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ASSESSMENT OF PENNSYLVANIA'S CONSERVATION RESERVE ENHANCEMENT PROGRAM: RIPARIAN FOREST BUFFER PARTICIPANTS AND SUCCESSFUL TREE ESTABLISHMENT

A Thesis in

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ABSTRACT

Riparian forest buffers have been considered one of the best management practices for improving water quality in stream ecosystems in North America in areas where forest cover was the predominant land cover. Afforestation in riparian areas can be a slow and difficult process and presents many challenges for successful establishment of streamside forests for natural resource professionals and private landowners. One of the many conservation programs that offer assistance to private landowners for the establishment of riparian forest buffers is the USDA Conservation Reserve Enhancement Program (CREP). This program provides technical assistance and financial incentives to landowners to retire their riparian lands from production and install riparian forest buffers. This study explores the attitudes and opinions of landowners enrolled in Pennsylvania CREP riparian forest buffer initiative. It investigates the motivations for actions taken to ensure successful establishment of the trees as well as future plans for the buffer. A mail questionnaire was developed and administered to 538 CREP riparian forested buffer participants in 43 Pennsylvania counties.

This study identified some of the underlying factors that led to engagement and active participation in the maintenance of riparian forest buffers by private landowners in Pennsylvania. The participant response to the questionnaire yielded distinct patterns in landowner attitudes, level of engagement, and understanding of maintenance required for the successful establishment of their riparian forest buffer. Pennsylvania CREP riparian forest buffer participants indicated a strong motivation for improving water quality and environmental stewardship that led them to enroll their streamside land in CREP for the establishment of a riparian forest buffer. Results confirm that frequency of visits and the perceived importance of maintenance tasks by program participants were significant predictors of the level of engagement in maintenance of the riparian buffer. Landowners who participated in this study had a clearly stated intention to keep the

riparian forest buffer intact when their contract expired and to continue program participation by re-enrolling their forest buffer for an additional 10 or 15 years. Landowner attitudes and beliefs about environmental stewardship, improving water quality, the aesthetic value of streamside buffers, and wildlife habitat guided their decision making about voluntary conservation and restoration efforts over the long term. Possible management implications for these findings are advanced.

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Chapter 1

Introduction

Forest was the predominant vegetation cover for a large part of North America during most of the last 10,000 years (Sweeney, Czapka, & Yerkes, 2002). Prior to European colonization in the 1600s, forests covered 95 percent of the 41 million acre Chesapeake Bay watershed, the largest estuary in the United States (Horton, T., & Eichbaum, 1991). In eastern North America, where riparian vegetation was historically forest, significant areas of land were deforested to enable human occupation and activity and to improve aesthetics during the time of European colonization (Matlack, 1997). Dramatic changes in land cover occurred as colonists cleared forests for fuel, farming, settlements, and the export of hardwood lumber. By the early 1900s, only 30 percent of the forests remained in the Chesapeake Bay watershed, and while much of the land that was previously harvested or cleared for farming has since returned to forest cover, an estimated 60 percent of the streamside forests have been removed or severely impaired (Palone & Todd, 1998).

The deforestation of riparian areas has been a major factor in the decline of water and habitat quality in stream ecosystems in North America and the re-establishment of riparian forests is widely considered "best management practice" for restoring these stream and river ecosystems (R Lowrance, Hubbard, & Williams, 2000; Sweeney et al., 2002). In the Chesapeake Bay watershed, governmental and nongovernmental organizations have particular interest in restoring riparian forests along the watershed's 111,000 miles of perennial and intermittent streams (Dutcher, et al. , 2004). Although comprising only five to ten percent of the total land area of the Bay watershed, riparian areas play a critical role in maintaining the health of the Bay in its entirety (Palone & Todd, 1998). It is widely known that forest buffers prevent nonpoint source

pollutants such as nutrients and sediment from entering small streams (Palone & Todd, 1998; Peterjohn & Correll, 1984; Rheinhardt, Brinson, Meyer, & Miller, 2012). Recent research has demonstrated that forested buffers also enhance in-stream processing of both nonpoint and point source pollutants, thereby reducing their effects on downstream rivers and estuaries (Sweeney et al., 2004).

Research Problem

Restoration of streamside forests throughout the Chesapeake Bay watershed is largely dependent on voluntary efforts of farmers and private landowners. Agricultural land management and conservation practices are significantly influenced by both government policy and farmers' attitudes and motivations (Ryan et al., 2003). Many federal and state cost-share programs are currently available to encourage the adoption of conservation practices on private lands. In 1996, the Conservation Reserve Enhancement Program (CREP) was authorized under the Federal Agriculture Improvement and Reform Act (commonly referred to as the Farm Bill) to coordinate federal and state resources to improve water quality, soil erosion, and wildlife habitat (Armstrong et al. 2011). In Pennsylvania, CREP has been the program most widely used by private landowners to establish riparian forested buffers with 24,833.5 acres enrolled in this land use as of December 2013 (PA DEP, 2014).

In large part, improving water quality depends on the land management decisions of private landowners. This makes it critically important to understand what motivates them to engage in conservation practices in riparian areas (Ryan et al., 2003). Reestablishing natural forests can be a slow and difficult process and improving water quality with riparian forests depends on developing afforestation practices that maximize seedling survival and growth (Sweeney et al., 2002). Many programs provide funding assistance to landowners for tree

seedling planting to establish forested buffers on private lands. Landowners who participate in such programs assume the responsibility to maintain the trees and ensure that tree survival meets program requirements. Given the widespread problems of slow seedling growth and high mortality due to herbivory and competition from invasive plants, prescriptions for restoring a natural and diverse streamside forest need to include a proactive program for maintenance (Sweeney & Czapka, 2004).

Study Objective and Design

This study had two objectives. The first was to assess landowner motivations for establishing forested buffers using CREP cost-share incentives and their understanding of the maintenance responsibilities needed to ensure successful establishment. The second was to understand the long-term goals of landowners with respect to their forested buffers and continued participation in CREP. Previous studies were reviewed to understand landowner attitudes towards forested buffers, challenges and opportunities for establishing streamside forests, and management prescriptions for successful afforestation.

To accomplish these objectives, a questionnaire was developed to understand landowner participation in CREP and their level of involvement in the maintenance of their forested buffers. In 2008, Pennsylvania CREP became the first program in the United States to provide additional cost share to landowners for maintenance of forested buffers to ensure successful establishment and survival of tree seedlings (Chesapeake Bay Program, 2014). Landowners in Pennsylvania within the Chesapeake Bay watershed who had installed CREP forested buffers after 2008 were selected to participate in this study. Specifically this study examined landowner motivations for program enrollment and attempted to identify actions that lead to successful riparian plantings and future continuation in the program.

Chapter 2

Literature Review

Riparian Forested Buffers

The condition of vegetation adjacent to streams has a major effect on water quality in downstream rivers, lakes, and estuaries (Rheinhardt et al., 2012). Activities that occur alongside stream corridors have both direct and indirect physical, biological, and chemical impacts on the stream. Excessive amounts of nutrients and sediments from upland activities such as agriculture or residential development can have significant ecological impacts on streams, rivers, and estuaries into which they flow (Peterjohn & Correll, 1984). Nonpoint-source water pollution of streams is a significant environmental problem throughout the United States and agricultural crop land is a major source of such pollutants, including nutrients, sediment, pesticides, and pathogenic microbes (Dosskey, 2001). When adjoining land uses are significantly different, for example the differences between developed or disturbed lands and the stream or aquatic environment, it is common practice to create a buffer between them to mitigate such impacts (Palone & Todd, 1998).

Riparian forests provide significant ecosystem services for water quality and quantity, flood regulation, erosion control, recreational benefits, carbon sequestration, and wildlife corridors (Sweeney et al., 2004). One of the most critical functions of riparian forests is their capacity to intercept and remove nutrients and sediments originating from uplands to protect downstream water quality (Rheinhardt et al., 2012). Streamside forests are particularly effective at filtering fine sediments and promoting deposition of sediment as water infiltrates into forest soils (Lowrance et al., 1997). Forest vegetation in riparian areas can also assimilate and detain

diffuse-source nutrients in both surface and groundwater that would otherwise be transported downstream (Peterjohn & Correll, 1984).

The deforestation of riparian areas in the Northeastern U.S. region and subsequent replacement with grass or shrub vegetation has negatively impacted the structure and function of stream ecosystems by significantly altering physical and chemical characteristics, trophic dynamics, and aquatic plant and animal species life history characteristics (Sweeney & Czapka, 2004). Cover type has proven to be one of the best indicators of a riparian zone's capacity for trapping sediments, de-nitrification (particularly in groundwater), nutrient assimilation, and maximizing stream habitat quality (Rheinhardt et al., 2012). While grass buffers are effective at removing sediment and sediment-bound nutrients, forested buffers have a significant ability to also remove soluble nutrients (Lee, Isenhart, & Schultz, 2003). Tree roots provide exudates that are essential for microbial de-nitrification and the heterogeneous microenvironment for denitrifying microbes, which explains why forested riparian zones are more conducive to de-nitrification than herbaceous dominated ones (Rheinhardt et al., 2012). In addition, forested streams are able to process two to ten times more nitrogen than grass buffered streams, significantly enhancing the in-stream processing of both nonpoint and point source pollutants (Sweeney et al., 2004).

Afforestation of Riparian Areas

The reestablishment of riparian forested buffers is a critical component of achieving a balanced, integrated, adaptive community of riparian and aquatic organisms capable of removing sediment, nutrients, and providing an array of other ecosystem services (Welsch, 1991). However, the question of when and where to pursue active restoration of riparian ecosystems is challenging because of the tension between the desire for immediate amelioration of highly

degraded sites and the longer time it takes for ecosystems to recover naturally. Active restoration is often the method of choice. Here, intervention is needed to address erosion on steep slopes, to improve water quality, or to reduce sedimentation: this type of restoration requires substantial funding to ensure project success (Holl & Aide, 2011). In regions where competition from foreign invasive plants and herbivory cause high seedling mortality rates, the natural reestablishment of riparian forests can be a slow and difficult process (Sweeney et al., 2002). Given the myriad factors affecting the success of afforestation in riparian areas, most prescriptions for restoring functioning streamside forests must include a proactive program to enhance seedling survival and growth (Sweeney & Czapka, 2004).

Vegetation change following abandonment of agricultural fields, often called "old field succession," tends to develop toward some phase of the regional upland forest in naturally forested regions (Fike & Niering, 1999). Reestablishment of forests in abandoned agricultural fields is challenging due to reduced local seed availability and perturbed site conditions caused by plowing, grazing, cultivation, pesticides, and fertilizers (Sweeney et al., 2002). Succession in floodplain ecosystems is a complex process and is difficult to predict due to the influence of flooding, herbivory, root competition, and a variety of other biotic and abiotic factors that affect the establishment of tree seedlings (Jones et al. 1994). The type, intensity, and duration of past land uses affects a variety of site-specific factors such as propagule availability and seedling herbivory that influence the rate of afforestation (Holl & Aide, 2011). While passive restoration is the simplest and most economic approach, the decision between passive or active restoration of riparian areas depends in part on the relative effectiveness of the restoration activity (Watanabe et al., 2005).

The primary goal of active restoration is to increase the rate and success of natural succession (Holl & Aide, 2011). Restoration of forest buffers to improve water quality and stream ecosystem function requires afforestation practices that maximize seedling survival and growth

while augmenting natural species diversity in the canopy (Sweeney et al., 2002). Viable practices for afforestation include seedling planting (Sweeney & Czapka, 2004), direct or live staking (Schaff et. al 2003), direct seeding (Allen et al., 2000; Doust et al., 2006), and soil amendments (Bradshaw, 2000). Often, because of site difficulties and conditions, these approaches are combined to achieve success.

Research from a four-year Maryland study on the success of seedling plantings in riparian areas demonstrated no significant difference in survival and growth between stock type (bare root vs. containerized) and significantly higher growth and survival in sheltered versus unsheltered seedlings (49% and 77.6 cm. vs. 12.1 % and 3.6 cm respectively: Sweeney et al., 2002). In that study, the highest four-year growth and survival was associated with seedlings protected by shelters and combined with herbicide applications to reduce herbaceous plant competition (88%). Only plots where seedlings had a combination of tree shelters and either herbicide or tree mats had greater than 50% survival, which is considered an acceptable minimum rate in the region. Increased growth attributed to tree shelters has been shown to relate to one or more of the following factors: reduced deer and small mammal herbivory, reduced water stress, accelerated stem elongation, reduced tapering due to lateral branching suppression, protection from herbicide drift during weed management, reduced mechanical damage, and reduced trunk tapering (Kjelgren et al., 1994; Sweeney et al., 2002). Mulching, tree mats, and herbicide have been used effectively with afforestation to reduce competition from invasive plants (Sweeney et al., 2002) and growth has been shown to be significantly faster for seedlings with herbicide control of vegetation within 0.9 m of the seedling (Sweeney et al., 2002). These insights are valuable for developing protocols for riparian tree plantings that ensure wise use of scarce economic resources and provide the best chances for successful establishment and mitigation of abiotic and biotic pressures on tree seedling survival.

