 75th percentile. Substitution was applied for specific special circumstances. For example, there were some records in the population where NASS had special agreements with operators to minimize the number of contacts; if this type of operator was sampled, the next record in the order of the sorted population was substituted as needed.

The survey was administered by the Southern Plains Regional Field Office of NASS using a 4-stage mailing protocol that followed Dillman's *Tailored Design Method* (Dillmanet al. 2009). The first stage included a postcard notifying participants they had been selected for the study and to expect receipt of the survey within a few days. The postcard also contained a URL link giving participants access to the online version of the survey by entering their unique identification number. Approximately one week after the postcards were distributed, individuals who chose not to complete the survey online received an initial survey packet containing a hand-signed cover letter with instructions on completing the survey, a paper questionnaire, a $1 bill incentive, and a business reply envelope to return the completed questionnaire. A $1 incentive payment was included to maximize response rates. Small prepaid incentives have been shown to increase response rates by 8% to 31% compared to no incentive (Dillman et al. 2009). A follow-up reminder postcard was sent approximately one and one-half weeks after the initial survey packet mailing. Approximately two weeks later, a second survey packet was mailedto non-respondents that included a hand-signed cover letter, paper questionnaire, and a pre-paid return envelope; no incentive payment was included in the second survey packet mailing. Nineteen postcards and/or survey packets were returned undeliverable, 14 individuals reported they had sold all of their cattle, and 43 individuals indicated they did not wish to participate in the study. This yielded a frame error of 4.5% and reduced the total sample to 1,624 beef cattle producers. A total of 93 surveys (5.7%) were completed online and 686 (42.3%) were completed on paper for a total response rate of 48.0% (table 2). This response rate is higher than other similar adoption survey studies (Cardona 1999: 32%; Rahelizatovo 2002: 29%; Kim et al. 2005: 41%).

Empirical Model

A univariateprobit model (Greene 2003) was used to predict the probability of a producer adopting each of the 18 water quality BMPs given the influence of 30 explanatory variables (table 3) comprising the capacity, attitude, environmental awareness, and farm characteristics constructs identified by Prokopy et al. (2008). The probit model is a binary choice model often used to understand the choice behavior of an individual facing two alternatives and opting for one (Kim et al. 2005). The probability of a producer choosing whether to adopt or not adopt a specific BMP, and ultimately choosing to adopt the practice can be expressed as in equation (1),

$$\Pr(Y_i = 1) = \Phi(\beta_i X_i) \quad (1)$$

where,

Pr = probability
Φ = cumulative distribution of a standard normal random variable,
Y_i= dichotomous dependent variable
β_i = parameter coefficients, and
X_i = vector of explanatory variables (Greene 2003, Kim et al. 2005).

Probit models allow interpretation of marginal effects to understand the influence of a specific explanatory variable on the probability of adoption. Marginal effects for continuous explanatory variables on the probability of Pr(Y_i= 1), holding all other variables constant, can be expressed as in equation (2)(Greene 2003, Kim et al. 2005),

$$\frac{\partial P_i}{\partial x_{ik}} = \Phi(X_i'\beta)\beta_k \qquad (2)$$

where,

Φ = probability density function of a standard normal random variable.

Marginal effects for binary explanatory variables can be expressed as in equation (3)(Greene 2003, Kim et al. 2005),

$$X_b = \Phi(\overline{X}\beta, d = 1) - \Phi(\overline{X}\beta, d = 0) \qquad (3)$$

where,

d = the dummy variable.

Goodness of fit for each model was estimated using McFadden's R^2 statistic and the percent correctly predicted measure. In addition, multicollinearity among all 30 independent variables was analyzed prior to analysis using variance inflation factors and condition indices. No evidence of multicollinearity was found; thus, all 30 predictor variables were included in the models. It is recognized that using multivariate probit analysis to examine adoption of similar BMPs bundles would have potentially yielded interesting results. However, correlations between the 18 practices revealed low Pearson's correlation coefficients for all practices indicating weak linear relationships among the practices. Furthermore, test runs of multivariate models revealed there were too few observations to run models adequately, resulting in models that did not converge or produced non-significant parameter estimates (Rahelizatovo and Gillespie 2004). There were 18 binary dependent variables representing each of the BMPs included in the survey instrument. For each BMP, respondents were asked to mark either Yes or No for practices they had adopted on land they either rented or owned in the last 5 year period. Dependent variables took a value of 1 if producers adopted the specific practice and 0 otherwise. Independent variables were largely selected for inclusion in the study based on previous research by Prokopy et al. (2008). Furthermore, to address issues of endogeneity commonly seen in regression analyses, variables were selected based on the expectation they would increase, rather than decrease, adoption rates among producers; only 3 variables characterizing debt to asset ratio, percent land rented, and off-farm income were expected to decrease adoption rates. The 30 explanatory variables comprised four constructs including capacity, attitudes, environmental awareness, and farm characteristics as described below.

Capacity

Operator age has been shown to influence adoption decisions; however, the literature appears inconsistent as to whether the influence is positive or negative. For example, age has been shown to be negatively correlated with adoption (Featherstone and Goodwin 1993, Soule et al. 2000), positively correlated (Harper et al. 1990, Kim et al. 2005, Petrzelka et al. 1996), and insignificantly correlated (Daberkow and McBride 2003, McCann et al. 1997).We expected age to be positively correlated with adoption given the nature of the population sampled. Livestock and crop diversity were expected to enhance adoption behavior based on findings by Rahelizatovo and Gillespie (2004) who suggested increased diversity qualifies the landscape for a wider variety of BMPs, thus,allowing operators to experiment with new innovations. Livestock and crop diversity were included as dummy variables to indicate whether the producer owned more than one kind of livestock or grew more than one crop. The education level of a producer can affect adoption rates (Caswell et al. 2001, Gould et al. 1989, Kim et al. 2005, Park and Lohr 2005). Research suggested more highly educated producers are better able to make informed decisions and are more likely to be aware of alternatives available to them in their operation (Kim et al. 2005). Formal education was included as a dummy variable to indicate whether the producer had obtained at least a bachelor's degree. Closely related to education is the role information plays in the adoption of conservation technologies. The availability and accessibility of information related to BMPs is critical to securing their adoption (Traoré et al. 1998, Alonge and Martin 1995). Avenues that can increase access to information include networking channels between producer and agency personnel, other members of the agricultural sector, and neighbors (Prokopy et al. 2008). Research suggested that when exposed to the ideas of others through networking opportunities, adoption of practices was likely to increase (Belknap and Saupe 1988, Norris and Batie 1987, Prokopy et al. 2008). Networking was captured through two dummy variables representing interactions producers had with Extension and the Natural Resources Conservation Service (NRCS) in a typical year.

