Willingness to Adopt Best Management Practice Bundles by Beef Cattle Operations in an East Tennessee Watershed

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Abstract

Voluntary programs to reduce nonpoint source pollution are an important component of efforts to reduce water quality degradation in the U.S. Understanding the factors influencing the willingness of nonpoint sources such as farms to participate in these programs is critical to effectively designing and implementing these programs. This study examines factors influencing willingness to adopt four different best management practices—rotational grazing, pasture improvement, stream water crossing, and water tank systems—by beef cattle operations in an East Tennessee watershed. Factors examined include farm and farmer characteristics, farmer attitudes, and a hypothetical incentive program to encourage adoption of these practices. Younger, more educated producers with higher income levels and larger households were more willing to adopt the BMPs. Producers were more willing to adopt pasture improvement and least willing to adopt stream crossings. Producers also seemed willing to adopt a bundle comprised of pasture improvement, rotational grazing and water tanks.

Introduction

The leading contributors to water quality impairment in the United States (U.S.) are nonpoint sources (USEPA 2011; USEPA 2014). Leading the pack is agriculture, which contributes to the impairment of more miles of rivers and streams in the U.S. than any other single source and lags only "atmospheric deposition" and "unknown" in its contribution to the impairment of U.S. lake, reservoir and pond acres (USEPA 2014). Thus, reducing pollution from agriculture and other nonpoint sources is essential for reducing water quality impairment in the U.S. (Ribaudo, Horan, and Smith 1999). Current policy approaches to reducing nonpoint source pollution rely heavily on voluntary programs designed to promote the adoption of best management practices (Rahelizatovo and Gillespie 2004; Ice 2004; Adler 2013).[1] When used in this context, best management practices (BMPs) refer to management and production practices and structures that permit economically viable production while limiting the adverse impact of such production on the ambient environment.

Thus, implementing BMPs on farms has the potential to reduce pathogen, nutrient, and sediment loading of rivers and streams and can sometimes improve the overall farming operation. However, monetary incentives may be necessary to promote economically efficient levels of voluntary BMP adoption as producers are unlikely to capture all of the benefits of such adoption (Ribaudo, Horan, and Smith 1999). For agriculture, these incentives are provided by both state programs funded under Section 319 of the Clean Water Act and U.S. Department of Agriculture (USDA) programs such as the Environmental Quality Incentives Program (EQIP) and the Water Quality Incentive Program (WQIP). EQIP offers educational and technical assistance as well as cost-shares or incentive payments after BMPs are adopted (Gillespie, Kim,

[1] In other words, BMPs are techniques that minimize the impacts of operation choices on water quality (Ice 2004).

and Paudel 2007; Kim, Gillespie, and Paudel 2004). Since BMP adoption by farmers is largely voluntary, the success of programs promoting BMP adoption depends on farmer willingness to adopt (WTA).

This project analyzes the willingness of cattle producers in a group of watersheds in southeast Tennessee in which water quality has been adversely impacted by livestock grazing to adopt one or more of four different livestock-related BMPs (i.e., pasture improvement, alternative water sources, stream crossings, and rotational grazing). Program and producer characteristics that influence WTA are also analyzed. Information about producer WTA and the program and producer characteristics that influence WTA will be useful in the design and implementation of programs promoting BMP adoption and in estimating the cost of the incentives needed to induce a specific level of adoption (Kim, Gillespie, and Paudel 2004) or to achieve a specific level of water quality improvement. This information can also be used to guide agricultural extension efforts to educate farmers on BMP adoption.

BMPs Analyzed

The BMPs analyzed in this study contribute to water quality improvement primarily by improving land capacity to reduce runoff and decreasing the amount of time cattle spend in or near streams. Studies have shown that decreased time in/near streams lessens fecal bacteria pollution of the water (Giuliano 2009; Hoorman and McCutcheon 2005; Redmon et al. 2008; Adams 1994). Other positive impacts of these BMPs include decreased disturbance of stream beds and therefore lower water turbidity, less sediment and nutrient runoff from surrounding pastureland, a healthier riparian zone, and greater capacity to support diverse life in and around the stream. Perhaps the most direct way to exclude livestock from streams is simply to fence animals out using exclusionary fencing. However, producers in the research area are reluctant to use such fencing because of frequent flood events that wash out fences or require periodic removal of debris from the fences. Thus, the BMPs analyzed are designed to entice cattle to voluntarily reduce time spent in the riparian zone.

