Cattle Producers East of the 100th Meridian: A Study of Afforestation Adoption and Use of Pasture Management Practices

A Thesis Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

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May 2015

Abstract

This thesis explores two topics related to cattle producers: the adoption of afforestation on pastureland and the use of pasture management practices. Chapter 1 uses a triple hurdle model to analyze a decision process related to the adoption and acreage enrollment of afforestation in a hypothetical program. The results suggest that producers interested in afforestation are more likely to have a college degree, own woodland, attend extension workshops, and have previous experience with afforestation. Producers who were offered a lower incentive enrolled more acres in the hypothetical program. Producers who were offered a higher incentive enrolled fewer acres.

Chapter 2 analyzes the use of ten pasture management practices. These practices were then categorized into three subgroups based on the type of practice: riparian health, soil fertility management, and other types of practices. Adoption of these practices were compared with univariate statistics and analyzed using a trivariate probit regression. The results of the trivariate probit regression revealed that ownership of woodland, extension workshop attendance, and average annual precipitation were significant predictors of adoption. As the results demonstrate, extension workshops have a large positive effect on the conservation behavior of cattle producers. Producers who are most interested and willing to adopt and use these practices are those who are most likely to attend to attend extension workshops. Therefore, extension workshops as a way to reach out to those who are interested could be a way to increase producer participation.

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Introduction

This thesis contains two chapters related to the adoption and use of conservation practices by cattle producers. The first chapter analyzes the adoption of afforestation on pastureland, given a hypothetical incentive program. Chapter 2 examines the current use of ten pasture management practices. Both chapters provide a unique opportunity to examine cattle owner behavior and perceptions about afforestation of pastureland and pasture management practices.

Chapter 1: A Study of Cattle Producer Willingness to Afforest Pastureland

Abstract

The agricultural sector is under mounting political pressure to curb greenhouse gas (GHG) emissions. The beef industry, in particular, is often singled out for its disproportionate GHG emissions rate compared with other agricultural production. For example, on a pound for pound basis, the production of beef emits ten times more GHG than the production of chicken. One way to mitigate atmospheric carbon accumulation is to create sinks or environmental structures that sequester GHG. On agricultural land, sinks can be created by maintaining quality pasture land or planting trees. Research suggests that sequestration on agricultural lands has the potential to offset a significant portion of the GHG emissions from agricultural production. Afforestation of pastureland is a practice that could affect GHG emission from beef production.

This chapter analyzes the willingness of beef cattle producers in the eastern U.S. to afforest pastureland. Using data from over 2,000 respondents to a mail survey that included a choice experiment with a hypothetical incentive program, willingness to afforest pastureland is analyzed using a triple hurdle model and a conditional mixed process model. The survey included questions regarding producer characteristics and attitudes, and previous and present conservation behavior. The triple hurdle in the model is comprised of results from questions focusing on general interest in afforestation, willingness to afforest given a hypothetical incentive level (annual per acre payments of $60, $90, $120, $150, or $180), and intensity of afforestation.

Percent of income from cattle production, education, previous afforestation and ownership of woodlands are all significant variables in the first hurdle, which asks about general interest in afforestation. In the second hurdle, which is based on willingness to afforest given a hypothetical incentive level, incentive payment level and respondent's age are significant. The regional variables, latitude and longitude coordinates, are significant in the third hurdle, which is concerned with the numbers of acres a respondent is willing to enroll in the hypothetical program**.** These results can be

used to better understand producer willingness to afforest and can help in establishing successful afforestation programs in the future.

Problem Identification and Explanation

The accumulation of atmospheric greenhouse gases (GHG) is causing changes in the world's climate (USEPA 2013). Agriculture contributes between six and nine percent of all United States GHG emissions (USEPA 2013; Lewandrowski et al. 2004). The majority of GHG emissions from agriculture are nitrous oxide (N_2O) and methane (CH_4). Beef production is responsible for a disproportionate share of emissions (USEPA 2013). For example, on a pound-for-pound basis, the production of beef emits ten times more GHG than the production of poultry (Jones, Kammen, and McGrath 2008).

The concentration of atmospheric GHG can be reduced in one of two general ways: decreasing GHG emissions or sequestering GHG into sinks such as oceans, soils, or forests. For example, in beef production, net GHG reduction could be achieved by either decreasing cattle production, thereby reducing methane emissions, or by increasing the carbon storage capacity of pasture land. One way to increase the sequestration of carbon on agriculture lands is to reallocate agricultural land to grassland, scrub, or forests (USEPA 2013; Gasson and Potter 1988; Paustian et al. 2006).

For all these reasons, there is currently an increased focus on agricultural and forestry offsets designed to reduce GHG emissions from agricultural production and increase the sequestration of carbon by agricultural lands. For example, the American Clean Energy and Security Act, which passed in the U.S. House of Representatives in 2009 but not the Senate, aimed to reduce U.S. GHG emissions 17 percent by 2020, by among other things, increasing the amount of total forested acres (U.S. Congress 2009).[1] The American Power Act, introduced by Senators John Kerry and Joe

[1] Other reduction strategies included renewable requirements for utilities, studies and incentives regarding new carbon capture and sequestration technologies, energy efficiency incentives for homes and buildings, and grants for green jobs.

Lieberman, aimed to reduce GHG emissions 83 percent by 2050 through a regulatory cap and trade program. The act emphasized the need for carbon offset programs, specifically on grazing and forest land, to create incentive programs through the United States Department of Agriculture (USDA) to encourage participation and support (U.S. Congress 2009).

Research suggests that sequestration can offset a significant portion of the GHG emissions from agricultural production (Paustian et al. 2006; Woodberry, Smith, and Heath 2007). Agricultural soils sequester 12 million metric tons of carbon per year (Paustian et al. 2006), but the amount could be much greater with changes in prevailing land use practices. Removing land from intensive agricultural production through land use diversion can increase carbon storage capacity and reclaim lost habitat and productivity (Gasson and Potter 1988). The adoption of best management practices (BMPs) such as no-till, erosion control, and riparian buffers can increase carbon storage in soils and improve land productivity (Kim, Gillespie and Paudel 2005). The effects of forest management practices on carbon sequestration rates have been extensively researched (Canadell and Raupach 2008; Hoen and Solberg 1994; Jandl et al. 2007; Michetti and Rosa 2012). Afforestation has received some attention in the U.S. (e.g. Niu and Duiker 2006; Stanturf, Schweitzer, and Gardiner 1998), but more attention has been given to this practice in Europe, Africa, and Asia (e.g. Schirmer and Bull 2014; Marey-Pérez and Rodríguez-Vicente 2009; Saliu, Alao, and Oluwagbemi 2010; Ni Dhubháin and Greene 2009; Xu 1995).

Although forests and agriculture are not traditionally seen as related enterprises, incorporating forests into agricultural production may effectively mitigate the effects of climate change. Forests generally sequester carbon at higher rates than other land uses.[2] In the U.S., forests account for 90

[2] Increasing the sequestration of GHG emissions by forests can also occur though reforestation, avoided deforestation, and improved forest management (Bull and Thompson 2011). In the U.S, avoided deforestation is not necessarily a concern, because most deforestation occurred prior to the twentieth century, and total forest area has remained relatively stable ever since. Although number of

percent of carbon sequestration, while covering about 30 percent of U.S. land area (Woodbury, Smith, and Heath 2007). Afforestation, as defined by the Intergovernmental Panel for Climate Change (IPCC), is "the establishment of forest on land that has been without forest for a period of time and was previously under a different land use" (Watson 2000). Research suggests that afforestation can be a cost-effective GHG mitigation strategy (Moulton and Richards 1990; Parks and Hardie 1995). Although the rate of sequestration fluctuates depending on climate, ground management, soil, and tree species (USEPA 2013; Niu and Duiker 2006), afforestation has the potential to sequester relatively large amounts of carbon (Graham, Wright, and Turhollow 1992; Xu 1995).

Lewandrowski et al. (2004) found that afforestation on grazing land could sequester more carbon than other practices such as reduced pasture fertilizer use, rangeland management, and pastureland management. Birdsey (1996) predicted that afforested pasture could sequester between 0.73 and 2.09 Mt/acre, while Follett, Kimble and Lal (2001) estimated grazing management practices could sequester 0.30 to 1.30 Mt/acre (Lewandrowski et al. 2004). Feng et al. (2006) looked at incentive payments offered to farmers for enrolling land into either land retirement programs or changing practices on working land. Their results suggest that converting land to forests is more cost-effective in reducing atmospheric GHG than adopting conservation practices on working farmland.

Despite potential benefits, afforestation has some potential drawbacks. According to Ciscell (2010), carbon offset programs, such as afforestation projects, have the potential to be ineffectual, have adverse environmental effects, and distract attention from the need to decrease emissions. Nonetheless, afforestation projects are likely to remain part of the climate mitigation portfolio (Schirmer and Bull 2014).

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forested acres decreased from the years 1949 to 1997, between the years 2002 and 2007, the amount of forestland in the United States increased three percent (USDA 2011).

Afforestation could be accomplished either through regulation or voluntary incentive programs (Ribaudo, Hansen, and Hellerstein 2011). For example, the Chicago Climate Exchange (CCX) is a voluntary trading program that incentivizes carbon sequestration. While afforestation can be economical, especially on marginal land (Moulton and Richards 1990), incentivizing afforestation projects remains challenging (Parks and Hardie 1995). Given the difficulties of measuring carbon sequestration from afforestation across diverse geographical landscapes, some researchers conclude that market-based trading may not be practical (e.g. Antle et al. 2000). Thus, policies are likely to rely on per acre payments for specified land use changes or land use management, such as the Conservation Reserve Program (CRP), a buy-out program created by the USDA that is structurally similar to a potential carbon sequestration program (Shoemaker 1989). The primary goal of the CRP is to reduce soil erosion by taking marginal land out of production. Unlike BMP adoption, afforestation usually eliminates other productive land uses. As a result, voluntary programs that aim to increase forested acres typically provide start-up costs and reimbursements for the opportunity costs associated with taking land out of agricultural production (McCarl and Callaway 1995).

This study seeks to enhance understanding of cattle producer attitudes toward afforestation and participation in a voluntary incentive program to promote afforestation. In 2002, 782 million acres of land (35 percent) of total U.S. land area was pastureland. Thus, there is ample opportunity for widespread afforestation of pastureland. There is also precedent, as extensive amounts of grazing land have been converted to wildlife, recreational, and environmental uses since the 1940s (Lubowski et al. 2006). Further, through practices such as management intensive grazing (MIG), less land can be devoted to pasture grazing without reducing cattle production (Gillespie, Kim, and Paudel 2007). In addition, research finds that many land users underutilize their pasture acres, resulting in inefficient use of forage and foregone revenues (Lyons and Machen 2001). Utilizing pastureland efficiently means maintaining a balance between maximizing stocking densities while not exceeding the land's carrying capacity.

To design and implement a voluntary policy that is cost effective and reduces the GHG emissions associated with cattle production, it is important to understand cattle producer attitudes regarding carbon sequestration and afforestation. Knowledge of markets and payments is important for determining the factors influencing afforestation adoption, but little is known about cattle producer willingness to convert land to forest and how this willingness varies across producer and farm characteristics and cost-share incentives. Afforestation is often targeted at small, private landowners, so understanding characteristics of these producers is essential in understanding adoption behavior (Schirmer and Bull 2014).

Research Objectives

The primary objective of this research is to estimate the willingness of cattle producers east of the 100th meridian to convert pasture land to forest. This research also analyzes how producer willingness to adopt afforestation varies across demographic and farm characteristics (e.g. income, geographic location, age, etc). Cattle producer's acreage response to cost share incentives for conversion to forestland is estimated.

Literature Review

Afforestation can productively use marginal land, improve water quality, and provide supplemental income to farmers through conservation program payments and timber sales (Howley 2013; Plantinga and Wu 2003; Plantinga, Alig, and Cheng 2001). When looking at potential afforestation adoption rates among cattle producers, there are several strands of literature to consider. In addition to the literature related to the adoption of afforestation, forest owner motivations and conservation under land retirement programs can provide useful insights as well.

Afforestation

There are several studies that examine the adoption of land use change, including afforestation, for the purpose of carbon sequestration. Schirmer's and Bull's (2014) study examines private landholder willingness to afforest for carbon sequestration in a hypothetical program in Australia. Using survey data, several willingness to afforest factors were analyzed: social acceptability of afforestation, landowner knowledge of afforestation, attributes of afforestation, and land and landowner characteristics. The results indicated that 13.6 percent of respondents were actively thinking about afforestation and that producers are open to afforestation as long as it does not interfere with their current level of agricultural production. Generally, producers were more willing to afforest if they enrolled small parcels of marginal land as compared with large ones. Landholder beliefs also played a significant role in willingness to afforest; agrarian priorities were important to respondents and the results suggest that afforestation is counterintuitive to a "productivist ethic." Schirmer and Bull argue that afforestation programs should be developed in a way that will not challenge farmer attitudes or detract from food production.

In a study of Canadian farmers, Shaikh, Sun, and van Kooten (2007) analyzed the probability of landowner participation and willingness to accept (WTA) payments for a program promoting afforestation. The results suggested that farmers are unwilling to convert agricultural land to forest without financial incentives. However, farmers were willing to convert land into forests for payments for less than the returns from agricultural production. The authors proposed that non-timber forest amenities, such as shade, improved water quality, and wildlife habitat, may explain why producers are willing to accept a lower return. The results also found that WTA is positively correlated with producer age and negatively correlated with income. The level of education was found to positively influence adoption rates. The authors also asserted that foregone returns from agricultural production do not measure the willingness to convert land to forest because: 1) there are geographic and climate variations, 2) financial returns from trees are long-term, causing a disruption in liquidity, and 3) farmers have differing opinions toward forests and agricultural land. The authors recommended that landowners be compensated based on their WTA instead of estimated net returns, as some farmers receive benefits from the positive externalities associated with planting trees. Plantinga (2003) points out that these benefits are not typically taken into consideration in abatement cost estimates. However, as Tassone, Wesseler, and Nesci (2003) found, afforestation is unprofitable for farmers unless governments can provide subsidies, as in the case of afforestation programs in the European Union.

Several studies examined forest owner participation in conservation programs through surveys of forest owners. Dickinson et al. (2012) estimates the probability of forest owners participating in carbon offset programs. They find that forest owners are less likely to participate if there is a large time commitment or the program requires an intricate management plan. Similarly, Kilgore et al. (2008) find several factors influenced participation in a carbon sequestration program: awareness of the program, compensation amount, total acres owned, and "opposition to the program's land covenant." Even so, they find that participation rates can be increased by raising awareness and increasing payments. Langpap (2004) argue that participation in forestry programs can be increased by targeting younger producers interested in conservation and creating wildlife habitat.

Studies examining landowner motivation for converting land to forest may also provide insights into the characteristics that are likely to influence producer willingness to afforest pastureland. A number of these studies have focused on Irish landowners (i.e., Frawley and Leavy 2001; Kearney 2011; Ní Dhubháin and Gardiner 1994; Ní Dhubháin and Greene 2009; Howley 2013). In a review of the literature related to farmer attitudes toward forestry, Kearney (2001) found that the most important factor affecting afforestation over time is its profitability as a land use option. The author concludes that cattle production is in direct competition with acres that could be forested.

Frawley and Leavy (2001) find a similar result from a survey analyzing the factors that influenced farmers to convert some portion of their land to forest. More than half of the respondents perceived forestry favorably. Reasons given for not afforesting included “farm too small” and “prefers to farm.” Nonetheless, for those respondents who had afforested, maximizing land value was cited as the main reason, and 90 percent of farmers who had converted land to forest indicated they were happy with their experience. The authors suggest that lack of tradition and knowledge of forestry practices may explain why afforestation is a low preference land use option for producers. Ní Dhubháin and Gardiner (1994) studied farmer attitudes toward forestry and factors that influence the decision to afforest by surveying people who previously planted trees. The most-frequently cited reason for afforestation was to provide shelter for cattle followed by financial reasons. Eighty-four percent of respondents maintained that neither their farm output nor workloads were affected by afforesting. Lack of suitable land and limited land resources were the most common reasons why people did not afforest. Ní Dhubháin and Greene (2009) found that landowners afforested to “use up marginal land” and because of financial opportunities. “Ecological value,” “cover for game and wildlife,” and “to produce timber for sale” were among some of the other reasons to convert land to forest. Howley (2013) looked at factors that influence forest owner forest management. His results showed that sorting forest owners into groups based on their ownership objectives (i.e. lifestyle, economic, and multifunctional) allowed for policy makers to effectively influence forestry adoption. Collectively, these Irish studies suggest that while the decision to afforest agricultural lands is primarily motivated by financial concerns, farmers do view forested lands differently than they view agricultural land.

Other studies explain willingness to afforest. Zubair and Garforth (2006) found that farmer willingness to plant trees is related to their attitudes toward forestry. In this Pakistani study, farmers who planted trees believed that the financial and economic benefits were greater than the “adverse effects.” The influence of peer pressure, such as the opinions of family members, friends, and politicians, was also found to influence tree planting. Results show that farmers planted trees to increase income, provide firewood, provide ecological benefits, and because costs were low. Saliu, Alao, and Oluwagbemi (2010) evaluated participation in a Nigerian afforestation program. The authors determined that afforestation was conditional on the farmer income level. In one European study, the authors investigated how different types of producers (i.e., hobby, part-time, full-time, or retired) managed land, mainly focusing on afforestation (Praestholm, Reenberg, and Kristensen 2006). Analyzing survey results, they found that hobby and part-time farmers have a higher willingness to afforest than retired and full timers. Tom (2010) found that several factors negatively influenced afforestation rates in Kenya, including poor land use practices, lack of capital, insufficient land holdings, insecure land tenure, competing land uses, and labor shortages. Competing use of land was the predominant reason why land owners did not afforest.