It is expected that producers having at least one professional contact with each agency in a typical year will have higher adoption rates of BMPs. Farming experience can either negatively or positively influence the adoption decisions of livestock producers (Caswell et al. 2001). Producers with many years of experience are often better equipped at incorporating new technologies into production because of their increased expertise. Conversely, those with substantial experience and time in the business may be more reluctant to change technologies, especially if the new technologies are not compatible with the current operation. Producers were asked to indicate how many years they had been running their livestock operation, and this was included as a continuous variable in the models. Percent income obtained from on- and off-farm sources can influence adoption rates of conservation practices. It was expected that a higher percentage of income derived from the operation would increase adoption rates while a higher percentage of off-farm income would have the opposite effect. Producers were asked to indicate the percentage of household net income obtained from their beef cattle operation and an off-farm source in 2012.

Attitudes

Attitude is defined as "a disposition to respond favorably or unfavorably to an object, person, institution, or event" (Ajzen1988, 4).A number of variables were hypothesized to favorably influence an individuals' attitude and, therefore, their conservation behavior including prior receipt of conservation payments, farm heritage, and risk preference. Featherstone and Goodwin (1993) suggested if a producer is already receiving financial incentive payments, he or she will be more likely to participate in additional programs that assist in long-term BMP implementation. Participants were asked to indicate whether they had ever participated in a government-funded cost-share program to aid in implementation of a BMP. It was expected that prior participation in a conservation incentive program will positively influence adoption behavior. Research suggested the adoption of conservation practices will increase when a farm or operation stays in a family for a long period of time (Ervin and Ervin 1982, Norris and Batie 1987, Kim et al. 2005, Prokopy et al. 2008). Having a long-range plan for the operation in terms of ownership can help increase the planning horizon and, therefore, make it easier for a producer to comprehend the long-term benefits of implementing a conservation practice (Kim et al. 2005). Participants were asked to indicate whether a family member planned to take over the farm, and this was included as a dummy variable in the models.

Risk refers to the uncertainty a producer might face regarding the benefits, costs, overall effectiveness, and timing of effectiveness for implemented practices (Cary et al. 2001). Whether the risk associated with implementation of a practice is real or perceived, research suggested the risk of a negative outcome or increased uncertainty regarding a practice can be a substantial barrier to adoption (Baide 2005). The risk preference of producers was measured by asking them to indicate whether they preferred to take on a substantial amount of risk in investment decisions, preferred to stay neutral, or preferred to avoid risk when possible. Risk aversion was then included as a dummy variable in the models to indicate producers preferring to avoid risk in their adoption decisions. Finally, two attitudinal scales were utilized to measure overall environmental and water quality attitudes. Environmental attitudes were measured using the New Environmental Paradigm (NEP) scale developed by Dunlap et al. (2000). The NEP scale is comprised of 15 items designed to elicit opinions on various hypothesized aspects of an ecological worldview (Rahelizatovo and Gillespie 2004). A higher score on the NEP scale would indicate a pro-environmental worldview, which would be expected to correspond with higher adoption rates of BMPs. The water quality attitude scale was adapted from the Macatawa Watershed Agricultural Survey conducted in 2010 by the Macatawa Area Coordinating Council (Fales and Scheerhorn 2011). A higher score on this scale would indicate favorable water quality attitudes, which would be expected to positively influence adoption behavior. A coefficient alpha of $\alpha=0.83$ was found for the NEP scale and a coefficient alpha of $\alpha=0.74$ was found for the WATT scale indicating reasonable internal consistency of both scales.

Environmental Awareness

Attitudes and awareness are intricately linked.Forsyth et al. (2004) utilized the phrase "appraisal" to suggest awareness of an issue is the first step in developing an attitude about an issue. The awareness an individual has concerning their surrounding environment has been shown to affect adoption rates of conservation practices. If producers are not aware an environmental problem exists, they will not be highly motivated to adopt practices intended to enhance environmental protection (Napier and Napier 1991).

Furthermore, awareness is more than knowing a problem exists; an individual must also be aware of existing approaches to solve the environmental problem (Napier and Napier 1991). In this study, the environmental awareness of a producer was measured through a series of fouryes/no questions that tested knowledge concerning common water quality terms and issues. In addition, producers were asked to rate their overall perception of water quality in their area. Rahelizatovo (2002) utilized in a similar approach in her study finding a major barrier to adoption was the lack of knowledge producers had regarding legislation and efforts to control nonpoint source pollution through the use of BMPs and other programs.

Farm Characteristics

Total acreage and land tenure have been examined in technology adoption studies (Prokopy et al. 2008, Belknap and Saupe 1988, Caswell et al. 2001); however, there is much debate in the literature regarding the influence of farm size on adoption rates (Prokopy et al. 2008). In this study, it was hypothesized that producers operating larger farms would have higher adoption rates given their ability to spread equipment costs over larger areas and the lower management cost per unit output (Lee and Stewart 1985). Land tenure has been found to be negatively correlated with adoption (Caswell et al. 2001, Khanna 2001), positively correlated with adoption (Belknap and Saupe 1988, Daberkow and McBride 2003, Kim et al. 2005), and not significantly correlated with adoption (Bosch et al. 1995, Lynne et al. 1988). The relationship between land tenure and adoption rates is complex and not fully understood (Weinkauf 2008). In this study, it was hypothesized that producers who own a greater percentage of their land will have higher adoption rates. Additional variables related to farm characteristics include operator gender, ratio of debts to assets, and proximity of the operation to a water body. Gender has been previously investigated with some research suggesting women have stronger environmental ethics and are, therefore, more likely to adopt conservation practices (Zelezny et al. 2000)and other research suggesting conservation is a “man’s job” (Bayard et al. 2006). Given the nature of the population in this study, it was hypothesized that men would have higher adoption rates of conservation practices. Potential endogeneity issues are associated with using debt-asset ratio as a predictor of adoption, which can result in ambiguous interpretation of the coefficient sign (Kim et al. 2005). For example, a high debt load can result from credit constraints or from recent investments made by the farmer (Kim et al. 2005). However, Ervin and Ervin (1982) suggested producers with a high debt-asset ratio and, therefore, lower capital, lack the capacity to adopt conservation practices and will, out of necessity, focus on production rather than conservation. Consequently, a higher debt to asset ratio is expected to decrease adoption rates in this study. Proximity of a farm to a water body can influence an individual’s awareness concerning water quality as well as his or her desire to implement conservation practices to protect water quality (Gillespie et al. 2007). Rahelitazovo (2002) evaluated the impacts of location relative to a water body on the adoption of dairy BMPs and found a positive correlation. Nyaupane and Gillespie (2009), however, found that having a stream running through an operation negatively influenced the adoption of conservation practices. It was hypothesized that operators living close to a water body would exhibit higher adoption rates of conservation practices.