Pasture improvement is designed to prevent erosion and runoff of bare soil. Planting shade and cover crops such as trees, shrubs and varieties of grasses, fertilization to improve cover growth, and riparian buffers help reduce erosion, stabilize stream banks, and trap many contaminants carried by runoff to the stream (Hoorman and McCutcheon 2005; Undersander and Pillsbury 1999; Ice 2004; Adams 1994). By improving the appearance of the farm, pasture improvement can also increase the farm's aesthetic and property value (Hoorman and McCutcheon 2005).

Alternative water sources provide livestock with drinking water away from streams and rivers without fencing (USEPA 2012; George et al. 2008; Hoorman and McCutcheon 2005; Giuliano 2009; Adams 1994). Alternative water sources are often a necessary component of grazing regimes that control livestock movement, such as rotational grazing and exclusion fencing, but also are an option for farmers who are unwilling or unable to physically restrict cattle movement and have been found to be effective by themselves of decreasing cattle activity in and around streams (Adams, 1994; Hoorman and McCutcheon 2005; Redmon et al. 2008; Sheffield et al. 1997; Wagner et al. 2008). Alternative water sources can also increase producer flexibility in pasture management, help ensure a supply of clean drinking water, reduce injury risk to cattle along stream banks, and improve the performance of feeder calves transitioning from pastures to feedlots (Giuliano 2009; Adams 1994).

Stream crossings are single points in a stream that provide a stable way for livestock and vehicles to move between pastures separated by water (Undersander and Pillsbury 1999). Gravel, rock, or geo-textile is often used to line the bottom of a stream to provide a firm, stable footing for cattle or farm vehicles to cross without difficulty (Undersander and Pillsbury 1999). Fences and gates may be installed as an alley for the cattle to cross, but fencing is not necessary (Adams 1994). “Cattle tend to use the easiest locations in a stream to cross,” so if the crossing is constructed in a convenient and familiar location, the transition should be successful (Henry and Reynolds 2003). Stream crossings can improve water quality by reducing the erosion of stream banks (Undersander and Pillsbury 1999) and reducing the total waste entering the stream by discouraging livestock from gathering and remaining in the stream (Hoorman and McCutcheon 2005). Use of stream crossings can also decrease the risk of injury to the cattle caused by falling down eroded banks (Undersander and Pillsbury 1999).

Rotational grazing is a controlled access BMP in which fencing separates pasture into smaller sections known as paddocks (Wagner et al. 2008; USEPA 2012; Giuliano 2000; Buschermohle et al. n.d.). Temporary electric wire fencing can be used in lieu of traditional fencing to maximize flexibility and reduce the cost and difficulty of installation and maintenance (White and Wolf 2009). With rotational grazing, the farmer controls the intensity—when, where, length of time—of the livestock in each section (Hoorman and McCutcheon 2005). As many grazing issues are caused not by overstocking of animals but by uneven distribution of livestock over pasture land, rotational grazing allows the farmer to change the distribution patterns of the cattle (George et al. 2008; White and Wolf 2009). Rotational grazing can increase the available forage by managing the growth and harvest of the vegetation, as vegetation in the first stage of growth—the leafy stage—is easiest to digest and provides higher percentages of protein than later stages of plant growth (White and Wolf 2009). Farmers must manage paddocks and rotate the cattle through the grazing areas so that the cattle can consume the vegetation in this leafy stage and allow time for the plants to re-grow their leaves and maintain a healthy root system (White and Wolf 2009). As distribution of the cattle across the land improves, stocking rates can rise by 30-50% because forage waste is reduced, plant re-growth is maintained in the leafy stage longer (increasing available forage), and the grazing season can be extended by planting different forage types in each paddock (White and Wolf 2009). Adoption of rotational grazing can increase farm productivity, decrease input expenses (feed costs), and protect the environment (Hoorman and McCutcheon 2005).

BMP Adoption Studies

The factors influencing the adoption of BMPs or other conservation-oriented practices by farmers have been extensively studied (Prokopy et al. 2008; Knowler and Bradshaw 2007; Kabii and Horwitz 2006; Baumgart-Getz, Prokopy, and Floress 2012; Pannel et al. 2006). For example, Prokopy et al. (2008) use the results of 55 studies to examine general patterns in the effect of farm characteristics and farmer capacity, awareness, and attitudes on BMP adoption.[2] In general, they find little evidence to suggest that farm income had a major influence on BMP adoption and mixed evidence on the effects of farmer experience and tenure. While their findings suggest that older farmers are less likely to change management practices than younger farmers, there is some evidence suggesting that some older beef cattle producers may farm "as a hobby and place high importance on the [health] of the land [and water]" (Prokopy et al. 2008, 307). They find that time and effort required for installation and maintenance influenced adoption for most BMPs, but evidence for those regarding water or livestock management is unclear. Farms with better soil quality were found to be more willing to adopt BMPs, likely because BMP adoption would preserve that resource. They also find that grain farms were more likely overall to adopt BMPs