Landowner Attitudes about Riparian Buffers

Improving water quality in agricultural watersheds is largely dependent upon the decisions private landowners make about how they manage their land, and the focus for establishing riparian forests is on lands, whether actively farmed or not, that were once forests. Existing cost-share incentive and outreach programs focus on these lands, which may be held by farmers or others not engaged in farming activities, but want to convert riparian lands to forests. Most of the literature refers to farmers; however, it is important to recognize that the programs focus on restoring riparian forests more than farming per se.

Farmers are directly dependent on the natural resources on their land, and the condition of the soil and streams on their farms can have significant impacts on their agricultural productivity. Conservation programs for agriculture are by necessity mediated through farmers, whose decisions about land management are affected by such programs but also by other factors ranging from government regulations to general societal norms (Ahnstrom & Hockert, 2009). Many federal and state soil and water conservation programs rely on voluntary participation by farmers. For state and federal agencies and others interested in protecting water quality, it is important to understand what motivates farmers to engage in riparian zone conservation practices (Ryan et al., 2003).

Previous studies of farmer participation in conservation programs have yielded numerous factors affecting what motivates adoption of best management practices. Much of this research has focused on soil and water conservation practices at the whole farm level and has demonstrated that it is difficult to predict adoption using socioeconomic, farm structure, and public policy variables (Napier et al., 2000). Traditional adoption-diffusion theory (Rogers, 1976) is frequently used to assess the probability of implementation of conservation practices including soil management, riparian buffers, and most other agricultural conservation practices (Armstrong

et al., 2011). This model suggests there is a fundamental connection between farmers' attitudes and their adoption of new technologies (Carlson & Schnabel, 1994). Positive associations between awareness of environmental problems, attitudes towards possible solutions, and willingness to adopt those solutions were found in research on the role of attitudes in decisions to adopt agricultural conservation practices (Arbuckle, 2013). Similar research has shown that farmers who owned larger parcels, were more educated, and had knowledge about riparian areas and streams were more likely to implement conservation practices (Armstrong & Stedman, 2012). In a study of agricultural landowners in Kansas, the importance landowners attributed to local streams had a significant effect on their acceptance of alternative management strategies (Schrader, 1995).

Stewardship

Farmers in the United States self-identified as good stewards of the land and 82% of farmers surveyed from 17 states considered themselves sustainable managers of natural resources (Ahnstrom & Hockert, 2009). Research suggests farmers were strongly motivated to be good land stewards and that the visual appearance of one's farm played an important role in demonstrating such stewardship to peers and neighbors (Ryan et al., 2003). Personal beliefs and values, neighborhood and social pressures, and agricultural traditions also affected farmers' decisions to adopt conservation practices (Norris, 1983).

Farmers have been shown to hold negative perceptions of conservation practices including riparian forest buffers that contradicted aesthetic norms for attractive agricultural land (Nassauer, 1989). In the same study, farmers were found to be more likely to participate in conservation programs that enhanced the look of their farms, as neatness was regarded as a reflection on the farmer and made his/her farm appear well managed. Landowners were often

driven to mow and clear along streams because of a cultural norm of neatness that shaped their perspectives on landscape management, and they were often reluctant to abandon the ordered landscapes to which they were accustomed (Dutcher et al., 2004). However, similar research (Ryan et al., 2003) found that farmers who had strong intrinsic motivation and attachment to the land were significantly more likely to indicate willingness to maintain woody cover along their streams than those who were slightly less intrinsically motivated. These studies underscore the importance of the aesthetic quality of conservation practices and the direct link to beliefs and attitudes that farmers have about stewardship of their land and adoption of conservation measures.

Economics

One factor affecting landowner support for conservation practices on riparian lands is the costs of planting and maintenance of forested buffers (Dutcher et al., 2004), particularly for farmers who actively managed these lands for hay production or pasture for livestock grazing. Adoption of conservation practices affects a farmer's land management system but also has direct impacts on his/her economic bottom line. Government programs seek to offset some installation and maintenance costs for conservation practices in an effort to motivate participation in conservation programs. The effectiveness of such financial assistance, both in successfully changing farmers' and landowners' attitudes towards conservation and conservation practice adoption, is widely debated.

In a study of farmers in three Midwestern states, researchers found that receiving financial support from the government had little or no significant influence on conservation practice adoption (Napier et al., 2000). This same study found that farmers with higher gross farm income and larger farms were more likely to adopt conservation practices. In contrast, an inverse

relationship between farmers' attitudes toward conservation and farm size was found in a study of Michigan and Ohio farmers (Ryan et al., 2003). In the latter study, small-scale farmers reported more non-economic motivations and more support for soil conservation, whereas larger-scale farmers reported more economic motivations.

While government subsidies or incentive payments received by farmers through federal and state conservation programs may serve as an impetus to adopt conservation practices, a fundamental shift in attitudes towards farm management must occur in order for practices to be sustained in the long term. Ahnstrom and Hockert (2009) reported that funding through federal programs was the initial motivator for conservation efforts, but ultimately did not change farmers' attitudes towards conservation. For farmers who held negative attitudes towards conservation, funding was reported to have only minimal and short-term impacts on their management decisions. A similar study of Midwest farmers found that government subsidies were neither enough to motivate farmers to participate in conservation programs nor did they create long-term shifts in farmers' conservation ethic (Ryan et al., 2003). This study found that farmers were motivated more by intrinsic factors such as stewardship, legacy, and the love of their land to adopt conservation practices than they were extrinsically motivated by economics. Similar research found that while economic incentives were shown to encourage conservation practices when combined with government subsidies, economic subsidies were insufficient to motivate farmers to adopt conservation practices (Napier et al., 2000).

Riparian Conservation Programs

The establishment of the Conservation Reserve Program (CRP) under Title XII of the U.S. Food Security Act of 1985 (commonly referred to as the Farm Bill) was instrumental in efforts to conserve and improve soil, water, and wildlife resources on farmland in the United

States (Feather, Hellerstein, & Hansen, 1999). The CRP is a voluntary land retirement program administered by the U.S. Department of Agriculture that supported the implementation of long-term conservation measures to control soil erosion, improve the quality of ground and surface waters, and enhance wildlife habitat on environmentally sensitive agricultural land. CRP was the federal government's largest private land environmental improvement program (U.S. Department of Agriculture Farm Service Agency, 2004). CRP has continued to be reauthorized under subsequent Farm Bill legislation since 1985, and over 26.9 million acres have been enrolled in the program on 700,000 contracts (USDA, 2013).

The Conservation Reserve Enhancement Program (CREP) was established in 1996 under the authority of CRP to address high priority agriculture related environmental issues in specific geographic areas such as watersheds like the Chesapeake Bay by establishing conservation practices on farmlands (U.S. Department of Agriculture Farm Service Agency, 2004). In exchange for removing environmentally sensitive lands from agricultural production and implementing conservation practices, landowners were paid an annual rental rate. Participation was voluntary and the contract period was typically ten to fifteen years. Funding for the program included federal, state, and nongovernmental support for cost-share to implement the practices, rental payments, and other federal and state incentives (FSA, 2014). Enrollment for CREP in Pennsylvania began in 1999 in 20 counties in the southeastern and south-central regions of the state (Cooper & Jacobson, 2009). Cooper and Jacobson (2009) found that PA CREP riparian buffer landowners were motivated by water quality improvements, environmental stewardship, incentive payments, and improvements to non-game wildlife habitat and were likely to leave their buffer intact when their CREP contract expired.

Since the establishment of the first Farm Bill, the objectives of conservation policy have shifted from a focus on agricultural resource conservation that enhanced productivity with large "on-farm" benefits to environmental management and improvement with large "off-farm"

benefits such as clean water and a host of other ecological benefits (Cox, 2007). The 1990 Food, Agriculture, Conservation and Trade Act advanced the priorities of environmental management and water quality through the creation of the Wetlands Reserve Program (WRP) and the Water Quality Incentive Program (WQIP) (NRCS, 2014.). In 1996, the Food and Agriculture Improvement Act created the Environmental Quality Incentives Program (EQIP) to assist farmers in meeting federal, state, and local environmental regulations through voluntary incentives rather than expanded regulatory measures (Cox, 2007). Collectively these federal programs offer landowners a variety of options for participation in voluntary conservation to improve water quality and natural resource management on farms.

Chapter 3

Methods and Analysis

This chapter provides a description of the data collection process and analytical methods used in this study. A participant description and approach to the survey development is discussed. The mail survey questionnaire that was used is explained. Data from the questionnaire responses was coded and entered into Statistical Package for the Social Sciences (SPSS 2012). Descriptive statistics, including frequencies and percentages, were used to describe general characteristics of survey respondents. Quantitative data analysis was explored using factor analysis and a linear regression model.

Study Participants

At the time of the mailed survey, study participants were enrolled in the Pennsylvania USDA Conservation Reserve Enhancement Program riparian forest buffer initiative. The list of participants for this study was obtained from the USDA Farm Service Agency (FSA) and included landowners enrolled in the Pennsylvania CREP riparian forest buffer initiative ("Conservation Practice 22") in the Susquehanna and Potomac River basins in Pennsylvania after January 1, 2008.

In order to access the list of participants from FSA, a USDA 1619 Cooperator Memorandum of Understanding between USDA Farm Service Agency and Penn State University was obtained on July 6, 2012. Individuals or organizations (governmental or nongovernmental) certified by FSA as working in cooperation with the Secretary of Agriculture by providing assistance to USDA programs that require access to data protected by Section 1619 of the Food,

Conservation and Energy Act of 2008 are known as USDA Section 1619 Cooperators. This agreement authorized access to otherwise protected agricultural information approved for disclosure under the Memorandum of Understanding used by Penn State University in this study to conduct research that would provide assistance in CREP outreach to private landowners about the benefits of developing riparian forested buffers and to guide efforts to improve establishment and maintenance.

The initial list supplied by FSA identified 842 participants in the CREP riparian forest buffer initiative in Pennsylvania. Participants with contracts that began between January 1, 2008 and December 31, 2009 and that were located in the Chesapeake Bay watershed within Pennsylvania were selected for inclusion in this study. These dates were chosen to include participants with a minimum of three growing seasons on their riparian forest buffer. The resulting study population included 538 landowners across the Commonwealth as indicated in Table 3.1. The majority of survey respondents were located in Bradford County, followed by about half as many in Susquehanna and Tioga County, with the remainder or respondents distributed throughout the Commonwealth.

Table 3-1: Geographic distribution of survey respondents by USDA Service Center of survey respondent (N=538).

County	*N*	*County*	*N*
Adams	9	Indiana	15
Allegheny	1	Juniata	3
Armstrong	3	Lackawanna	7
Beaver	2	Lancaster	20
Bedford	9	Lawrence	3
Berks	2	Lebanon	3
Blair	1	Luzerne	3
Bradford	101	Lycoming	19
Butler	5	McKean	6
Cambria	1	Mercer	3
Centre	10	Montour	7
Clarion	15	Northumberland	5
Clearfield	1	Perry	6
Columbia	8	Potter	31
Crawford	1	Schuylkill	4
Dauphin	5	Snyder	6
Elk	2	Somerset	5
Erie	2	Sullivan	20
Fayette	6	Susquehanna	52
Franklin	2	Tioga	50
Fulton	7	Union	1
Greene	13	Venango	2
Huntingdon	2		

Mail Questionnaire

The questionnaire was based on existing literature, past studies, and direction from key personnel working with this user segment. To create and administer the survey, Dillman's Tailored Design Method (TDM) was used (Dillman, 2000) in order to reach participants within a large area on a small budget. Dillman (2000) recommends developing a self-administration survey designed so that all potential respondents will interpret questions in the same manner.

All written materials developed for this study [(survey, cover letters, and reminder postcard (Appendices A, B, C, D, and E respectively)] were reviewed by Penn State's Institutional Review Board (IRB) to ensure subject confidentiality and to meet requirements

necessary for obtaining implied consent for research involving human subjects. The study was approved by the IRB on March 6, 2012 (IRB #38869).

The final draft questionnaire was pre-tested with ten landowners in Pennsylvania and reviewed by colleagues, advisors, and representatives of agencies that work with CREP (i.e., Chesapeake Bay Foundation, local conservation districts, and USDA Natural Resource Conservation Service). These pre-test respondents were chosen because they were enrolled in the CREP riparian forested buffer initiative and had experience and familiarity with the program. Some of their suggestions were incorporated into the survey, but pre-tests did not result in any major changes in the survey design.

