Assessing Landowner Level Costs for Riparian Forest Buffer System Adoption on Farms in Virginia's Chesapeake Bay Watershed

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(Abstract)

Riparian Forest Buffer Systems contribute to non-point source pollution control and improve the physical and trophic qualities of streams. There is a limited understanding of the full range of costs incurred when implementing a RFBS. Establishment costs will vary with the site characteristics. The amount of forgone income will vary with the current land-use. RFBS enterprises may yield returns that partially or fully offset forgone income. Section A discusses the physical characteristics and functions of RFBS in the Chesapeake Bay Watershed. Section A argues that RFBS design and site characteristics alter the physical ability of RFBS to produce environmental services. Altering design specifications may come at little environmental loss but might greatly reduce landowner costs. Section B describes a decision support system that can provide landowners and policy makers with financial information on the site specific changes in costs that occur as RFBS designs are altered. Section C utilizes the decision support system software to simulate the common design and site characteristics found within the Chesapeake Bay Watershed of Virginia. Generalizations are drawn concerning reduction efficiencies of a RFBS based on the physical characteristics of the regions. Section D discusses government policies and incentive programs, as well as additional private income opportunities, that may influence the cost and adoption of RFBS. Findings revealed a range of annual per acre cost of adoption between $140.09 rising to a positive return of $124.79, depending on assumptions of site characteristics, land-use, and supplemental financial incentives.

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Introduction

The Chesapeake Bay Agreement committed the State of Maryland, the Commonwealths of Pennsylvania and Virginia, the District of Columbia and the Environmental Protection Agency (EPA) to restoring the and protecting the water quality and living resources of the Chesapeake Bay Watershed (CBW) (Chesapeake Bay Executive Council, 1983; http://www.chesapeakebay.net/bayprogram/pubs/83agree.htm). As part of the ongoing implementation strategy, in October of 1994 the Chesapeake Executive Council issued a directive forming the Riparian Forest Buffer Panel. The panel was charged to compile accepted definitions of riparian forests, develop quantifiable goals as targets for the maintenance and restoration of riparian forests, and recommend policy strategies for achieving the goals (Chesapeake Executive Council, 1994; http://www.chesapeakebay.net/bayprogram/pubs/dir94_1.htm). The charge to the panel was motivated by the recognition that restoration of streamside riparian areas can contribute to non-point source pollution control and improve the physical and trophic qualities of streams (Lowrance, et. al 1995, xiii).

The interim report of the Riparian Forest Buffer Panel defines a riparian area as "streams or rivers and other bodies of water and the adjacent land to them, which serve as a transitional environment and directly affects or is affected by the presence of that water". (Riparian Forest Buffer Panel 1995, 8). Among its many findings, the panel reported to the Executive Council that economic loss would be a significant issue for agricultural landowners who are asked to install Riparian Forest Buffer Systems (RFBS). They noted:

> "As with other BMP's, landowners and developers may experience a loss of economic income associated with the installation or retention of a forest buffer. For farmer's, the amount of land removed from production may be small but the level of impact may vary. … Economic benefits and trade-offs of forest buffer retention and establishment are not well understood or documented." (Riparian Forest Buffer Panel 1995, 13; http://www.chesapeakebay.net/bayprogram/committ/ripfor/pubs/interim.htm).

This conclusion provides the motivation for this report. Such financial information is important to the individual landowner. In addition, a policy maker designing regulatory actions, financial incentives and market creation strategies needs to understand how those approaches will affect landowner costs and their willingness to adopt a RFBS.

Costs of Riparian Forest Buffer Systems

There is a limited understanding of the full range of costs incurred when implementing a RFBS. These costs can fall into several different categories.

Establishment Costs

RFBS have two types of establishment costs. First, site preparation costs are incurred to assure the survival of planted species and the best possible environmental functions from the buffer. Establishment costs will vary with the site characteristics. Sites with ephemeral channels and gullies will require repair. Stream bank stabilization may be required elsewhere. Fencing to prevent compaction and uncontrolled stream crossing by livestock may be necessary. Each additional site preparation activity has a cost associated with the type and scale of the activity.

Planting costs are the expenses associated with establishing the vegetative cover of the RFBS. Planting costs also vary with site specific characteristics. The species and planting requirements must be adjusted for the objectives of the buffer and the physical conditions present at the adoption site.

Financial Opportunity Costs

In examining the adoption of a RFBS, foregone income must be considered. The amount of forgone income will vary with the current use. For example, the forgone income associated with row crop production may exceed the forgone income from cattle production.