[2] In contrast to this study, all studies included in the Prokopy et al. (2008) analysis were of actual, and not hypothetical, BMP adoption.

than livestock operations. In general, they found that BMP adoption was significantly influenced by producer attitudes toward such issues as risk, profit potential, cost-share programs, heritage, and, not surprisingly, environmental stewardship. Finally, Prokopy et al. (2008) note that the literature is focused on the relationship between soil quality, nutrient deficiencies, and pest management and BMP adoption, and that the relationship between water quality concerns and BMP adoption is underrepresented in the literature. Thus, while much attention has been paid to BMP adoption, further research is needed to better understand water quality and livestock-related BMP adoption in particular.

In a similar review of studies from 1982 to 2007, Baumgart-Getz, Prokopy, and Floress (2012) also focus on actual BMP adoption (instead of WTA measures) and the factors that influence adoption. They find that adoption is positively correlated with the importance a farmer places on water quality and the farmer's perception of the profitability of the practice. However, they find that other attitudinal and environmental awareness questions asked in surveys are not as helpful in understanding adoption decisions. Questions regarding non-point pollutants were not specific enough, nor did the questions clearly define connections of BMP adoption to environmental and water quality improvements. They conclude that many questions pertaining to attitude and preference were not specific enough to explain possible behaviors.

The factors influencing the adoption of new conservation practices by rural landowners are also analyzed in a review of literature conducted by Pannel et al. (2006). They find that BMPs are adopted only when the practice is perceived by the farmer to be beneficial, i.e., to help the farmer meet his economic, social and environmental goals. They also find that ease of adoption, the simplicity of BMP operation, and both social and environmental benefits gained from the practice characterize BMPs with higher adoption levels. These results led the authors to conclude that the real challenge in promoting BMP adoption is identifying practices that are both better for the environment and economically superior to current management practices.

There have also been studies focused on the adoption of water-quality related BMPs by cattle producers. Through the use of a mail survey, Gillespie, Kim, and Paudel (2007) analyze BMP adoption by Louisiana beef producers. They find that adoption was influenced by farm size, BMP type, and labor availability to implement the practice. They find that the three BMPs with the highest adoption rates were waste management systems (83%), grazing management practices (80%), and prescribed grazing (72%). Other BMP adoption rates ranged from 19% to 75%, but “few producers had adopted BMPs with incentive or cost-share payments” (p. 94). The most frequently adopted BMPs all had immediate economic benefits. The farmers who were more likely to adopt BMPs typically possessed greater capital and labor resources, faced highly erodible soil risks, and had been exposed to information from extension efforts. Gillespie, Kim, and Paudel (2007) assert that extension and educational programs and outreach should provide both economic and environmental costs and benefits of BMP adoption to farmers to enable farmers to better calculate the cost and environmental effectiveness of the BMPs.

Using some of the data also used in this study, Lambert et al. (2014) find rotational grazing and pasture improvement systems to be more popular among cattle owners than water tanks and stream crossings. The single most popular choice was to adopt cattle water tanks, rotational grazing and pasture improvement practices as a bundle. Producers who had already taken steps to improve their pastures were more likely to be willing to adopt cattle water tanks, stream crossings, and to make additional improvements to their pasture. Respondent WTA seemed to be positively influenced by the expanded cattle management options afforded by the BMPs and the possibility of improved cattle health and productivity associated with rotational grazing and pasture improvement. The amount of the cost share offered respondents seemed to have more influence on the adoption of cattle water tanks and pasture improvement systems than on stream crossings and rotational grazing.

In a study on crop-related BMP adoption, Cooper (1997) estimated the WTA of farmers across four critical watersheds—eastern Iowa and Illinois basin, Albermarle-Pamlico basin in Virginia and North Carolina, Florida-Georgia coastal basin, and upper Snake River Basin—using responses to survey that included a hypothetical, dichotomous choice contingent valuation (CV) experiment. The sample frame consisted of farmers in the four watersheds not currently using the subject BMPs. The CV experiment provided bids per acre to track WTA at various cost-share amounts randomly assigned with equal probability across the sample (Cooper 1997). The study extended the results from the hypothetical WTA responses to include farmers who currently use these BMPs without a payment incentive, assuming the latter to be willing to adopt the BMP with a cost share of $0. WTA measures provide a guide to creating cost-share programs, and minimum values are necessary to accurately estimate the optimal cost-share values to entice the largest number of participants.