Participation in land retirement programs

A number of studies have examined land diversion, land retirement, and changing land use practices. For example, Gasson and Potter (1988) studied British farmers' responsiveness to hypothetical programs that would compensate farmers for diverting working agricultural lands to untilled land, forests, or permanent pasture. The study found that payments for land diversion could achieve economic and environmental objectives, but that voluntary programs would have little effect on farms with no previous experience with conservation practices. The authors estimate that three percent of available farmland would be converted to forest under a hypothetical cost-share program. One study finding is that those farmers who already had forest on their property offered more land to forests than those who did not.

Using enrollment data from the Conservation Reserve Program (CRP), Plantinga, Alig, and Cheng (2001) estimated supply functions for grassland and forested land at different cost-share prices. Their results suggest that farmers in the East had a steep supply curve, i.e., a higher payment was required to encourage land enrollment into forests. The Southeast was more amenable to converting agricultural land to forest. In the North and South Plains, grassland enrollment was the most popular choice, because the regional climates are not ideal for forestry. Thus, to promote afforestation in these regions, additional incentives would be required. Lambert, Sullivan, and Claassen (2007) also analyzed participation in the CRP and choice of management practices implemented using data from the USDA's 2001 Agricultural Resource Management Survey (ARMS). The results show that farmers who earned a larger percentage of their income from farming enrolled more land than those who earned less of their income from farming. The study finds few demographic differences between CRP participants and non-participants. The authors find that land retirement is more appealing to retired or recreational farmers, for whom land diversion schemes can provide supplemental income. The results suggest that whole field retirement appeals to farmers who have marginal land and pasture that cannot be used for crop production.

Survey Data

The survey used a random sample of beef cattle, cow/calf, and backgrounding/stockering operations from the eight Economic Research Service (ERS) Regions east of the 100th meridian. The ERS regions are based on commodity production, geographical specialization, and other characteristics (USDA-ERS, 2007). The sample was drawn by USDA's National Agricultural Statistics Service (NASS) and was limited to operations with at least 20 head of cattle as reported by the 2007 Census of Agriculture to decrease the likelihood of sampling hobby farms. A copy of the survey is attached as Appendix A. A total of 8,875 operations were randomly chosen from the population of 267,413 farms. The survey sample represented three percent of the total population. The sampling intensity and design was based on a three percent margin of error at a 95 percent confidence interval. Post stratification weights were developed based on the cross tabulation of farm sales classes and ERS regions (Lambert et al. 2014a). USDA/NASS sent out the survey in early 2013 with an initial mailing, a reminder postcard (one week later), and second follow up mailing (two weeks later). A total of 2,448 completed surveys were returned for a 28 percent response rate.

The survey was divided into three sections. The first section ("Your Farming Operation") focused on the characteristics of the producer and the operation. The next section ("Afforestation") informed respondents about what afforestation is and how it might benefit both them and the environment. Respondents were then asked about a hypothetical program including an incentive paid over a 10 year period as well as a 75 percent purchase and installation cost share to either afforest acres, or, for those who had already afforested pursuant to a government program, to expand the number of acres afforested. Five versions of the survey were administered. Each version was the same in all respects, except for the hypothetical incentive level offered. The annual incentive levels were $60, $90, $120, $150, and $180 per acre. The price points were based on a presurvey of 300 producers. The survey versions were randomly distributed across the sample. If respondents had afforested land through a government program such as CRP or EQIP, they were asked about acres they had enrolled in the program and payment per acre received. Respondents were also asked their opinions about factors influencing their participation and the outcomes they anticipated from afforested land. The final section of the survey ("About You") included questions designed to obtain information on respondent demographics and factors that might influence willingness to afforest.

The survey collected information on respondent willingness to participate in a hypothetical incentive program for afforesting land via a series of three questions. The first question asked about respondent interest in afforestation and provided respondents with three response options: not interested in afforestation, interested in afforestation if it were profitable, and interested even if it was not profitable to afforest. Respondents who indicated they were either interested if profitable or interested even if not profitable were asked whether they would afforest, given the hypothetical per acre incentive payment. Respondents who accepted the hypothetical incentive and indicated willingness to covert acreage on their farm to forest were asked how many acres they would be willing to enroll in the hypothetical afforestation program. A tiered modeled approach is adopted to accommodate this survey design, with levels of analysis: (1) willingness to afforest; (2) willingness to participate in the hypothetical incentive program, given willingness to afforest and the incentive level offered; and (3) participation intensity, or the number of acres the respondent would be willing to enroll in the program, given acceptance of the incentive and participation in the program. Producers are assumed to have two options for each acre of pasture: continue as pasture or afforest. It is expected that if producer prefers to convert their land to some other use, say, plant corn, he or she would have already done so.

Conceptual model

Interest in afforestation

The conceptual model follows Jensen et al. (2015). Afforestation is hypothesized to occur when the producer's utility (u) from afforesting is greater or equal to the producer's utility from not afforesting. A producer afforests when $u(1, I; x) \geq u(0, I; x)$, where 1 denotes adoption of afforestation and 0 is no adoption of afforestation; I is income; and $\boldsymbol{x}$ is a vector of operator characteristics and farm structure attributes affecting the decision of whether to afforest or not.

McFadden (1974) provides the random utility model, which provides the framework for modeling the adoption of afforestation. The utility from afforesting (u_a) is defined as $u_A^j = \beta^j x + \varepsilon_A^j$ where the state of afforestation is represented by j = 0,1. The coefficient of the farm structure or producer characteristics vector ($\boldsymbol{x}$) is β, and ε_A^j is an unobservable, independent and identically distributed error term. In practice, the producer's utility function is unknown because some components are unobserved. The incomplete function of utility can be noted by ε^j, where j represents the state of afforestation. As described above, afforestation is a discrete choice, and all that is observable is the discrete choice decision, not the underlying latent utilities. When the latent variable is positive, or $\bar{u}_A = u_A^1 - u_A^0$, the producer is expected to adopt afforestation.

Using the random utility model, the probability that a producer will afforest is $\Pr(j = 1) = \Pr(u_A^0 + \varepsilon_A^0 \leq u_A^1 + \varepsilon_A^1) = \Pr(\varepsilon_A^0 - \varepsilon_A^1 \leq x\beta)$, where β are the parameters to be estimated (Cooper 1997). The probability of afforesting is $\Pr(j = 1) = F_{\varepsilon A}(x\beta)$, where $F_{\varepsilon A}$ is a cumulative distribution function of ε_A (Cooper 1997). The probability that a producer will adopt afforestation is a function of his or her demographic variables.

Willingness to afforest given a hypothetical incentive payment

The offer of an incentive for producers to afforest could be expected to alter the producers' decision making. Offering a hypothetical incentive, changes the condition for afforestation to $u(1, I + P; x, \varepsilon_A) \geq u(0, I; x, \varepsilon_A)$ where 1 denotes participation and 0 is non-participation; *P* is a net program incentive; and *I* and *x* are as before (Jensen et al. 2015). *P* is a net program incentive, because the respondents are responsible for 25 percent of afforestation costs.

Because utility is subjective, each respondent's utility function is comprised of different components: $u(j, I + jP; x, \varepsilon_A)$. Given these assumptions, producer willingness to participate in the program, given the net incentive *P*, is $u_a(1, I + P; x, \varepsilon_A) + \varepsilon^1 \geq u_a(0, I; x, \varepsilon_A) + \varepsilon^0$ (Jensen et al. 2015).

As Jensen et al. (2015) show, producers adopt afforestation, when $\gamma_0^0 + \gamma_1 \cdot I + \varepsilon^0 \leq \gamma_0^1 + \gamma_1 \cdot (I + P) + \varepsilon^1$ where γ_1 is strictly positive. The probability a producer participates in the program, or accepts *B*, is extended to $\Pr(accept \leq B) = \Pr(u^0 + \varepsilon^0 \leq u^1 + \varepsilon^1) = \Pr(\varepsilon^0 - \varepsilon^1 \leq \gamma_0 + \gamma_1 \cdot B)$. Other covariates (*x*) related to respondent's finances may influence program participation given an incentive level. Given incentive payment *P*, the probability of participating is $\Pr(accept \leq B) = F_\varepsilon(\gamma_0 + \gamma_1 \cdot P + x \cdot \gamma)$, where F_ε is a cumulative distribution function of the error term ε.

Participation intensity

Producers willing to accept the incentive to participate in the program are also asked to indicate the extent to which they are willing to participate, or how many acres they would be willing to enroll. An important determinant of the acres enrolled into the program is the amount of acreage producers have to enroll in the program. It is assumed that any such scale effects influencing the program acres supply function are fixed in the short term, i.e. that a respondent's total acreage directly affects the number of acres that could be enrolled into the program (Jensen et al. 2015). Acres enrolled into the program are only observed among the set of producers expressing a willingness to participate in the program, meaning the respondent answers yes to both the first and second hurdles.

Forest-specific considerations

Unlike other BMPs, afforestation usually requires exclusive use of land.[3] Similar to agriculture production, afforestation has risks: the uncertainty of potential diseases, land value, and timber values all have an effect on willingness to afforest. As a result, many farmers may be reluctant to afforest even when returns from forestry are higher than those from agriculture (Wiemers and Behan 2004). Conversely, some producers may derive utility from forest ownership and be willing to afforest even when financial returns from afforestation do not exceed those from continued agricultural production (Schatzki 2001). As previously stated, the producer is assumed to have two options for each acre of pasture: continue as pasture or afforest.

Because the benefits and costs of afforestation are dynamic, a simple net revenue equation becomes more complicated. Marginal benefits of conversion can include forest benefits and incentive payments. Forgone agriculture products, changes in land value, and added risk are included in marginal opportunity costs. It can be assumed that producers make land-use decisions in order to

[3] However, there are several studies that analyze multiple land use policies, such as joint livestock and timber production (e.g. Riiters, Brodie, and Hann 1982; Watson 2000)

maximize net present value (Schatzki 2001). Absent an incentive program, an owner of pasture land would strive to maximize economic returns to the land by maximizing the present value of net benefits (PVNP) for pasture land (Parks 1993):

(1) $$\text{PVNP} = \max \int_0^{\infty} \left[\pi_a(A_t, p_t;\ \alpha) - C_t F_t + \pi_f(F_t,\ p_t;\ \alpha) \right] e^{-rt} dt \quad \text{s.t. } L_t = A_t + F_t$$

where α describes producer characteristics that influence profitability (e.g. extension workshops, farm size, income, etc), A_t is acres in pasture at time t, F_t is acres in forest at time t, C_t is the per-acre cost of converting land to forestry, and input and output prices are represented by p_t. Equation 1 is subject to a land constraint. While it is possible for producers to buy or lease more land, land availability is restricted.

In addition to the hypothetical incentive payments for converting land to forests, expected future timber harvest profits are also considered by the producer. After the ten year contract is over, the producer faces another land-use decision. He or she can renew the afforestation contract (assuming one is available), convert land back to agriculture, or leave the land in forest (no contract). It can be assumed that some producers consider afforestation to be a permanent or irreversible land-use change. According to Parks (1993) land irreversibility is determined by "1) the marginal agricultural lands are insufficiently productive to ever justify payment for land-clearing costs after being converted to forests, 2) post-conversion forest benefits permanently exceed agricultural opportunity costs or 3) conversion to forests under a land policy is required to be permanent." Perhaps as a result of increased commodity prices, some producers may choose to return to agriculture production on forested acres. Assuming that ten years is not enough time for optimal harvest, participants may want to leave their land in trees to harvest in the future, or maybe they find utility in the afforested acres. Schatzki (2003) suggests that producers will opt for land uses that have greater flexibility and lower start-up costs. To promote conversion of grazing land to forests, these potential barriers should be considered in the implementation of program policy.

Parks (1993) observes that producers do not think statically; rather, they consider "capital gains" when making decisions in the long term. Assuming prices are known and discount rates are constant, a model of producer decision making, taking future land-use decisions into account, could take into consideration the following formation of net present value:

$$\text{(2)} \qquad \text{PV}=\int_0^{\infty} \pi_a(A_t, p_t;\ \alpha)e^{-rt} + \int_0^{10} I_f\ Fe^{-rt} - C_f F + V_F{}^{*}e^{-rt}$$

Where, π_a is the discounted stream of profits from pasture. The annual per-acre incentive payments are represented by I_f . C_f is the same as above. The variable $V_F{}^{*}$ represents the value of the afforested land, discounted, after the expiration of the contract, i.e., ten-years:

$$\text{(3)} \qquad V_F{}^{*}=\text{Max}\begin{bmatrix} (\text{p} * \text{q} - h_f)F \ + \int_{10}^{\infty} \pi_a(A_t, p_t;\ \alpha)e^{-rt} \\ \int_{10}^{\infty} \pi_f\ (F_t, p_t;\ \alpha)e^{-rt} \end{bmatrix}$$

Equation three represents the maximum of two different possible values – the value of the afforested land if the timber was harvested and the land was converted back to pasture or the value of the land if left in timber production. Price (p) could be that of board feet and q as the quantity. The per acre cost of harvesting is represented by h_f. Assuming land would be converted back to agriculture after timber harvest, agriculture profits are also considered.

Empirical model and estimation

Acreage enrolled in the hypothetical afforestation program is modeled beginning with willingness to afforest (*interest*), willingness to participate in the hypothetical program given the cost share and annual payment offered (*accept*), and the number of acres the respondent is willing to enroll in the program (*logacres*) given acceptance of the hypothetical offer. This triple hurdle model is modeled using a conditional mixed process model (Roodman 2011). As adopted from Jensen et al. (2015), a triple hurdle regression (equations 4-10) models the afforestation adoption decision sequence in three decisions, where latent variables represent the producer's choice in each hurdle.

(4) $$interest_i^* = \beta X_{1i} + \varepsilon_{Ai}$$

$$interest_i = \begin{cases} 1\,, & interest_i^* > 0 \\ 0, & interest_i^* \leq 0 \end{cases}$$

(5) $$accept_i^* = \gamma X_{2i} + \varepsilon_i$$

$$accept_i = \begin{cases} 1\,, & accept_i^* > 0 | \ interest_i^* > 0 \\ 0, & accept_i^* \leq 0 | \ interest_i^* > 0 \end{cases}$$

(6) $$logacres = \eta X_{3i} + e_i$$

$$logacres_i = \begin{cases} logacres\,, & accept_i^* > 0 \\ \quad - \quad, & accept_i^* \leq 0 \end{cases}$$

In the first hurdle (equation 4), producers were asked if they would be interested in afforesting. Respondents expressing interest (*interest=1*) moved then to the second hurdle (equation 5). In this hurdle, producers were offered an upfront cost share and per acre annual payment. Producers either refused ($accept$ = 0) or accepted the offer ($accept$ = 1). If *accept*=1, producers were asked to supply an acreage amount given their willingness to afforest and participate in the incentive program (i.e., $interest = 1$ and $accept$ = 1).

The triple hurdle model listed above is recursive (equations 4-6), so it can be assumed that the error terms are correlated and assumed to be multivariate normally distributed each with an expected value of zero (Jensen et al. 2015):

(7) $$\begin{bmatrix} \varepsilon_{Ai} \\ \varepsilon_i \\ e_i \end{bmatrix} \sim MVN\left(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho_{12} & \sigma\rho_{13} \\ \rho_{12} & 1 & \sigma\rho_{23} \\ \sigma\rho_{13} & \sigma\rho_{23} & \sigma^2 \end{bmatrix}\right).$$

Based on these assumptions, the parameter vectors (β, γ, η) and the covariance matrix in (equation 7) can be jointly estimated using full information maximum likelihood. Jensen et al. (2015) provide a log likelihood function for the model:

(8)

$$\ln L =$$

$$\sum_{interest \le 0} \ln\big(\Phi(-\beta X_{1i})\big) + \sum_{\substack{interest>0 \\ accept_i^* \le 0}} \ln\big(\Phi_2(\beta X_{1i}, -\gamma X_{2i}, -\rho_{12})\big) +$$

$$\sum_{\substack{accept_i^*>0 \\ interest_i^*>0}} \ln\big(h(logacres_i|\beta X_{1i}, \gamma X_{2i}, \eta X_{3i}, \rho_{12}, \rho_{13}, \rho_{23}, \sigma)\big).$$

Marginal effects

Calculating the marginal effects for this triple hurdle model is not straightforward, and it is important to note that independent variables included in superior tiers indirectly influence the marginal effects of dependent variables in lower tiers even if those variables are not in the equation (Jensen et al. 2015). Using the conditional and unconditional means formulations of acres enrolled into the program, marginal effects can be derived. The unconditional expected mean acres enrolled are calculated as (for example, Yen and Rosinski 2008);

(9) $$E(logacres_i) = \left(\eta X_{3i} + \frac{\sigma^2}{2}\right) \cdot \Phi_2(\beta X_{1i} + \sigma\rho_{13}, \gamma X_{2i} + \sigma\rho_{23}, \rho_{12}).$$

The conditional mean of acres enrolled into the program is calculated as:

(10) $$E(logacres_i|logacres_i > 0, accept = 1) = \left(\eta X_{3i} + \frac{\sigma^2}{2}\right) \cdot \frac{\Phi_2(\beta X_{1i}+\sigma\rho_{13}, \gamma X_{2i}+\sigma\rho_{23}, \rho_{12})}{\Phi_2(\beta X_{1i}, \gamma X_{2i}, \rho_{12})}.$$

The marginal effects equations 9 and 10 are estimated using a finite difference approximation algorithm suggested by Cameron and Trivedi (2009) and applied by Jensen et al. (2015), where the variable's marginal effect is equal to the mean difference between the unconditional and conditional means. For the binary decisions, willingness to afforest (*interest*) and willingness to participate (*accept*), the marginal effects are derived from the numerator and denominator of the bivariate cumulative density ratio in the conditional mean expression.