RFBS enterprises may yield returns that partially or fully offset forgone income. RFBS products might include timber, ginseng, harvested grasses, and sale of pollution reduction credits. The actual types and quantities of returns will depend both on the productive capabilities of the RFBS and the market for the services. *Forgone income less the returns from the RFBS is a measure of the financial opportunity costs of the RFBS.* Opportunity costs can be expected to vary with site characteristics and RFBS design.

The RFBS Adoption Decision

RFBS may provide a landowner with non-marketable services such as improved wildlife observation, fishery enhancement, and noise reduction. If these are highly prized by the landowner, these RFBS services may encourage the landowner to bear RFBS costs. Of course for many streams, voluntary adoption only will occur when it does not present a substantial financial burden to the landowner. When the burden is large, a financial barrier to adoption exists.

To overcome such barriers, financial incentives programs offer enrollees payments in return for RFBS adoption. Since these programs are funded by tax dollars, there should be a careful assessment of the environmental gains achieved in relation to the incentive payments made. Ignoring this relationship will lead to spending that will quickly exhaust limited budgets with fewer of these systems protecting and enhancing the watershed.

However, there are other barriers to adoption of RFBS. Obtaining information imposes a time cost on landowners; therefore information costs are reduced when a landowner is familiar with RFBS costs, on-site benefits and financial incentive programs.

Educational programs reduce the information costs to the landowner.

Without adequate information, land managers can not rationally undertake any new enterprise. Also, policy makers will have limited information on which to design polices that may overcome the financial barriers to adoption. This study improves the information on the financial effects of RFBS adoption at the farm level.

Even more complete information and low cost access to that information may not motivate adoption. Farm structure and size, operator education and a variety of other social variables have been shown to influence the adoption decision for many conservation practices, although few studies have examined adoption of long-term conservation measures like a RFBS.

Report Outline

Section A discusses the physical characteristics and functions of RFBS in the Chesapeake Bay Watershed. Section A argues that RFBS design and site characteristics alter the physical ability of RFBS to produce environmental services. Such knowledge becomes part of the landowner cost and policy question, because altering design specifications may come at little environmental loss but might greatly reduce landowner costs. If so this makes the case for site specific RFBS designs especially strong.

Section B describes a decision support system that can provide landowners and policy makers with financial information on the site specific changes in costs that occur as RFBS designs are altered. Establishment costs will vary directly with the design requirements. Both present and future foregone income varies dramatically with returns from land use. Financial returns from the buffer will also vary with buffer design and site characteristics. Assessing the sensitivity of all cost estimates to changes in a large number of variables requires the consideration of multiple permutations. A computer software model -- a combination of Excel spreadsheet and Visual Basic Programming -- can be used to rapidly assess changes in hypothesized site conditions. The estimation model offers the opportunity to significantly lower the information costs to landowners considering the adoption of RFBS. Therefore, the model is designed as a *decision support system* for assessing the financial impacts of adoption on actual farms in Virginia. A complete user's manual and description is also available.

To prepare Section C the software was used to simulate the common design and site characteristics found within the Chesapeake Bay Watershed of Virginia. Generalizations are drawn concerning reduction efficiencies of a RFBS based on the physical characteristics of the regions. To exploit the range of efficiencies, buffer design is tailored to site characteristics. Although characteristics can vary dramatically within a region, the constructions of scenarios represent the general characteristics of the region. A county lying within each region is chosen. Based on survey data, the characteristics of the county are identified. A buffer is designed to provide environmental benefits based on the characteristics of the county. The decision support system is utilized to assess the financial effects of adoption on the representative scenario. Thus a measure of financial sensitivity of buffer adoption across regions can be established. Tests for the sensitivity of the financial effects to changes in individual variables are conducted on a base case.

Section D discusses government policies and incentive programs, as well as additional private income opportunities, that may influence the cost and adoption of RFBS. Landowners considering adoption face a variety of policies, programs, and opportunities which alter the financial effects of adoption. Estimates of the financial effects of policies and programs are examined on a single scenario. Discussions of market opportunities are also discussed for each of the three regions. Also, the effects of attitudes and non-market values on the adoption decision are reviewed.