Research Area

The Oostanaula Creek watershed (Hydrologic Unit Code TN06020002083) located in southeastern Tennessee, fails to meet national water quality standards due to sediment, phosphorus, and pathogens—particularly fecal coli-form bacteria (Tennessee Department of Environment and Conservation 2002; Tennessee Department of Environment and Conservation 2012; Hagen and Walker 2007). Oostanaula Creek is listed on the 303(d) list of impaired water-bodies because it does not fully support its designated use classifications: recreation, fish and aquatic life habitat, irrigation, and livestock watering (Tennessee Department of Environment and Conservation 2002). Total Maximum Daily Load (TMDL) safety limits have been exceeded and reductions of 54.4-72.2% in E-coli, 79.2% in phosphorus, and 59.4% in sediment must be met for the stream to be removed from the 303(d) list (Hagen and Walker 2007). A measurement of non-point sources of pathogens using the Bacterial Source Tracking (BST) method has determined a majority of fecal loads (22-92% at various site locations) are of bovine origin (Hagen and Walker 2007). Much of the agricultural land in this watershed functions as pasture for grazing livestock, predominantly cattle. Therefore, adoption of BMPs by cattle producers is a major focus for efforts to improve Oostanaula Creek water quality.

Concerns exist because microorganisms present in livestock waste pose potential threats to human health. These threats include several diseases that can be transmitted from infected animals to humans through contact with contaminated water (Ribaudo, Horan, and Smith 1999). Even healthy cattle are not immune: up to 25% of cattle are infected with E-coli, 13% are infected with salmonella, and others carry cryptosporidium, campylobacter, listeria, and giardia (Wagner et al. 2008). These pathogens can cause abdominal pain, nausea, vomiting, fever, diarrhea, renal failure, and even death in humans (Wagner et al. 2008).

Methods

Data Collection

For this research, a survey instrument was used to collect data from cattle farmers to estimate WTA specific BMPs in the Oostanaula Creek and surrounding watersheds. The survey list frame was developed from tax parcel information managed by three counties in Tennessee: McMinn, Bradley and Monroe. The tax parcel information is publicly available and includes the physical addresses of land owners and classification of the parcels based on land use (Clark, Park, and Howell 2006). Parcels classified as either “agricultural” or “farm” were selected for this study. The distinction between the agricultural and farm classifications is that parcels classified as agricultural land are enrolled in Tennessee's Greenbelt Program (Agricultural, Forest and Open Space Land Act of 1976), while those classified as farmland are not (Chervin, Gibson, and Green. 2009). Tax parcel records were used to construct the survey list frame so that respondents could be geospatially located in the watershed since one purpose of the survey was to gather information for a biophysical model of the watershed. One disadvantage of using tax parcel records to compile a list frame is that there is no reliable way to identify cattle producers from the individuals who owned parcels that were classified as either agricultural or farm. Thus, the entire population of agricultural or farmland owners was sampled without prior information about who owned cattle in two different waves. A first wave was sent in March 2011 to 1,480 unique owners of 1,736 agricultural parcels located in the portions of Oostanaula Creek and five surrounding watersheds contained within McMinn County [i.e., Sweetwater (HUC TN 06020003100), Mouse Creek (HUC TN 0602000208), Middle Creek (HUC TN 060200020502), Pond Creek (HUC TN 06010201013) and Lower Chestuee Creek (HUC TN 0602000205)]. After collection of tax parcel data from Bradley and Monroe Counties, a second wave was sent in February 2013 to 3,678 unique owners of 4,720 agricultural parcels located in the parts of the Hiwassee (HUC TN 06020002), Lower Little Tennessee (HUC TN 06010204) and Watts Bar Lake (HUC TN 06010201) watersheds contained within Bradley, McMinn, and Monroe Counties. See Figure 1.

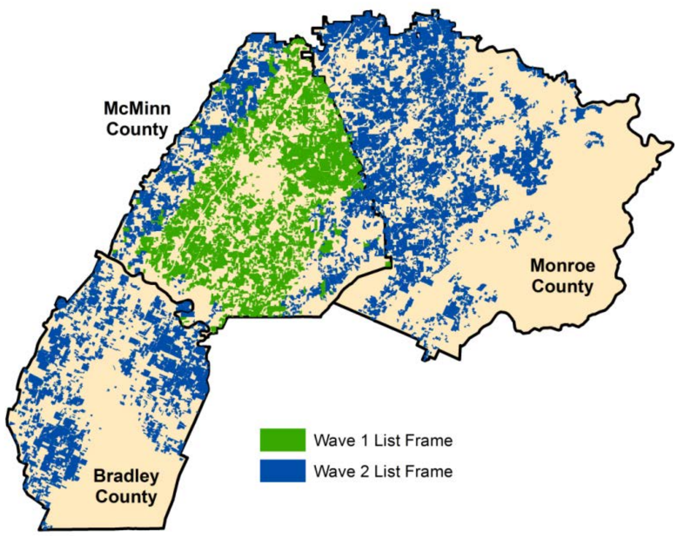

Figure 1. List Frames for Wave 1 and Wave 2

Each wave was mailed to parcel owners following Dillman's tailored design method (Dillman, Smyth, and Christian 2009). A package containing a cover letter, survey instrument, and a self-addressed, stamped envelope were mailed to land owners. A follow-up reminder postcard was mailed one week after the first survey mailing. Non-responders were sent a second survey containing another cover letter, the survey instrument, and a self-addressed, stamped envelope two weeks after the reminder postcards were sent.