Questionnaire Design

The questionnaire was designed to assess riparian forest buffer planting success and attitudes and perceptions of landowners enrolled in the CREP riparian forested buffer initiative. The majority of questions used a Likert scale (1-5) to indicate the degree to which respondents placed a relative level of importance on statements. The questionnaire (Appendix A) had four primary sections related to the following topics: 1) Land use and riparian forested buffer participation, 2) Riparian forested buffer participant involvement, 3) Participant satisfaction with riparian forested buffer and CREP Program, and 4) Sociodemographics.

Section 1. Land use and Riparian forested buffer Participation

Questions 1- 4 in Section 1 related to participants' land in Pennsylvania. Participants were asked to report the total number of acres owned and the acreage currently enrolled in Pennsylvania's CREP riparian forest buffer. Participants were asked how many years they had

farmed in Pennsylvania as many CREP participants are farmers. However, the CREP riparian forest buffer is the only CREP practice for which USDA FSA does not require proof of crop history as a requirement for enrollment, thus CREP riparian forest buffer participants may not be farmers. To understand how land use might relate to actions, participants were asked to indicate how their property was used by assigning an acreage amount to each of the nine land use categories provided: pasture, crops/vegetables/grains, livestock, fallow fields, forest, nursery, specialty crops (Christmas trees, mushrooms, organic produce), residence, and other. Individuals were likely to enroll in the CREP program for various reasons. To understand this, respondents were given 20 possible reasons why landowners enroll in CREP's forested buffer program and asked to identify their reasons for enrolling using a 5-point Likert scale of very unimportant to very important for each reason.

Section 2. Riparian forested buffer Participant Involvement

Section 2, questions 5 – 12, explored participant involvement in the establishment and maintenance of their riparian forest buffers. Participants were asked a series of questions about activities related to the tree planting and maintenance of their buffer and asked to identify whether or not they had done the activity and the person(s) responsible. They were asked to indicate how often they visited their buffers, what types of activities the typical visit included, and what they had personally invested in the buffers. Participants were given a list of potential maintenance tasks for riparian forest buffer establishment and asked to rate their relative importance using a 5-point Likert scale of very unimportant to very important.

Believing that participation might relate to engagement with the funding agency and technical advisors, respondents were asked a series of questions related to the information they received their riparian forest buffer. Participants were asked to identify the agency that

communicated the contractual responsibilities for the maintenance of their buffer from a list provided and if, in their opinion, this information was adequate. A list of potential sources of information on buffer maintenance was provided and participants were asked to select which sources were useful to them. They were asked if they were interested in receiving additional information on buffer maintenance and if so, what topics and how they would like to receive the information.

Section 3. Participant Satisfaction with Riparian forested buffer and CREP Program

Section 3, questions 13 – 17, created an understanding of participant satisfaction with their forested buffers as well as with the CREP program. Participants were asked to rate their level of satisfaction with CREP program administration related to following on a 5-point Likert scale from completely dissatisfied to completely satisfied; the amount of paperwork and time to get a contract, knowledge and help from trained staff, amount of money received, and ability to understand the contract terms and information received on buffer maintenance. Participants were asked to report when they received professional assistance on their forested riparian buffer. To understand challenges related to forested buffer establishment, participants were asked to report the main obstacles to tree survival and growth observed in their buffers from a list that included the following; deer, rodents, competition from other plants, drought, flood damage, soil conditions, and incorrect tree selection. Participants were asked about future plans for their riparian forested buffers when their CREP contract expires and asked to rate the likelihood of each of the following on a 5-point Likert scale from not likely to very likely; leave the buffer intact, remove the buffer to regraze or crop, manage buffer as a timber crop for the future, re-enroll the buffer in CREP, harvest non-timber forest products, manage for wildlife habitat, leave the buffer intact for aesthetic value, or other. To assess landowner interest in continued

participation in CREP, participants were asked a series of questions about their awareness of the potential for re-enrolling their buffer for an additional contract term, understanding of the requirements for re-enrollment using a scale ranging from very uncomfortable to very comfortable, and if given the opportunity whether or not they would re-enroll for a 10 or 15 year contract.

Section 4. Sociodemographics

Section 4, questions 18 - 24, addressed personal information about the participant. Questions about gender (i.e., male=1, female=2), age (year born), income (categories with range of total household income), occupation (i.e., farmer=1, retired=2, white-collar=3, blue-collar=4, other=5), and education (i.e., did not complete high school=1, high school diploma or GED=2, some college credits=3, college degree=4, some post-graduate credits=5, post graduate degree=6) were gathered to relate participant attitudes and opinions to land use decisions. These simple yet important questions were placed at the end of the survey because they tend to be least interesting to the respondents (Dillman, 2000).

Questionnaire Mailing Packet

The original TDM approach (Dillman, 2000) was modified for this study due to time constraints and limited funding availability. There was no initial contact made with the participant to inform him/her that a questionnaire would be arriving in the mail. To track non-respondents, each survey was assigned an identification number that corresponded to an identification number for each landowner in order. The questionnaire (Appendix A) was mailed to 538 landowner addresses provided by FSA. The survey packet included a cover letter explaining the project

(Appendix B), the questionnaire and postage-paid return envelope and was mailed on November 1, 2012. This time period was chosen because it was before the holiday season and the majority of farmers had harvested their crops. A reminder postcard (Appendix C) was sent one week later on November 8, 2012 to all participants encouraging them to complete and return the survey if they had not already done so and to thank those who had responded. Four weeks after the initial mailing, a second survey packet was sent on November 28, 2012 to all participants (342) who had not responded to the first mailing. This survey packet included a cover letter (Appendix D) explaining that their survey had not been received and asked them to please return the enclosed survey, as their participation was vital to the study. Six weeks after the initial mailing a third survey packet with cover letter (Appendix E) and additional survey was sent on December 11, 2012 to all participants (291) who had not responded to either the first or second mailing.

Analysis

Data from the questionnaire responses was analyzed using Statistical Package for the Social Sciences (SPSS 2012). Cases were excluded pairwise; respondents who did not provide an answer to a question used as part of the data analysis were excluded from the analysis related to that question, but not excluded from the study entirely. Descriptive statistics were used to provide a general overview of the original measurements. Frequencies were employed to describe characteristics of survey respondents. Factor analysis was used in three multiple question batteries (Q4, 9, and 14) to reduce the number of variables by forming scales that explain observed correlations between variables. Principal Component Analysis (PCA) was the extraction method used and component factors were selected that had a factor loading of at least 0.50. Factors were rotated using Varimax rotation, which maximizes the variance among the loadings.

Factor analysis infers the existence of factors from patterns that are observed in the data (Rummel, 1988).

A multiple regression model was used to understand the relationship between maintenance of CREP riparian forest buffers performed by landowners and various indicators that were used to predict this behavior. The following indicators were hypothesized to be significant in predicting the level of landowner engagement in forest buffer maintenance: sociodemographic characteristics, land ownership information, adequacy of information on maintenance, and factors extracted using factor analysis reduction for the importance of maintenance tasks and future plans for the buffer. Six models were run to deduce those variables significant in predicting the dependent variable, which was called buffer activity. Relationships were significant if they had a p-value at or below 0.05. These indicators were entered into a block regression analysis that first analyzed sociodemographics, followed by the addition of land characteristics, then factors for maintenance and frequency of visits, then adequacy of information received on maintenance, and finally future plans for the buffer. The reduced model included only those variables that were significant in predicting buffer activity.

An additional linear regression model was run to explore the relationship between respondents' reasons for enrolling in CREP riparian forest buffer and respondent future plans for their riparian forested buffers. The factor that was extracted for Question 4 (reasons for enrolling in CREP) was entered into the linear regression analysis to predict future plans for respondents' riparian forest buffers.

Chapter 4

Results

Descriptive Statistics

Survey Response

The original mailing list from FSA was screened for duplicate and insufficient addresses; as a result, a total of 538 participants received the survey. One survey was undeliverable due to an incorrect address. In total, 378 (70.2%) surveys were returned during the study period. Ten surveys were returned but none of the questions were completed. The surveys were separated by date, survey identification number verified, and each questionnaire was filed for data entry. Forty-seven percent of the surveys were returned within the first four weeks and the remaining fifty-three percent were returned within thirteen weeks from the first mailing date.

Nonrespondents

Thirty percent of CREP riparian forest buffer participants in Pennsylvania were selected for this study did not respond to the survey. There was no additional effort made to contact nonrespondents due to a lack of time and financial resources.

Social Demographics

Gender, age, education, primary occupation and level of income were among the demographic information obtained from participants. One respondent reported having a large land

ownership of 14,959 acres. Upon further inquiry, this participant was identified as a large Pennsylvania land conservancy that did not represent the study population; this case was removed from the analysis. The majority of respondents were male [N = 344; 85% male and 15% female (Table 4.1)]. Average age of respondents was 61 with the majority over the age of 54 (73%). Thirty-nine percent of respondents had high school level education. Nineteen percent had a college degree and thirteen percent had a graduate degree. The most common primary occupation was retired (30.9%) with a fairly even split between farmer (18.8%), white-collar (19.7%), and blue collar (19.1%) occupations. Seventeen percent of respondents had a total household income of 25,000 to 49,999 dollars per year followed by thirty-eight percent at 50,000 to 99,999 dollars and twenty-three percent at more than 100,000 dollars per year.

Table 4-1: Distribution of gender, age, education, primary occupation, and household income for Pennsylvania CREP riparian buffer participants.

Characteristics	%	SD
Gender (n = 344)		0.36
Male	84.9	
Female	15.1	
Age (yrs.) (n=341)		0.83
64 or older	44.6	
54-63	28.4	
53 or less	27	
Education Level (n = 340)		1.46
Did not complete high school	3.8	
High school	39.1	
Some college credits	17.9	
College degree	19.4	
Some post-graduate credits	6.5	
Graduate degree	13.2	
Primary Occupation (n = 340)		1.28
Farmer	18.8	
Retired	30.9	
White-collar	19.7	
Blue-collar	19.1	
Other	11.5	
Household Income (n = 308)		1.90
Below $24,999	11	
$25,000 - $49,999	17.6	
$50,000 - $99,999	38.3	
More than $100,000	23	

Land Characteristics

Survey participants were asked a series of questions about their land ownership in Pennsylvania (Questions 1 – 3). The amount of land owned (Question 1) ranged from 0 to 2,000 acres (N = 365) and the average was 173.8 acres. Participants reported an average of 51 acres farmed at the time of the survey (Question 1b). Surveyed participants had been farming, on average, for 20 years in Pennsylvania (Question 2), although less than one-quarter considered farming their primary occupation and 30% reported they had never farmed. The amount of land enrolled in Pennsylvania's CREP (Question 1c) at the time of the survey averaged 15 acres, or slightly less than 10% of their total land ownership.

Participants were asked to identify current agricultural practices on their land and assign an acreage amount to each item (Question 3; Table 4.2). Forest was the largest land use; 82 percent indicated they had forest on their land with an average of nearly 73 acres (72.9), with a range of half an acre to 1,870 acres. Over half of the survey respondents had pasture and crops/vegetables/grains, making this the second largest land use (41.9 acres on average). Land devoted to livestock, nursery, and specialty crops (e.g., Christmas trees, mushrooms, organic produce) each averaged less than three acres.

Table 4-2: Participants land use average acres and percentage of landowners partaking in each land use (Q3).

Land Uses	*N*	*SD*	*Percentage of Respondents*	*Average Acres*
Forest	363	183.69	82.1	72.9
Crops/vegetables/grains	365	78.92	58.9	41.9
Pasture	365	31.58	54.4	17.1
Fallow fields	364	31.21	44.0	13.1
Other	360	60.94	43.3	13.1
Residence	365	15.77	72.9	4.5
Specialty crops	364	36.11	8.2	2.5
Livestock	365	7.18	15.3	1.9
Nursery	365	5.01	7.4	0.8

Riparian Forested Buffer Questions

Landowners identified their reasons for enrolling in the Pennsylvania CREP forested buffer initiative (Question 4; Table 4.3) using a Likert scale from 1 (very unimportant) to 5 (very important). The four primary reasons for enrolling in CREP riparian forest buffer program were to improve water quality (mean = 4.13), environmental stewardship (mean = 4.04), improve non-game wildlife habitat (mean = 3.73), and help protect the Chesapeake Bay (mean = 3.66). Some participants in other category provided additional reasons for enrolling in CREP (mean = 4.14, N=44) that included environmental benefits (e.g. air quality improvement, forest diversity and health, forest buffer as part of a farm management improvements such as rotational grazing, and as a requirement for participation in farm preservation). The least important reasons were to decrease farm acres and because neighbors had installed a buffer.