Section A: Riparian Forest Buffers

A riparian forest buffer is "a forested area between a land use and an adjacent body of water which is designed and managed 1) to help maintain the hydrologic, hydraulic and ecological integrity of the stream channels and shorelines, 2) help prevent upland water sources of pollution from reaching surface waters by trapping, filtering, and converting sediments, nutrients and chemicals and 3) protecting fish and other wildlife by providing food, cover and thermal protection" (Riparian Forest Buffer Panel 1995, 8). The design of the Riparian Forest Buffer System directly affects its potential for influencing water quality and the physical and trophic qualities of streams.

Physical Description – Size, Vegetation, and Management

In 1991, the United States Department of Agriculture-Forest Service with assistance from the USDA-Agricultural Research Service, USDA-Soil Conservation Service, Stroud Water Research Center, Pennsylvania Department of Environmental Resources, Maryland Department of Natural Resources, and the United States Department of Interior Fish and Wildlife Service developed draft guidelines for riparian forest buffers. This effort resulted in a booklet entitled "Riparian Forest Buffers – Functions and Design for Protection and Enhancement of Water Resources" (Welsch 1991, Appendix "Specifications…") which specified a riparian buffer system consisting of three zones (Figure 1, below). The most recent guidelines suggest a variable buffer design, consistent with the objectives of the system.

Zone 1

A forested buffer includes an area of unmanaged forest, usually designated Zone 1 (see Figure 1, above). Standing alone, Zone 1 must stretch upslope 15 feet from the upper edge of the active channel (Natural Resources Conservation Service 392, 2-4) Ideally, the vegetation will resemble the historic, undisturbed riparian forest likely to be present in the area . Identification of benchmarks in the area can establish the most effective species selection (Lowrance, et. al 1995, 8). Livestock should be excluded, and pests must be adequately controlled. Harvests are severely limited in Zone 1.

> "Occasional limited removal of… high value trees is permitted provided the intended purpose is not compromised by the loss of vegetation or harvesting disturbance" (Natural Resources Conservation Service 392, 2).

Zone 2

Zone 2 begins at the upslope edge of Zone 1 and extends a minimum width of 20 feet. However, total minimum width of Zones 1 & 2 must equal 100 feet or 30 percent of the geomorphic floodplain. The earliest recommendations suggested width should correspond to the specific soil properties of the site.

Dominant vegetation should be a managed forest. Species choice is not limited, although a list of preferred species is provide in the standards (Natural Resources Conservation Service 1996, 10). Periodic and regular harvests of forest products are permissible and less restricted than Zone 1. However, the environmental objective of the buffer system should not be compromised by harvest activities.

Zone 3

In some situations, a grass vegetated filter strip will be required. The Zone 3 extends 20 feet upslope from the edge of the forested buffer. Stiff-stemmed grasses are established and maintained. Proper management includes regular harvesting and periodic repair if channels from in the buffer area.