Factor analysis

The survey included a question on the importance of a number of different factors on the respondent's decision to participate in the afforestation program (figure 1 in appendix B) and a question on the likelihood of various effects of participation in the afforestation program on the respondent's operation (figure 2 in appendix B). Responses to these questions were included as explanatory variables in the model through factor analysis.

Factor analysis simplifies the dimensionality of multiple variables, collapsing variable sets into a few common factors using a loading score. Factor analysis is useful when working with several variables that are expected to be positively correlated with one another, and is used to determine the relationship between the questions and the latent traits that are displayed through respondent answers (Thurstone 1931).

Answers to the questions included in the factor analysis are relevant to the motivations of a respondent participating in the afforestation program. Using a factor analysis on the two questions eliminates the possibility of having collinear variables. The factor analysis was performed using the *factor* command in Stata.

Common factor analysis produces orthogonal factors by estimating a common variance among the original variables. When determining factors, a common rule is any factor with an eigenvalue exceeding one should be included in the analysis (Thurstone 1931). Prior to rotation, factor loadings may not sort well, which is indicated when the large eigenvalue values for the first factor for the importance and the likelihood question, 5.89 and 4.50, respectively (tables 1 and 2 in appendix B). Factor loadings may be clearly differentiated after rotation (Comrey and Lee 2013). After rotation, the eigenvalues for the importance question changed to 3.62 (first factor) and 2.53

(second factor) for the importance question and 2.57 (first factor) and 2.24 (second factor) for the likelihood question. No other factors for either question had eigenvalues greater than one. Rotation of the factor loadings was performed using Stata's *rotate* command (StataCorp 2013)

Factor loadings range from negative one to positive one, and represent the correlation between the variable and factors. Based on Kaiser-Meyer-Olkin (KMO) statistics, any loading with a score above 0.6 should be considered in an analysis (Kaiser 1974). Fabrigar et al. (1998) also argues for a 0.6 minimum. Nonetheless, factor loading should be considered in terms common sense and not solely defined by a cutoff level. As explained below, the factor analysis results produced factors loadings which met the recommended 0.6 minimum and made intuitive sense.

The importance question asked respondents to rank each characteristic's importance from "not at all important" to "extremely important" on their decision to participate in the program. The question listed ten items, and the factor analysis created two main factors, which are labeled as "private costs" (*privcosts*) and "social benefits" (*socialben*) (table 1 in appendix B). "Private costs" include time and labor requirements, investment cost of converting land to forest, amount of paperwork required, limitations on end uses of timber harvested, and per acre program payment offered for converting land to forest. "Social benefits" include those characteristics that do not exclusively benefit the respondent: carbon offset potential, knowledge about afforestation practices, and the impact of afforestation on the environment.

For the afforestation impacts question, respondents were asked to indicate the likelihood of various impacts of program participation on their operation on a five point scale ranging from "highly unlikely" to "highly likely." Two common factors stood out. They are labeled "environmental benefits" (*environmental)* and "production benefits" (*production*) (Table 2 in appendix B). Reducing the amount of soil erosion, improving water quality, improving farm appearance, and improving wildlife habitat are associated with the *environmental* factor. Belief that program participation was likely to increase farm profitability, free up land for other agricultural uses, and improve forage production correlate with the *production* factor.

Hypothesized effects of explanatory variables

A list of explanatory variables and hypothesized effects are found in table 4 in appendix B. Respondents were faced with three decisions in this survey. The first was whether the respondent was interested in afforesting or expanding afforestation (*interest*). Respondents who were interested were then asked if they would adopt or expand afforestation given a hypothetical incentive payment (*accept*). Several non-monetary variables included in the first hurdle were excluded in the second hurdle, because the *accept* decision is based on a payment level. Because the incentive payment (*incentive*) is introduced in the second hurdle, it is logical that only variables directly affecting a respondent's financial circumstance are included. The introduction of the incentive payment reflects a change in the context of the decision from a general set of factors of afforestation interest to factors directly relating to the profitability of afforestation. While, the variables' effects on these two decisions are expected to be similar, the significance levels are expected to differ. For example, if *age* is hypothesized to be negative in the *interest* level, there would be no reason to believe that *age* would change signs in the *accept* decision.

The third choice question asked for the number of acres the respondent would be willing to afforest in exchange for the incentive payment (*logacres).* The variables included in the *interest* and *accept* decisions are mainly farm and operator characteristics. The decision of *logacres* is assumed to be directly influenced by incentive level, respondent total farmed acres, and each county's geographic coordinates. Because the *logacres* decision is a function of *interest* and *accept*, including all of the variables included in those hurdles in unnecessary. However, several variables are thought to influence the amount of acres respondents are willing to afforest and, thus, are included in the *logacres* regression: *incentive, acrfarm, latitude* and *longitude*. The county centroid coordinates (*latitude*, *longitude*) are included because they are purely exogenous and can be a proxy for climate, vegetative cover, and rainfall.

Socio-demographic attributes

Duesburg et al (2014), Frawley and Leavy (2001), and Ni Dhubhain and Gardiner (1994) find that respondents with larger farms are more willing to adopt afforestation. This finding makes intuitive sense, because respondents with larger operations usually have more resources to adopt technology and conservation practices. However, Basarir (2002) and Gillespie et al (2007) did not find adoption rates of BMPs to be affected by farm size. For this study, operators of larger farms (*acrfarm*) are expected to be more likely to express an interest in afforestation and acceptance of the payment. It is expected that respondents who already own woodland (*ownwood*) will be more likely to afforest. The presence of forests can be an indicator that an operator's land quality, land slope, and climate are suited for forests. In addition, if a respondent has previously afforested (*prevafforest*), it is expected that he or she is more likely to afforest in the future. For example, Duesberg et al (2014) found that farmers who had previously planted trees were 12 percent more likely to afforest in the future.

Schirmer and Bull (2014) found that age was inversely related with willingness to afforest and/or reforest. Duesburg et al (2014) found that those operators between the ages of 45-64 were more likely to afforest compared with older respondents. In a literature review of BMP adoption, Prokopy et al (2008) found that that age is negatively correlated with adoption rates. It is hypothesized that age (*age*) will be negatively correlated with *interest* and *accept*.

Afforestation is a long term investment. If the respondent plans for his or her family to take over the farm operations (*famtkovr*), the respondent may be more likely to afforest (Kim, Gillespie, and Paudel 2008). This variable is hypothesized to positively influence *interest* and *accept*. Because afforestation is tied to the land, it makes sense that the future of the farm should be taken into consideration.

In an analysis of Irish forest owners, Howley (2013) found that having an off-farm job had a positive effect on a producer's likelihood of planting trees. If a producer has an off farm job, he or she might be more inclined to choose a land use with a limited time demand, such as forest. Similarly, Duesburg et al (2014) found that full-time farmers were less likely to afforest. Thus, the dummy variable identifying those who worked off the farm *(offfarmwork)* is expected to be positively correlated with *interest* and *accept.*

Respondent total household income (*income*), on and off farm, is expected to positively correlate with *interest* and *accept*. Kim, Gillespie, and Paudel (2008) found that cattle producers with higher incomes were more likely to adopt BMPs. Similarly, Gillespie et al (2007) found the percent of income from cattle and beef operations to be positively correlated with BMP adoption rates. Thus, the percent of income from cattle and beef operations (*cowpercent*) is hypothesized to be positively correlated with *interest* and *accept*. It is hypothesized that respondents who did not graduate from college will be less likely to afforest than those who attended or graduated from college (*socol* and *college*). Respondents with more education are probably more likely to be aware of possible conservation and environmental efforts.

Lastly, the incentive level (*incentive*) is expected to have a positive influence on *accept* and *logacres*. As the incentive level increases so does the return to afforestation. A significant and positive coefficient on *logacres* indicates that those producers who are offered a higher incentive payment are willing to enroll more acres in the afforestation program.

Regional characteristics

In addition to farm and producer characteristics, several variables representing characteristics of the area in which the operator is located were included. The county centroid for each respondent was represented latitude and longitude coordinates. Geographic coordinates are straightforward and can be easier to interpret than regional variables, such as the Farm Resource Regions produced by USDA's Economic Research Service in which regions are delineated on the basis of production, temperature, rainfall, etc. Latitude lines are the "y" coordinate on a map (latitude) with higher latitudes in the north and lower in the south. Longitude lines are the "x" coordinate (*longitude*), which begin at zero on the prime meridian in Europe and are positive to the east and negative to the west. In the U.S., longitude decreases from east to west. It is hypothesized that both latitude (*latitude*) and longitude (*longitude*) will be negatively correlated with willingness to afforest. As Plantinga, Alig, and Cheng (2001) find, conservation costs are highest in Appalachia, the Delta States, the Northeast, and the Southeast relative to other regions. The areas that are more "cost effective" are the Northern Plains, Great Lake States, the Corn Belt, and the Southern Plains. Nonetheless, the change in county population density from the 2000 to the 2010 census (*changeindensity*) is expected to be negatively correlated with willingness to afforest. Increasing population density implies higher land values and greater opportunity costs to afforestation. Increases in population density may be associated with increases in development pressure and decreases in the likelihood that forest will be the most profitable or desirable land cover. Producers in regions with increasing population density might be reluctant to enroll in a ten year contract because of uncertainties about future land values. A chart of the adoption decision process is shown in figure 3 in appendix B.

Results

There are several sets of results presented in this chapter. First, each hurdle of the adoption process is estimated individually. The first two decisions, *interest* and *accept*, are modeled using probit regressions. The third adoption decision, *logacres*, is a continuous variable. However, because each adoption decision affects the subsequent decision, modeling each decision separately does not account for the sample selection that occurs as respondents navigate the hurdles. Thus, these results are not of primary interest. However, the results of the single equations are provided in tables 5-7 of appendix B for reference and comparison with the main results of the system of equations.

Of more interest are the results from the triple hurdle model. The triple hurdle model is significant overall. The rejection of the null hypothesis, that beta is equal to zero, demonstrates that the covariates are jointly significant in explaining the three afforestation decisions. The correlation between the error terms ($\rho_{12}, \rho_{23}, \rho_{13}$) of each adoption decision are significant (table 8 of appendix B).

Respondents answered questions regarding a hypothetical cost-share afforestation program. The program promised to match 75 percent of the planting costs and provide an annual payment for 10 years. Of the respondents who answered the interest question (hurdle 1), 314 (29 percent) were interested in afforestation. Out of those respondents, 179 indicated they would be willing to afforest. These respondents who said yes to the second hurdle were willing to enroll an average of 73 acres in the hypothetical afforestation program.

Interest in Afforestation

There are 19 variables included in the *interest* regression, eight of which are significant at the 10% level (table 8, appendix B). The percent of respondent's farm income from cattle production (*cowpercent*) has a positive effect on *interest*; the more cattle revenue a producer brings in compared to his or her overall farm income, the more likely he or she is to be interested in afforestation. This result might seem counterintuitive. One might expect that a greater percent of revenue from cattle would be associated with a lower interest in planting trees on potentially profitable grazing land. In addition, *cowpercent* could be a proxy for the prioritization of cattle on a respondent's farm. However, the positive coefficient could reflect a desire among producers to diversify their farming operations. Compared with those who attended or graduated high school (i.e., *highsch* used a base case in model), respondents who graduated from college (*college*) are more likely to be interested in afforesting. Thus, respondents who only attended high school are less likely to be interested. As hypothesized, age was found to have a negative effect on interest. Older producers are less likely to be interest in planting trees than younger ones.

The variables *prevafforest* and *ownwood* are also positively correlated with *interest*. Those respondents who have previously afforested or are currently afforesting (*prevafforest*) or who own woodland (*ownwood*) are more likely to be interested in afforestation. The *prevafforest* variable reflects purposeful action by the respondent (i.e., planting trees), while the *ownwood* variable merely reflects passive ownership. Nonetheless, both variables proxy what type of land a respondent owns and both could reflect owner preferences for woodland.

Four factor variables were included in the interest hurdle (*socialben, privcosts, environmental, production*). These variables were positive and significant. *Socialben*, *environmental,* and *production* were expected to be positively associated with willingness to afforest, because they involved questions regarding afforestation benefits. Although expected to be positive, *privcosts* involved questions regarding possible land use drawbacks. If the respondent believes that time and labor are a concern then he or she would be more willing to afforest. Relative to other agricultural land uses, afforestation may be less time consuming. Thus, this significant positive relationship is logical.

Finally, farm size (*acrfarm*), household income (*income),* off-farm employment *(offfarmwork)* and the regional variables (*latitude, longitude*) were not significant in the *interest* regression.

Willingness to afforest and hypothetical incentive payments

Out of the 314 respondents expressing interest in afforestation (and, thus, moving from the first to the second hurdle), 179 replied they would adopt afforestation given a hypothetical incentive payment. Figure 4 in appendix B shows the number of producers who were willing to afforest at each incentive level along with the cumulative total at each level. Surprisingly, as the incentive payment gets larger, fewer producers are willing to commit to afforest.

The model of the adoption decision (*accept*) includes explanatory variables related to the respondent's monetary or fiscal characteristics. Three of the eight variables are significant at the 10% level. *Age* is significant in this decision; it is positively associated with willingness to afforest. *Age* switches sign in the second hurdle (relative to the first hurdle), once the incentive payment is offered, which possibly indicates that among those producers who are interested in afforesting, older producers are more influenced by monetary incentives than younger producers.

The incentive level (*incentive*) is positive and significant at the 10% level. The higher the incentive payment, the more likely a respondent will accept the incentive and afforest. As hypothesized, total acres farmed (*acrfarm*) is also positive and significant. The results indicate that farmers with more land are more likely to enroll in the afforestation program. Unlike in the interest decision, the percent of income from cattle production (*cowpercent*) and income (*income*) were not found to be significantly different from zero.

Acreage conversion

The 179 respondents who said yes to both of the first two afforestation questions (*interest, accept*) were then asked to state the number of acres they would be willing to afforest. The average number of acres provided by the respondents is 73 (figure 5, appendix B). Interestingly enough, the average number of acres respondents were willing to commit to the program decreased as the amount of the incentive payment increased. Compared to respondents at the $180 incentive, the average amount of acres offered at the $60 incentive was three times as much.

Of the four variables included in the supply of acres decision, two are significant at the 10% level. Contrary to expectations, the coordinates (*latitude, longitude*) are negative and significant. Regional characteristics have a large effect on adoption decisions. Respondents who are willing to participate in the afforestation program and who live in southern latitudes are willing to convert more acres into forests than participants who live in more northern latitudes. As Plantinga, Alig, and Cheng (2001) note, forestry is a “viable alternative” to farming in the Southeast, which is consistent with our results. Similarly, respondents who live further west are more likely to convert land to forests than eastern producers. Farm size (*acrfarm*) and the incentive level (*incentive*) are not significant at the 10% level in this hurdle. Thus, the results suggest that the amount of the incentive payment significantly influences a respondent’s willingness to afforest but not the intensity or extent to which the respondent is willing to afforest (number of acres). This result suggests that people who enroll acres in the afforestation program may be more influenced by the non-pecuniary benefits forests can provide such as, wildlife habitat, water quality improvement, timber production, and aesthetics.

The conditional mean number of pasture acres enrolled in the hypothetical program was 62.14, compared to the unconditional mean of 20.43. The conditional mean reflects acreage conversion among those respondents who expressed interest in afforestation. The unconditional mean is an estimation of afforestation acreage conversion among all 304 respondents.

As the incentive level (*incentive*) increases by one dollar, respondents enroll 0.18 less acres (table 8, appendix B). Respondents who previously afforested (*prevafforest*) are willing to enroll 17.49 more acres than those who have not previously afforested in the program. Operators owning woodland (*ownwood*) are willing to enroll 6.65 more acres than those who did not. Respondents with a college degree (*college*) were willing to enroll 8.49 more acres than respondents who only attended high school. For every one percent increase percent of income from cattle (*cowincome*), respondents convert 0.007 less acres. For every one acre increase in total acres farmed (*acrfarm*), respondents enroll 0.03 more acres. For every one degree increase in latitude, respondents enroll 7.01 fewer acres. Similarly, for every one degree increase in longitude, respondents enroll 2.03 fewer acres. Respondents enroll 0.62 more acres for every year older they are.

Discussion

This analysis provides useful insights into cattle producer interest in and willingness to afforest grazing lands. The results suggest a moderate level of interest in afforestation with 31 percent of respondents expressing interest in afforestation. Several factors significantly influence a respondent's interest, including having a college degree, owning woodland, having previously afforested, being younger, and earning a greater percentage of farming income from cattle.