Table 4-3: Participant reasons for enrolling in CREP (Q4).

Reasons for enrolling in CREP	*N*	*Mean*	*SD*
Improve water quality	325	4.13	0.94
Environmental stewardship	324	4.04	1.01
Improve non-game wildlife habitat	323	3.73	1.89
Help protect the Chesapeake Bay	322	3.66	1.17
Stabilize stream bank	321	3.63	1.26
Prevent non-point source pollution from entering the stream	316	3.45	1.25
Leave a legacy	321	3.38	1.30
Incentive payments	320	3.37	1.20
Improve hunting	321	3.35	1.32
Increase farm income	320	3.31	1.29
Improve fisheries habitat	315	3.30	1.33
Signing bonus	317	3.22	1.25
Protect a specific site downstream	316	3.12	1.25
Retiring	317	2.90	1.32
Improve farm productivity	314	2.77	1.21
Keep livestock out of stream	317	2.70	1.44
Improve herd health	314	2.40	1.28
Neighbors installed a buffer	306	2.37	1.20
Other	44	4.14	1.25

Participants were asked a series of questions related to the establishment and maintenance of their riparian forested buffer (Questions 5-9). Specifically, they were asked which activities had been performed in the forested buffer and to identify the person(s) responsible for doing them (Question 5; Table 4.4). Almost 70 percent of respondents reported all the listed establishment and maintenance activities had been performed. Over three-quarters (82.4%) reported site preparation prior to tree planting had been done and of these respondents 51 percent had done site preparation themselves, 38 percent had hired a contractor, and 10 percent had a combination of contractors and self complete this task. The majority of landowners had a contractor complete tree planting (83%) and nearly half (48%) had a contractor perform herbicide application. Activities performed primarily by the landowners themselves were mowing alleyways between trees (89%), replanting trees (48%), shelter maintenance (88.6%), and controlling invasive and noxious weeds (77.6%).

Table 4-4: Riparian forested buffer establishment and maintenance activity (Q5).

Buffer Activity	*N*	*Have Done Activity (%)*	*Self (%)*	*Contractor (%)*	*Both (%)*
Tree planting	324	93.8	10.2	83.3	6.5
Shelter maintenance	324	92.3	88.6	6.5	4.9
Controlling weeds	324	91.0	77.6	14.6	7.8
Site preparation	330	82.4	51.1	38.2	10.7
Herbicide application	326	77.3	44.0	48.6	7.4
Replanting trees	323	70.3	47.9	40.1	12
Mowing alleyways	322	68.0	89.2	9.1	1.7

Participants were asked how frequently they visited their buffers each year and what a typical visit included (Question 6). The majority of respondents visited their buffers several times a year (37%), monthly (32%) or at least once a week (27%). Less than four percent visited yearly (3.3%), less than once a year (1.2%) or never (0.9%). Participants were asked what a typical visit to their riparian forested buffer included (Question 7). Typical visits by survey respondents were a combination of both passive and actual maintenance activities within the forested buffer.

Passive activities such as viewing the site from outside the buffer (66%) or personal enjoyment of the area such as walking, wildlife viewing, or fishing (65%), were reported by a majority of participants. Maintenance activities were performed in the buffer area by 73 percent of participants during a typical visit and 78 percent looked at individual sheltered trees to check their condition. Participants were also asked what they had personally invested in their riparian forested buffer (Question 8). Nearly all participants reported having invested time (95%) and over three-quarters (77%) had invested money in addition to the program cost-share for buffer maintenance and care.

Participants were presented with potential maintenance tasks for riparian forested buffer establishment and asked to indicate how important each were to the success of their riparian forested buffer on a Likert scale of 1 (very unimportant) to 5 (very important) (Question 9; Table 4.5). The three most important maintenance tasks reported were shelters to protect trees from animals (mean = 4.45), maintaining 70% of the original number of trees and shrubs planted (mean = 4.17), and hiring a qualified professional to plant the trees (mean = 4.16).

Table 4-5: Importance of maintenance tasks for riparian forest buffer establishment (Q9).

Importance of maintenance tasks	*N*	*Mean*	*SD*
Using tree shelters to protect trees from deer browsing, rodents, and small mammals	357	4.45	0.91
Maintaining 70% of original number of trees and shrubs planted (naturally regenerating plants can be counted)	357	4.17	0.91
Hiring a qualified professional to plant trees	357	4.16	1.17
Efforts to control noxious weeds	357	4.08	0.94
Using tree shelters to protect trees from herbicide	349	4.03	1.10
Repairing downed tree shelters immediately after flooding	346	3.95	1.08
Application of herbicide around tree shelters for the first three years after planting	357	3.94	1.10
Removing shelters from trees when tree are 1.5 inches in diameter at top of shelter	334	3.74	0.92
Application of herbicide before planting the trees	347	3.70	1.21
Mowing between trees for the first three years after planting the trees	343	3.67	1.15

CREP Contracting Process and Information Received by Landowner

Participants were asked about their experiences with the administration of CREP and the information they received about their responsibilities and maintenance of their riparian forest buffers (Questions 10-12). Contractual responsibilities were reported to have been communicated primarily by FSA (70%) and NRCS (53%) (Question 10). The majority of participants (91%) responded that the information provided was, in their opinion, adequate (Question 10b). Useful sources of information about the maintenance of the forested buffer (Question 11) were CREP contract materials (NRCS guidelines, maintenance and post planting establishment landowner

assurances[1]) (82%), FSA staff (64%) and NRCS staff (46%). Forty-three percent of respondents were interested in more information about the maintenance of their riparian forest buffers (Question 12). Participants were asked to rate their overall experience with CREP administration (Question 13; Table 4.6). They were most satisfied with the knowledge and help from trained staff on paperwork and their contract (mean=4.29), knowledge and help from trained staff on technical side of project installation (mean=4.2), length of time to get a contract (mean=4.07), and tree planting by landscape crew (mean=3.98).

Table 4-6: Participant satisfaction with CREP administration (Q13).

Participant satisfaction with CREP administration	*N*	*Mean*	*SD*
Knowledge from staff on contract	360	4.29	0.87
Knowledge from staff on technical aspects	337	4.20	0.89
Length of time to get a contract	361	4.07	0.89
Tree planting by landscape crew	349	3.98	1.14
Amount of money received	359	3.96	1.00
Ability to understand contract terms	357	3.92	0.98
Information received on buffer maintenance	357	3.87	0.98
Amount of paperwork	359	3.77	1.02

In order to understand what participants' intentions were for future use of their forested buffers, participants were asked to rate the likelihood of various uses for their forested buffers (Question 14; Table 4.7). Participants reported to be most likely to leave the buffer intact (mean=4.66), leave the buffer intact for aesthetic value (mean=4.28), and manage buffer for wildlife habitat (mean=4.18). Conversely, participants were least likely to remove the buffer to plant crops (mean=1.30), remove the buffer to re-graze (mean=1.41), or harvest non-timber forest products (mean=1.93).

[1] NRCS guidelines, maintenance and post planting establishment landowner assurances are part of the printed contract materials that are given to CREP participants by USDA FSA or NRCS at the time of contract signing.

Table 4-7: Participant future plans for riparian forest buffer (Q14).

Participant future plans for forested buffer	*N*	*Mean*	*SD*
Leave the buffer intact	349	4.66	0.77
Leave intact for its aesthetic value	337	4.28	0.97
Manage for wildlife habitat	347	4.18	1.04
Other	16	3.76	1.57
Re-enroll the buffer in CREP	339	3.63	1.42
Manage as timber crop for the future	341	2.98	1.49
Harvest non-timber forest products	333	1.93	1.42
Remove the buffer to re-graze	343	1.41	0.87
Remove the buffer to crop	340	1.30	0.77

Participants were asked to report all of the main obstacles to tree survival and growth on their site from a list provided (Question 15; Table 4.8). The five most common obstacles noted were competition from grasses on site at the time of planting (52.9%), soil excessively wet (40.5%), deer browsing (37.9%), noxious and invasive plants (34.2%), and flood damage (33.9%).

Table 4-8: Obstacles to tree survival and growth (Q15).

Obstacles to tree survival and growth (N = 348)	*%*
Competition from grasses that were present on site at planting time	52.9
Soil excessively wet	40.5
Deer browsing	37.9
Noxious and invasive plants	34.2
Flood damage	33.9
Rodents gnawing on roots or stems	33.0
Drought	31.6
Buck rubbing	37.9
Rodents nesting in shelters	21.0
Other	20.7
Incorrect tree selection for site	17.5
Compaction of soils	5.5
Competition from grasses planted on site (only for prior cropland)	4.0

Participants were asked if they were aware of the potential for re-enrolling their riparian forested buffers for additional rental payments through a second ten to fifteen year contract (Question 16a); only 34 percent responded that they were aware (66 percent were unaware). When asked to rate their understanding of re-enrollment requirements using a scale ranging from

1 (very uncomfortable) to 5 (very comfortable), the average response was in the middle (mean = 2.45 Question 16b). Participants were asked if, given the opportunity, they would they choose to re-enroll their forested buffers (Question 16c). Participants were given the option to respond to their interest in a ten- as well as a fifteen-year contract. Seventy-three percent reported that they would re-enroll for ten years and 64 percent would re-enroll for fifteen years.

Participants were asked when they received professional assistance on their riparian forest buffers (Question 17). The majority of respondents received professional assistance at the time of buffer installation (75%) and during the establishment period of the first three years of the contract (50%). A small percentage had never received professional assistance (9%) or had received such assistance after the establishment period (8%).

Factor Analysis

Factor analysis Questions 4, 9, and 14 were approached as an exploratory factor analysis using the Principal Component Analysis technique to reduce the number of variables within each question and discern patterns in the participant responses. Each of these questions was a battery addressing a specific idea: reasons for enrolling in CREP (Q4), importance of maintenance tasks (Q9), and future plans for the riparian forest buffer (Q14).

Question 4 asked participants to indicate the level of importance of various reasons provided for their decision to enroll their land in riparian forest buffer establishment through CREP using a five-point Likert scale where 1=very unimportant to 5=very important. The factor analysis of Question 4 reduced the 20 original items into three factors and produced three new composite variables (Table 4.9) entitled Environment, Agricultural Productivity, and Economics. Environment accounted for the most variation (25 percent) followed by Agricultural Productivity

(14 percent) and Economics (11 percent). These three factors combined accounted for 50 percent of the total variation.

Table 4-9: Varimax rotated factor loadings for items measuring reasons for enrolling in CREP (Q4)

Reasons for enrolling	*Factor 1*	*Factor 2*	*Factor 3*
Environmental stewardship	0.797	-0.142	-0.080
Help protect Chesapeake Bay	0.782	0.026	0.036
Water quality	0.769	-0.043	-0.082
Fisheries	0.666	0.193	0.178
Wildlife habitat	0.631	-0.044	0.155
Prevent pollution	0.618	0.359	-0.068
Legacy	0.585	0.113	0.166
Stabilize bank	0.578	0.239	0.002
Protect site downstream	0.494	0.367	-0.066
Herd health	0.048	0.876	-0.021
Restrict livestock access	0.117	0.785	-0.109
Improve productivity	0.096	0.733	0.242
Neighbors	0.145	0.560	0.189
Decrease farm acres	-0.043	0.526	0.114
Incentive payments	0.078	0.050	0.873
Signing bonus	0.090	0.050	0.858
Farm income	-0.057	0.263	0.775
Retiring	0.210	0.379	0.400
Hunting	0.318	0.174	0.376
Other	0.174	0.241	-0.348
Eigenvalue	5.1	2.9	2.2
Percent of variation	25	14	11

Question 9 asked participants to indicate the level of importance of various tasks for riparian forest buffer establishment using a five-point Likert scale where 1=very unimportant to 5=very important. Responses to all original questions in this battery scored highly by respondents indicating that the maintenance tasks listed were considered relatively important to participants. After exploring multiple variations of factor analysis with various rotations applied and number of factors to be extracted, ultimately the original factors produced one new composite variable that was the best fit (Table 4.10). This factor was entitled Maintenance and accounted for 46

percent of the total variation for this question. All items in the original question were highly correlated and only one factor (mowing) was not included in the final extraction for this factor.