Results and Discussion

Figure 1 illustrates adoption rates of all 18 BMPs by Texas beef cattle producers. The most frequently adopted water quality BMPs were watering facilities (80.8% adoption), followed by fencing (73.9% adoption), feed/salt/mineral locations (69%) adoption), prescribed grazing (60.0% adoption), and pesticide management (56.9% adoption). All but the pesticide management practice fall within the broader category of grazing management BMPs, which represents the category with the highest number of adopted BMPs among respondents. This result is not surprising given our sample was comprised of beef cattle producers. The least frequently adopted BMPs were in-stream water points (15.2% adoption), filter strips (15.2% adoption), stream bank/shoreline protection (18.6% adoption), and stream crossings (18.7% adoption). All but in-stream water points fall within the broader category of erosion and sediment control BMPs, which represents the category with the least number of adopted BMPs among respondents. The low adoption frequency of these practices is likely due to the fact that only 35% of respondents reported having a stream running through their operation. The four least-adopted practices assume the presence of a stream on or near the property in order to be effectively implemented. Table 4 presents marginal effects for each of the 18 probit models. In the following paragraphs, we summarize results for variables belonging to each of the four constructs and discuss results in terms of parameter sign and significance.

Capacity

Operator age (AGE) was positively associated with the probability of adopting pesticide management, shade structures, and watering facilities. This result differs from most of the literature pertaining to conservation practice adoption, which generally concludes older producers have shorter planning horizons and, therefore, often choose not to adopt practices. However, one possible explanation is provided by Basarir (2002), who found that older beef cattle producers value land conservation and maintenance and are, therefore, more prone to adopting practices that will maintain and conserve their land. It is also worth noting that pesticide management and shade structures are relatively less capital-intensive BMPs, possibly indicating the "shorter planning horizon" hypothesis might not necessarily apply. Concerning watering facilities, which are generally more capital-intensive, older producers may be implementing this practice because they have greater financial resources than younger producers. Furthermore, pesticide management, shade structures, and watering facilities are all practices with direct observable benefits to cattle production, a characteristic that older producers may find more appealing. Livestock (Q1_RC) and crop diversity (Q2_RC) were both positively associated with the adoption of several BMPs. Raising more than one type of livestock (i.e., in addition to beef cattle) increased the probability of adopting a watering facility by 12.4% and control access by 19.9%. Crop diversity (i.e., growing more than one type of crop in addition to raising beef cattle) increased the probability of adopting critical area planting by 15.6%, diversions by 25.8%, field borders by 26.9%, filter strips by 19.5%, grassed waterways by 24.8%, in-stream watering points by 15.8%, pesticide management by 25.2%, soil testing/nutrient management by 21.7%, and stream crossings by 13.6%. The association of crop diversity with the adoption of these BMPs is interesting given the majority of BMPs in this list are vegetated practices that would likely require the same type of equipment used for planting crops. In addition, management practices such as pesticide and nutrient management are likely practices already in use by the landowner for the purposes of planting and growing crops. These results follow prior research, which suggests producers with diverse operations are more likely to experiment with new innovations and that this diversity qualifies the landscape for a wider variety of BMPs (Rahelizatavo and Gillespie 2004).

Having a college bachelor's degree or higher level of education (Q17_RCD) was negatively associated with the probability of adopting diversions, field borders, and soil testing/nutrient management. In fact, this variable was negatively associated (although not significant in all cases) with the adoption of 16 out of the 18 BMPs included in the study. This result was unexpected given the conservation practice adoption literature generally agrees that some level of college education is positively associated with conservation practice adoption. In one study, however, Banerjee et al. (2009) found college education to be insignificantly associated with the adoption of conservation-tillage practices and herbicide-resistant seed in cotton production. No explanation was given as to this potential nature of this relationship. One possible interpretation of the negative relationship between formal education and adoption among Texas beef cattle producers may be that producers with a college education have professional off-farm jobs that limit their time to adopt practices. Indeed, 52.1% of the sample indicated they received more than 80% of their income from an off-farm source. Another potential reason for this negative relationship perhaps involves explanation of another predictor variable: producer visits with Extension. The number of times a producer had business contact with Extension in a year (Q25_RCD) was significantly and positively associated with the adoption of several BMPs. Having at least one visit with Extension per year significantly increased the probability of adopting control access by 26.5%, field/salt/mineral locations by 20.1%, filter strips by 12%, heavy use area protection by 13.3%, pesticide management by 26.1%, soil testing/nutrient management by 38.8%, and stream crossing by 12.1%. In fact, this predictor variable produced the largest probabilities of adoption (i.e., marginal effects) out of all 30 explanatory variables included in the models. This potentially indicates that Extension and the information and services it provides are very effective in influencing adoption rates among beef cattle producers. Rahelizatovo (2002) found similar results in her study of Louisiana dairy producers as did Nyaupane and Gillespie (2009) in their study of Louisiana crawfish producers. Even more telling is the fact that 60% of survey respondents reported having zero visits with Extension in a typical year. This emphasizes just how significant even one visit per year with Extension can be in helping promote the adoption of conservation practices to protect water quality. The significant influence of Extension visits on adoption might help explain the negative influence of college education on adoption.

This inverse relationship suggests that education in the form of informal meetings, seminars, and workshops offered by groups like Extension may be more important in influencing adoption behavior than education in the form of a formal four-year or advanced college degree. Furthermore, the area of study of respondents who indicated they had a college bachelor's or advanced degree is unknown. A non-agricultural related degree, for example, would not be expected to be positively associated with the adoption of agricultural-related conservation practices. Another interesting finding pertains to the number of visits a producer had with NRCS in a year (Q26_RCD). Having at least one visit with NRCS per year significantly decreased the probability of adopting control access by 14.6%, critical area planting by 22%, field borders by 13.6%, and in-stream watering points by17.5%. In fact, this variable decreased the probability of adoption (although not significant in all cases) for every single BMP included in this study. On the surface, this result is unexpected given one of the primary roles of the NRCS is to promote conservation practice adoption among landowners and livestock producers. Consequently, one might expect having at least one visit with NRCS per year would increase the probability of adopting a majority of BMPs. Indeed, Kim et al. (2005) found positive associations between adoption and at least one visit with NRCS.