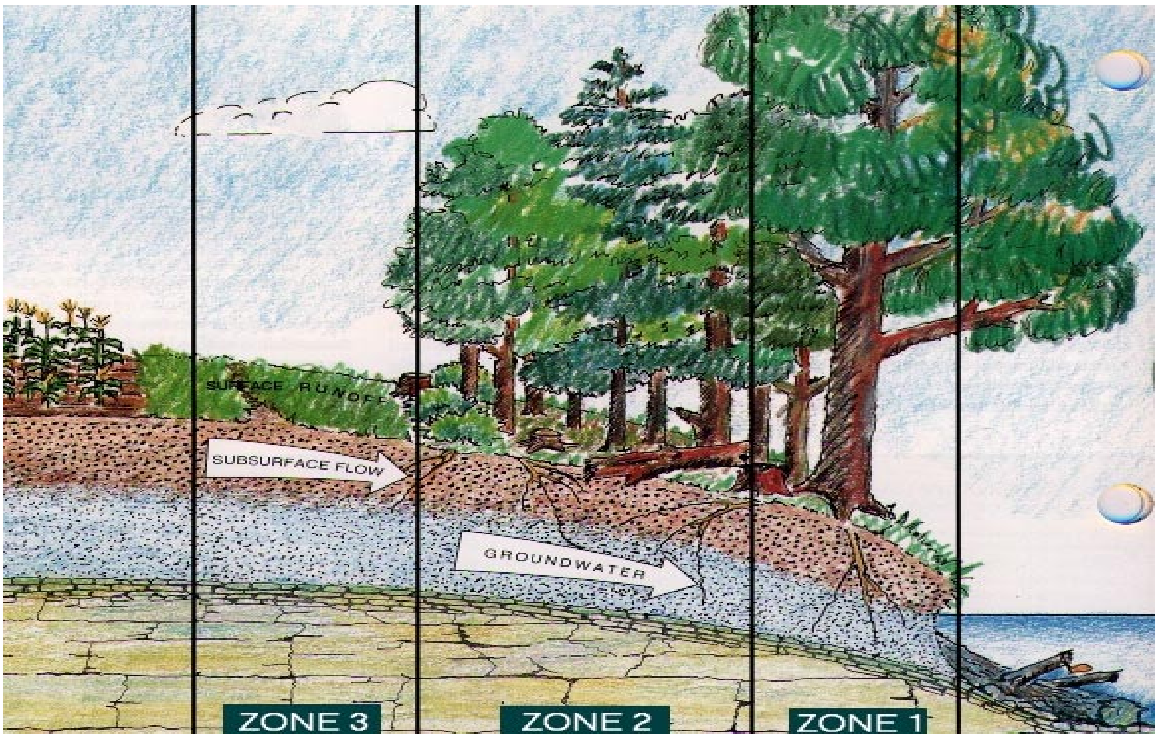

Figure 1: Schematic of a Riparian Forest Buffer System (http://www.chesapeakebay.net/bayprogram/bay_eco/wetforst/rfb2.htm)

Water Quality Functions - Nutrient, Sediment, and the Stream Environment

The potential of each of the three zones is analyzed in the sections below. Site characteristics critical to the functioning of the zone are noted, and comments on the range of potential environmental benefits across the watershed are made.

Zone 1 of the RFBS

The Stream Environment

Zone 1 is the primary contributor to ecosystem stability within the immediate riparian area. The potential of Zone 1 to supply control to the stream environment is well-documented. Little regional variation occurs. It should be noted that contiguous buffers provide greater benefits.

The unmanaged forest within a RFBS contributes to stream channel stabilization. Channel narrowing has been demonstrated on small order steams where forest is replaced by permanent grassland due to the lack of shading. Riparian forests can also prevent stream widening by reducing stream bank erosion and straightening through retention of soil in the root systems. Large woody debris from adjacent forests additionally reduces erosion by slowing stream flows (Lowrance, et al. 1995, 9-11).

Large woody debris yielded by Zone 1 is a critical part of the ecology of a stream and an important factor in the abundance and diversity of fish populations. Woody debris forms important habitat for macro invertebrates. Pooling behind logs creates space, depth, and protection for fish during extreme events, as well as diverse micro-environments. Large woody debris also impounds stream flows, allowing increased utilization by aquatic species (Lowrance, et. al. 1995, 9-11).

The close canopy of Zone 1 helps to maintain natural stream temperatures, a critical part of the habitat of aquatic species. Heat budget modeling for predicting stream and river temperatures developed in the late 1960's, with major studies indicating solar radiation as the primary contributor to peak summer temperatures. Additionally, Sweeney (1992) found lower than average temperatures for November through March in the Piedmont area of Pennsylvania. Ample, direct evidence of temperature increases from 4-15 C in deforested streams exists (Lowrance, et al 1995 for review). In the Pennsylvania Piedmont, temperature changes of 2-6 C can alter the life-history characteristics of most species studied. Other studies produced similar findings (Lowrance, et al 1995, 9-11).

Food can be the limiting factor in species diversity. RFBS increase both the diversity and total food production. Proportions of diatomic and filamentous algae can also be effected, but the ultimate consequences are uncertain. The production of fruits and undergrowth in mature forest provides food and cover for terrestrial wildlife as well. All manners of wildlife can use the forest as a protective corridor for greater movement and range.

Control of Nutrients

Nutrient uptake occurs where the water table intersects the root zone. As the unmanaged forest ages, the root zone becomes deeper and can intersect subsurface drainage from upland sources. Nutrients in the stream can also be taken up by the growing trees. Where wet soils persist, flood-tolerant species will uptake nutrients in concomitance with the aeration status of the soil. Flood-intolerant species will likely adapt both metabolic activity and the growth of adventitious roots. Denitrification in Zone 1 will likely be high due to the persistence of a higher water table in the immediate riparian area. Decomposing organic matter from litter will also increase localized anaerobic conditions (Lowrance, et al 1995, 11-15).

Several studies on nitrate removal from shallow groundwater in riparian forest buffers found that most reduction takes place in the first 10m to 15m [30ft to 45ft] of forest. The potential for denitrification is high in Zone 1 (Lowrance, et al 1995, 6).