Respondents who expressed interest in afforestation were asked, hypothetically, if they would afforest if given an incentive payment to do so. Of the respondents who expressed interested in afforestation, 56 percent stated that they were willing to afforest given the incentive payment. Willingness to afforest was positively influenced by the level of the incentive payment, and producer age and total acres farmed. Not surprisingly, producers were more willing to afforest and accept the hypothetical payment if the payment was larger. While older producers were less likely to be interested in afforestation, they were more likely to be willing to accept the incentive and afforest, if interested. These results may suggest that, when it comes to afforesting pasture, older producers are more financially motivated than their younger counterparts.

Producers who were willing to afforest were asked to provide an acreage amount for conversion. Acreage intensity was only affected by two geographic variables – latitude and longitude. The number of acres a producer who was willing to afforest was greater in southern latitudes than in northern latitudes. Similarly, producers who live in more western states are willing to enroll more acres than those who live in the east. Respondents who are willing to afforest acres do not appear to be particularly responsive to the incentive payment, as the incentive level had little influence on the number of acres producers were willing to enroll in the hypothetical program. One possible explanation is that the incentive payment and acres afforested is something similar to a backward bending labor supply curve. In this example, it means that producers are making enough income, either on and/or off farm, to work less and consume more leisure. This idea is highlighted by figure 5 in the appendix B. At the 60 dollar incentive payment, the average amount of acres provided was almost three times greater than the 180 dollar incentive. Further research could be done on how incentive payments affect acreage conversions in order to better understand this relationship.

One use for the results generated by this paper is to attempt to predict actual enrollment rates and associated levels of carbon sequestration. What follows is a back-of-the-envelope stab at such predictions, ignoring what are undoubtedly a large number of complications that should cause one to take these predictions with a rather large grain of salt. That said, afforestation hypothetical enrollment predictions and estimated carbon sequestration rates can be found in table 9 in appendix B. The projected addition afforestation acres were estimated from the econometric model, based on the conditional acreage enrollment. From across all ERS regions the total projected acres is 2.4 million, with the majority being in the Eastern Upland and Southern Seaboard. As stated previously, afforestation has the potential to sequester large amounts of carbon (Lewandrowski et al 2004; Birdsey 1996; Feng et al 2006). Using Birdsey's (1996) estimates of 1.39 Mt/acre, projected carbon sequestration rates under the hypothetical program were estimated (table 9). The potential total amount of carbon sequestration was found to be 3.39 million Mt.

Future researchers could focus on why a respondent would want to afforest. For example, a respondent could be interested in afforesting, because he or she is ready to retire from farming, while another respondent could be interested in afforestation, because he or she has marginal land that is not productive for grazing cattle. Similarly, agroforestry or joint cattle and woodland operation could be of interest to respondents. Agroforestry can provide many benefits to a cattle operation such as shade, wind protection, and erosion reduction. Further research should try to capture these motivations, in order to better understand cattle producers' views of forests, because knowing these motivations would help policy makers design and implement effective programs to increase conservation efforts while maintaining productivity.

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Appendix A

Cattle Operation and Woodlands Management Survey

Dear Agricultural Producer:

The U.S. Department of Agriculture estimates that there are about 922 million acres of farmland in the U.S. About 575 million of those acres are grazed by livestock. The grazing and land management practices used on America's farms have important effects on farm profits and on the environment. The University of Tennessee Institute of Agriculture is attempting to gather information on agricultural producers' views of ***afforestation of pastureland.***

Thus, we ask that you complete the enclosed survey, place it in the enclosed postage-paid envelope, and return it to us by mail. The survey should take about 10-15 minutes to complete. Responding to this survey gives you an opportunity to let policymakers know about your views of and experiences with this management practice along with your willingness to voluntarily adopt ***afforestation*** if you were to receive a payment to do so.

You can be assured of confidentiality. Your name or other identifying information will not be linked with your responses. University of Tennessee research protocols prohibit the release of your name or personal information to any other agency or individual. The list of those invited to participate in the study will be destroyed after responses are collected. Finally, only summary results from the survey will be publicly reported.

Please do not hesitate to contact us if you have any questions or concerns. Thank you for taking time out of your busy schedule to help us out! If you are interested, a summary of the survey results will be available at www.beag.ag.utk.edu once we have collected and summarized the data.

Sincerely,

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Please indicate if you are no longer farming at the top of the blank survey and return it to us. Thanks!

We ask that the primary farm/ranch decision maker complete this survey. If you are NOT the primary decision maker please forward the survey to that person. Your expert knowledge and participation are much appreciated. Please answer the following questions to the best of your ability. All responses are voluntary. No individual information will be released. This survey will take about 10-15 minutes to complete. Thank you for your help!

Your Farming Operation

Q1. Did you own farm land OR raise cattle in 2012? Check one.

Yes ☐ → *Continue to Q2* No ☐ → *Skip to Q24 on page 6*

Q2. How many total acres did you farm in 2011 and how many of these acres were rented from someone else?

	Total Acres Farmed	Acres Rented
Pasture		
Hay		
Harvested Cropland		
Woodland (grazed)		
Woodland (not grazed)		
Other (Please specify:)		
Totals		

Q3. If you rented land from others, how long were the rental terms? ______ Years

Q4. How much farmland and woodland did you own, but rent to others in 2012? ______ Acres

Q5. Did you have any of the following types of livestock on your farm in 2012? Check all that apply.

Hogs ☐ Poultry ☐ Cattle ☐ ⇨ *If you did not have cattle in 2011, skip to Q24 on page 6.*

Goats/Sheep ☐ Horses ☐

Q6. How many of the following types of cattle were in your care on January 1, 2013?

Brood Cows ______ Backgrounded Calves ______ Stockers ______

Replacement Heifers ______ Bulls ______ Dairy Cows ______

Other ______ (Please describe:)

Q7. Did your cattle graze on pasture owned or rented by you in 2012? Yes ☐ No ☐

Q8. About how many days per year do you graze your cattle? ______ Days per year

Q9. Which of the following <u>pasture management</u> practices do you use? Check all that apply.

Apply manure as fertilizer to pastures	☐
Apply N,P, or K fertilizer (DAP, urea, LAN, etc.) to pastures	☐
Water cattle at site other than stream or pond	☐
Have buffer strips of woody or grassy vegetation along waterways	☐
Have shade structures, scratching posts, and feed supplements placed away from streams	☐
Have improved stream crossings	☐
Control livestock access to streams	☐
Protect heavy use areas with geotextiles	☐
Replant bare pasture with legumes or native grasses	☐
Periodically test soil	☐

Afforestation

The next section asks you some questions about afforestation. Before answering these questions, we ask that you read the following to ensure that you understand how afforestation is defined in this survey.

What is afforestation?

- Afforestation is the *conversion of bare or cultivated land into forest*. For example, afforestation can occur by converting marginal pasture or cropland to fast growing trees or to native species.
- *There are a variety of programs* that pay landowners to convert pasture or cropland to forest in order to remove carbon, a greenhouse gas, from the atmosphere. These programs typically prohibit landowners from harvesting the trees, including thinning, for a certain period of time.
- While these programs *allow trees to be sustainably harvested at the end of the program period,* they may *prohibit* the forest product that is harvested from being *burned or turned into fuel in order* to prevent the release of the carbon stored in the trees back into the environment.

How would afforestation benefit you?

- Enhances potential wildlife habitat which could provide hunting and wildlife viewing opportunities
- Provides a buffer from surrounding landscapes
- Can produce fast-growing trees on marginal lands

What would you need to do to afforest your land?

Before afforestation:

- Prepare the site (removal of competing vegetation, seedbed preparation -mowing, tillage and herbicide application)
- Plant the trees (plants, labor for plant, shelters and mats, shipping and handling, hand planting vs. mechanical planting)

Afforestation maintenance:

- Maintain the stand (weeding, mowing, herbicide application, tilling, herbivore control)
- Replant trees (account for minimum survival rate in trees per area)
- Have afforestation monitored periodically
- Keep records of forest maintenance
- At the end of the program, either maintain the stand or limit harvest to sustainable methods

Q10. Do you currently own land you have afforested or are in the process of afforesting?

Yes ☐ No ☐

Q11. The following table provides cost estimates (by region) for the establishment and maintenance of afforested land. Please review the cost estimates for your region before answering the questions below. We realize that these costs will vary depending on where you purchase the materials.

Region[a,b]	*Establishment Costs/Acre (Year 1)*[c]	*Maintenance Costs/Acre (Year 2)*	*Maintenance Costs/Acre (Avg. in Years 3-10)*
Appalachia	*$300*	*$84*	*$49*
Corn Belt	*$304*	*$87*	*$49*
Delta	*$300*	*$84*	*$49*
Lake	*$303*	*$87*	*$49*
Northeast	*$300*	*$84*	*$49*
Northern Plains	*$303*	*$86*	*$49*
Southeast	*$260*	*$116*	*$49*
Southern Plains	*$302*	*$82*	*$49*

[a] **Northeast:** CT, DE, ME, MD, MA, NH, NJ, NY, PA; **Lake States:** MN, WI, MI; **Corn Belt:** IL, IN, IA, MO, OH; **Northern Plains:** KS, NE, ND, SD; **Appalachia:** KY, NC, TN, VA, WV; **Southeast:** AL, FL, GA, SC; **Delta:** AR, LA, MS; **Southern Plains:** OK, TX

[b] *The example fast growing woody crop is hybrid poplar for all regions but the Southeast which is pine. Based on US Billion Ton Update (Oak Ridge Natl Lab.).*

[c] *Forest establishment costs include cuttings, plantings, machinery, fertilizer, and chemicals; Maintenance costs in year 2 include cultivation, fertilizer, and herbicide; Maintenance costs in years 3 to 10 include cultivation and fertilizer.*

Which of the following best describes whether you would adopt or expand afforestation? Check one answer.

I would <u>not</u> adopt or expand afforestation if it was profitable to do so. ☐ → *Skip to **Q22** on page 5*

I <u>would</u> adopt or expand afforestation even if it was <u>not</u> profitable to do so. ☐ → *Continue to **Q12***

I would adopt or expand afforestation <u>only</u> if it was profitable to do so. ☐ → *Continue to **Q12***

Q12. We are now going to ask you about a HYPOTHETICAL PROGRAM to encourage farmers and ranchers <u>to adopt or expand afforestation</u> of pastureland. Assume the program would:

- Pay 75% of the costs of purchasing and installing the components needed to begin afforestation on pastureland acres on your farm or ranch;
- Pay you continuing annual payments for 10 years if you follow all of the practices described in the box on page 4 and document these practices each season;
- Not limit the number of acres you can enroll; and
- Be limited to acres not enrolled in another conservation program.

Would you be willing to convert acreage on your farm to forestland for a 10 year period if you were offered a) the 75% installation cost share described above and b) an ANNUAL payment of <u>$180 per acre</u> for each of the 10 years you practice afforestation?

Yes, I <u>would</u> adopt or expand afforestation ☐ → *Continue to **Q13***

No, I would <u>not</u> adopt or expand afforestation ☐ → *Skip to **Q22** on page 5*

Q13. If yes, how many acres would you afforest? ______ **Acres**

Q14. After adopting afforestation, how will the number of cattle change on your farm?

☐ **Decrease by** ______ %

☐ ***No Change***

☐ ***Increase by*** ______ %

Q15. In 2012, did you receive payments for afforesting land through a government program, such as the Conservation Reserve Program (CRP) or Environmental Quality Incentives Program (EQIP)?

Yes ☐ → *Continue to **Q16*** No ☐ →*Skip to **Q22** on page 5*

Answer Q16 – Q21 Only if You Have Received Payments for Afforestation...

Q16. How many acres did you manage as afforested land under this program in 2012? ________ **Acres**

Q17. Did you receive a per acre annual payment in 2012 to maintain the afforested land?

Yes ☐ → *Continue to **Q18*** No ☐ →*Skip to **Q19***

Q18. What per acre annual payment did you receive in 2012? ________ **$/acre**

Q19. Did you receive any cost share for expenses you incurred to begin afforestation?

Yes ☐ → *Continue to **Q20*** No ☐ →*Skip to **Q22***

Q20. Approximately how much did you receive as a cost share for adopting afforestation? **$** ________

Q21. In what year did you receive the cost share? ________

If you graze cattle answer Q22 – Q36...

Q22. How important were the following in determining your decision to participate in the program for afforestation?

	Not at all Important	Somewhat Unimportant	Not Sure	Somewhat Important	Extremely Important
Amount of time/labor required to convert land and manage forestland.	☐	☐	☐	☐	☐
Attitudes of friends and other farmers toward converting land to forest.	☐	☐	☐	☐	☐
Availability of Extension or forestland management education.	☐	☐	☐	☐	☐
Investment cost of converting land to forest.	☐	☐	☐	☐	☐
Amount of paperwork required to participate in the program.	☐	☐	☐	☐	☐
Effect on your farm's ability to offset carbon emissions.	☐	☐	☐	☐	☐
Your level of knowledge about afforestation practices.	☐	☐	☐	☐	☐
Limitations on end uses of timber harvested.	☐	☐	☐	☐	☐
Per acre program payment offered for converting land to forest.	☐	☐	☐	☐	☐
Impact of adopting afforestation on the environment.	☐	☐	☐	☐	☐

Q23. How likely do you believe participating in the afforestation program would be to:

	Highly Unlikely	Somewhat Unlikely	Not Sure	Somewhat Likely	Highly Likely
Increase the profitability of your farming operation.	☐	☐	☐	☐	☐
Reduce the amount of soil erosion on your farm.	☐	☐	☐	☐	☐
Improve water quality in the streams on or near your farm.	☐	☐	☐	☐	☐
Improve the appearance of your farm.	☐	☐	☐	☐	☐
Improve wildlife habitat on your farm.	☐	☐	☐	☐	☐
Free up land for other agricultural uses.	☐	☐	☐	☐	☐
Improve the quality and amount of forage produced on your farm.	☐	☐	☐	☐	☐
Increase your supplemental feed costs to support more cattle.	☐	☐	☐	☐	☐

About You

Q24. Years as primary farm business decision maker? ________ **Years** **Age in Years?** ________ **Years**

Q25. Which of the following best describes your farming business?

Sole Proprietorship ☐ Partnership ☐ Corporation ☐ Other ☐ (Please describe: ____________________ ____________________)

Q26. What is your highest level of education?

Less than High School ☐ Some College ☐

High School Graduate ☐ College Degree or Higher ☐

Q27. Which category best reflects your total taxable household income from <u>both farm and non-farm sources</u> for 2012? *Check one answer. Please know that laws prohibit us from sharing your personal information.*

Less than $10,000 ☐ $50,000 to $99,999 ☐ $200,000 to $499,999 ☐

$10,000 to $29,999 ☐ $100,000 to $149,999 ☐ $500,000 or more ☐

$30,000 to $49,999 ☐ $150,000 to $199,999 ☐

Q28. What percent of the total taxable household income (both farm and non-farm sources) for 2012 do you estimate came from farming? ________ **%**

Q29. What percent of your 2012 farm income do you estimate came from your cattle operation? ________ **%**

Q30. On average, how many hours a week do you spend working: **on your farm?** ________ **Hrs/week**

off your farm? ________ **Hrs/week**

Q31. How many hours of hired labor do you usually use on your farm in a week? ________ **Hrs/week**

Q32. Have you participated in any of the following government programs? Check all that apply.

Conservation Reserve Program (CRP)	☐
Grassland Reserve Program (GRP)	☐
State Programs (ex: state conservation or agricultural enhancement programs)	☐
Other (Please describe: ______)	☐

Q33. How many Extension or other educational workshops did you attend in 2011? ______ **Workshops**

Q34. Please indicate the extent to which you disagree or agree with each of the following statements.

	Strongly Disagree	Somewhat Disagree	No Opinion	Somewhat Agree	Strongly Agree
For me, farming is not only a business it is a way of life.	☐	☐	☐	☐	☐
I tend to wait until others have adopted new technologies or practices before I adopt them.	☐	☐	☐	☐	☐
The government should offer incentives to farmers to adopt conservation practices.	☐	☐	☐	☐	☐
I am concerned that climate change will negatively impact the yield of my product.	☐	☐	☐	☐	☐
As a farmer, I am a steward of the land I farm and it is my obligation to protect it for use by future generations.	☐	☐	☐	☐	☐

Q35. Which of the following best describes your plans for your farming operation?

Your children/grandchildren will farm your land after you cease farming. ☐

Your land will be sold or leased to another farmer after you cease farming. ☐

Your land will be sold for development after you cease farming. ☐

Other ☐ (Please describe: ______)

Q36. Do you use the Internet to make farm purchases or farm management decisions? Yes ☐ No ☐

Please return the completed survey to us in the enclosed, postage-paid envelope.

Thank you for participating in this study. If you are interested, please check the following website, http://beag.ag.utk.edu/, for a summary of results in the coming months.