Our study findings, however, potentially speak to themes of government mistrust and a strong propensity to protect private property rights. In a study of private property owners in Texas and Utah, Jackson-Smith et al. (2005) found respondents strongly agreed their individual property rights were being threatened by government agencies implementing public policies to protect both environmental quality and human health on private lands. Furthermore, respondents strongly agreed that land ownership obligated them to be good stewards of the environment suggesting personal responsibility, rather than public or government responsibility, is preferred in the protection of natural resources on private lands. In our study of Texas beef cattle producers, respondents also demonstrated this similar attitude with more than 94% of respondents agreeing with the statement, "It is my personal responsibility to help protect water quality." The negative relationship between visits with NRCS and adoption of water quality BMPs can also potentially be explained by a general dissatisfaction among some participants with NRCS services. Sanders (2005) found consistent complaints among landowners with regard to how the NRCS handled requests for installation of specific BMPs.Finally, it is worth noting that beef cattle producers have traditionally participated in fewer USDA conservation programs as compared to crop producers. Consequently, it is logical to observe a negative relationship between adoption and interactions with the NRCS. Furthermore, this study included a variety of practices applicable to not only rangeland and pasture, but cropland as well. As a result, the observed negative relationship might simply be explained by the fact that not all practices were applicable to our sample. Having at least one other family member working on the farm (Q23_RCD) positively influenced the probability of adopting critical area planting by 13.2%, filter strips by 9.2%, and shade structures by 17.3%. These findings are in agreement with previous research findings, which suggest extra labor on the farm is positively correlated with adoption.

The number of years spent running the livestock operation (Q21) only marginally increased the probability of adopting fencing and prescribed grazing by less than 1% each. This result is not surprising given previous research findings being split on the influence farming experience has on adoption behavior. Also worth noting is the number of years producers planned to run their operations in the future did not significantly influence adoption of any of the 18 BMPs included in the study. This finding could potentially speak to the changing trend of Texas agricultural lands being transferred to younger generations not reliant on agricultural production for income. Annual income (Q29) was positively associated with the adoption of several BMPs. A higher salary increased the probability of adopting diversions by 8.0%, fencing by 4.5%, field borders by 6.8%, grassed waterways by 6.7%, heavy use area protection by 8.1%, stream bank/shoreline protection by 6.1%, and watering facilities by 4.3%. Several of these BMPs were capital-intensive BMPs, substantiating the positive relationship between salary and adoption. It is interesting to note, however, that although significant, a higher salary only increased the probability of BMP adoption by a small percentage across all BMPs. Similar to annual income, the percentage of income coming from the beef cattle operation (Q30) was positively associated with the adoption of several BMPs. A higher percentage of income from the operation significantly increased adoption of diversions by 15.3%, field/salt/mineral locations by 11.6%, fencing by 10.2%, grassed waterways by 10%, pesticide management by 15.1%, prescribed grazing by 10.2%, and shade structures by 9.4%. Previous research suggested a strong correlation between income from the operation and adoption of BMPs that maintain the long-term health of the operation (Kim et al. 2005). Collectively, these BMPs would be expected to promote long-term benefits for the operation in terms of forage health and production as well as erosion control. The percentage of income from an off-farm source (Q31) was positively associated with the adoption of several BMPs.

A greater percentage of income from an off-farm source significantly, but only marginally, increased the probability of adopting diversions by 9.9%, heavy use area protection by 5.5%, in-stream watering points by 6.4%, mortality management by 5.8%, and watering facilities by 3.5%. Previous research suggests a greater percentage of off-farm income is associated with the adoption of capital-intensive practices, such as those noted above, rather than labor-intensive practices (Gedikoglu and McCann 2007). Finally, membership in a Texas livestock organization (Q34) significantly increased the probability of adopting fencing by 13.6%, but decreased the probability of adopting filter strips by 9.5%, grassed waterways by 18.7%, heavy use area protection by 11.7%, shade structures by 14.2%, and stream bank/shoreline protection by 10.4%. This result was unexpected given a major goal of livestock organizations such as the Texas and Southwestern Cattle Raisers Association is to provide education to livestock producers about best management practices. Rahelizatovo (2002) found a similar result with membership in the Louisiana Dairy Herd Improvement Association (DHIA) negatively influencing adoption of several conservation practices. She attributed the result to potential conflicting goals between the DHIA and conservation practices themselves; DHIA seeks to maximize producer profit through increased productivity although some conservation practices favor overall environmental improvement over profit maximization. In our study of Texas beef cattle producers, one potential explanation may have stemmed from the 76% of respondents who indicated they did not belong to a Texas livestock association. Furthermore, practices with negative associations might not necessarily be applicable to producers managing range/pasture operations. Consequently, the negative impacts of organization membership may be somewhat misleading.

Attitudes

The attitudinal construct was comprised of 5 different variables. Environmental attitude (EATT) and water quality attitude (WATT) were significant predictors of adoption for only 3 of the included practices. Higher EATT and WATT scores denote favorable environmental and water quality attitudes. According to the results, a one unit increase in EATT scores would increase the probability of adopting feed/salt/mineral locations by 13.1% and field borders by 12.9%. A one unit increase in WATT scores would increase the probability of adopting in-stream watering points by 13.1%. The lack of more significant impacts of EATT and WATT on producer adoption behavior is likely due to the fact that grand mean EATT and WATT scores were M=3.19 (SD = 0.54) and M=3.54 (SD = 0.50), respectively suggesting very neutral attitudes among respondents with regard to water quality and the environment.
Prior participation in a government-funded cost-share program (Q12) significantly impacted adoption for 7 out of the 18 practices. These practices were control access, critical area planting, field borders, grassed waterways, heavy use area protection, in-stream watering points, and prescribed grazing. The greatest increases in probabilities were seen for critical area planting and prescribed grazing. Prior participation in a government-funded cost-share increased the probability of adopting critical area planting by 27.7% and prescribed grazing by 24.0%. Prior participation had the least impact on the adoption of heavy use area protection, only increasing the probability of adoption by 14.7%. Having a family member planning to take over the operation upon the producer's retirement (Q24_RCD) was unexpectedly and significantly negatively associated with the adoption of diversions, filter strips, heavy use area protection, and in-stream watering points. In fact, this variable was negatively associated (although not significant in all cases) with the adoption of 12 out of the 18 BMPs included in the study. Kim et al. (2005) found similar negative associations, but failed to provide an explanation.A potential explanation in this study stems from the growing trend of agricultural land in Texas changing hands to a younger generation who may not be inclined to rely solely on agricultural production for income. A significant portion of this land is being managed for recreational purposes, which may preclude adoption of several agricultural BMPs. The producer's tendency to avoid risk (Q33_RCD) was surprisingly and significantly negatively associated with the adoption of field borders and mortality management, but positively associated with the adoption of shade structures and stream crossings. Stated differently, risk aversion reduced the probability of adopting field borders by 12.9% and mortality management by 20.7%. In fact, risk aversion was negatively associated (although not significant in all cases) with the probability of adopting 13 out of the 18 BMPs included in the study; one might expect just the opposite to be true. Kim et al. (2005) found this negative association in their study as well and attributed it to the fact that risk averse producers require sufficient information about the costs and benefits associated with the adoption of both management-intensive and capital-intensive practices prior to implementation.

Field borders and mortality management could both be considered management-intensive, and even capital-intensive, practices suggesting beef cattle producers did not have enough information about the costs and benefits associated with these practices prior to implementation.