Table 4-10: Factor loadings for items measuring importance of maintenance tasks (Q9)

Factor 1: Maintenance	**Factor Loading**
Using shelters for protection from animals	0.78
Efforts to control noxious weeds	0.77
Using shelters for protection from herbicide	0.76
Application of herbicide around tree shelters for 3 years after planting	0.75
Maintaining 70% of original tree numbers	0.73
Repair downed tree shelters after flooding	0.68
Herbicide application before tree planting	0.66
Removing shelters when trees are 1.5 inches in diameter	0.61
Hiring qualified professional to plant trees	0.55
Eigenvalue: 4.6	
Percent of variation: 46	

The third question factor analyzed asked landowners about their future plans for the riparian forested buffer (Q14) using a five-point Likert scale where 1=not likely to 5 =very likely. Responses to original questions in this battery that scored highly by respondents indicate a strong likelihood of leaving the buffer intact after their CREP contract expires. After exploring multiple variations of factor analysis with various rotations applied and number of factors to be extracted, ultimately the original items produced one new composite variable that was the most appropriate fit. This factor was entitled Future Plans and accounted for 38 percent of the total variation for this question. Of the nine items in the original question, five were highly correlated and four factors (manage as timber crop for the future, re-enroll the buffer in CREP, harvest non-timber forest products, and other) were not included in the final extraction for this factor.

Table 4-11: Factor loadings for items measuring landowners' future plans for riparian forest buffers (Q14)

Factor 1: Future plans	**Factor Loading**
Leave the buffer intact	0.820
Remove the buffer to re-graze	-0.784
Leave intact for its aesthetic value	0.758
Remove the buffer to crop	-0.723
Manage for wildlife habitat	0.616
Eigenvalue: 3.0	
Percent of variation: 38	

Regression Analysis

This study hypothesized that landowner involvement in the maintenance of their riparian forested buffers could be predicted by considering several variables: sociodemographics, land characteristics, opinions regarding maintenance, frequency of visits to the buffer, adequacy of information on maintenance, and future plans for the buffer. To test this theory, a block regression was conducted where each set of variables was tested against the dependent variable to predict the level of maintenance activity for each respondent. The dependent variable was developed using Question 5 that asked participants about various activities that related to the establishment and maintenance of their riparian forest buffers. A score was calculated for each participant using Part I of the question that asked whether or not each activity was performed ("yes" or "no" answer). Seven questions were included in this battery. Negative ("no") responses were scored zero and positive ("yes") responses were given a score of one. The total number of positive responses for each respondent was then divided by the total number of responses for the respondent to produce a score that measured buffer activity. Scores ranged between zero and one.

The first block in the multiple regression model tested the relationship between sociodemographic characteristics including gender, age, employment status, education level, primary occupation, and household income with the dependent variable buffer activity (Table

4.12). This model explained 1.3 percent of the total variance in buffer activity. None of the variables were significant in predicting buffer activity.

The second block in the multiple regression model added land characteristics including acres owned, acres farmed, acres enrolled in CREP, and years farmed. This model explained 0.2 percent of the total variance. The addition of these variables did not yield any significant relationship to the dependent variable. It was hypothesized that landowners with more acreage, acres in agricultural production, larger CREP acreage enrolled, and more years farming would lead to less time and ability to actively perform maintenance in the buffer. This hypothesis was not supported by the data.

The third block in the multiple regression model included the factor Maintenance and Frequency of Visits and explained 11.2 percent of the total variance. Both of these variables were significant (0.005 and 0.000 respectively). Maintenance was measured as a score for each landowner that represented the understanding and attitude toward the relative importance of multiple maintenance tasks for buffer establishment. The hypothesis was that landowners with higher scores for Maintenance would have higher levels of Buffer Activity. Similarly it was predicted that landowners who visit their buffers more frequently would have a higher level of Buffer Activity.

The fourth block in the multiple regression model included the variable of adequacy of information on maintenance. This variable was not significant in predicting buffer activity and explained 10.9 percent of the total variance. The hypothesis was that landowners who reported having received adequate information on contractual requirements for buffer maintenance, central to the importance of this information being the steps necessary to ensure successful establishment of the trees, would presumably have a higher level of Buffer Activity.

The fifth block in the multiple regression model included future plans for the buffer and explained 11.4 percent of the total variance. Nothing about buffer activity was learned with the

addition of this variable. It was predicted that landowners who reported a high likelihood of maintaining the forested buffer as a streamside forest in the future would have a high level of Buffer Activity to ensure that the buffer was successfully established.

The final model (Model 6) was a reduced multiple regression that included only the two variables that were significant in the block regression model: maintenance and frequency of visits (0.015 and 0.000 respectively). Together these three independent variables predicted 10.1 percent of Buffer Activity by respondents.

Table 4-12: Linear regression model of relationship between buffer activity and independent variables

	Model 1		*Model 2*		*Model 3*	
Variable	*B*	*Significance*	*B*	*Significance*	*B*	*Significance*
Gender	-0.064	0.377	-0.071	0.338	-0.020	0.778
Age	-0.082	0.309	-0.078	0.354	-0.076	0.352
Employment status	0.011	0.900	0.028	0.753	0.015	0.860
Education level	0.113	0.132	0.109	0.154	0.087	0.231
Primary occupation	0.061	0.402	0.060	0.440	0.032	0.665
Household income	0.109	0.166	0.110	0.180	0.120	0.123
Acres owned			-0.018	0.831	-0.007	0.930
Acres farmed			0.022	0.800	0.031	0.703
Acres enrolled in CREP			-0.079	0.315	-0.090	0.225
Years farmed			-0.013	0.872	0.047	0.539
Maintenance					0.190	*0.005
Frequency of visits					0.288	*0.000
Adequate information						
Future Plans						
Adjusted R square	0.013		0.002		0.112	
F	1.48		1.05		3.24	
		Model 4	*Model 5*		*Reduced Model*	
Variable	*B*	*Significance*	*B*	*Significance*	*B*	*Significance*
Gender	-0.019	0.789	-0.028	0.695		
Age	-0.069	0.404	-0.057	0.489		
Employment status	0.013	0.875	0.019	0.820		
Education level	0.091	0.213	0.102	0.165		
Primary occupation	0.030	0.692	0.017	0.817		
Household income	0.114	0.150	0.106	0.178		
Acres owned	-0.003	0.973	0.016	0.843		
Acres farmed	0.029	0.721	0.014	0.862		
Acres enrolled in CREP	-0.092	0.218	-0.093	0.213		
Years farmed	0.055	0.484	0.084	0.299		
Maintenance	0.186	*0.006	0.170	*0.014	0.135	*0.015
Frequency of visits	0.293	*0.000	0.281	*0.000	0.291	*0.000
Adequate information	0.037	0.588	0.033	0.626		
Future Plans			0.103	0.152		
Adjusted R square	0.109		0.114		0.101	
F	3.0		2.99		17.76	

*Variables with significance $p < 0.05$
B: Standardized Beta

Future Plans for Buffers

To understand the relationship between reasons for enrolling in CREP and future plans for riparian forest buffers, a multiple regression model was used to predict future outcomes for buffers (Table 4.13). The factors extracted from Question 4 assessing landowner reasons for enrolling in CREP (Environment, Agricultural Productivity, and Economics) were used as the independent variables to predict the dependent variable for future plans for buffers using Future Plans extracted from Question 14. The factor Environment was significant (0.000) in predicting future plans for the buffer. These variables explained 15.6 percent of the total variance in future plans for buffers. The factor Environment included (in order of factor loading) environmental stewardship, help protect the Chesapeake Bay, improve water quality, improve fisheries habitat, prevent non-point source pollution from entering the stream, leave a legacy, and stabilize stream bank. These variables can all be described as natural resource stewardship and long-term environmental benefits of the establishment of a riparian forest buffer. The factor Future Plans included three actions that scored highly on factor loadings: leave the buffer intact, leave intact for its aesthetic value, and manage for wildlife habitat. The likelihood for landowners to either remove the buffer to re-graze or remove the buffer to crop scored as least likely options for landowners to pursue as future plans for the buffer.

Table 4-13: Multiple regression model of relationship between reasons for enrolling in CREP and future plans for the buffer.

Independent variable	*Standardized Beta*	*Significance*
Environment	0.405	0.000*
Agricultural productivity	0.018	0.768
Economics	-0.060	0.312
Adjusted R square	0.156	
F	17.033	

*Variables with significance $p < 0.05$

The multiple regression analysis helped to describe some of the underlying relationships that led to an engagement and active participation in the maintenance of riparian forest buffers by landowners in this study. Of the many independent variables assessed for likelihood of predicting buffer activity, only three proved to be significant. Maintenance of a riparian forested buffer required an actual physical presence of a person on the land to perform tasks such as straightening downed tree shelters after a flood or applying herbicide around tree shelters. Thus, it is reasonable to expect that the frequency of landowner visits would effectively predict the level of buffer activity. In a similar regard, landowners who have an understanding of the importance of maintenance tasks to the successful establishment of a riparian forest buffer would be most likely to have a higher level of buffer activity. The standardized beta for economics was not significant in the model; however, it is useful to note that the coefficient was negative. This suggests that respondents were not motivated by economic values that comprise this factor (i.e., incentive payments, spring incentive, farm income) in their decision to participate in the CREP program.

Chapter 5

Discussion

This study assessed attitudes and motivations of landowners enrolled in Pennsylvania CREP riparian forested buffer initiative. The strong response from survey respondents to the questionnaire yielded distinct patterns in landowner attitudes, level of engagement, and understanding of maintenance required for the successful establishment of their riparian forest buffer. More comprehensive results about connection between the success of riparian forest buffer establishment and maintenance performed by landowners could have been gained had field verification of the survey questionnaire results been feasible.

General Overview

The high response rate of 70 percent indicates landowners' have much interest in their riparian forest buffers. In order to complete and return a self-administered questionnaire, participants must have both cognition and motivation (Dillman 2000). Pennsylvania CREP riparian forest buffer participants were strongly motivated to improve natural resources and environmental stewardship. The two primary reasons Pennsylvania landowners participated in CREP were to improve water quality and environmental stewardship. These reasons were consistent with previous research on CREP riparian forested buffer landowners conducted in 2005 at the beginning stages of the CREP forested buffer initiative's existence in Pennsylvania (Cooper, 2005). Other important reasons for CREP enrollment were to improve nongame wildlife habitat and help protect the Chesapeake Bay.

Respondents sociodemographic characteristics varied but several patterns emerged that can be compared with previous research on the Pennsylvania CREP riparian forest buffer

initiative. In this study, forest was the largest land use by acreage; 82 percent of the respondents reported holding woodlands with an average ownership of 73 acres. The second largest land use by acreage was crops/vegetables/grains with 42 acres held on average by 59 percent of respondents. Other agricultural land uses noted included 54 percent of respondents with pasture, 44 percent with fallow fields, and only 15 percent with livestock.

In comparison, Cooper's 2005 study on CREP participants showed the largest land use by acre was crops/vegetables/grains with 64 acres on average and 71 percent of respondents who reported this land use. The second largest land use by acre was forest with 45 acres on average and 79 percent of respondents reported this land use. Other agricultural land uses included 67 percent of respondents with pasture, 34 percent with fallow fields, and only 13 percent with livestock.

While neither of these surveys sought to assess the specific type, if any, of agricultural production or overall land management of respondents, the information about land use, primary occupation, years farming, and age could help inform an understanding of the potential current and future land management of participants as they relate to their riparian forest buffers. Less than 20 percent of respondents considered farming their primary occupation and nearly one-third had no land in farming. The average age of participants in Cooper's study was 58 and participants in the current study had an average age of 61. The most common primary occupation was retired with less than 25 percent of respondents reporting farming as their primary occupation in both studies.

The analysis of this study explored the idea that occupation might influence landowner participation and engagement in buffer maintenance. Statistical analysis was used to determine if farmers responded differently to questions relevant to buffer maintenance than respondents who selected all other occupations. Results showed that occupation, namely whether or not a

respondent identified themselves as a farmer versus all other occupations, was not a significant predictor in buffer activity.

Forest establishment is usually considered a long-term land use change and CREP contracts were either for 10 or 15 years. With program participants averaging 61 years old, many of whom were retired, long-term stewardship of the recently established riparian forest buffer had the potential to affect considerations in land management regarding legacy, ownership changes, and varying ability to actively care for the buffer. While canopy closure was possible within the ten to fifteen year timeframe, the robust growth that resembles a more mature forest and the increased ability of the streamside forest to perform valuable ecosystem services such as providing clean water and wildlife habitat happen over a longer period of time.

Survey respondents were asked about their future plans for the riparian forest buffer and over 77 percent indicated they were very likely to leave the buffer intact when the contract expired. Results from this study indicate that landowners were most likely to leave the buffer intact either for its aesthetic value or to manage the buffer for wildlife habitat. Cooper (2005) found similar results as 70 percent of respondents indicated they were very likely to leave the buffer intact when their contract expires. Participants were asked if they were aware of the potential for re-enrolling their riparian forest buffer in CREP; the majority (66%) indicated they were unaware of this option. Participants were then asked if given the opportunity would they choose to re-enroll for ten or fifteen years. The majority (73 and 64 percent respectively) indicated they would do so if given the chance.