Appendix B

Table 1: Factor Analysis of Importance of Items on Program Participation

Variables	Factor 1	Factor 2	Factor Description
Socio-demographic/environmental questions			
Amount of time required	**0.7886**	0.2496	
Investment cost	**0.8442**	0.3135	"Private Costs"
Amount of paperwork	**0.7647**	0.3272	(*privcosts*)
Per acre payment offered	**0.6680**	0.5007	
Limitations on end uses of timber	**0.6176**	0.4739	
Offset carbon emissions	0.3040	**0.7268**	"Social Benefits"
Level of knowledge about afforestation	0.5291	**0.6021**	*(socialben)*
Impact of afforestation on the environment	0.4092	**0.7384**	
Availability of Extension services	0.5325	0.4949	
Attitudes of friends	0.2136	0.3278	

Table 2: Factor Analysis of Likelihood Impacts from Program Participation

Variable	Factor 1	Factor 2	Factor Description
Socio-demographic/environmental questions			
Reduce soil erosion on farm	**0.7987**	0.3587	"Environmental
Improve water qualitsy on farm	**0.8039**	0.317	Benefits"
Improve farm appearance	**0.6055**	0.5035	*(environmental)*
Improve wildlife habitat	**0.5941**	0.2664	
Free up land for other ag. uses	0.3368	**0.7462**	"ProductionBenefits"
Improve forage	0.3546	**0.7808**	(*production)*
Increase feed costs	0.3057	0.4482	
Increase profitability	0.4926	0.5671	

Table 3: Variables and descriptive statistics included in the triple hurdle model

Name	Variable Description	Mean	N	Minimum	Maximum
DEPENDANT VARIABLES					
interest	1 if respondent interested in afforestation, 0 otherwise	0.30	1010	0	1
accept	1 if respondent would afforest given incentive level offered, 0 otherwise	0.57	304	0	1
logacres	Acres would afforest given incentive level	3.43	171	0	7.83
INDEPENDENT VARIABLES					
incentive	Annual per acre incentive payment offered ($60, $90, $120, $150, $180)	121.97	304	60	180
acrfarm	Total acres farmed	491.39	1010	2	20999
age	Age of respondent	61.73	1010	24	95
income (a)	Total household income of respondent	4.01	1010	1	8
highsch (omitted)	1 if respondent only attended or graduated high school, 0 otherwise	0.36	1010	0	1
socol	1 if respondent attended college, 0 otherwise	0.25	1010	0	1
college	1 if respondent graduated college, 0 otherwise		1010	0	1
latitude	Latitude coordinate	36.90	1010	26.39	48.86
logitude	Longitude coordinate	-90.53	1010	-99.99	-68.09
prevafforest	1 if has previously afforested, 0 otherwise	0.08	1010	0	1
stockdensity	Stocking Rate= (.92*cows+ .08* calves+ 1.35*bulls+ .6*backgrounder calves+ .6*stocker calves+.92*dairy cows+ .8*replacement heifers +.8*miscellaneous cattle)/ total number of pasture acres farmed (Holt 2013)	0.64	1010	0	27.83
famtkovr	1 if respondent's family will take over farm, 0 otherwise	0.66	1010	0	1
cowpercent	Percent of farm income from cattle	37.20%	1010	-10%	100%
offfarmwork	1 if repondent works off farm, 0 otherwise	0.52	1010	0	1
privcosts	Factor analysis score	0.07	1010	-2.01	1.78
socialben	Factor analysis score	0.02	1010	-2.26	2.16
environmental	Factor analysis score	0.07	1010	-1.56	2.30
production	Factor analysis score	-0.02	1010	-1.76	2.44
Changeinden-sity	% change in county population density from the 2000 to the 2010 census	181.17 %	1010	-99.63%	25293.6 %

a Likert scale: 1 = less than $10,000, 2 = $10,000 - $29,000, 3 = $30,000 – $49,000, 4 = $50,000 - $99,000, 5 = $100,000 - $149,999, 6 = $150,000 - $199,999, 7 = $2,000 - $499,999, 8 = $500,000 or more

Table 4: Variables included in the triple hurdle model, along with hypothesized effects at each level

Name	Variable Description	Hypothesized Effects *Interest*	*Accept*	*logacres*
incentive	Annual per acre incentive payment offered ($60, $90, $120, $150, $180)		+	+
acrfarm	Total acres farmed	+	+	+
age	Age of respondent	-	-	
income	Total household income of respondent	+	+	
highsch	1 if respondent attended or graduated high school, 0 otherwise		omitted	
socol	1 if respondent attended college, 0 otherwise	+		
college	1 if respondent graduated from college, 0 otherwise	+		
latitude	Latitude coordinate	-	-	-
logitude	Longitude coordinate	-	-	-
prevafforest	1 if has previously afforested, 0 otherwise	+		
stockdensity	*see footnote in table 3	+		
famtkovr	1 if respondent's family will take over farm, 0 otherwise	+		
cowpercent	Percent of farm income from cattle	+	+	
offfarmwork	1 if farmer works off farm, 0 otherwise	+	+	
privcosts	Factor Analysis score	+		
socialben	Factor Analysis score	+		
environmental	Factor Analysis score	+		
productionprof	Factor Analysis score	+		
changeindensity	% change in county population density from the 2000 and 2010 censuses	-		

Table 5: Results of Probit Regression of Respondent Interest in Afforestation (first hurdle)

Variable	Est Coef.	Std. Err.	z	
acrfarm(x100)	0.0030	0.0002	0.25	
cowpercent	0.0040	0.0014	2.93	***
age	-0.0063	0.0044	-1.44	
income	0.0321	0.0368	0.87	
socialben	0.3450	0.0616	5.81	***
privcosts	0.3881	0.0642	6.04	***
environmental	0.2614	0.0583	4.43	***
production	0.0903	0.0573	1.61	
latitude	-0.0158	0.0111	-0.59	
longitude	0.0034	0.0084	0.41	
changeindensity	0.0001	0.0000	1.73	**
stockdensity	0.0305	0.3545	1.99	
prevafforest	0.6957	0.1587	4.38	***
ownwood	0.2941	0.1032	2.85	***
famtkovr	0.1357	0.0996	1.36	
college	0.2884	0.1121	2.57	***
socol	0.2034	0.1224	1.66	*
offfarmwork	0.1729	0.1011	1.71	*
intercept	-0.301	0.9671	-0.31	
N= 1010 LLR Test Wald $\chi^2(18)$= 252.52*** McFadden's R^2=0.2044				

Significant at the 10% level (*), 5% level (**) and 1% level (***)

Model fit: Wald Test reject $H_0: \beta = 0$

Table 6: Results of Probit Regression of Respondent Adoption Given a Hypothetical Incentive Payment (second hurdle)

Variable	Est Coef.	Std. Err.	z	
acrfarm (x100)	0.0200	0.0010	1.68	*
cowpercent	0.0010	0.0020	0.04	
incentive	0.0031	0.0017	1.77	*
age	0.0043	0.0066	0.65	
latitude	-0.0127	0.0177	-0.72	
longitude	0.0226	0.0116	2.50	**
income	-0.0813	0.0562	-1.45	
offfarmwork	0.2083	0.612	1.29	
intercept	2.7589	1.4089	1.96	**
N= 314 LLR Test Wald χ^2 (8)= 14.94 McFadden's R^2=0.0348				

Significant at the 10% level (*), 5% level (**) and 1% level (***)

Model fit: Wald Test reject $H_0: \beta = 0$

Table 7: Results of OLS regression of Respondent Acreage Conversion (third hurdle)

logacres	Est. Coef.	Std. Err.	t	
Acrfarm (x100)	0.0010	0.0010	2.30	**
incentive	-0.0015	0.0020	-0.71	
latitude	-0.0949	0.0199	-4.75	***
longitude	-0.0288	0.0127	-2.25	**
intercept	4.4711	1.4489	3.09	**
N= 179 F test (4, 174)= 9.22*** McFadden's R^2=.1559				

Significant at the 10% level (*), 5% level (**) and 1% level (***)

Model fit: Wald Test reject $H_0: \beta = 0$

Table 8: Estimated Coefficients and Marginal Effects for Triple Hurdle Regression

	Estimates			Marginal Effects		
	logacres	*accept*	*interest*	*logacres*	*accept*	*interest*
incentive	-0.0001	0.0030**	--	-0.1804	0.0016	--
acrfarm (x100)	0.0056	0.0030**	0.0020	0.0280	0.0001	0.0018
latitude	-0.0914***	-0.0081	-0.0089	-7.0060	-0.0256	-0.032
longitude	-0.0517**	0.0225	0.0037	-2.0318	0.0105	0.0012
income	--	-0.0589	0.0181	-3.8668	-0.0160	0.0065
age	--	0.0105**	-0.0090*	0.6213	0.0027	-0.0032
college	--	--	0.3047***	8.4989	--	0.1093
socol	--	--	0.1759	4.8796	--	0.0622
offfarmwork	--	0.1457	0.1029	7.7757	0.0387	0.0370
cowpercent	--	-0.0004	0.0031**	-0.0056	-0.0012	0.1353
ownwood	--	--	0.2388**	6.6570	--	0.0858
famtkovr	--	--	0.0599	1.5688	--	0.0200
prevafforest	--	--	0.6103***	17.4507	--	0.2166
socialben	--	--	0.3016***	1.4024	--	0.1264
privcosts	--	--	0.3441***	2.3419	--	0.1134
environmental	--	--	0.3158***	2.1366	--	0.1134
production	--	--	0.1259*	0.9681	--	0.0412
stockdensity	--	--	0.1219	0.3169		0.0043
changeindensity	--	--	0.0001	0.0005	--	0.0001
constant	2.9481	2.2249	-0.1537			
N	179	314	1010			
Percent Correctly Classified		54.18%	55.63%			
Wald test against intercept only (4 df)			21.35***			
Log pseudolikelihood			-104803.98			
σ_1	1.5952**					
ρ_{12}	-0.8299**					
ρ_{13}	0.4685*					
ρ_{23}	-0.8369**					

Significant at the 10% level (*), 5% level (**) and 1% level (***)

Model fit: Wald Test reject H_0: $\beta = 0$

Table 9: Expanded Acreage Enrollment Estimates and Carbon Sequestered

ERS Region	Estimated Acres Enrolled (1000s)	Standard Error	Metric tons carbon $Acre^{-1}Year^{-1}$ (1000s)	Standard Error
Heartland	344.53	22.45	485.78	25.24
Northern Crescent	60.18	4.93	84.85	5.21
Northern Great Plains	75.63	11.93	106.64	11.97
Prairie Gateway	827.65	197.57	1166.99	198.87
Eastern Upland	440.80	36.03	621.54	40.52
Southern Seaboard	419.06	32.86	590.87	33.68
Fruitful Rim	104.34	11.60	147.12	13.64
Mississippi portal	132.57	11.19	186.93	10.10
Total	2404.53		3390.72	

Q22. How important were the following in determining your decision to participate in the program for afforestation?

	Not at all Important	Somewhat Unimportant	Not Sure	Somewhat Important	Extremely Important
Amount of time/labor required to convert land and manage forestland.	☐	☐	☐	☐	☐
Attitudes of friends and other farmers toward converting land to forest.	☐	☐	☐	☐	☐
Availability of Extension or forestland management education.	☐	☐	☐	☐	☐
Investment cost of converting land to forest.	☐	☐	☐	☐	☐
Amount of paperwork required to participate in the program.	☐	☐	☐	☐	☐
Effect on your farm's ability to offset carbon emissions.	☐	☐	☐	☐	☐
Your level of knowledge about afforestation practices.	☐	☐	☐	☐	☐
Limitations on end uses of timber harvested.	☐	☐	☐	☐	☐
Per acre program payment offered for converting land to forest.	☐	☐	☐	☐	☐
Impact of adopting afforestation on the environment.	☐	☐	☐	☐	☐

Figure 1: Importance Factor Analysis Question

Q23. How likely do you believe participating in the afforestation program would be to:

	Highly Unlikely	Somewhat Unlikely	Not Sure	Somewhat Likely	Highly Likely
Increase the profitability of your farming operation.	☐	☐	☐	☐	☐
Reduce the amount of soil erosion on your farm.	☐	☐	☐	☐	☐
Improve water quality in the streams on or near your farm.	☐	☐	☐	☐	☐
Improve the appearance of your farm.	☐	☐	☐	☐	☐
Improve wildlife habitat on your farm.	☐	☐	☐	☐	☐
Free up land for other agricultural uses.	☐	☐	☐	☐	☐
Improve the quality and amount of forage produced on your farm.	☐	☐	☐	☐	☐
Increase your supplemental feed costs to support more cattle.	☐	☐	☐	☐	☐