Environmental Awareness

The environmental awareness construct consisted of six variables measuring overall knowledge of water quality issues and producer perception of water quality ratings in their area. The first variable (Q4) related to knowledge of the term “best management practice.” Of all 5 knowledge questions included in the study, this one had the greatest influence on adoption. Knowing the term “best management practice” significantly increased the probability of adopting control access by 18.6%, fencing by 18.8%, prescribed grazing by 13.0%, and soil testing by 17.5%. The second knowledge question (Q5) dealt with the term “nonpoint source pollution.” Knowing what this term meant significantly influenced the probability of adopting filter strips by 16% and watering facilities by 14%. Having the knowledge of bacteria being the major cause of water quality impairment in Texas (Q6) only significantly increased the probability of adopting stream crossings by 8.2%. Knowledge of efforts to control nonpoint source pollution through the Clean Water Act (Q7) did not significantly increase the probability of adopting any of the 18 items included in the study.

Finally, knowledge of the availability of financial assistance programs to help control nonpoint source pollution (Q8) significantly increased the probability of adopting field/salt/mineral locations by 15.0% and stream crossings by 19.3%. Collectively, knowledge of water quality issues appeared to have a fairly substantial influence on the adoption of water quality BMPs significantly contributing to the adoption of eight out of the 16 BMPs included in the study. It could be argued that increased knowledge should influence adoption of all BMPs included in this study. One potential factor preventing this is the number of respondents reporting very low knowledge levels for each of the five knowledge questions. Only 50% of respondents were aware of the term “best management practice,” which was the highest rated knowledge question. Approximately 23% of respondents knew the term “nonpoint source pollution,” 37% were aware bacteria was the major cause of water quality impairment in the state, 31% were aware of efforts to control nonpoint source pollution through the Clean Water Act, and only 15% were aware of the availability of financial assistance programs to implement BMPs. Even despite the seemingly low knowledge level among respondents, knowledge still positively contributed to the adoption of half of the BMPs suggesting the important role that knowledge and information can play in influencing adoption behavior. The final environmental awareness variable dealt with the perception respondents have to water quality in their area (Q36_RCD). A perception of water quality being rated good or very good (as compared to fair or poor) significantly decreased the probability of adopting shade structures by 17.5% and watering facilities by 10.3%. This variable was only significant for 2 practices, but perhaps speaks to the point that individuals are less likely to be proactive about something they do not see as a problem in the first place. Or, if they see it as a problem, they may not necessarily see it as their problem to fix as is the case with many common good resources (Hardin 1994). Mean water quality rating among all respondents was 3.28 (SD = 1.11; scale ranged from 1 to 5 with 1 being very poor and 5 being very good). A closer look at frequencies for each rating category revealed that respondents were evenly divided—roughly 50% perceived water quality to be rated good or very good while roughly 50% perceived water quality to be rated fair or worse.

Farm Characteristics

Operator gender (Q15) significantly influenced adoption of several practices. Being a female operator significantly reduced the probability of adopting critical area planting by 16.5%, field borders by 25.3%, grassed waterways by 22.4%, heavy use area protection by 19.7%, in-stream watering points by 13.1%, and shade structures by 15.1%. In addition to the number of yearly visits with Extension, gender seemed to be a fairly significant factor affecting adoption behavior. It is worth noting that only 13% of respondents were female, substantiating the overwhelming significant influence of this variable. Furthermore, 84.3% of females in our sample were older than 50 and 30.1% were older than 70. This finding is similar to what other research has found on gender differences in conservation practice adoption especially related to labor-intensive practices (Bayard et al. 2006). This finding directly supports new initiatives spearheaded by nonprofit groups such as American Farmland Trust to help empower female landowners to become conservation leaders. According to the 2007 Census of Agriculture, nearly 30% of all farms in the United States are operated by women, an 11% increase since 2002. The American Farmland Trust (2013) labels women operators as the “largest underserved group in agriculture.” As a result, the American Farmland Trust, the Women, Food, and Agriculture Network (WFAN), and others are partnering to provide women-only learning opportunities designed to promote awareness of conservation issues and increased adoption of conservation practices.

Initiatives likes these will undoubtedly become more critical as the number of female operators increase across the nation. The total acreage included in the operation (Q19), did not significantly increase the probability of adopting any of the 18 items included in the study. In fact, this variable influenced predicted probabilities the least out of all the variables included in the study. In addition, the ratio of land owned to total land operated (OWN_PER) and the ratio of land rented to total land operated (RENT_PER) did not significantly increase the probability of adopting any of the 18 items included in the study. The lack of significance for these two variables is not all that surprising given the relationship between land tenure and adoption rates is complex and not fully understood (Weinkauf 2008). Debt-asset ratio (Q32_RC) positively influenced the probability of adopting diversions by 7.9% and in-stream watering points by 5.4%. A higher debt-asset ratio is indicative of two different things (Rahelizatovo 2002). First, it may indicate a recent investment in adoption technology, which would increase the probability of adoption. Conversely, it may indicate investment in something other than adoption technology (e.g., college education, mortgage, car, medical bills), which would decrease the probability of conservation practice adoption. Both diversions and in-stream watering points are fairly capital-intensive practices suggesting the positive relationship between debt-asset ratio and adoption to mean a higher investment in conservation practice technology as suggested by Feder et al. (1985). Having a stream running through the property (Q35_RCD) significantly increased the probability of adopting an in-stream watering point by 19.6%, but significantly decreased the probability of adopting pesticide management by 15.1%, shade structures by 13.8%, and watering facilities by 14.2%. The decreased probability associated with the adoption of pesticide management can potentially be explained by the risks associated with applying pesticides near surface water and the impacts of mechanical, biological, and cultural pest suppression techniques on water quality, erosion, and natural resources. The decreased probability associated with the adoption of shade structures can potentially be explained by the fact cattle are using shade provided by the stream's riparian area, negating the adoption of a separate shade structure. Finally, the decreased probability associated with the adoption of watering facilities suggests cattle are drinking water directly from the stream running through the property.

Summary and Conclusion

Factors influencing the adoption behavior of Texas beef cattle producers were investigated in this study. Adoption rates were lowest for erosion and sediment control practices and highest for grazing management practices. The highest adopted practice overall was watering facilities with over 80% of producers indicating as having adopted this practice in the last 5-year period. The lowest adopted practice overall was filter strips with a 15.6% adoption rate.