These findings are significant for government agencies like NRCS, FSA, DEP, and EPA as well as nonprofit organizations working to restore streams and improve habitats in the Chesapeake Bay watershed. There is a clearly stated intention to keep the buffer intact when the contract expires and an interest in re-enrolling the buffer for ten or fifteen additional years. Based on this assessment of attitudes and beliefs of survey respondents, communication and outreach to

CREP riparian forested buffer participants that highlight long-term benefits of forested buffers such as improvements in water quality, forest stewardship, and improved wildlife habitat would likely resonate with program participants. Dedicated efforts by agencies to ensure ongoing technical assistance and information throughout the duration of a CREP contract could help significantly to secure long-term gains in streamside forest establishment and the myriad of other benefits.

Maintenance

Afforestation of riparian areas in the Northeast is a relatively new restoration practice and research on planting and maintenance techniques, tree survival, and benefits of streamside forests is now beginning to contribute to the working knowledge base of restoration practitioners and natural resource managers. For voluntary conservation programs such as CREP to benefit from such research, the results must be more effectively translated and communicated to the landowners who are responsible for establishing and maintaining the riparian forest buffer. This study's participants varied by several sociodemographic characteristics such as levels of education, primary occupation, and household income. Efforts by the agencies administering CREP and providing technical assistance to landowners would benefit from having effective informational and instructional materials and in-person communication that is tailored to program participants for the most significant results.

This study was designed to assess CREP landowners' understanding of maintenance required to successfully establish their riparian forest buffers. Scientific research and lessons learned from the collective experience of the thousands of landowners who have enrolled in the riparian forest buffer initiative in Pennsylvania are testaments to the challenges that make successful tree establishment in riparian areas difficult. Questions about the participants'

involvement with their CREP riparian-forested buffers, performance of various maintenance activities, and opinions about the importance of various maintenance tasks were designed to assess their understanding of buffer maintenance.

Based on the expertise and experience of USDA, DEP, PSU, and Chesapeake Bay Foundation staff, seven maintenance activities were identified to be the most critical to successful buffer establishment and included in this survey question (Question 9). The vast majority of participants (over 68%) indicated all buffer maintenance activities listed had been performed by themselves, a contractor, or both. Eighty-two percent of respondents indicated site preparation prior to planting that included mowing and herbicide application had been performed. Site preparation has been shown to be an important first step in buffer establishment in order to control competition from existing vegetation and reduce weed germination to give the new tree seedlings the best chance for survival. Interestingly, six percent of respondents indicated that tree planting had not been done. Given that this is the central component to participation in the riparian buffer initiative, it can be presumed that these respondents have actually planted the trees but perhaps misunderstood the question.

Several of the tasks listed (Question 9) can be described as ongoing maintenance activities that have been shown to increase successful establishment of riparian-forested buffers. Research has demonstrated that a combination of mowing alleyways between trees rows, use of tree shelters to protect seedlings, and herbicide application to control competition from vegetation surrounding shelters leads to increased growth and higher tree seedling survival (Sweeney, Czapka, & Yerkes, 2002). The majority of respondents indicated that all of these tasks had been performed. Mowing alleyways for the first three years was completed by 68 percent of respondents. Herbicide application around tree shelters during the establishment period for the first three years was reported by 77 percent of landowners. Shelter maintenance that included straightening tubes after flood events, removing bird nets, and removing shelters when trees are

1.5 inches in diameter at the top of the tube was reported by 92 percent of participants. Other ongoing maintenance activities such as replanting trees to replace those that had died (70 percent of respondents) and controlling invasive and noxious weeds in the buffer (91 percent) were also representative of the overall commitment to buffer maintenance.

Changes to the CREP program in Pennsylvania to address the importance of maintenance to riparian forest buffer survival in 2008 included a quality assurances agreement by the Pennsylvania Department of Environmental Protection. This agreement required a higher level of maintenance for participants to receive the state CREP cost share of up to 50 percent of total eligible costs for the buffer planting. As part of this agreement, a participant requesting state cost share agreed to have a qualified professional to apply an appropriate herbicide around tree shelters in six-foot wide circles or six-foot wide strips centered on the tree row for the first three years of the contract. This technical guidance was based on tree seedling survival and establishment research and was intended to ensure the best chance for riparian forest buffer success by suppressing competition for water and nutrients from existing vegetation like grass growing directly adjacent to tree shelters. Although 77 percent of respondents in this survey indicated herbicide application had been performed, less than half (49%) reported that a contractor had done this task and 44 percent indicated they applied the herbicide themselves. While Pennsylvania law does not require landowners to have an applicator license to apply chemicals on their own property, herbicide application in riparian areas that contact waters of the Commonwealth does require such a license and the selection of appropriate chemicals is critical to protect water quality and aquatic life. For CREP participants who are farmers and that are familiar with herbicide application, many of whom have Pennsylvania applicator licenses, their knowledge and experience may be sufficient for applying herbicide in their riparian forest buffer. However, herbicide misapplication in riparian areas has the potential to cause significant harm to water quality, aquatic life, and trees in the riparian forest buffer.

This study hypothesized that participants who were more involved in the maintenance of their buffers would have more successful establishment. While field verification of this hypothesis was not feasible, survey results suggest that the frequency of visits and the perceived importance of maintenance tasks by program participants are significant predictors of maintenance performance. Over half of the respondents (59%) indicated they visited their buffers at least monthly. An additional 37 percent visited their buffer several times a year. Maintenance activities were performed in the buffer area by 73 percent of participants during a typical visit and the majority of respondents (78%) looked at individual sheltered trees to check their condition. It is interesting to note that participants reported their typical visits included a combination of maintenance activities and personal enjoyment of the area such as walking, wildlife viewing, or fishing. These findings were consistent with the underlying themes of stewardship and concern about improving water quality and wildlife habitat reported by landowners. Another clear indicator of the commitment of CREP landowners to the successful forested buffer establishment was that nearly all participants reported investing time (95%) and over three-quarters (77%) had invested money.

Communication to Landowners about CREP

CREP is a voluntary conservation program jointly administered by USDA FSA and NRCS. In addition to these two lead agencies, a collaborative CREP partnership of multiple state and nongovernmental agencies provide ongoing technical assistance and guidance to landowners throughout the duration of a landowners' CREP contract for this initiative. One objective of this study was to assess aspects of the program related to information conveyance, ability of landowners to understand contract terms and maintenance responsibilities, and the adequacy of information about buffer maintenance. Findings from this survey could help guide future

communications with CREP landowners and lead to improvements in program delivery, landowner satisfaction, and an increase in successful riparian forest buffer establishment. Pennsylvania CREP has been one of the most successful private lands conservation programs for restoring riparian forest buffers in the U.S. and is frequently looked to as a model for success for this best management practice. Implementing the findings from this study would thus improve Pennsylvania CREP's success and also the other programs that are modeled on this system.

Landowners were asked in this survey to rate their overall experience with CREP program administration. Survey results suggested that CREP participants were most satisfied with staff knowledge on contract information (83%) and program technical aspects (81%). Respondents indicated satisfaction with length of time to get a contract (75%), amount of money received (70%), and ability to understand contract terms (70%). These findings indicate an overall high level of participant satisfaction with CREP. The majority of landowners who participated in this survey indicated an interest in re-enrolling their CREP buffer (73% for 10-year and 64% for 15-year contract) if given the opportunity, yet 66 percent were unaware of this option. While the opportunity to re-enroll in CREP was dependent on program availability and adequate government funding, these findings highlight the importance of communicating about long-term stewardship of the forested buffer to landowners early and often throughout the current contract period.

Landowners were asked specifically about their satisfaction with the information they received on buffer maintenance including the agency that communicated contractual responsibilities for buffer maintenance, the adequacy of information provided, and their interest in receiving additional information on maintenance. Contractual responsibilities were reportedly communicated primarily by FSA and NRCS and the majority of respondents (91%) indicated this information was adequate. When asked to rate the level of satisfaction with the information received on buffer maintenance, 67 percent of respondents indicated they were satisfied. The

most useful sources of information were CREP contract materials that included NRCS guidelines for buffer establishment, maintenance, and post planting establishment landowner assurances.

While the majority of landowners reported satisfaction with the information they received on buffer maintenance, 44 percent expressed an interest in additional information about riparian forest buffer maintenance. One-third of survey respondents took the time to write in specific suggestions on topics they would like to know about. Topics included what tree species to replant, information on long-term maintenance, how to encourage natural tree regeneration in the buffer, noxious weed control, shelter removal, and tree survival. The vast majority of these respondents requested to receive this information in the mail, and relatively few expressed an interest in having this information delivered electronically or in person. These findings are useful in guiding outreach and communication by agencies and CREP partners who deliver ongoing technical assistance to CREP forest buffer landowners.

Chapter 6

Conclusion

The re-establishment of riparian forests is now widely considered best management practice for restoring stream and river ecosystems where the deforestation of riparian areas has led to a decline in water and habitat quality in North America (Lowrance et al., 2000; Sweeney et al., 2002). Improving water quality through conservation practices in riparian areas is largely dependent on private landowners' land management decisions and understanding their attitudes and motivations is critical to success (Ryan et al., 2003). In the Chesapeake Bay watershed, CREP has played a major role in the restoration of rivers and streams in Pennsylvania by providing a government funded voluntary conservation program that improves stream ecosystem function through the establishment of riparian forest buffers. Given the widespread problems of slow seedling growth and high mortality due to herbivory and competition from competitive and invasive plants, prescriptions for restoring a natural and diverse streamside forest must include a proactive program for maintenance (Sweeney & Czapka, 2004). Results and insights from this study can help guide the future efforts of those in the Chesapeake Bay watershed working to restore riparian forests along the watersheds' 111,000 miles of streams by ensuring that private landowners that participate in riparian forest buffer initiatives have the information, resources, and technical assistance necessary for successful establishment.

Summary

The objectives of this study were to examine landowner motivations for enrolling in CREP and identify actions that lead to successful riparian plantings and their future continuation in the program. The study population indicated a strong motivation for improving water quality

and environmental stewardship that led them to enroll their streamside land in CREP for the establishment of a riparian forest buffer. These findings were consistent with previous research on landowner reasons for enrolling in CREP (Cooper 2005) and suggested that a stewardship or land ethic drove participation in voluntary conservation efforts in riparian areas. Results from this study confirmed that landowner understanding of maintenance actions required for successful riparian forest buffer establishment and the frequency of visits to the buffer were significant predictors of the level of engagement in maintaining the buffer.

The vast majority (68%) of participants in this study indicated that all of the buffer maintenance activities listed had been performed during the riparian forest buffer establishment period. Moreover, the three maintenance tasks most critical to tree survival and establishment as identified through scientific research (Sweeney & Czapka, 2004) were reported to have been performed by the majority of participants: mowing alleyways (68%), herbicide application around tree shelters (77%), and maintaining, repairing, and removing tree shelters (92%). The intention of this study was to include a field assessment of riparian forest buffer establishment (Appendix F) to determine how landowners' understanding of maintenance responsibilities and motivation to perform buffer maintenance affected successful buffer establishment. While the results suggest that the performance of these maintenance activities should lead to successful tree establishment, a field assessment would be needed to verify the effectiveness of these actions. These results did, however, indicate a clear understanding by landowners of the maintenance required for successful forest buffer establishment.

This study demonstrated that the frequency of visits and perceived importance of maintenance tasks by landowners were significant predictors of the level of engagement in maintenance of the riparian buffer. Linear regression analysis of these two variables predicted 10.1 percent of the buffer activity reported by respondents. Typical visits by landowners to the buffer included a combination of maintenance activities and personal enjoyment of the area such

as walking, wildlife viewing, or fishing. Another clear indicator of the commitment of landowners to the maintenance of their forest buffer was that nearly all participants indicated personal investments of time (95%) and money (77%) to ensure successful establishment. These insights helped to understand what landowners have invested in the restoration of their land and their motivations for taking these actions.

Landowners who participated in this study stated a clear intention to keep the riparian forest buffer intact when their current contracts expire and continue to participate in the program by re-enrolling the buffer for ten or fifteen additional years. Respondents were most likely to leave the buffer intact either for its aesthetic value or to manage the buffer for wildlife habitat. While the majority of landowners indicated they would re-enroll in CREP when their contracts expired, most were unaware of this option. Landowner attitudes and beliefs based on environmental stewardship, improving water quality, aesthetic value of streamside forests, and wildlife habitat were common themes that emerged from this research. These themes appeared to guide landowner decision making about voluntary conservation and restoration efforts over the long term.