Figure 2: Likelihood Factor Analysis Question

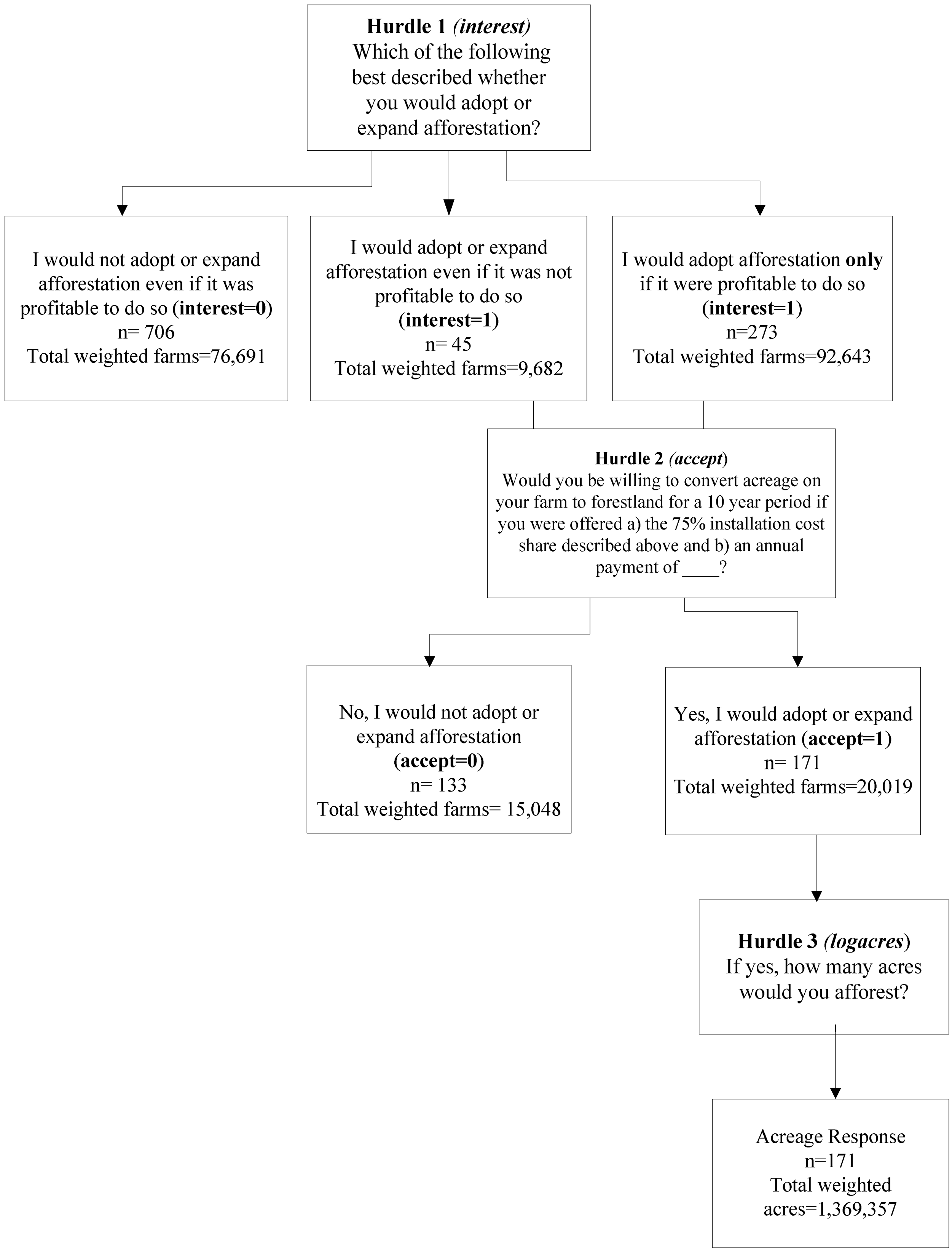

Figure 3: The Adoption Decision Process

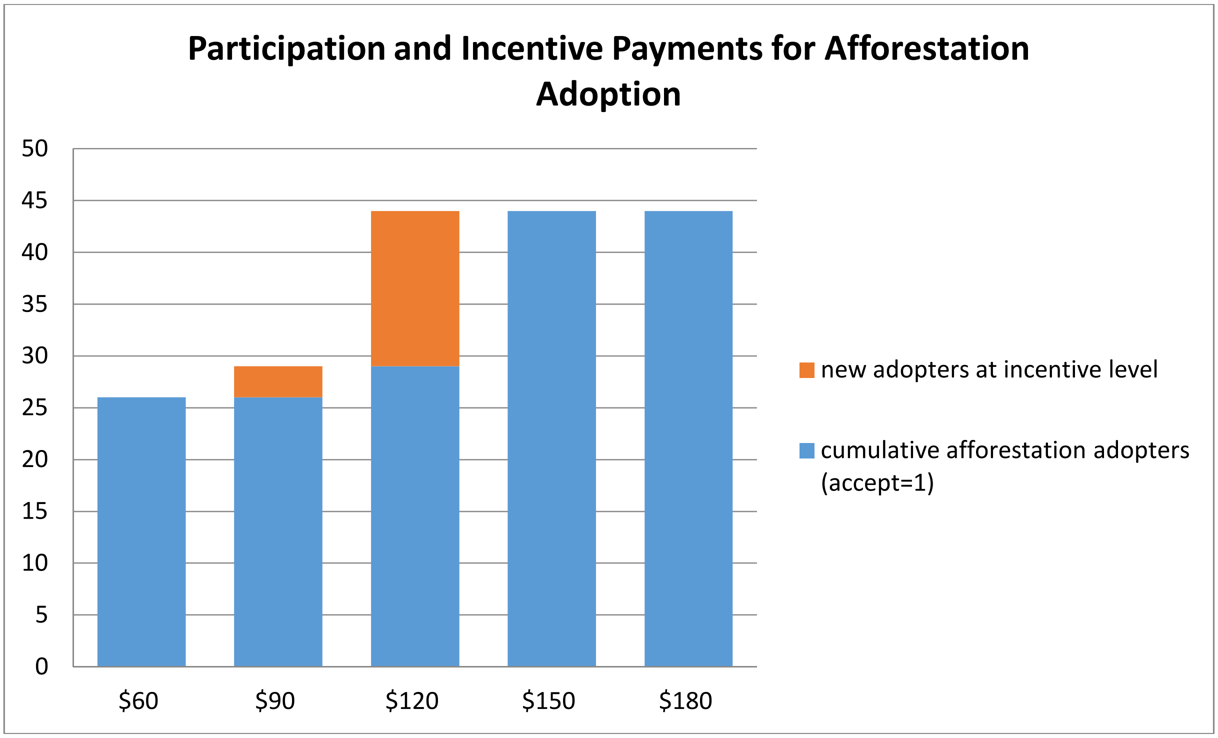

Figure 4: Participation and Incentive Payments for Afforestation Adoption

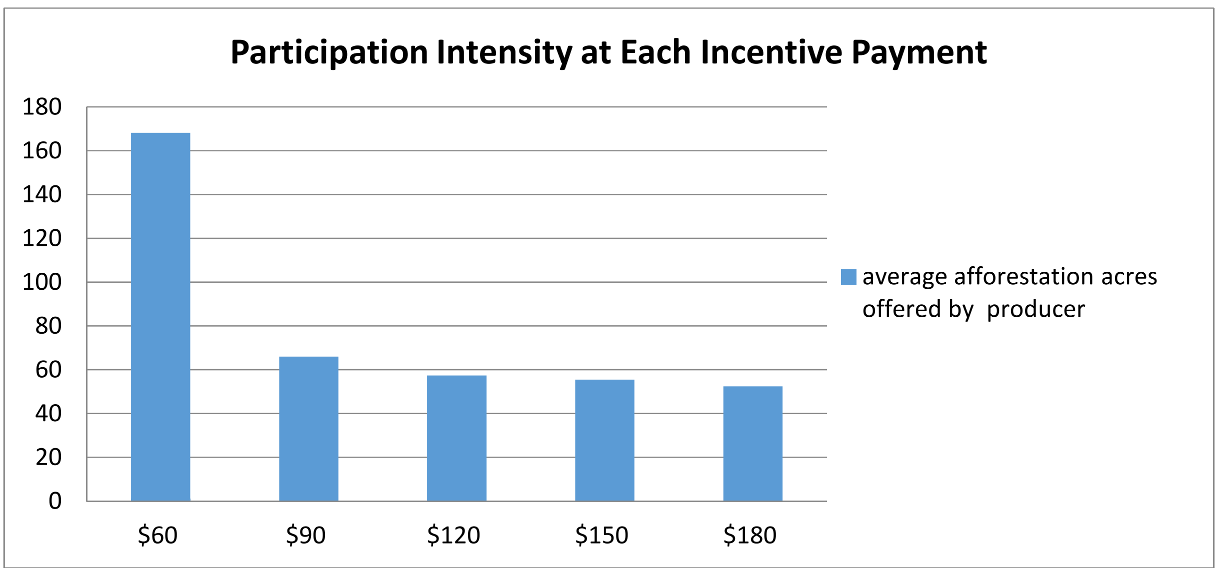

Figure 5: Participation Intensity at Each Incentive Payment

Chapter 2: Modeling Use of Pasture Management Practices

Abstract

The use of pasture management practices can provide many benefits for cattle producers including increased forage and production capacity, reduced soil erosion, and better pasture and water quality. Despite these benefits, many cattle producers do not implement pasture management practices.

This study analyzed the results of a mail survey of over 4,000 cattle producers east of the 100th meridian to determine the factors that influence the usage of ten pasture management practices. The ten pasture management practices were grouped into three classifications on the basis of factor analysis results and multivariate probit model was used to analyze producer use of one or more practice from each group. The dummy variable representing extension workshop attendance was significant ($p<0.10$) and positive in every equation. Other positive significant variables were woodland acres owned, income, and education. Age was found to have a negative effect in all cases. Education through extension efforts is associated with the use of pasture management practices. If policy makers want to increase the use of these practices, targeting producers who attend extension workshops could be a solution.

Introduction

The use of pasture management practices has many benefits including reduced soil erosion, increased biodiversity and vegetative cover, and reduced degradation. Pasture management practices can also reduce the cost of production and maintain soil fertility. For example, sediment is the largest surface water pollutant in the United States (EPA 2014). Exposing bare soil to rainfall oftentimes results in a large nutrient loss which can reduce future profits as the soil becomes less productive over time. The use of pasture management practices can help alleviate sediment loss. These practices are also important in helping manage imbalances of soil quality on pastureland. Practices such as soil testing, fertilizer use, manure application, and replanting pasture can restore soil nutrients. In addition, use of conservation practices can coincide with a successful and profitable farm by lowering costs and increasing overall animal health (Lemus 2008).

Cattle producers have traditionally relied on ponds, streams, or rivers to water cattle. However, providing cattle direct access to waterways can damage water banks, increase sediment loading, increase invasive species growth, and spread water-borne diseases. Research has shown that by providing an alternative water source, stream bank erosion and fecal bacteria entering streams can be reduced. For example, Edwards et al. (2007) found that controlling stream access and using nutrient management on pasture land significantly increased aquatic health. Despite the implementation of government programs, as well as educational and extension efforts, the use of pasture management practices, including best management practices (BMPs), varies from one producer to the next. Many operators have not adopted pasture management practices, because they struggle with prioritizing both farming and conservation adoption (Ellis 2014). Economic, political, social, and geographic variables, such as site-specific environmental characteristics, lifestyle choices, and attitudes on environmental stewardship, also contribute to why farmers use or do not use pasture management practices (Gillespie, Kim, and Paudel 2007; Lambert et al. 2007). In order to design educational programming or policy to increase pasture management usage, an understanding of the factors influencing use and patterns of use is beneficial.

The objectives of this chapter are to 1) analyze factors influencing the use of ten pasture management practices that have proven farm benefits and 2) explore whether or to what extent there are patterns in terms of the use of these practices (e.g. whether some more or less tend to be used together).

Literature Review

Studying BMP adoption can be useful in understanding adoption of pasture management practices. In addition, BMP adoption and the factors which influence adoption by farmers has been extensively researched (Prokopy et al. 2008; Knowler and Bradshaw 2007; Kabii and Horwitz 2006; Baumgart-Getz, Prokopy, and Floress 2012). For example, Prokopy et al. (2008) examine 55 BMP adoption studies published from 1982 to 2007. The authors studied respondents who had previously adopted BMPs. Studies of adoption by both livestock and crop farms were included in their literature review. The study finds that education levels, farm size, access to information, positive environmental attitudes, environmental awareness, and utilization of social networks are often positively associated with adoption. The authors found conflicting information on how income and age affect adoption rates. In addition, the authors found that the type of statistical analysis used in the studies did not affect the results in most cases. Similarly, Baumgart-Getz, Prokopy, and Floress (2012) analyzed the actual adoption of BMPs in 46 studies published between 1982 and 2007. Of the findings relevant to this study, extension and environmental awareness were found to be positively related to BMP adoption rates. The effect of age was found to be significant and negative on adoption in many of the studies.

Knowler and Bradshaw (2007) reviewed past conservation agriculture (i.e., mostly soil conserving) studies to identify factors that could explain adoption. Household income and farm size were among the variables that were positively correlated with adoption. Negatively correlated variables included age and off-farm income. As the authors suggested, an increase in off-farm income could lead to a decrease in prioritization of agriculture, which could result in a reduced interest in soil conservation practices. Financial incentives influenced most producer decisions to use conservation agriculture. Kabii and Horwit (2006) examined the factors that influence landowner decision-making regarding conservation practices. The authors suggested that farmers are motivated to adopt conservation practices if they have more financial flexibility, are more knowledgeable about conservation, and farm as a way of life.

In addition to these literature reviews, some studies focused specifically on the factors that influence cattle producer adoption of BMPs (e.g. Kim, Gillespie, and Paudel 2005; Gillespie, Kim, and Paudel 2007). Kim, Gillespie, and Paudel (2005) analyzed the adoption of 16 BMPs by Louisiana cattle producers. The authors found that beef cattle producer adoption was relatively low compared with other agricultural operations, including dairy operators. Education levels were positively correlated with adoption rates. The authors found that age was positively correlated with adoption rates. They hypothesized that this was because many of the BMPs had been promoted for years. Older producers were more familiar with the BMPs and likely had more time due to retirement from off-farm jobs.

Gillespie, Kim, and Paudel (2007) also studied grazing management practices. Mortality, nutrient and pesticide management were found to be the most frequently adopted BMPs among cattle producers. The authors noted that these BMPs can have significant economic benefits for the producer. Some common reasons for BMP non-adoption were non-applicability of particular BMPs to the farm, unfamiliarity, unaffordability, or time required to implement. The authors emphasized that extension and educational programs designed to promote BMP adoption should provide information on the economic and environmental costs and benefits of BMP adoption.

Survey Data

The data for this study came from two versions of a survey of cattle producers. The first version focused on the adoption of prescribed grazing, and the second focused on the adoption of afforestation. Both surveys used a random sample of beef cattle, cow/calf, and backgrounding/stockering operations in the eight Economic Research Service (ERS) regions east of the 100th meridian (figure 6 in appendix C). Thus, producers from the following states are included in this study: AL, AR, CT, DE, FL, GA, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, NC, ND, NE, NH, NJ, NY, OH, PA, RI, SC, SD, TN, TX, VA, VT, WI, and WV. The ERS regions are based on commodity production, geographical specialization, and other environmental similarities. The sample was collected by USDA's National Agriculture Statistics Service (NASS) and had a 20 head of cattle minimum in order to eliminate hobby farmers. Every individual in the sample was randomly assigned to one of the two survey versions. Each version had a sample size of 8,875 (for a total of 17,750) out of a total 267,413. Each sample represented roughly three percent of the total available population (six percent total). The prescribed grazing version had a total of 2,551 completed surveys, for a 29 percent response rate, and the afforestation version had a total of 2,448 completed surveys for a response rate of 28 percent.

Each version of the survey had a similar structure. The survey was divided into three sections. The first section ("Your Farming Operation") included questions about farm size, rental terms, and woodland acres owned. The second section ("Prescribed Grazing" or "Afforestation," depending on the version) included questions specific to each version. Respondents' answers to these sections are not included in this analysis as they are not relevant to this analysis. The third section ("About You") asked questions regarding producer characteristics, such as income, age, conservation attitudes and hours worked per week.

Included in the "Your Farming Operation" section was a set of questions regarding current use of pasture management practices. Responses to these questions are the focus of this chapter. Respondents were asked which of a specific list of pasture management practices they used. The specific practices considered were: 1) Apply manure as fertilizer to pastures, 2) Apply N, P, or K (DAP, urea, LAN, etc) to pasture, 3) Water cattle at site other than stream or pond, 4) Have buffer strips of grassy vegetation along waterways, 5) Have shade structures, scratching posts, and feed supplements placed away from the streams, 6) Have improved stream crossings, 7) Control livestock access to streams, 8) Protect heavy use areas with geotextiles, 9) Replant bare pasture with legumes or native grasses, and 10) Periodically test soil. Pasture management practices definitions, mean use rates, total pasture acres managed, and a brief summary of possible benefits are found in table 10 in appendix C. While most of these practices might be considered BMPs, several are not. For example, while in some cases the application of fertilizer or manure is considered a BMP, the survey does not specify an amount or use rate. Thus, to call these pasture management practices BMPs, might imply more than is contained in the pasture management descriptions.

The pasture management practices were divided into three groups based on factor analysis results: soil fertility and management (*soilfertility*), riparian health (*riparianhealth*), and other practices (*other*). Practices related to soil fertility are *npk, soiltest*, and *replantpasture*. Riparian health included the following practices: *shade, bufferstrips, streamacces*, and *crossings*. Other practices are *alternativewater*, *geotextiles*, and *manure*. In addition, table 6 in appendix C shows the pasture management practice categories.

Weights

To help compensate for producer non-response, post-stratification weights are used in the trivariate probit model. The weights are based on each respondent's ERS region (figure 6 in appendix C) and household income. The weights allowed us to predict the number of farms that would be in the same income and regional groups according to the 2007 Agriculture Census. Farms categorized in the corresponding ERS region and income group are weighted similarly (Lambert 2014a).

Statistical Analysis

Means and Associations

Univariate statistics are used to compare users of pasture management practices with non-users. For the purposes of this study, "users" are identified as respondents who used at least one out of the ten pasture management practices. Assuming unequal variances among the groups in this study, t-tests are used to determine if two sets of data are significantly different from one another. Specifically, the hypothesis tested is the following: does the mean number of pasture acres significantly differ between users and non-users of pasture management practices? Unequal variances are assumed because a more conservative estimate is produced by not assuming normality of the underlying population (Ruxton 2006). The null hypothesis is rejected if the difference in each of the variable means is significantly different from zero at the ten percent level.

Correlation Modeling

Correlation coefficients are used to analyze patterns of pasture management practice use across respondents, i.e. which pairs of practices are more or less likely to be used together. Spearman's correlation is used to compare the variables. This is non-parametric and does not assume linearity (Spearman 1904). It is hypothesized that use patterns exist among the pasture management practices. It is expected that practices in the same group (*soilfertility*, *riparianhealth*, and *other*) will exhibit higher correlations than practices across different groups. In addition, current federal programs, such as Environmental Quality Incentives Program (EQIP), promote certain pasture management practices that might be familiar to some respondents. Thus, one might expect that practices supported by incentive or cost share programs to be more likely adopted in tandem, such as the use of buffer strips and controlled stream access.

Adoption Analysis

Random Utility Model

The Random Utility Model (McFadden 1974) provides a framework for analyzing a discrete decision. The choice decision is whether a producer uses a particular pasture management practice. Although producer preferences are unobserved, it can be assumed that producers make decisions based on the choice that maximizes utility. The Random Utility Model will be used to analyze producer use of pasture management practices.

A respondent can choose to use or not use a pasture management practice. The variables representing pasture management practice use are binary, with 0 denoting non-use and 1 use. Let U_{iP} represent the *ith* consumer's utility for using one of the pasture management practices and U_i be the utility from not using a pasture management practice. The *ith* producer will use a pasture management practice if

$$(1) \qquad U_{iP} > U_i$$

Because the dependent variables are binary, the *ith* producer's use of a pasture management practices (y_i) is

$$(2) \qquad \mathrm{y_i} = \begin{cases} 0 \text{ if } y^*_{\mathrm{ip}} \leq 0 \\ 1 \text{ if } \mathrm{y}^*_{\mathrm{ip}} > 0 \end{cases}$$

where the latent propensity to use a pasture management practice is $\mathrm{y}^*_{\mathrm{ip}}$. The Random Utility Model can be extended to a probabilistic framework: $\Pr(\mathrm{j} = 1) = \Pr(\mathrm{u}^0_\mathrm{i} + \varepsilon^0_\mathrm{i} \leq \mathrm{u}^1_\mathrm{i} + \varepsilon^1_\mathrm{i}) = \Pr(\varepsilon^0_\mathrm{i} - \varepsilon^1_\mathrm{i} \leq X\beta)$ after the typical normalization $\beta = \beta^1 - \beta^0$ (Greene 2011). $\boldsymbol{\beta}$ is a vector of parameters, and $\boldsymbol{X}$ is a matrix of producer characteristics. The probability of using a pasture management practice is $\Pr(j = 1) = F_\varepsilon(X\beta)$, where F_ε is a cumulative distribution function of ε_i (Cooper 1997).

A probit model can be used to analyze the use of one pasture management practice, as estimated with maximum likelihood

(3) $$\ln L = \sum_i [\ln \Phi(\beta\alpha + \boldsymbol{\beta}\mathbf{X}_i) + (1 - y_i)\ln(1 - \Phi\boldsymbol{\beta}\mathbf{X}_i)]$$

where the Cumulative Distribution Function (CDF) of the standard normal distribution is Φ. Overall significance of the model is contained in the Log Likelihood Ratio (LLR) test. The LLR test compared the log likelihood from the model with all variables to an intercept-only model. The test statistic is LLR=-2($L_nL_r - L_nL_u$) where L_r is the log likelihood of the intercept only model, whereas parameters are equal to zero and L_u is the log likelihood of the unrestricted model. This test statistic is distributed as x^2 variate with *k* degrees of freedom, where the number of explanatory variables included in the model is *k* (Greene 2011).