This study also showed the adoption of BMPs by Texas beef cattle producers is influenced by variables related to capacity, attitudes, environmental awareness, and farm characteristics. Results from the probit models suggested the number of visits with Extension to be the most significant factor influencing conservation practice adoption. Interestingly, the number of visits with NRCS was the most significant factor reducing the probability of adopting several BMPs. This may speak to a strong underlying private property rights orientation among beef cattle producers in the state. The overwhelming positive influence of Extension suggests the potential impact this agency can have in influencing adoption behavior among not only beef cattle producers, but all types of landowners in the state. It also suggests a significant opportunity to increase educational opportunities promoting BMP adoption, a suggestion echoed by other similar adoption studies (Rahelizatovo and Gillespie 2004; Kim et al. 2005). Furthermore, these findings are evidence that the NRCS could benefit from a strategic and purposeful long-term partnership with Extension to promote the sustained adoption and management of conservation practices through true collaborative efforts. This innovative partnership would combine the technical and financial assistance opportunities provided by the NRCS with the educational expertise of Extension professionals to identify land areas in most need of protection, educate land managers/owners in these areas on practices and their environmental benefits, and secure participation of these individuals in effective and sustained implementation of well designed management practices and systems.

Results from the probit analyses also revealed formal education levels appear to reduce the probability of adopting BMPs. This result conflicts with other research findings that suggest increased educational levels translate to increased adoption of conservation practices. As previously discussed, this could be the result of respondents receiving non-agricultural degrees or it could suggest that informal education received through Extension programs and workshops are more important in influencing adoption behavior than formal education received through a four-year college degree.

Operator gender appeared to significantly influence adoption rates of BMPs with females being less likely to adopt several practices, particularly vegetated practices requiring planting such as cover crops, filter strips, and grassed waterways. This finding is similar to what other research has found and supports the utilization of women-only educational opportunities to secure adoption from this important population group. The American Farmland Trust and other organizations are addressing these opportunities through women-only learning circles designed to empower women to become leaders in conservation agriculture. Other significant predictors of adoption included prior participation in a government-funded cost-share program, annual income, percent income from the operation, and crop diversity. Participants who had previously participated in a government cost-share program were more likely to adopt several BMPs as compared to respondents who had not participated in a cost-share program before. Annual income was positively associated with the probability of adopting BMPs, particular those practices that were highly capital-intensive. Finally, the percentage of income derived from the operation positively influenced adoption behavior. Those with a higher portion of their income originating from the operation were more likely to adopt several practices, particularly those that helped ensure forage health and production as well as erosion control. Participants indicating they grew two or more types of crops were much more likely to adopt several practices, particularly vegetated practices requiring planting of seeds as well as pesticide and nutrient management BMPs. Producer environmental and water quality attitudes only marginally influenced adoption. This finding is perhaps somewhat misleading given respondents had fairly neutral attitudes as measured on both attitude scales. A greater effect might have been observed had producer attitudes measured more negative or more positive. The consistent negative association between membership in a Texas livestock organization and BMP adoption was not as expected. Rahelizatovo (2002) found a similar result in her study of Louisiana dairy producers. One potential explanation for this stems from the fact that very few respondents actually belonged to a livestock organization, which could have produced this negative association. Total land acreage as well as land tenure did not significantly influence adoption of BMPs. Furthermore, percent income from an off-farm source, the proximity of the closest water body to the operation, operator experience, and the number of years planning on running the operation only marginally influenced adoption behavior among respondents. These findings could speak to the growing trend in Texas of agricultural land changing hands to younger operators who do not intend on relying on agriculture production for income. In summary, the most significant predictors of adoption among survey respondents included visits with Extension, prior participation in a government cost-share program, crop diversity, annual income, and percent income from the operation. The most significant factors reducing the probability of adoption among survey respondents included formal education, gender, visits with NRCS, membership in a livestock organization, and having a family member take over the operation.

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Figure 1: Adoption of Water Quality Best Management Practices by Texas Beef Cattle Producers

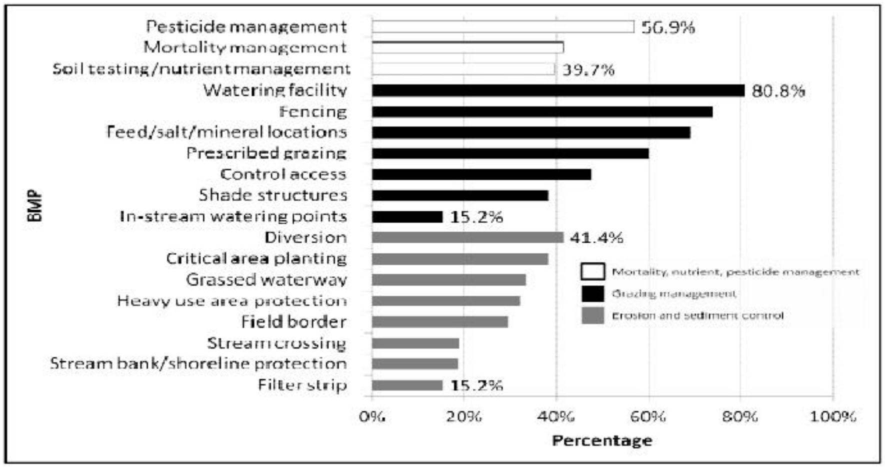

Table 1: Best Management Practices for Texas Beef Cattle Producers

Best management practice	Description[1]
I. Erosion and sediment control practices	
Critical area planting	Planting vegetation to protect highly erodible or critically eroding areas.
Diversion	Channel constructed across a slope to divert excess water for use or safe disposal in another area.
Field borders	Strip of permanent vegetation established at the edge or around the perimeter of a field.
Filter strips	Strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and waste water.
Grassed waterways	Shaped or graded channel established with vegetation to carry surface water at a non-erosive velocity to a stable outlet.
Heavy use area protection	Establishment of stable surface with suitable materials to protect heavily used areas from livestock, vehicles, or development.
Stream crossing	Stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles.
Stream bank and shoreline protection	Using vegetation or structural techniques to stabilize and protect banks of streams, lakes, estuaries, or excavated channels against scour and erosion.
II. Grazing management practices	
Access control	Temporary or permanent exclusion of animals, people, vehicles, and/or equipment from an area.
Fencing	Constructed barrier to livestock, wildlife, or people.
Field, salt, and/or mineral locations	Placement of feed, salt, and/or minerals off-stream as an attempt to improve grazing distribution and encourage livestock to move away from sensitive riparian areas.
In-stream watering point	Providing limited access to stream for purposes of watering livestock.
Prescribed grazing	Controlled harvest of vegetation with grazing or browsing animals, managed with the intent to achieve a specified objective.
Shade structure	Permanent or portable framed structure to provide shade for livestock away from riparian area and to improve grazing distribution.
Watering facility	Permanent or portable device to provide an adequate amount and quality of drinking water for livestock and/or wildlife.
III. Mortality, nutrient, pesticide management	
Mortality management	Properly managing on-farm mortality through composting, burial, or other means.
Pesticide management	Sustainable approach to manage pests using a combination of techniques and technologies that may include chemical, biological, cultural, habitat manipulation, and use of resistant plant varieties.
Soil testing and nutrient management	Managing amount, source, placement, form, and timing of the application of nutrients and soil amendments.