The survey instruments used in each wave were similar, but not identical. Each contained four major sections. The first section, "Your Farm Operation," focused on characteristics of the farm operation and included a question on the importance to the farmer of various objectives related to the BMPs (e.g., improving forage quality, providing cattle access to a year-round supply of clean drinking water). The second section, "Best Management Practices (BMPs)," began with questions about cattle owners' experience with various BMPs, followed by a description of the actions needed to be taken to implement the four BMPs being analyzed, including maintenance, materials that needed to be installed, and managerial activities, and the possible benefits from adoption of the BMP.

Respondents were also provided estimated per unit establishment costs for each practice based on cost share amounts reported by Tennessee NRCS (TN NRCS 2010): pasture improvement = $253.33 per acre; stream crossing = $3.87 per foot; rotational grazing = $32.00 per acre; and cattle water tanks = $1,533.33 per tank. These full costs were determined by dividing the equipment and practice cost share amounts reported by Tennessee NRCS by 0.75. The cost share amounts offered to respondents were then determined by multiplying these expected costs by 50%, 62.5%, 75%, 87.5%, 100% (the base), 112.5%, and 125%. These values represent the amount producers would be eligible to receive for implementing a practice. Cost share amounts varied randomly between practices. Cost shares exceeding 87.5% were included because we were interested in learning about how producers would respond if the technologies were provided at no out-of-pocket cost (the 100% cost share rate) or if they were paid an amount in excess of the Tennessee NRCS estimate of the cost to adopt a technology (the 112.5% and 125% cost share rates).

In total, there were 47 possible survey combinations. We used the SAS statistical software package (SAS version 9.2) macro %MkTex to determine an optimal factorial design, which resulted in 49 versions of the survey. The 49 versions of the survey instrument were randomly distributed across respondents. Respondents were then asked if they would adopt each of the four practices and, if so, how many acres or units they would adopt given the cost share rate the respondent observed. The practices were presented in the same order to all respondents: pasture improvement, cattle water tanks, stream crossing, and rotational grazing. The second section concluded with a series of debriefing questions about the respondent's decision to hypothetically adopt one or more of the BMPs. The third section, "Your Opinions," probed respondent perception of local water quality and causes of water quality degradation, while the final section, “Information About You,” elicited producer demographics.

Analysis of Survey Responses

Responses to the survey are analyzed using univariate statistics. The variables used in the analysis are defined and summarized using means and standard errors. Some respondent attributes are comparable across operations *with* and *without cattle* and across *adopters* and *non-adopters*, where *adoption* is defined as the threshold at which a respondent responds that he or she would be willing to participate in a hypothetical program supporting the use of one or more of the BMPs. Since only those respondents who owned cattle were asked about their interest in adopting the BMPs, the distinction between adopters and non-adopters is relevant only for cattle owners. Thus, some attributes were only observed in the sub-group of respondents who owned cattle and, thus, only comparable across adopters and non-adopters. Group (*with* and *without cattle*; *adopters* and *non-adopters*) means were compared using *t*-tests assuming unequal variances between groups.

Statistical relationships farm and farmer characteristics and preferences for the BMPs are evaluated using partial correlation analysis (Johnson and Wichern, 2002). The partial correlation analysis focuses on the relationships between variables in six categories—farm structures, farm management activities, managerial objectives, operator characteristics, technologies, and cost/expense factors—and the adoption of each BMP separately. The reported partial correlations correspond with the variables listed under each of these general characteristic categories. For example, under the “Farm Structures” block, the correlation coefficient associated with “Acres Farmed” is only conditioned on the other variables in this set (e.g., “Tenure”, “Cattle”, and “Stream on operation”).

Results and Discussion

In terms of the characteristics of the farm operators, those owning cattle were, on average, younger, more likely to be male, had larger households, were more likely to plan on passing on their farm to a family member, and were more likely to live on their farm than were those respondents who did not own cattle (Table 1). In terms of farm characteristics, cattle owners generally farmed more acres, owned less of the land they farmed, and were more likely to have a stream on their operation (Table 2).