Multivariate Probit Model

The ten pasture management practices were divided into three groups based on factor analysis results. The three pasture management type equations can be estimated using individual probit models. However, a multivariate probit model can provide more efficient coefficient estimates if the error terms of the individual probit models are correlated (Giesbert, Steiner, and Bendig 2011). A trivariate probit model is used to analyze the effects of producer and farm characteristics on the use of pasture management practices among cattle producers (Cappellari and Jenkins 2003). Each pasture management practice (y_1^*, y_2^*, y_3^*) response depends on a set of unknown parameters (β_1,β_2, β_3), a vector of farm and producer characteristics (x_1, x_2, x_3), and the error terms (ε_1, ε_2, ε_3). The error terms contain unobservable factors that explain the probability of choosing a pasture management practice in one of the three groups (Giesbert, Steiner, and Bendig 2011). The three regressions (y_1^*, y_2^*, y_3^*) from equation 4 take the value of 1 if the respondent uses one or more pasture management practice from either of the three categories and 0 otherwise. The three equations are coded as binary variables y_j where j=1, 2 or 3. Y is equal to 1 if a respondent uses one or more of the pasture management practices from a particular group.

$$(4) \qquad y_1^* = \beta_1 X_1 + \varepsilon_1, \quad y_1 = 1\ (y_1^* > 0)$$
$$y_2^* = \beta_2 X_2 + \varepsilon_2, \quad y_2 = 1\ (y_2^* > 0)$$
$$y_3^* = \beta_3 X_3 + \varepsilon_3, \quad y_3 = 1\ (y_3^* > 0)$$

In the trivariate probit, each of the ε_j are derived from a normal distribution that has a mean of 0, and a covariance matrix Ω (equation 5), where the leading diagonal of the matrix is 1. Predicted joint probabilities are found using the estimated model coefficients, where $\rho_{1,2}, \rho_{1,3}, \rho_{2,3}$ represent the unobserved correlation between the stochastic component of each pasture management practice (Capellari and Jenkins 2003; Giesbert, Steiner, and Bendig 2011).

$$(5) \qquad \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \end{bmatrix} \sim MVN\left(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \quad \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{23} & 1 \end{bmatrix}\right)$$

To test overall significance, the LLR test is used. As shown in Capellari and Jenkins (2003) the joint estimation of the three equations in (4) is based the evaluation of the loglikelihood function

$$(6) \qquad \ln L = \Sigma_i^N\ w_i \ln \Phi_3(\mu_i, \Omega)$$

Where i=1,…N, N is the sample of independent observations, w_i is a weight for each observation, and Φ_3 is the trivariate normal cumulative density function with arguments μ_i and Ω.

$$(7) \qquad \mu_i = (K_{i1}\beta_1 X_{i1}, K_{i2}\beta_1 X_{i2}, K_{i3}\beta_3 X_{i3})$$

$K_{ij} = 2y_{ij} - 1$, so K_{ij} equals 1 if a respondent uses a pasture management practice or -1 otherwise. The constituent elements of matrix Ω are shown in (8) (Giesbert, Steiner, and Bendig 2011).

$$(8) \qquad \Omega_{jj} = 1 \text{ for } j = 1, 2, 3$$

Using the Geweke-Hajivassiliou-Keane (GHK) algorithm, the trivariate probit model estimates normal, multi-dimensional functions (Greene 2003; Capellari and Jenkins 2003). Under the above assumptions, the correlation coefficients summarize latent factors that determine the likelihood that a respondent will choose a pasture management practice from one of the three groups.

Hypothesized effects

Independent variables and their corresponding hypothesized effects on the use of pasture management practices are listed in table 12 in appendix C. It is hypothesized that respondents who manage more pasture acres (*pastureacres*) will be more likely to use pasture management practices. Larger operators can reduce the average cost by spreading costs of the practices over more acres (Feder et al. 1985). It is expected that a respondent's household income (*income*) as well as the percent of income from cattle production (*cowpercent*) will be positively associated with use of pasture management practices. Higher income (*income*) usually indicates a greater flexibility in adopting new technologies (Kim, Gillespie and Paudel 2005). In addition, a higher percent of income from cattle production could reflect a prioritization of long-run economic efficiency with respect to pasture and cattle production (Kim, Gillespie, and Paudel 2005). Stocking density (*stockdensity*) is likely to be positively correlated with use of pasture management practices, especially in the *soilfertility* group. If a respondent has a higher stocking rate, the respondent might have a greater need for practices that increase soil productivity.

It is hypothesized that a respondent's age (*age*) will be negatively associated with use of pasture management practices, while education level, *socol and college (highsch* is base case*)* will be positively associated with the use of pasture management practices. Prokopy et al. 2008 found that older and less educated producers are not as likely to adopt BMPs. Wu and Babcock (1998) found that education was positively associated with adoption rates, thus *college* and *socol* are expected to be positive relative to respondents who only attended high school. It is also interesting to note that Prokopy et al (2008) found no studies in which educational attainment had a statistically significant negative effect on adoption.

Rahelizatovo (2002) found that dairy producers who have contact with extension are more likely to adopt BMPs. *Extension* is a dummy variable indicating whether or not the respondent has attended an extension workshop within the past year, and it is expected to be positively correlated with use of pasture management practices.

It is expected that a respondent's future plans will influence use of pasture management practices. Producers, whose families will take over farming after their retirement (*cease*), are expected to have higher adoption rates (Kim, Gillespie, and Paudel 2007). It is expected that operation of the farm as a sole proprietorships (*soleprop*) will be positively associated with pasture management practice use. It is believed that those respondents who operate independently are more likely to adopt conservation measures than a corporate or jointly owned farm. However, Prokopy et al (2008) found that this characteristic was positive and negative in an approximately equal number of studies.

A dummy variable indicates whether a respondent had an off-farm job (*offarmdummy*). It is expected that having an off-farm job will have a negative effect on pasture management practice usage. In a study of CRP participation, Lambert, Sullivan, and Classen (2007) found this to be true. Respondents who are full-time farmers are more likely to be interested in using practices that increase production potential; alternatively, farmers who have off-farm sources of income might consider their farming operation to be of somewhat lower priority.

Geographical differences are represented by ERS regions. A map of these regions is shown in figure 1. There are eight regions (*heartland, northerncrescent, northerngreatplains, easternuplands, southernseaboard, fruitfulrim, mississippiportal*, and p*rairiegateway*). Several regions are combined to account for relatively small number of respondents representing those regions:

northerngreatplains with *prairiegatway* and *mississippiportal* with *southernseaboard*. These regional variables control for differences in growing seasons, weather conditions, common types of farms, and overall cost of production. It is difficult to provide hypothesis for the regional variables, because the variety of dimensions in which the regions differ (Allen 1993).

Rainfall data is represented by total annual rainfall (mm), averaged over 30 years, for the respondent's county. The data was derived by using PRISM GIS data from Oregon State University (PRISM 2013). The average annual amount of precipitation (*precip*) is expected to be positively correlated with use, especially with practices related to the *riparianhealth* group. The likely effect on the *soilfertility* group is unknown. On one hand, *precip* and *npk* might be negatively associated as nitrogen leaching can occur with greater amounts of rainfall. However, fertilizer is more effective when used with adequate rainfall, so a positive relationship is also feasible.

Woodland is a discrete variable indicating whether a respondent owns or rents woodland acres, grazed and non-grazed. The effect of woodland acreage on pasture management practice use has not been previously studied. It is hypothesized that woodland ownership (*woodland*) will have a positive effect on use, assuming that the decision to own and retain woodlands is a conscious decision, indicating a conservation ethic. It is hypothesized that respondents who have forested acres oftentimes do so because they appreciate the private amenities forests bring, such as hunting opportunities, wind protection, aesthetic value, and shade. Public benefits include carbon sequestration and increased water quality. Thus, it is hypothesized that respondents who value these benefits would also value similar environmental benefits from a productive pasture or healthy stream, suggesting a possible positive relationship between woodland acres and usage of pasture management practices.

Similarly, a proxy variable was developed to reflect a respondent's state's attitudes toward environmental conservation. If resident of a state in which a respondent resides actively promotes conservation behavior, it would be logical to assume that respondents would either reflect or be influenced by these activities. Leadership in Energy and Environmental Design (LEED) is a certification program which is given to buildings that meet a set of environmentally conscious prerequisites (Newsham, Mancini, and Brit 2009)**.** The process of obtaining LEED certification is often tedious and expensive. It is hypothesized that people who live in states with a greater square foot per capita of LEED certified buildings (*LEED*) will be more environmentally conscious, which should result in a positive relationship between *LEED* and pasture management practice use. Based on layered causality, if a respondent lives in a state that promotes conservation and "green" behavior, it is hypothesized that he or she will be more likely to conserve, or for the purposes of this chapter, use pasture management practices with demonstrable environmental benefits.

Finally, Prokopy et al. (2008) found that positive attitudes toward the environment generally had a positive effect on adoption rates. Therefore, it is hypothesized that when a respondent feels strongly about being a steward of the land (*steward*), he or she is more likely to use pasture management practices.

Results

As stated above, the overall response rate for the two surveys was approximately 28%. Overall, there were 338 respondents who did not use any of the ten pasture management practices, and 4,073 respondents who used at least one of the practices. Individual use means of each practice can be found in tables 10 and 11 in appendix C.

Mean comparisons

Univariate means test was used to test if there was significance difference in the means between users and non-users in each group of pasture management practices: *soilfertility*, *riparianhealth*, and *other*. The results are located in appendix C in tables 13, 14, and 15.

Of the 22 variables included, only nine variables were found to have significantly difference means between users and non-users in all three groups of practices. On average, users of all three pasture management groups were younger (*age*), better educated (*college*), and have more household income (*income*) than non-users. Users in all three groups were also more likely to attend extension workshops (*extension*), and these respondents are more likely to have woodland (*woodland*). Those respondents who worked off farm (*offfarmwork*) were more likely to use any of the pasture management practices, and stocking density rates (*stockdensity*) were higher among users as well. The only regional variable that was consistently significant throughout all pasture management practice groups was the ERS region *prairiegateway*.

Pastureacres and *socol* were the only variables in which there were no significant differences in means between users and non-users for any of the pasture management practice groups.

Spearman correlations

An analysis using Spearman correlations suggests that low-to-moderate correlations exist between the use of pasture management practices. It is interesting to note that while the correlations are relatively low, no correlation was found to be negative. Results of Spearman correlations are found in table 16 in appendix C.

In the *soilfertility* group, soil testing*, testsoil, had a* moderate correlation (0.364) with *npk. Testsoil* and *npk* also had a moderate correlation with *replantpasture*, 0.373 and 0.262, respectively. In the *riparianhealth* group, *Bufferstrips* and *streamaccess* had the strongest relative relationship with a correlation of 0.375, indicating that these two pasture management practices are used together somewhat frequently. In addition, *bufferstrips* also had a moderately strong positive relationship with *shade* (0.325) and *crossings* (0.311). *Crossings* had a moderate positive relationship with *streamaccess* (0.343). *Bufferstrips*, *crossings*, *shade*, and *streamaccess* are conservation intensive pasture management practices and all contribute to maintaining riparian and stream health. Thus it can be assumed that if a producer sees the benefit of adding buffer strips, he or she will also derive benefit from controlling stream crossings and access. These correlations could also indicate the presence of a stream. The practices included in the *other* group all have low correlations with one another, indicating that these practices are not necessarily used together.

Multivarirate probit

The results of the trivariate probit model are provided in table 17 of appendix C. Three dependent variables were included in the model: *soilmanagement*, *riparianhealth*, and *other*. Each pasture management practice group was tested against the same set of variables. The model as a whole is statistically significant (p<0.01), meaning that the unrestricted model fits better than a model with no predictors. The correlations between error terms were found positive and significant in each equation.

Soil fertility practices

Of the 19 variables included in the *soilfertility* equation, 12 were positive and significant at the 10 percent level. Respondents who attended (*socol*) or graduated from college (*college*) were more likely to use practices related to soil fertility than respondents who only attended or graduated high school. Respondents with higher incomes (*income*) are more likely to use this group of practices.

The more densely a producer stocks his cattle (*stockdensity*), the greater the chance of soil fertility use. If a respondent has a higher stocking density, there could be a greater need for these practices due to an overuse of resources. In addition, the greater the percent of income from cattle a respondent has (*cowpercent*), the more likely he or she is to use soil fertility practices. In addition, respondents who own woodland (*ownwood*) are more likely to use soil fertility practices.

If a respondent believed strongly in acting as a steward of the land (*steward*), he or she is more likely to use the *soilfertility* pasture management practices. Also, the variable representing the amount of LEED certified buildings per state (*LEED*) was found to be a significant influence on the use of soil fertility practices. If a respondent lives in a state with more LEED certified buildings per person, he or she is more likely to use soil fertility practices. Respondents who attended at least one extension workshop in the past year (*extension*) were found to be more likely to use this group of practices.

Several regional and geographic variables were found significant. Respondents from the heartland (*heartland*) and eastern uplands (*easternuplands*) are more likely to use soil fertility practices than respondents from the *prairiegateway* region. The heartland region has the highest value of production of any region, which could indicate that pastureland in this area is overused and in need of soil fertility practices to maintain high levels of production. In addition, the amount of precipitation (*precip*) was found to be positively related to soil fertility practices.

Riparian health practices

Six of the 19 variables included in *riparianhealth* equation were found to be significant. Unlike with the *soilfertility* group, regional variables were not found to have an effect on practices related to riparian health (*riparianhealth*). Age (*age*) has a negative effect and income (*income*) has a positive effect on the use of riparian health practices. Attendance of extension workshops (*extension*) has a significant positive relationship with these practices. Similarly to *soilfertility*, extension workshops often provide services, education, and materials for producers to improve farm health and production.

As in practices related to soil fertility, the amount of precipitation (*precip*) is positively related to the use of riparian health practices. This could be because if a respondent lives in an area with more precipitation, there is an increased likelihood that there would be a running stream on his or her property. In addition, the more pasture acres a respondent manages (*pastureacres*), the greater the likelihood the respondent uses a riparian health practice. If a respondent has woodland

(*woodland*), he or she is more likely to use this set of practices. This relationship is logical, because trees can act as buffer strips, offer shade, and control cattle's access to streams.

Other practices

Of the 19 variables included in the *other* practices equation, which are *alternativewater*, *manure*, and *geotextiles*, 12 were found to have a significant effect. Unlike with the other two groups, precipitation (*precip*) has a negative effect on other pasture management practices. The change of signs could be explained by the possible negative correlation between precipitation amounts and the use of *alternativewater*. Those respondents who use an alternative water source might do so because of the lack of precipitation. The amount of pasture acres (*pastureacres*) positively affects the use of *other* practices. For example, if a respondent has more pasture, it might be more convenient to recycle manure over many acres. In addition, more pasture acres might imply a greater need for supplemental water sources. Woodland acres (*woodland*), percent of income from cattle (*cowpercent*), and stocking density (*stockdensity*) also have a positive effect.

As in the *riparianhealth* equation, age (*age*) has a negative effect on use of *other* pasture management practices. Respondents, who are older, might be getting ready for retirement and not interested in investing time and money into using a new pasture management practice. Respondents who attended at least one extension workshop (*extension*) were found to be more likely to use this group of pasture management practices.

Compared with *prairiegateway*, all of the ERS regions (*heartland, easternuplands, southernseaboard, northercrescent,* and *fruitfulrim*) were found to have a positive effect on the use of *other* pasture management practices.

Between the three different groups of pasture management practices, only three variables were significant throughout: *extension, precip*, and *woodland. Extension* and *woodland* were positive in all three while *precip* was positive in both the *soilfertility* and *riparianhealth* equations but negative in the *other* equation.

Discussion

Pasture management practices can provide many benefits including increased soil and water quality, higher land productivity, improved forage, and decreased bank erosion, among many others. The usage of pasture management practices is not consistent among producers, as indicated by the means listed in table 9 of appendix C. This inconsistency could be due to time constraints, costs, and lack of familiarity of the practice.

Almost 4,000 producers were asked whether or not they used ten different pasture management practices. The most commonly used practices were the use of shade structures away from water and alternative water sources. The least common was the use of geotextiles. As shown by the means testing, many producer characteristics differed between user and non-users. Using factor analysis, the pasture management practices were sorted into three groups: soil fertility, riparian health, and other practices. In most cases, the practices included in each management group had a moderate correlation which one another, as shown by the spearman coefficients. Each group of pasture management practices was found to be significantly affected by a different set of producer and farm characteristics. The significance of the amount of LEED certified square feet per capita in the soil fertility group of pasture management practices could indicate that producers are influenced by local public attitudes. There were several variables that significantly influenced each equation in the trivariate probit model: attendance of extension workshops, precipitation amount, and ownership of woodland acres.

For future research, it would be interesting to explore how a running stream on a respondent's property affects the use of the pasture management practice groups. In addition, analyzing how incentives affect use of pasture management practices could also provide insight into who uses these practices and for what reasons.