[1] Descriptions adapted from USDA-NRCS practice standards

Table 2: Response Rate by Size Group

Size Group	Original Sample	UAA[1]	Out of Business	Refusal	Sample 1/[2]	Completed	Response Rate[3]
Small	460	8	5	9	438	228	52.1
Medium	784	7	6	26	745	342	45.9
Large	456	4	3	8	441	209	47.4
Total	1700	19	14	43	1,624	779	48.0

[1]UAA = undeliverable, post office returns.
[2]Sample 1/ excludes UAAs, Out of Business, and Refusals.
[3]Response Rate = Completed ÷ Sample 1/

Table 3: Summary Statistics for Explanatory Variables Included in Probit Analyses

Variable	Description	*M*	*SD*
Attitude		—	—
EATT	Summated score on NEP scale	3.19	0.54
WATT	Summate score on water quality attitude scale	3.54	0.50
Q12	Prior participation in government cost-share program	0.31	0.46
Q24_RCD	Dummy for whether any family plans to take over farm	0.39	0.49
Q33_RCD	Dummy for risk-averse operator	0.65	0.48
Capacity		—	—
AGE	Age of operator	62.90	11.70
Q1_RC	Dummy for livestock diversity	0.37	0.48
Q2_RC	Dummy for crop diversity	0.18	0.39
Q17_RCD	Dummy for holding a college bachelor's degree	0.42	0.50
Q23_RCD	Dummy for family members working on farm	0.60	0.49
Q21	Number of years running livestock operation	25.90	21.40
Q22	Number of years planning to run operation into future	38.70	409.20
Q29	Annual income (1-5 scale treated as continuous)	2.13	1.41
Q30	% operation income (1-5 scale treated as continuous)	2.04	0.96
Q31	% off-farm income (1-5 scale treated as continuous)	4.42	1.86
Q25_RCD	Dummy for visits with Extension	0.40	0.49
Q26_RCD	Dummy for visits with NRCS	0.33	0.47
Q34	Member of Texas livestock organization	0.24	0.43
Environmental Awareness		—	—
Q4	Knowledge of term best management practice	0.50	0.50
Q5	Knowledge of term nonpoint source pollution (NPS)	0.23	0.42
Q6	Knowledge of bacteria as major cause of impairment	0.37	0.48
Q7	Knowledge of Clean Water Act to control NPS	0.31	0.46
Q8	Knowledge of financial assistance programs for NPS	0.15	0.36
Q36_RCD	Dummy for rating of water quality in area	0.49	0.50
Farm Characteristics		—	—
Q15	Male/female	0.13	0.34
Q19	Total acreage in operation	1864.90	6539.60
OWN_PER	Ratio of land owned to total land operated	0.84	1.06
RENT_PER	Ratio of land rented to total land operated	0.33	0.40
Q32_RC	Dummy for debt-asset ratio	0.08	0.28
Q35_RCD	Dummy for nearest water body to operation	0.35	0.48

Table 4: Marginal Effects of Probit Analyses on the Adoption of best Management Practices by Texas Beef Cattle Producers

Variables	Control Access	Critical Area Planting	Diversion	Field / Salt / Mineral Location	Fencing	Field Border
Q4	0.18604***	0.07177	0.01963	0.03225	0.18776***	0.02701
Q5	-0.09721	-0.02867	-0.01131	0.00562	0.06234	0.09916
Q6	0.0443	0.04289	-0.03948	0.06133	-0.00211	0.00595
Q7	0.03836	0.00502	0.07893	-0.00903	-0.05079	0.06998
Q8	0.04705	0.08638	0.05863	0.14980*	0.13389*	0.02349
Q12	0.15368*	0.27715***	0.1172	-0.10909	0.00018	0.15474*
Q15	-0.08529	-0.16547*	-0.10613	0.03176	-0.02816	-0.25283***
AGE	-0.00376	-0.00468	-0.00224	0.00516	-0.00088	-0.00264
Q19	-0.36316D-05	-0.66042D-05	-0.55481D-05	0.22655D-04	-0.22683D-05	0.21423D-05
Q21	-0.00102	0.00064	0.00121	0.00123	0.00332*	0.00073
Q22	-.85246D-05	-0.57534D-04	0.83654D-04	-0.34478D-04	0.00057	-0.35875D-04
Q29	-0.00921	0.0271	0.08025***	0.03117	0.04483*	0.06792**
Q30	0.07612*	0.06313	0.15372***	0.11617**	0.10165**	-0.00022
Q31	0.00794	0.00924	0.09945***	0.01366	0.00985	0.00264
Q34	0.02538	0.02337	-0.10546	-0.03118	0.13616*	-0.08395
WATT	0.01744	0.0638	-0.03128	-0.05825	-0.07793	-0.03732
EATT	0.12204	0.03444	0.04068	0.13139*	0.03833	0.12895*
Q17_RCD	-0.01671	-0.10766	-0.13208**	0.05675	0.01494	-0.03785
Q23_RCD	-0.02016	0.13222*	-0.0916	0.05034	0.03939	-0.0611
Q25_RCD	0.26535***	0.11377	0.10481	0.20103***	0.03595	0.05437
Q26_RCD	-0.14548*	-0.21964***	-0.02885	-0.05984	-0.04895	-0.13627*
Q33_RCD	-0.04783	-0.10608	-0.07525	-0.08121	-0.03761	-0.12874*
Q35_RCD	0.02421	0.08553	0.06919	0.01044	-0.04032	-0.01088
Q36_RCD	0.10051	-0.02556	-0.09028	0.02153	0.00448	-0.0245
Q1_RC	0.19898***	0.02882	0.07176	-0.03463	0.04335	0.00956
Q2_RC	0.04685	0.15577*	0.25822***	0.12103	0.03496	0.26962***
OWN_PER	-0.14031	-0.01093	-0.07976	-0.03901	0.00378	0.09425
RENT_PER	0.02919	0.05353	-0.0248	0.09643	0.03078	0.11836
Q32_RC	0.02181	-0.01004	0.07930*	0.05753	0.01336	0.01202
Q24_RCD	0.00794	-0.06488	-0.12644*	-0.01883	0.00737	-0.10172
Observations	187	190	183	186	192	183
McFadden's R^2	0.226	0.166	0.257	0.223	0.166	0.222
% Correctly Predicted	63.64	62.11	66.67	67.74	67.71	67.76