Among cattle owners, those who were willing to adopt one or more of the BMPs were, on average, younger, more likely to have a college degree, had larger households, and earned higher incomes, than those who were not willing to adopt any of the BMPs (Table 1). Non-adopters owned more of the land they farmed and were less likely to have a stream on their operation (Table 2). Adopters were more likely to have previously taken steps to improve their pasture (Table 3). Adopters placed attached greater importance to improving drinking water for cattle, improving forage quality, reducing soil erosion, increasing their stocking rate, and improving their pasture management options than non-adopters (Table 4). Adopters also attached greater importance to all of the expense factors included in the analysis (Table 4), suggesting that non-adopters were not as concerned with the expenses associated with adoption.

The most frequently adopted BMP was pasture improvement, for which 67% of the cattle owners professed themselves willing to adopt, given the hypothetical cost share associated with adoption. The least popular was stream crossing, for which only 24% of the cattle owners were willing to adopt. The most popular bundle of BMPs was the rotational grazing, water tank, pasture improvement combination, followed by all four BMPs, pasture improvement only, and a combination of rotational grazing and pasture improvement (Table 5).

The results of the partial correlation analysis are presented in Table 6. Holding the other farm structure variables constant, acres farmed was positively correlated with adoption of a stream crossing, while having a stream on the farm was positively correlated with adopting cattle water tank(s). Holding the other farm management variables constant, pasture acres was positively correlated with adopting both water tank(s) and a stream crossing, stocking density was positively correlated with adoption of a stream crossing, and pasture improvement was positively correlated with adoption of the water tank(s), rotational grazing and pasture improvement. Holding the other managerial objective variables constant, respondents who attached greater importance to decreasing injuries to cattle crossing banks and to reducing soil erosion were more likely to adopt a stream crossing, while those who attached greater importance to improving drinking water quality for cattle and to improving the appearance of their farm were less likely to adopt a stream crossing. Those who attached greater importance to increasing pasture management options were more likely to adopt water tank(s), rotational grazing, and pasture improvement. Holding the other operator characteristic variables constant, older respondents were less likely to adopt water tank(s) and rotational grazing, those with a college degree were more likely to adopt rotational grazing and pasture improvement, those with higher incomes were more likely to adopt water tank(s) and a stream crossing, while those who planned to pass their farm on to a family member were more likely to adopt pasture improvement. Holding the other technology variables constant, respondents who had already improved their pasture were more likely to adopt water tank(s) and rotational grazing, while those who already used water tanks were more likely to adopt any of the other three. Finally, holding all other cost and expense factors constant, respondents who were offered a higher cost share were more likely to adopt a stream crossing or rotational grazing. Those who placed greater importance on installation costs and time needed for installation were more likely to adopt water tank(s), while those who placed greater importance on the time needed for maintenance were less likely to adopt pasture improvement. Finally, respondents who placed greater importance on the effect of adopting the BMP on cattle health and productivity were more likely to adopt all four of the BMPs.

Summary and Conclusion

Adoption by cattle producers of pasture improvements, water tanks, stream crossings, and/or rotational grazing may help mitigate the water quality impairments faced in the East Tennessee watersheds of this study. However, an estimation of the effectiveness of adoption of these BMPs requires a measure of the willingness of producers to implement the practices, a measure of the costs associated with adoption, and a measure of the degree of water quality improvement resulting from practicing these management structures.

This research surveyed agricultural land owners in McMinn, Monroe, and Bradley counties to analyze cattle producer willingness to adopt one or more of four BMPs. Results suggest that producers are willing to adopt BMPs if technical and financial aid is provided, but that this willingness varies from one BMP to another. A variety of factors related to farm and farmer characteristics, managerial objectives, and expense factors were found to be associated with willingness to adopt the BMPs. The results from this study may be useful in understanding the kind of programs necessary to target operators who are more willing to adopt these practices and to encourage further adoption to improve water quality in the Oostanaula Creek and surrounding watersheds. Further research will include multi-variable regression analysis of response data and potential estimates of cost and environmental effectiveness of adoption in the region.