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Appendix C
Table 10: Descriptions of Pasture Management Practices (n=3106)

Variable	Survey Description	Mean	Weighed Acres (1000s)	Benefits
soilfertility				
npk	Apply N,P, or K fertilizer to pastures	0.51	88.90	Improve forage quality, increase production, increase legume species growth.
testsoil	Periodically test soil	0.49	85.19	Help decide how much fertilizer needed to improve productivity
replantpasture	Replant bare pasture with legumes or native grasses	0.41	72.46	Increase production, maintain soil quality, increase water quality
riparianhealth				
shade	Have shade structures, scratching posts, and feed supplements placed away from streams	0.60	102.11	Increased water quality, decrease soil erosion and compaction, preserve desired vegetation
crossings	Have improved stream crossings	0.18	31.16	Promote uniform grazing, decrease stream bank erosion, improve water quality, decrease chances for cattle injury
streamaccess	Control livestock access to streams	0.20	34.43	Lessen sediment pollution, decrease erosion, improve water quality, and increase health of stream vegetation
bufferstrip	Have buffer strips of woody or grassy vegetation along waterways	0.34	58.99	Filter for pollutants, increase water quality, and maintain water banks.
other				
manure	Apply Manure as fertilizer to pastures	0.41	67.79	Manure can recycle nutrients, improve soil quality, and protect water quality.
alternative water	Water cattle at site other than stream or pond	0.60	106.41	Decrease stream or pond bank erosion, improve water quality, and maintain health and productivity of farm.
geotextiles	Protect heavy use areas with geotextiles	0.08	13.78	Provides a stable and non-eroding surface, decrease mud

Table 11: Pasture Management Practice Groups and Mean Use in ERS regions

	Pasture Management Practice Groups		
ERS Region	*soilfertility*	*riparianhealth*	*other*
heartland	0.8201	0.7306	0.8161
prairiegateway	0.5744	0.6686	0.6765
southernseaboard	0.8059	0.7521	0.7516
northerngreatplains	0.2976	0.6905	0.7500
easternuplands	0.7959	0.7059	0.7273
fruitfulrim	0.6822	0.6355	0.8879

Table 12: Variable List and Hypothesized Effects

Independent Variables	Description	Hypothesized Sign	Minimum	Maximum
pastureacres	number of total acres farmed (100s)	-	1	65,720
age	respondent's age	-	15	95
income	1 if respondent's total income is less than \$10,000; 2 if respondent's income is between \$10,000 and \$29,000; 3 if respondent's income is between \$30,000 and \$49,999; 4 if respondent's income is between \$50,000 and \$99,999; 5 if respondent's income is between \$100,000 and \$149,000; 6 if respondent's income is between \$150,000 and \$199,000; 7 if respondent's income is between \$200,000 and \$499,999; 8 if respondent's income is greater than \$500,000	+	1	8
cowpercent	Share or respondent's percent of income that comes from cattle	+	-10	100
extension	1 if respondent attended any extension workshops in 2012; 0 otherwise	+	0	1
highsch	1 if respondent attended only high school; 0 otherwise		omitted	
socol	1 if respondent attended some college but did not graduate; 0 otherwise	-	0	1
college	1 if respondent graduated from college; 0 otherwise		0	1
offfarmdummy	1 if respondent works off farm; 0 only on farm	-	0	1
woodland	1 if respondent owns woodland; 0 otherwise	+	0	1
soleprop	1 if farm operated as "sole proprietorship;" 0 otherwise	+	0	1

Table 12: Variable List and Hypothesized Effects continued

Independent Variables	Description	Hypothesized Sign	Minimum	Maximum
steward	1 if strongly disagree; 2 if somewhat disagree; 3 if no opinion; 4 if somewhat agree; 5 if strongly agree	+	0	1
cease	1 if respondent's children/grandchildren will farm land after they he/she ceases farming	+	0	1
$stockdensity^{a}$	Stocking Rate: (.92*cows+ .08* calves+ 1.35* bulls+ .6*backgrounder calves+ .6*stocker calves+.92*dairy cows+ .8*replacement heifers +.8*miscellaneous cattle)/ total number of pasture acres farmed		0	27.83
LEED	square foot per person by state	+	0.28	2.29
precip	annual rainfall per year (mm)	+	454.86	1794.30
heartland	0,1 ERS region	n/a	0	1
northerncrescent	0,1 ERS region	n/a	0	1
prairiegateway (base case)	0,1 ERS region		omitted	
easternuplands	0,1 ERS region	n/a	0	1
southernseaboard	0,1 ERS region	n/a	0	1
fruitfulrim	0,1 ERS region	n/a	0	1

a Stocking calculation was created by Holt (2013)

Table 13: Means of Producer Characteristics and T-Tests of Difference in Means of Users and Non-Users of Practices in the *soilfertility* Group

		soilfertility Group		
Operator Characteristic	All Pasture Owners (3194)	Users (2375)	Non-users (819)	Significance Level
pastureacres	306.71	305.13	316.37	
age	62.74	62.32	63.44	**
income (a)	3.97	4.03	3.79	***
cowpercent	34.57	36.64	31.62	***
extension	0.30	0.35	0.16	***
highsch	0.41	0.39	0.47	***
socol	0.23	0.23	0.22	
college	0.36	0.38	0.30	***
offfarmdummy	0.49	0.51	0.45	**
stockdensity	0.57	0.63	0.46	***
woodland	0.58	0.63	0.45	***
soleprop	0.79	0.78	0.82	**
steward (b)	4.58	4.62	4.49	***
cease	0.62	0.63	0.60	
LEEDcert	0.95	0.96	0.93	
precip	1080.50	1111.94	995.27	***
heartland	0.21	0.23	0.14	***
northerngreatplains	0.03	0.01	0.07	***
easternuplands	0.31	0.32	0.24	***
prairiegateway	0.21	0.16	0.35	***
southernseaboard	0.19	0.20	0.14	***
fruitfulrim	0.03	0.03	0.04	

Notes: means are shown in the parentheses
*** significant at 1% level, ** significant at 5% level, * significant at 10% level
a: Likert scale of income: 1 = less than $10,000, 2 = $10,000 - $29,000, 3 = $30,000 – $49,000, 4 = $50,000 - $99,000, 5 = $100,000 - $149,999, 6 = $150,000 - $199,999, 7 = $2,000 - $499,999, 8 = $500,000 or more
b: Likert scale: 1 = strongly disagree, 2 = somewhat disagree, 3 = no opinion, 4 = somewhat agree, 5 = strongly agree

Table 14: Means of Producer Characteristics and T-Tests of Difference in Means of Users and Non-Users of Practices in the *riparianhealth* Group

Operator Characteristic	All Pasture Owners (3201)	*riparianhealth* Group Users (2277)	Non-users (924)	Significance Level
pastureacres	306.71	271.43	395.94	
age	62.74	62.18	63.75	***
income (a)	3.97	4.04	3.79	***
cowpercent	34.57	35.69	34.48	
extension	0.30	0.34	0.22	***
highsch	0.41	0.39	0.47	***
socol	0.23	0.23	0.23	
college	0.36	0.37	0.33	***
offfarmdummy	0.49	0.51	0.47	***
stockdensity	0.57	0.62	0.52	***
woodland	0.58	0.62	0.49	***
soleprop	0.79	0.78	0.81	
steward (b)	4.58	4.61	4.54	*
cease	0.62	0.63	0.61	**
LEEDcert	0.95	0.96	0.92	**
precip	1080.50	1089.67	1064.38	***
heartland	0.21	0.21	0.19	
northerngreatplains	0.03	0.02	0.03	
easternuplands	0.31	0.30	0.31	
prairiegateway	0.21	0.17	0.22	***
southernseaboard	0.19	0.14	0.10	***
fruitfulrim	0.03	0.03	0.04	

Notes: means are shown in the parentheses
*** significant at 1% level, ** significant at 5% level, * significant at 10% level
a: Likert scale of income: 1 = less than $10,000, 2 = $10,000 - $29,000, 3 = $30,000 – $49,000, 4 = $50,000 - $99,000, 5 = $100,000 - $149,999, 6 = $150,000 - $199,999, 7 = $2,000 - $499,999, 8 = $500,000 or more
b: Likert scale: 1 = strongly disagree, 2 = somewhat disagree, 3 = no opinion, 4 = somewhat agree, 5 = strongly agree

Table 15: Means of Producer Characteristics and T-Tests of Difference in Means of Users and Non-Users of Practices in the *other* Group

Operator Characteristic	All Pasture Owners (3201)	*other* Group *Users (2411)*	*Non-users (790)*	Significance Level
pastureacres	306.71	275.84	402.32	
age	62.74	62.21	63.94	***
oncome (a)	3.97	4.02	3.80	***
cowpercent	34.57	36.19	32.69	**
extension	0.30	0.34	0.22	***
highsch	0.41	0.40	0.45	***
socol	0.23	0.23	0.23	
college	0.36	0.38	0.32	***
offfarmdummy	0.49	0.46	0.51	***
stockdensity	0.57	0.63	0.44	***
woodland	0.58	0.59	0.54	***
soleprop	0.79	0.79	0.79	
steward (b)	4.58	4.59	4.57	
cease	0.62	0.62	0.62	
LEEDcert	0.95	0.96	0.92	**
precip	1080.50	1078.80	1092.52	
heartland	0.21	0.22	0.15	***
northerngreatplains	0.03	0.03	0.03	
easternuplands	0.31	0.29	0.33	***
prairiegateway	0.21	0.19	0.27	***
southernseaboard	0.19	0.18	0.19	
fruitfulrim	0.03	0.04	0.02	***

Notes: means are shown in the parentheses
*** significant at 1% level, ** significant at 5% level, * significant at 10% level
a: Likert scale of income: 1 = less than \$10,000, 2 = \$10,000 - \$29,000, 3 = \$30,000 – \$49,000, 4 = \$50,000 - \$99,000, 5 = \$100,000 - \$149,999, 6 = \$150,000 - \$199,999, 7 = \$2,000 - \$499,999, 8 = \$500,000 or more
b: Likert scale: 1 = strongly disagree, 2 = somewhat disagree, 3 = no opinion, 4 = somewhat agree, 5 = strongly agree

Table 16: Spearman Correlations of Pasture Management Practices

	manure	*npk*	*Alternat-evewater*	*buffer-strips*	*shade*	*cross-ings*	*strea-maccess*	*geotex-iles*	*Replan-tpasture*
manure	1.000	--	--	--	--	--	--	--	--
npk	0.028	1.000	--	--	--	--	--	--	--
alternative-ewater	0.131	0.128	1.000	--	--	--	--	--	--
bufferstrips	0.152	0.145	0.186	1.000	--	--	--	--	--
shade	0.105	0.143	0.208	0.325	1.000	--	--	--	--
crossings	0.114	0.089	0.127	0.311	0.212	1.000	--	--	--
streamacc-ess	0.140	0.115	0.196	0.375	0.232	0.343	1.000	--	--
geotextiles	0.130	0.120	0.171	0.216	0.136	0.205	0.274	1.000	--
Replantpas-ture	0.201	0.262	0.168	0.256	0.264	0.212	0.240	0.226	1.000
testsoil	0.184	0.364	0.166	0.265	0.213	0.178	0.235	0.230	0.373

Table 17: Trivariate Probit Results and Estimated Coefficients

	Pasture Management Practice Groups (n=3190)		
Independent Variables	*soilfertility*	*riparianhealth*	*otherpractices*
precip	0.0015	0.0003	-0.0005
	(0.0002)***	(0.0002)*	(0.0002)***
LEEDcert	0.1517	0.0881	-0.0237
	(0.0602)**	(0.0554)	(0.0574)
pastureacres (x100)	0.0032	0.0033	0.0020
	(0.0026)	(0.0002)**	(0.0030)*
age	-0.0036	-0.0045	-0.0039
	(0.0023)	(0.0021)**	(0.0022)*
stockdensity	0.1108	0.0454	0.1184
	(0.0479)**	(0.0342)	(0.0594)**
income	0.0470	0.0612	0.0270
	(0.0196)**	(0.01771)***	(0.0190)
cowpercent	0.0025	0.0008	0.0020
	(0.0008)***	(0.0007)	(0.0008)***
extension	0.6108	0.3129	0.3020
	(0.0632)***	(0.0563)***	(0.0590)***
college	0.1546	0.0101	0.0829
	(0.0637)**	(0.0599)	(0.0613)
socol	0.1146	0.0195	0.0003
	(0.0687)*	(0.0643)	(0.0668)
cease	0.0686	0.0260	-0.0018
	(0.0540)	(0.0507)	(0.0522)
steward	0.0915	0.0400	-0.0149
	(0.0307)***	(0.0281)	(0.294)
soleprop	-0.0790	-0.0489	0.0494
	(0.0657)	(0.0622)	(0.0632)
woodland	0.2281	0.2753	0.0986
	(0.0564)***	(0.0528)***	(0.0551)*
northerncrescent	-0.0461	0.0236	0.6361
	(0.1251)	(0.1241)	(0.1369)***
heartland	0.5474	0.0271	0.4373
	(0.0865)***	(0.0811)	(0.0887)***
easternuplands	0.1613	-0.0765	0.2792
	(0.0927)*	(0.0893)	(0.0927)***
southernseaboard	0.0483	0.0478	0.4064
	(0.1093)	(0.1054)	(0.1108)***
fruitfulrim	-0.1899	-0.2017	0.9179
	(0.1591)	(0.1474)	(0.1910)***
_cons	-2.0853	-0.2366	0.7849
	(0.2922)	(0.2627)	(0.2818)***
ρ_{21}	0.3710***		
ρ_{31}	0.2702***	LLR Test	-267571.28***
ρ_{32}	0.3306***		

Note: Standard errors appear in parentheses; significance at 10% (*), 5% (**), and 1% (***)

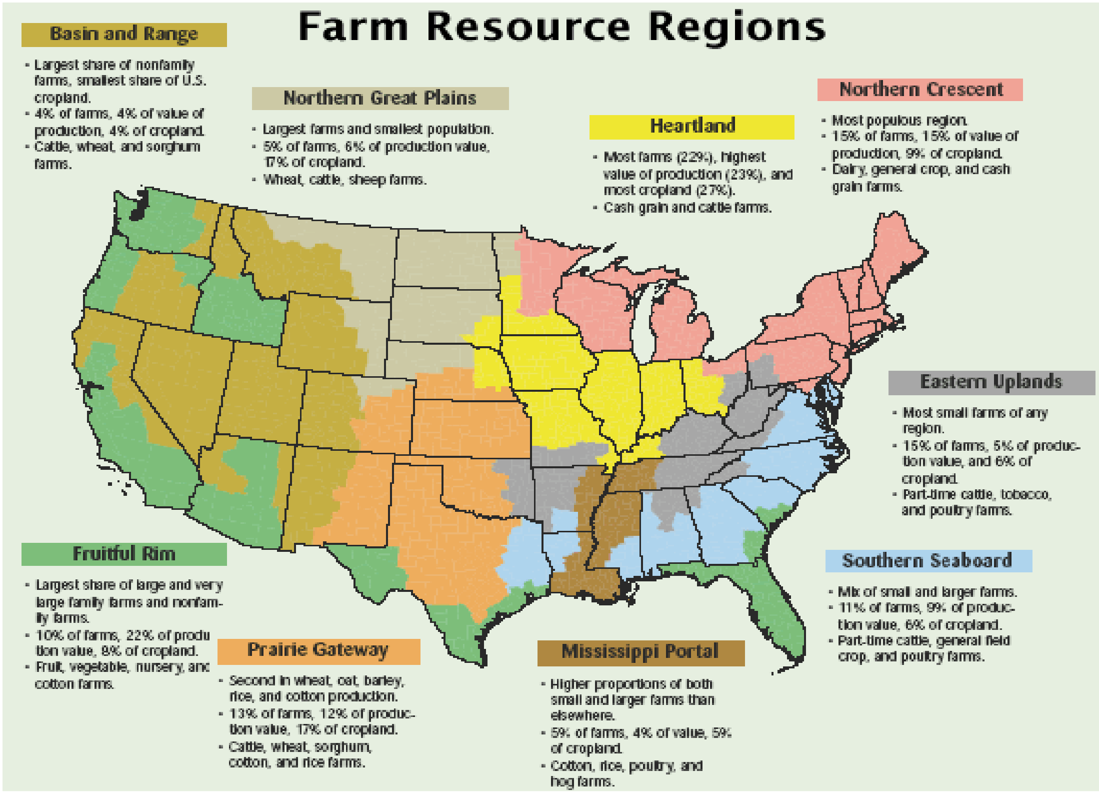

Figure 6: ERS Regions

Conclusion

As the literature shows, cattle producer decision making process is oftentimes different from their other crop and animal producers. This paper explored two different aspects of cattle producers: the adoption of afforestation in a hypothetical program and the use of pasture management practices. Chapter 1 found that producers who are interested in afforestation are more likely to have a college degree, own woodland, attend extension workshops, and have previous afforestation experience. It was also concluded that producers who are offered a lower incentive enrolled more acres in the afforestation program while those who were offered a higher incentive enrolled less acres. Chapter 2 looked at the use of ten pasture management practices. These ten practices were then divided into three subgroups based on the type of practice: riparian health, soil fertility management, and other types of practices. Ownership of woodland, extension workshop attendance, and precipitation were found to be significant in all three equations.

As shown by the results, extension workshops have a positive effect on the conservation behavior of cattle producers. Therefore, if policymakers want to increase producer participation, it is recommended that education through extension efforts be highly prioritized.

Vita

Hannah Claytor was born in Waynesboro, VA in 1990. She graduated high school in 2009 from John Handley High School in Winchester, VA. Hannah attended Emory & Henry College and graduated with a Bachelors of Arts in Environmental Studies and Economics in May 2013. Hannah enrolled in graduate school in August 2013 to study Agriculture and Resource Economics. She will graduate in May 2015. Hannah would like to thank her major professor, Dr. Christopher Clark and members of her committee: Drs. Kim Jensen and Dayton Lambert.