*** Values significant at 1% level
** Values significant at 5% level
* Values significant at 10% level

Table 4.17 Continued

Variables	Filter Strip	Grassed Waterway	Heavy Use Area Protection	In-Stream Watering Point	Mortality Management	Pesticide Management
Q4	-0.01349	-0.06889	0.01238	-0.08579	-0.01836	0.01837
Q5	0.15969*	0.03585	-0.01137	-0.06982	0.12797	0.14329
Q6	-0.00317	-0.03907	0.02926	-0.00385	0.02938	0.04935
Q7	0.10517	0.12233	0.01075	0.0979	0.06781	0.11779
Q8	0.0591	-0.02749	0.06093	0.00012	0.01167	0.00064
Q12	0.07881	0.23535**	0.14730*	0.23427***	0.15461	-0.06162
Q15	0.04725	-0.22411***	-0.19722***	-0.13075***	0.07757	0.01037
AGE	-0.00111	-0.00291	0.00264	0.00141	-0.00363	0.00673*
Q19	0	-0.47851D-05	0.34714D-06	0	-0.18370D-05	-0.70658D-05
Q21	0.00116	-0.00086	0.72647D-04	0.00132	0.00232	-0.00183
Q22	0.61147D-05	-0.48194D-04	-0.21401D-04	0.15177D-04	-0.00029	0.87509D-04
Q29	0.00885	0.06734***	0.08123***	0.0076	0.03385	0.02237
Q30	0.0019	0.09998***	0.06739	0.0468	0.03916	0.15130***
Q31	0.03395	0.02202	0.05066*	0.06416*	0.05839*	0.03661
Q34	-0.09520**	-0.18691***	-0.11765*	-0.03846	0.02328	-0.03321
WATT	-0.00045	0.01742	0.02587	0.13081**	0.03172	-0.08832
EATT	-0.05586	0.05421	0.02948	0.05072	-0.03021	0.07291
Q17_RCD	-0.02197	-0.02763	-0.05242	-0.03294	-0.06127	-0.00366
Q23_RCD	0.09157*	0.01409	0.0379	0.04662	-0.1046	0.02576
Q25_RCD	0.12030**	0.09988	0.13321*	0.02885	0.07182	0.26099***
Q26_RCD	-0.09891	-0.10002	-0.07934	-0.17530***	-0.11405	-0.09343
Q33_RCD	0.06103	0.09455	-0.084	-0.04092	-0.20688***	-0.10543

Q35_RCD	0.01255	0.01742	-0.05039	0.19604***	0.02549	-0.15105**
Q36_RCD	0.008	-0.03311	0.02253	0.09656*	-0.06159	0.0635
Q1_RC	-0.00101	0.00205	0.10778	0.02168	-0.00081	-0.03062
Q2_RC	0.19528***	0.24827***	0.03005	0.15787**	0.10899	0.25285***
OWN_PER	0.02545	-0.12726	-0.01413	-0.09659	-0.21095	-0.00325
RENT_PER	-0.06376	-0.09986	-0.24001	-0.14358	-0.2594	-0.14055
Q32_RC	0.02195	0.028	-0.00572	0.05428*	0.04377	0.03991
Q24_RCD	-0.14960***	-0.00043	-0.16730***	-0.09087*	-0.00278	0.04429
Observations	181	184	183	181	185	186
McFadden's R^2	0.311	0.268	0.206	0.359	0.186	0.237
% Correctly Predicted	83.42	70.65	68.31	82.32	64.32	63.44

*** Values significant at 1% level

** Values significant at 5% level

* Values significant at 10% level

Table 4.17 Continued

Variables	Prescribed Grazing	Shade Structure	Soil Testing	Stream bank / Shoreline Protection	Stream Crossing	Watering Facility
Q4	0.12960*	-0.01896	0.17542**	0.04082	0.05346	0.01957
Q5	-0.0532	-0.07284	-0.08394	0.0863	0.10848	0.14152**
Q6	-0.02111	-0.08173	-0.04946	0.04111	0.08191*	0.15127***
Q7	0.1025	-0.02045	0.10835	0.06155	0.00906	-0.00778
Q8	-0.01957	0.00585	0.0886	0.04186	0.19269**	-0.04654
Q12	0.24112***	-0.04283	0.09222	0.06735	-0.00276	0.10196
Q15	-0.12365	-0.15093*	-0.02668	0.16463	-0.02268	0.01808
AGE	0.00498	0.01265***	0.00627	0.0026	0.00065	0.00591*
Q19	-0.73692D-05	-0.96817D-06	-0.85678D-05	0.13702D-05	0.47878D-06	0.11551D-04
Q21	0.00414*	0.18070D-05	-0.00347	0.0002	0.0016	-0.00162
Q22	-0.47208D-04	-0.00018	-0.51548D-04	-0.18757D-04	0.00024	0.00048
Q29	-0.01391	0.03985	0.03787	0.06081**	0.02867	0.04319*
Q30	0.10236**	0.09364**	0.05471	0.03659	-0.00764	0.06274
Q31	0.03406	0.01606	0.03932	-0.0023	0.00308	0.03452*
Q34	0.02734	-0.14171*	0.00309	-0.10444**	0.0124	-0.02451
WATT	0.0029	-0.08539	0.00986	0.06091	0.0347	-0.08334
EATT	0.01857	0.04406	-0.02473	-0.03767	-0.04407	0.05411
Q17_RCD	-0.1128	-0.02332	-0.15342**	-0.03376	-0.00523	-0.07306
Q23_RCD	-0.00738	0.17349***	-0.01143	0.0233	0.07114	0.00254
Q25_RCD	0.09339	0.0094	0.38781***	0.08722	0.12049**	0.00973
Q26_RCD	-0.05622	-0.11412	-0.10123	-0.07693	-0.08074	-0.08673
Q33_RCD	-0.10059	0.13352*	-0.00504	-0.03983	0.09447*	0.00429
Q35_RCD	-0.05604	-0.13820**	-0.00603	0.09845	0.07478	-0.14212**
Q36_RCD	-0.07946	-0.17522***	0.08509	0.07107	0.00735	-0.10260*
Q1_RC	0.12691	0.08407	-0.03519	-0.07904	0.01437	0.12419*
Q2_RC	0.13075	0.05959	0.21739***	-0.00982	0.13547*	0.0616
OWN_PER	-0.12404	0.08398	0.04522	-0.16643	0.00554	0.05724
RENT_PER	0.04955	0.20689	0.16527	-0.10999	-0.01244	0.17215
Q32_RC	-0.02432	0.04917	0.00229	-0.03674	-0.01135	-0.02519
Q24_RCD	0.0821	0.08752	-0.05226	-0.03995	-0.06367	0.06437
Observations	186	181	182	180	175	189
McFadden's R^2	0.171	0.213	0.266	0.309	0.327	0.179
% Correctly Predicted	62.37	66.85	67.03	80.00	84.00	72.49

*** Values significant at 1% level

** Values significant at 5% level

* Values significant at 10% level