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Table 1. Farm Operator characteristics

Farm Operator Characteristics	Respondents without Cattle	Cattle Owners		
		All	Non-Adopters	BMP Adopters
Respondent Age (years)	65.51[a] (0.43)	62.05[a] (0.69)	65.62[b] (1.43)	60.74[b] (0.77)
Male (1 = yes)	0.69[a] (0.02)	0.89[a] (0.02)	0.86 (0.04)	0.91 (0.02)
College Degree (1 = yes)	0.36 (0.02)	0.37 (0.03)	0.23[b] (0.04)	0.42[b] (0.03)
Household Size (including respondent)	2.40[a] (0.05)	2.65[a] (0.08)	2.44[b] (0.13)	2.73[b] (0.09)
Income Level (Likert scale[c], 1 - 8)	3.29 (0.05)	3.66 (0.08)	3.32[b] (0.16)	3.78[b] (0.08)
Pass on Farm to Family Member(s) (1 = yes)	0.24[a] (0.02)	0.86[a] (0.02)	0.80 (0.04)	0.88 (0.02)
Lived on Farm (1 = yes)	0.26[a] (0.02)	0.90[a] (0.02)	0.91 (0.03)	0.90 (0.02)
n	802	339	91	248

Notes: Standard errors in parentheses

[a] Mean of respondents with cattle different from respondents without cattle at the 10% level of significance

[b] Mean of adopters different from non-adopters at the 10% level of significance

[c] Likert scale: 1=<$10,000; 2=$10,000 to $29,999; 3=$30,000 to $49,999; 4=$50,000 to $99,999; 5=$100,000-$149,999; 6=$150,000 to $199,999; 7=$200,000 to $499,999; 8=>$499,999

n=number of operations

Table 2. Farm Structure Characteristics

Farm Structure Characteristics	Respondents without Cattle	Cattle Owners		
		All	Non-Adopters	BMP Adopters
Acres Farmed	17.28[a] (2.62)	158.81[a] (12.12)	136.45 (25.96)	167.42 (13.48)
Tenure	0.25[a] (0.03)	1.39[a] (0.10)	1.06[b] (0.09)	1.52[b] (0.13)
Stream on Farm (1 = yes)	0.23[a] (0.01)	0.73[a] (0.02)	0.64[b] (0.05)	0.77[b] (0.03)
Cattle (number)		69.39 (9.07)	52.25 (12.76)	75.98 (11.55)
n	824	367	102	265

Notes: Standard errors in parentheses

[a] Mean of respondents with cattle different from respondents without cattle at the 10% level of significance

[b] Mean of adopters different from non-adopters at the 10% level of significance

n=number of operations

Table 3. Farm Management Characteristics of Cattle Operations

Characteristic	Non-adopters	BMP Adopters
Applied Manure (1 = yes)	0.67 (0.05)	0.74 (0.03)
Pasture Managed[a]	93.29 (15.39)	108.84 (9.53)
Stocking Density	0.70 (0.08)	1.27 (0.44)
Practiced Rotational Grazing (1 = yes)	0.56 (0.05)	0.63 (0.03)
Had Stream Crossing (1 = yes)	0.31 (0.05)	0.30 (0.03)
Had Water Tanks (1 = yes)	0.36 (0.05)	0.45 (0.03)
Had Improved Pasture (1 = yes)	0.48[b] (0.05)	0.68[b] (0.03)
n	90	235

Standard errors in parentheses

[a] Includes both grass and woodland pastures as survey did not distinguish between the two.

[b] Mean of adopters different from non-adopters at the 10% level of significance.

Table 4. Mean Importance Levels of Managerial Objectives and Expense Factors

Objective or Factor	**Non-Adopters**[a]	**BMP Adopters**[a]
Clean Drinking Water for Cattle	4.04	4.17
Decreasing Injuries to Cattle Crossing Banks	3.26	3.49
Improving Drinking Water Quality for Cattle	3.57[b]	3.83[b]
Improving Forage Quality	3.78[b]	4.06[b]
Reducing Cattle Exposure to Waterborne Disease	3.72	3.86
Improving Farm Appearance	3.65	3.81
Reducing Soil Erosion	3.71[b]	4.02[b]
Increasing Stocking Rate	2.89[b]	3.40[b]
Increasing Pasture Management Options	3.30[b]	3.76[b]
Improving Water Quality in Local Streams	3.63	3.82
n	94	255
Amount of the Cost Share	2.02[b]	3.74[b]
Installation Costs	2.28[b]	3.76[b]
Maintenance Costs	2.31[b]	3.64[b]
Time Needed for Installation	2.20[b]	3.37[b]
Time Needed for Maintenance	2.34[b]	3.36[b]
Effect on Cattle Health and Productivity	2.28[b]	3.88[b]
Prior Experience with Cost Share Programs	1.91[b]	2.83[b]
n	65	234

[a] Means of Likert Scales: 1=Not at All Important to Decision to 5=Extremely Important to Decision

[b] Mean of adopters different from non-adopters at the 10% level of significance.