Recommendations

Findings from this survey could be used to help guide future communications with CREP landowners to current contract holders as well as recruitment of new participants and would likely lead to increased success of the objectives of the program. Survey results indicated an overall high level of participant satisfaction with CREP. Building on this success and landowner satisfaction by making improvements to the delivery of information and technical assistance to currently enrolled landowners could help ensure that long-term benefits of riparian forest buffers are realized. CREP participants expressed an interest in receiving additional information on the

long-term maintenance of their riparian forest buffers. The duration of CREP contracts was such that consistent and effective communication must continue to reach participants throughout the ten or fifteen year contract period to maintain landowner engagement and to ensure the best results with the riparian forest buffer.

Participants in this study were asked to rate their level of satisfaction with the information received on buffer maintenance. The majority of respondents indicated they were satisfied, yet more importantly nearly half of the landowners expressed interest in additional information about riparian forest buffer maintenance. Landowners who demonstrated an understanding of the maintenance required for successful buffer establishment had a higher level of engagement in performing maintenance tasks and overall involvement in their buffers. One-third of survey respondents took the time to write in specific suggestions on topics that they would like to know more about to further assist the establishment of their buffer. An investment by the CREP agencies in designing and delivering such information on maintenance would serve the program, buffer landowners, and water quality of the region significantly.

For landowners to benefit from the insights gained from scientific research on buffers and the valuable lessons learned from other CREP participants, the results must be communicated in an effective and timely manner. The majority of respondents who reported an interest in additional information on maintenance requested that the information be received in the mail. Results from this study have demonstrated the positive effect of landowner understanding of maintenance on the level of activity and engagement in their riparian forest buffer. Action by the agencies that administer CREP to ensure that this information on maintenance reaches participants would significantly aid landowners in their continued efforts to successfully establish and maintain their riparian forest buffers.

The majority of survey respondents indicated clear intentions to keep their riparian forest buffers intact after the CREP contract expired. They also expressed an interest in re-enrolling in

the program for an additional term, yet most were unaware of the option to do so. Given the time it takes for successful riparian forest buffer establishment, the substantial public and private investment made for this best management practice, and the significant improvements to stream ecosystems from CREP, it is essential that information on forest buffer maintenance requested by participants of this study be addressed and implemented expeditiously.

Pennsylvania has the largest Conservation Reserve Enhancement Program in the nation and the state has invested more than $50 million for this program (Hines, 2010) in addition to the more than $50 million in federal funds in Pennsylvania. Riparian forest buffers play a central role in Pennsylvania's plans to meet the U.S. Environmental Protection Agency established Total Maximum Daily Load (TMDL) for pollutants entering the Chesapeake Bay (Chesapeake Bay Program, 2014). Without restored riparian forest buffers, Pennsylvania's requirements to meet the pollution load reductions outlined in the TMDL and the state's associated Watershed Implementation Plans will be significantly more difficult and costly to achieve (Campbell, 2014).

Results from this study indicate that landowners who enrolled in PA CREP are motivated by environmental stewardship, improvements to non-game wildlife habitat, and helping to protect the Chesapeake Bay. Recruitment of new participants for CREP should focus on effectively communicating landowner the identified motivations to install riparian buffers and the importance of engagement in maintenance of the buffer for successful forest establishment. In addition, engaging landowners early in the establishment of their buffer in visiting the buffer and performing maintenance activities will increase the success of establishment and build a foundation for long-term stewardship of and commitment to restored streamside forests.

While the majority of respondents to this study indicated a clear understanding of the maintenance required for the successful establishment of their CREP riparian forest buffers, this study was unable to assess and validate measurable results for riparian forest buffer establishment without a field assessment. Significant investments in scientific research, programmatic

improvements, and financial cost-share for maintenance were made to enable Pennsylvania to become the first in the nation to offer substantial support for maintenance of CREP riparian forest buffers to program participants in 2008. To date, there has been no research conducted to assess the quantitative effects of these investments on riparian forest buffer establishment. Future research that builds from this study of Pennsylvania CREP participants should include a field assessment that quantitatively assesses the establishment of tree seedlings in CREP riparian forest buffers.

Of particular interest to the Pennsylvania Department of Environmental Protection could be an assessment of their Landowner Assurances Agreement that is required of CREP participants that request cost share from the state (up to 50% of costs). Results from this study demonstrated that the majority of landowners (77 %) indicated herbicide application around the tree shelters had been performed for the first three years after tree planting, yet nearly half (44%) reported doing the herbicide application themselves. The Landowner Assurances Agreement has specific maintenance requirements including hiring a qualified professional to apply an appropriate herbicide and that the herbicide be applied in either six foot wide continuous strips or circles centered on the tree shelter, as advised by technical experts and scientific research. An assessment of the actual implementation of such maintenance could contribute to a more comprehensive understanding of what leads to successful establishment as well as ensure strategic investment of public funds for forest buffer restoration both currently and in the future.

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Appendix A

Questionnaire

A Survey of Riparian forested buffer Owners

The following questions are specific to land you own in Pennsylvania. According to our records, you have enrolled part of your land in the USDA Conservation Reserve Enhancement Program (CREP) riparian forested buffer conservation program.

If you do not own any land in Pennsylvania, please return the survey in the postage-paid envelope enclosed so we can remove your name from the mailing list.

Q1a. How many acres of land do you own in Pennsylvania? _____Acres

1b. Of the total acreage you own, how many acres are currently farmed? _____Acres

1c. How many acres of your land is currently enrolled in Pennsylvania's Conservation Reserve Enhancement Program (CREP) riparian forested buffer? _____Acres

Q2. For how many years have you farmed, or did you farm, in Pennsylvania? _____Years

Q3. Please indicate how your property is used by assigning an acreage amount to each of the categories which apply to your land. (Please check that your sum equals your farm's ***total*** number of acres)

A. _____Pasture acres
B. _____Crops/vegetables/grains acres
C. _____Livestock acres
D. _____Fallow fields acres
E. _____Forest acres
F. _____Nursery acres
G. _____Specialty crops (Christmas trees, mushrooms, organic produce) acres
H. _____Residence acres
I. _____Other acres , please describe_____
J. _____= **Total acres**

Q4. Listed below are reasons landowners enroll in CREP. Please indicate how important or unimportant each of these reasons was in your decision to enroll acreage as riparian forested buffers.

1 = Very Unimportant (VU)
2= Unimportant (U)
3 = Neither Unimportant or Important
4 = Important (I)
5 = Very Important

Please CIRCLE one for each reason:

Reasons for enrolling in CREP forested buffer	IMPORTANCE				
	VU	**U**	**N**	**I**	**VI**
A. Improve water quality	1	2	3	4	5
B. Increase farm income	1	2	3	4	5
C. Decrease farm acreage	1	2	3	4	5
D. Protect a specific site downstream	1	2	3	4	5
E. Environmental stewardship	1	2	3	4	5
F. Help protect the Chesapeake Bay	1	2	3	4	5
G. Neighbors installed a buffer	1	2	3	4	5
H. Stabilize stream bank	1	2	3	4	5
I. Leave a legacy	1	2	3	4	5
J. Improve farm productivity	1	2	3	4	5
K. Improve herd health	1	2	3	4	5
L. Keep livestock out of stream	1	2	3	4	5
M. Prevent non-point source pollutions from entering the stream	1	2	3	4	5
N. Improve hunting	1	2	3	4	5
O. Retiring	1	2	3	4	5
P. Improve non-game wildlife habitat	1	2	3	4	5
Q. Improve fisheries habitat	1	2	3	4	5
R. Incentive payments	1	2	3	4	5
S. Signing bonus	1	2	3	4	5
T. Other, please describe_____	1	2	3	4	5

The following questions are about your level of involvement with your CREP riparian forested buffer.

Q5. Each of the following activities relates to the establishment and maintenance of your riparian forested buffer. In Part I, please indicate if any of the activities have been done on your forested buffer. In Part II, please indicate who was responsible for each activity.

BUFFER ACTIVITY	PART I HAVE DONE? *..circle one..*	PART II PERSON RESPONSIBLE *..circle one..*
A. Site preparation prior to planting (mowing, herbicide application)	No Yes	Yourself Contractor
B. Tree Planting	No Yes	Yourself Contractor
C. Mowing alleyways between tree shelters during establishment period (first 3 years)	No Yes	Yourself Contractor
D. Herbicide application around tree shelters during establishment period (first 3 years)	No Yes	Yourself Contractor
E. Replanting trees to replace those that died	No Yes	Yourself Contractor
F. Shelter maintenance (straightening tubes after flood events, removing bird nets, removing tubes when tree is 1.5 inches diameter at the top of the tube)	No Yes	Yourself Contractor
G. Controlling invasive and noxious weeds	No Yes	Yourself Contractor

Q6. How often do you visit your riparian forested buffer?

A. ____ At least once a week
B. ____ Monthly
C. ____ Several times a year
D. ____ Once a year
E. ____ Less than once a year
F. ____ Never

Q7. What does a typical visit include? (Please check all that apply)

A. ____ Looking at buffer from outside the buffer
B. ____ Looking at individual sheltered trees to check their condition
C. ____ Performing maintenance in the buffer area
D. ____ Personal enjoyment of area (walking, wildlife viewing, fishing)
E. ____ Other (please specify)_____

Q8. What personally have you invested in your riparian forested buffer? (Please check all that apply)

A. ____Time (performing maintenance tasks, replanting trees, weed control)
B. ____Money (replanting trees, cost of maintenance)
C. ____Other, please describe_____

Q9. Listed below are potential maintenance tasks for riparian forested buffer establishment. Please indicate how important each of following are to the success of your riparian forested buffer.

1 = Very Unimportant (VU)
2= Unimportant (U)
3 = Neither Unimportant nor Important (N)
4 = Important (I)
5 = Very Important (VI)

MAINTENANCE TASK	**IMPORTANCE**				
	VU	**U**	**N**	**I**	**VI**
A. Application of herbicide before planting the trees	1	2	3	4	5
B. Hiring a qualified professional to plant the trees	1	2	3	4	5
C. Hiring a qualified professional to apply herbicide for the first three years after planting	1	2	3	4	5
D. Using tree shelters to protect trees from deer browsing, rodents, and small mammals	1	2	3	4	5
E. Using tree shelters to protect trees from herbicide	1	2	3	4	5
F. Repairing downed tree shelters immediately after flooding	1	2	3	4	5
G. Removing tree shelters when trees are 1.5 inches in diameter at the top of the shelter	1	2	3	4	5
H. Mowing between trees for the first three years after planting trees	1	2	3	4	5
I. Efforts to control noxious weeds	1	2	3	4	5
J. Maintaining 70% of original number of trees and shrubs planted (naturally-regenerating plants can be counted)	1	2	3	4	5

Q10a. Who communicated your contractual responsibilities for the maintenance of your riparian forested buffer to you? (Please check all that apply)

A. _____Natural Resource Conservation Service (NRCS)
B. _____Farm Service Agency (FSA)
C. _____Department of Environmental Protection (DEP)
D. _____Chesapeake Bay Foundation (CBF)
E. _____Other, please describe_____

Q10b. In your opinion, was this information adequate?

____ Yes ____ No

Q11. Which of the following were useful sources of information for the maintenance of your riparian forested buffer? (Please check all that apply)

A. ____CREP contract materials (NRCS guidelines, Maintenance and Post Planting Establishment Landowner Assurances)
B. ____Natural Resource Conservation Service (NRCS) staff
C. ____Farm Service Agency (FSA) staff
D. ____DCNR Bureau of Forestry staff
E. ____Chesapeake Bay Foundation staff
F. ____PA Game Commission staff
G. ____Resource Conservation and Development Council (RCD) staff
H. ____Landowner Guide to Buffer Success Calendar (28 page color document)
I. ____Penn State Extension
J. ____Other, please describe_____

Q12a. Are you interested in more information about the maintenance of your riparian forested buffer?

___ Yes ____ No

Q12b. If Yes, what topics would like to know about? _____

_____

Q12c. If yes, how would you like to receive this information?

_____

The following questions relate to your satisfaction with your riparian forested buffer and the CREP program.

Q13. How would you rate your overall experience with CREP administration? Please use the following scale where 1 is Completely Dissatisfied and 5 is Completely Satisfied. Please CIRCLE the number that most closely matches your opinion.

	Completely Dissatisfied				Completely Satisfied
A. Amount of paperwork	1	2	3	4	5
B. Length of time to get a contract	1	2	3	4	5
C. Knowledge and help from trained staff					
On paperwork/contract/ etc	1	2	3	4	5
On technical side of project installation	1	2	3	4	5
D. Amount of money received	1	2	3	4	5
E. Tree/shrub planting by landscape crew	1	2	3	4	5
F. Ability to understand the contract terms	1	2	3	4	5
G. Information received on buffer maintenance	1	2	3	4	5

Q14. Using the following scale, how likely or unlikely (where 1 is Not Likely and 5 is Very Likely) are you to do each of the following when your CREP contract expires?