The removal or storage of nutrients occurs in RFBS through two processes. The deeply rooted vegetation of a forest will actively uptake nitrogen and phosphorous where the water table and root zone intersect. Uptake includes nutrient loading from both upland and upstream sources. Litterfall will release nutrients as organic matter into the soil, but these released nutrients may be further affected by microbial, physical and chemical processes. Net increases in soil organic matter indicate nutrient storage (Lowrance, et al 1995, 11-15).

Microbial processes are the second major influence on the fate of nutrients in a RFBS. Microbes immobilize nutrients in the same manner as plants and release or mineralize the nutrients after death of the microbial tissue. Denitrification or "gasification" occurs as microbial processes convert nitrate to nitrogen gas. Increases in carbon, organic matter, and poor drainage will all increase rates of denitrification. Wetland soil have particularly high rates of denitrification and are often found in Zone 1, as well as in poorly-drained soils throughout the CBW (Lowrance, et al 1995, 11-15).

Across regions and in specific sites, the nutrient reduction rates will range widely.

> "In optimum areas, removal may be as high as 98% declining to 0% in hydrologic systems with deep percolation or extreme runoff efficiency. Surface runoff treatment is affected more by slope and degree of soil permeability. In the Bay watershed, water quality benefits of riparian forest establishment and retention may be highest in the Coastal Plain, Piedmont, and specific areas of the Ridge and Valley."
>
> Riparian Forest Buffer Panel 1995, 9-10

Control of Sediment

Long-term deposition of sediment has been demonstrated as substantial in riparian forests. However, the dispersed nature and limited undergrowth of a mature forest will do little to prevent channelization of runoff and makes management for the purpose of sediment control difficult (Lowrance, et al 1995, 15-16).

Runoff will be slowed in Zone 1 conditions, allowing deposition, infiltration, and dilution by rainfall, and adsorption/desorption. Heavy sediment is deposited near the edge of the RFBS, with finer sediments carrying more nutrients settling further into the RFBS. Sheet flow is required for the most effective filtration and deposition of surface-borne pollutants.

Channelization can occur where cover is sparse, surface runoff is high, or during extreme events. Channelized runoff bypasses the RFBS, reducing the effectiveness of surface-borne pollutant removal. Management techniques in site preparation, maintenance, planting, harvesting, and reestablishment within each zone influences sediment control.

Zone 2 of the RFBS

Stream Environment

Terrestrial wildlife benefits are provided by Zone 2. As in Zone 1, food production and cover for forest fauna is a recognized benefit. The additional area of Zone 2 allows more movement along the contiguous forest sections and can provide an important corridor between large forested areas. Specific management strategies can enhance the production of wildlife benefits.

Control of Nutrients

As in Zone 1, nutrient removal occurs through denitrification and plant uptake. Nutrient demand, and therefore uptake, is affected by crop tree management and growth rates. Higher rates occur for faster growing species and competition control. Hydrologic conditions will move water from the root zone more rapidly in Zone 2, reducing the nutrient removal and storage potential. The potential removal rates are higher in Zone 2 when periodic harvesting is implemented. Nutrients are removed at harvest, and the introduction of younger trees with higher growth rates ensures greater rates of uptake (Lowrance et. al. 1995, 14). Adjacent land use will also effect the reduction potential the same as in Zone 1.

Sites with high loading and high potential for removal will realize greater removal with the introduction of Zone 2. Higher uptake rates and the removal of biomass make Zone 2 an attractive option for buffer design. In some situations, the upslope location will remove the root zones from intersection with all but surface flow. Such conditions can reduce the reduction potential to zero.

Control of Sediment

The managed forest controls sediment identically to Zone 1. Infiltration rates and the existence of sheet flow are the greatest factors influencing reduction potentials. Management practices in Zone 2 also effect reduction potential. Depending on species selection and planting densities, greater sediment control will occur. As density and the number adventitious roots increase, sediment removal rates will also increase. The removal of undergrowth for competition control may reduce removal potential and allow for increased channel flow. Additionally, if heavy equipment is used in establishment, maintenance, or harvest, soil compaction will increase. Compaction decreases infiltration rates and thereby reduces sediment control.

Zone 3 of the RFBS

Stream Environment

Zone 3 vegetation provides food and cover for wildlife. Edge of field cover is particularly important to rodents and birds. Combined with forested buffers, the potential increase in wildlife production is high.