Table 5. BMP Adoption Patterns Among Cattle Owners

					BMP Bundle Adoption Rates[b]	
Rotational Grazing	Stream Crossing	Water Tanks	Pasture Improvement	**BMP Adoption Rates**[a]	All Cattle Owners	Adopters
■				49%	2%	2%
	■			24%	2%	2%
		■		45%	1%	2%
			■	67%	11%	15%
■	■				0%	0%
■		■			1%	1%
■			■		10%	14%
	■	■			1%	1%
	■		■		1%	1%
		■	■		5%	7%
■	■	■			0%	0%
■		■	■		19%	26%
■	■		■		3%	3%
	■	■	■		3%	4%
■	■	■	■		14%	19%
Cattle owners adopting any one or more BMPs				74%		
n					278	205

[a] Percentage of cattle owners adopting BMP, either alone or in combination with other BMP(s).

[b] Percentage of cattle owners adopting particular BMP bundle; column totals sum to 100%.

Table 6. Partial Correlations of Variables with Best Management Practice Adoption Among Cattle Producers

Variables	Cattle Water Tank	Rotational Grazing	Stream Crossing	Pasture Improvement
Farm Structures				
Acres Farmed	0.08	0.00	0.14**	0.01
Tenure (%)	-0.01	0.05	-0.08	0.05
Cattle, Calves (number)	0.04	-0.03	0.01	0.02
Stream on operation (1 = yes)	0.14**	0.09		0.06
n	367	367	268	367
Farm Management Activities				
Applied Manure (1 = yes)	0.03	-0.02	-0.04	0.02
Pasture Acres	0.12**	-0.03	0.16**	0.00
Cattle/Pasture Acres	0.08	-0.07	0.12*	0.04
Practiced Rotational Grazing (1 = yes)	-0.02	0.04	0.01	-0.07
Had Stream Crossing Structure (1 = yes)	-0.01	-0.02	-0.02	-0.06
Had Water Tanks (1 = yes)	0.06	0.02	-0.04	0.08
Practiced Pasture Improvement (1 = yes)	0.20**	0.25**	0.1	0.20**
n	325	325	238	325
Managerial Objectives				
Clean Drinking Water for Cattle	-0.04	-0.04	0.00	-0.01
Decrease Injuries to Cattle Crossing Banks	0.01	-0.01	0.14**	0.00
Improve Drinking Water Quality for Cattle	-0.01	-0.04	-0.11*	0.03
Improve Forage Quality	0.06	0.01	0.01	0.02
Reduce Cattle Exposure to Waterborne Disease	-0.05	0.00	-0.08	-0.06
Improve Farm Appearance	0.00	0.04	-0.13**	-0.08
Reduce Soil Erosion	0.06	0.02	0.14**	0.07
Increase Stocking Rate	0.07	-0.03	0.06	0.03
Increase Pasture Management Options	0.10*	0.18**	-0.02	0.14**
Improve Water Quality in Local Streams	0.00	-0.02	0.04	-0.03
n	349	349	264	349
Operator Characteristics				
Respondent Age (years)	-0.19**	-0.12**	-0.03	-0.06
Male (1 = yes)	0.03	0.02	0.04	0.08
Respondent had College Degree (1 = yes)	0.07	0.09*	0.04	0.13**
Household Size (Including Respondent)	0.05	0.08	0.00	0.02
Income Level (Likert, 1 - 8)	0.12**	-0.01	0.15**	0.06
Pass on Farm to Family Member(s) (1 = yes)	0.03	0.03	-0.07	0.14**
Lived on Farm (1 = yes)	0.04	0.05	0.00	0.00
n	339	339	252	339
Technologies				
Pasture Improvement	0.24**	0.19**	0.05	
Stream Crossing	0.07	-0.01		0.07
Rotational Grazing	0.06		0.02	0.07
Water Tank		0.30**	0.29**	0.37**
n	379	379	278	379
Cost/Expense Factors				
Pasture Cost Share	0.05	0.03	0.00	0.04
Water Tank Cost Share	-0.05	0.01	-0.13	-0.08
Stream Crossing Cost Share	0.09	0.03	0.25**	0.08
Rotational Grazing Cost Share	0.06	0.12*	0.11	0.08
Received Cost Share in the Past (1 = yes)	0.01	0.06	0.01	0.08
Amount of the Cost Share	-0.03	0.06	-0.06	0.10
Installation Costs	0.15**	0.02	0.07	0.02
Maintenance Costs	-0.07	0.05	-0.08	0.12
Time Needed for Installation	0.13*	0.02	0.11	0.10
Time Needed for Maintenance	-0.11	-0.07	-0.06	-0.21**
Effect on Cattle Health and Productivity	0.15**	0.18**	0.17**	0.25**
Prior Experience with Cost Share Programs	0.10	-0.09	0.00	-0.10
n	203	203	159	203

*$\rho < 0.10$, **$\rho < 0.05$

Note: Partial correlations correspond with the variables listed under each subheading.