	Not likely				Very likely
A. Leave the buffer intact	1	2	3	4	5
B. Remove the buffer to re-graze	1	2	3	4	5
C. Remove the buffer to crop	1	2	3	4	5
D. Manage it as a timber crop for the future	1	2	3	4	5
E. Re-enroll the buffer in CREP	1	2	3	4	5
F. Harvest non-timber forest products	1	2	3	4	5
G. Manage for wildlife habitat	1	2	3	4	5
H. Leave intact for its aesthetic value	1	2	3	4	5
I. Other, please describe_____	1	2	3	4	5

Q15. In your opinion, which of the following items were the main obstacles to tree survival and growth on your site? (Please check all that apply)

A. ____Deer browsing
B. ____Buck rubbing
C. ____Rodents gnawing on roots or stems
D. ____Rodent nesting in shelters
E. ____Competition from grasses and other herbaceous plants present on the site from the start
F. ____Competition from grasses that were sown on the site as part of the initial planting (done only on sites that were formerly cropland)
G. ____Drought
H. ____Flood damage
I. ____Soil excessively wet
J. ____Noxious and invasive plants
K. ____Incorrect tree selection for site
L. ____Compaction of soils
M. ____Other, please describe_____
_____

Q16a. Are you aware of the potential for re-enrolling your riparian forested buffer for additional rental payments through a second 10-15 year contract?

____ Yes ____ No

Q16b. How comfortable are you with your understanding of the requirements for re-enrollment? Using the scale ranging from 1 (Very Uncomfortable) to 5 (Very Comfortable), CIRCLE the number that most closely matches your opinion.

1 2 3 4 5

Q16c. Given the opportunity, would you choose to re-enroll your forested buffer for

10 years? ____ No ____ Yes
15 years? ____ No ____ Yes

Q17. When did you receive professional assistance on your riparian forested buffer?

(Please check all that apply)

_____Never

_____At the time of buffer installation

_____During the establishment period (first 3 years)

_____After the establishment period

Finally, we would like to ask some questions about you and your household. All information will be treated confidentially and will never be associated with your name or property. If you choose not to answer any particular question, please continue on to the next.

Q18. What is your gender? ____Male ____Female

Q19. In what year were you born? _____

Q20. What is your current employment status?
Please CHECK one:

A. ___ Full-time
B. ___ Part-time
C. ___ Retired
D. ___ Student
E. ___ Homemaker
F. ___ Non-employed (looking for work or laid off)

Q21. What is your highest level of education? (Please check one)

A. ____Did not complete high school
B. ____High school diploma or GED
C. ____Some college credits
D. ___ College degree
E. ____Some post-graduate credits
F. ____Post graduate degree

Q22. What is your primary occupation? (Please check one)

A. ____Farmer
B. ____Retired
C. ____White-collar
D. ____Blue-collar
E. ____Other

Q23. Which of the following are current sources of income in your household?
(Please CHECK ALL that apply):

A. ___ Wages and/or salary
B. ___ Income from business
C. ___ Interest and/or investments
D. ___ Income from rental properties
E. ___ Supplemental security income
F. ___ Other disability benefits
G. ___ Social Security payments
H. ___ Retirement pension payments
I. ___ Unemployment
J. ___ Food stamps
K. ___ Public assistance/welfare
L. ___ Other, please specify:_____

Q24. Which category best represents your total household income for 2011 including all sources? (Please check one)

A. ___ Less than $15,000
B. ___ $15,000 to $24,999
C. ___ $25,000 to $34,999
D. ___ $35,000 to $49,999
E. ___ $50,000 to $74,999
F. ___ $75,000 to $99,999
G. ___ $100,000 to $149,999
H. ___ $150,000 or more

THANK YOU!

Those are all the questions we have.

We appreciate you taking the time to complete this survey!

Please return this completed survey using the postage-paid enclosed envelope.

If you have any comments you would like to share with us, please use the space below and inside the back cover.

Appendix B

Survey Cover Letter

Salutation First Last
Address
City, State, Zip code

Dear First-Last:

Penn State is conducting a study of forest landowners who are participating in the USDA Conservation Reserve Enhancement Program (CREP) in Pennsylvania and we need your help. This study aims to understand riparian forested buffers – from the maintenance required to ensure their success to challenges landowners face in trying to establish them. Results from this study will help improve outreach and assistance to landowners as they work to maintain their riparian forested buffers.

You were randomly selected as a Pennsylvania CREP participant with a riparian forested buffer. Your insights are important and will help us understand the concerns and needs of riparian forest buffer landowners across Pennsylvania. Results from this survey will help Penn State, the USDA Farm Service Agency, and the USDA Natural Resource Conservation Service improve communication, education, and outreach programs for Pennsylvania landowners.

Your participation in this survey is completely voluntary and you may stop at anytime or skip any question you do not wish to answer. This study is being conducted for research purposes only. All your answers will remain confidential – we will only report summaries of our findings. If you have received this survey and are less than 18 years of age, please note this at the top of the questionnaire and return it to us using the postage-paid envelope enclosed. The identification number on your survey allows us to remove your name from the mailing list when you return your questionnaire, preventing the need for additional mailing costs. Your name will never be linked with your responses.

It should take 30 to 40 minutes to complete the questionnaire. When you are done, please use the postage-paid envelope to return the questionnaire to us. By completing and returning the questionnaire, you imply your consent to participate in this study.

If you have any questions about the study, please call us toll free at 800-235-9473. Please keep this letter for your records in case you have further questions about this project or would like to contact us in the future.

Thank you for your help in this study.

Sincerely,
Jim Finley, Ph.D.
Professor of Forest Resources

Appendix C

Reminder Postcard

Dear Pennsylvania Forest Landowner,

Last week you received a questionnaire about your riparian forested buffer. You are one of a few Pennsylvania forest landowners selected to participate in this Penn State study. Your response is very important.

If you have already completed and returned the questionnaire, please accept our sincere thanks. If not, please take some time to complete the questionnaire and return it to us in the postage-paid envelope provided. Your response will help improve outreach and assistance to forest landowners like yourself across the Commonwealth. This study is being conducted for research purposes only and your responses will always be kept confidential.

If you did not receive a questionnaire, or if it was misplaced, please call us toll free at 800-235-9473 and we will send you a replacement immediately.

Sincerely

Jim Finley, Professor
Forest Resources

Appendix D

Survey Cover Reminder Letter 1

Salutation First Last
Address,
City, State, Zip code

Dear First-Last:

A few weeks ago you should have received a survey as part of a study about riparian forested buffers in Pennsylvania. This study aims to understand riparian forested buffers – from the maintenance required to ensure their success to challenges landowners face in trying to establish them. As you may remember, you were randomly selected as a Pennsylvania Conservation Reserve Enhancement Program (CREP) participant with a riparian forested buffer. To the best of our knowledge, your survey has not been returned. If you have recently returned your completed survey, please ignore this letter and accept our sincere thanks for your participation.

Your insights are important and will help us understand the concerns and needs of riparian forest buffer landowners across Pennsylvania. Results from this survey will help Penn State, the USDA Farm Service Agency, and the USDA Natural Resource Conservation Service improve communication, education, and outreach programs for Pennsylvania landowners.

We want to remind you that your participation in this survey is completely voluntary and you may stop at anytime or skip any question you do not wish to answer. This study is being conducted for research purposes only. All your answers will be confidential. If you have received this survey and are less than 18 years of age, please note this at the top of the questionnaire and return it to us using the postage-paid envelope enclosed. The identification number on your survey is there so we can check your name off the mailing list when you return your questionnaire, preventing the need for additional mailing costs. Your name will never be linked with your responses.

It should take 30 to 40 minutes to complete the questionnaire. When you are done, please use the postage-paid envelope to return the questionnaire to us. By completing and returning the questionnaire, you imply your consent to participate in this study.

If you have any questions about the study, please call us toll free at 800-235-9473. Please keep this letter for your records in case you have further questions about this project or would like to contact us in the future.

Thank you for your help in this study.

Sincerely,

Jim Finley, Ph.D.
Professor of Forest Resources

Appendix E

Survey Cover Reminder Letter 2

Salutation First Last
Address
City, State, Zip code

Dear First-Last:

In November you should have received a survey as part of a study on riparian forested buffers in Pennsylvania. This study aims to understand riparian forested buffers – from the maintenance required to ensure their success buffers to challenges landowners face in trying to establish them. As you may remember, you were randomly selected as a Pennsylvania Conservation Reserve Enhancement Program (CREP) participant with a riparian forested buffer. To the best of our knowledge, your survey has not been returned. If you have recently returned your completed survey, please ignore this letter and accept our sincere thanks for your participation.

Your insights are important and will help us understand the concerns and needs of riparian forest buffer landowners across Pennsylvania. Results from this survey will help Penn State, the USDA Farm Service Agency, and the USDA Natural Resource Conservation Service improve communication, education, and outreach programs for Pennsylvania landowners. The survey responses we've received so far have been very diverse and helpful.

We want to remind you that your participation in this survey is completely voluntary and you may stop at anytime or skip any question you do not wish to answer. This study is being conducted for research purposes only. All your answers will be confidential. If you have received this survey and are less than 18 years of age, please note this at the top of the questionnaire and return it to us using the postage-paid envelope enclosed. The identification number on your survey is there so we can check your name off the mailing list when you return your questionnaire, preventing the need for additional mailing costs. Your name will never be linked with your responses.

It should take 30 to 40 minutes to complete the questionnaire. When you are done, please use the postage-paid envelope to return the questionnaire to us. By completing and returning the questionnaire, you imply your consent to participate in this study.

If you have any questions about the study, please call us toll free at 800-235-9473. Please keep this letter for your records in case you have further questions about this project or would like to contact us in the future.

Thank you for your help in this study.

Sincerely,
Jim Finley, Ph.D.
Professor of Forest Resources

Appendix F

Field Data Collection Protocol

Site Data Information Sheet

1. Owner or ID Number
2. Planting Area: (acres)
3. Site Treatment: Area wide herbicide
4. Row herbicide
5. Spot herbicide
6. No herbicide
7. Common Competitive Plants: (list)
8. Assessment of Competitive Plant Control: (From a site level perspective, how successful has competitive plant control been? How are competitive plants affecting planted tree success and natural recruitment?)
9. Indications of Maintenance: (Narrative about general appearance and signs of care, mowing, tubes in good repair, herbicide effectiveness)
10. Indications of Disturbance: (Narrative on flooding, small mammals, invasive plants)
11. Site Narrative: (General observations on soils, land shapes, aspect, design, seed sources for natural regeneration (observe, adjacent tree species, especially upwind), observations on damage to natural regeneration (e.g., browsing, rabbits, groundhogs).

Systematic Tree Sample

1. Start by determining the number of trees planted per acre based on spacing. For example, if the planting design is 20ft x 20ft there are about 110 trees per acre.
2. Select 30 trees per acre for evaluation using a systematic sample. For example, if the spacing is 12ft x 12ft, there will be 302 trees per acre, every 10^{th} tube will be assessed.
3. Use the last digit on your vehicle odometer to choose the location of the first tube selected at the end of the "first" row. Then assess every x^{th} tube from that point, at the end of a row, turn into the next while continuing the count. If tubes are missing, count the location in your systematic sample.

Variable Assessed at each tube:

1. Species: mnemonic
2. Condition: Live/Dead/Live but substantially impaired/Missing
   a. Cause of Death: Voles/Rodents/Planting/Site/Competition/Tube/Flooding/
3. Missing/Unknown
   a. Tube Condition: Erect/Leaning/Bent and Closed/Missing
   b. Competition Control: Herbicide Band/Herbicide Spot/No Weed Control

Natural Regeneration Assessment

Select 30 tubes per site for natural regeneration assessment using a systematic sample. To determine the location of these plots, take the number of trees planted per acre and divide by 30 to calculate the x^{th} tube location that will be assessed for natural regeneration. For example, if there are 300 planted trees/30 = every 10^{th} tree will be sampled for natural regeneration. If the tube is missing in the systematic pattern, approximate the location for assessing natural regeneration.

Around each tube (or missing tube, as explained above) in the systematic selection assess natural regeneration. The first 3 foot radius will be excluded from the natural regeneration assessment to account for potential herbicide treatment. Count seedlings within the next 3 foot radius (starting at 3 feet from the shelter and continue to 6 feet out from the shelter).

Variable Assessment at each tube:
Species: mnemonic
Number by Species: Count of established seedlings by species. A seedling is established if is out of the cotyledon stage.