Control of Nutrients

Nutrient uptake by plant growth will also occur in Zone 3. Periodic removal of both nutrient laden sediments and vegetation removes nutrients from the buffer system. Nutrient uptake from manure may be significantly higher than the forested zones due to increased trapping efficiencies. Most nutrient removal will occur from surface water due to the shallow root zone of grasses. In sites where infiltration to groundwater occurs upslope of Zone 3, little nutrient reeducation potential exists.

Control of Sediment

Sediment reductions in Zone 3 have been shown to be extremely high. Periodic removal of sediment, reestablishment of vegetation, and destruction of ephemeral channels increases the life span of zone 3. If the high potential for substantial control of sediments is to be realized, proper management is essential (Lowrance, et. al 1995, 16-17).

Grass filter strips, when properly managed with farm equipment, spread runoff to sheet flows. This provides protection for Zone 1 and Zone 2 and ensures the highest rates of sediment and nutrient reductions in the forested zones. In locations of high erosion and storm events, periodic removal and re-establishment must occur at greater frequencies. Real world recovery will be a function of vegetal recovery rate, rainfall, runoff, depth of accumulation (Dillaha, et. al 1986a,).

Compaction and harvest practices effect trapping efficiencies. Hard pans from equipment use should be broken to increase infiltration. Vegetative height at cutting should remain greater than 10 cm. The need for maintenance must be stressed. Shallow, uniform flow and the resulting effectiveness decreases with time. On-farm observations found most grass filter strips to be ineffective because of concentrated flows (Dillaha et. al 1986b, 19)

Functions and Design

The three functions of controlling the stream environment, reducing nutrient pollution, and removing sediment help achieve the larger goals of nutrient reduction and restoration of the Bay’s living resources as set forth in the Chesapeake Bay Agreement. The potential of the water quality control functions is very high. However, the actual level of control is highly dependent on site characteristics.

Three major hydrologic regions have been identified as relevant to RFBS effectiveness. General hydrologic pathways vary from region to region. Variations in the underlying geology influence the depth of the water table and movement to surface waters. Slope, soil permeability, and geochemical environments also influence the environmental service production potential of the RFBS. Land-use upslope of the riparian area affects the loading received in the buffer. Many land-uses exist in the watershed, and loading rates vary in both quantity and quality across land uses (Lowrance, et. al 1995).

Table 1: The Effect of Different Size Buffer Zones on Potential Reductions of Sediment and Nutrients from Field Surface Runoff (Lowrance, et al. "Water Quality Functions...")				
RFBS Width	***Buffer Type***	***Sediment Reduction***	***Nitrogen Reduction***	***Phosphorous Reduction***
Ft.		%	%	%
15	Grass	61	4	28.5
30	Grass	74.6	22.7	24.2
62	Forest	89.8	74.3	70
75	Forest/Grass	96	75.3	78.5
95	Forest/Grass	97.4	80.1	77.2

Buffer size and reduction potential have been simulated from forested and grass filter studies in the Coastal Plain. However, the studies are not easily transferred to other regions. Additional studies are needed for the Ridge and Valley, and for multiple zone Riparian Forested Buffer Systems. Declining returns in potential reduction to buffer expansion is demonstrated in Table 1 for the sites studied. Other sites will most likely have different reduction potentials for the same size buffers.

Section B: The Decision Support Framework

RFBS size and design are an important determinant of establishment and/or opportunity cost. Therefore, a complete understanding of the environmental potential of alternative RFBS designs and size should be developed for each site so that costs can be understood and justified. For this assessment to be readily made, a method for determination of how costs change with buffer design must be established. Also, variation in costs occurs across regions as well as across fields within an individual farm. Capturing such variation requires a decision support system that allows for specification of multiple variables that describe the conditions at a specific locations. Such a cost analysis capacity is provided by the RFBS decision support framework.

Visual Basic Programming for Applications provides simple input windows and programming code for readily modifying the site description and rapidly making the cost calculation. Input boxes record user information, farm identification, watershed location, management and general field information, and individual field and buffer design information. Partial budgets for each possible land use activity in the RFBS area are included in an Excel spreadsheet. As input is entered, the model calls on the partial budgets to make cost calculations for the RFBS specifications and reports of the financial impacts of adoption on the farm operation.

The DSS is set up so that the user can examine the financial effects of RFBS for the whole farm operation. Thus, the user must characterize the whole farm by specifying the number of separate fields and by specifying some of the financial characteristics of the farm operation. For each separate field the user would design the appropriate RFBS.

Riparian Forest Buffer System Design

RFBS designs should consider the likely hydrologic pathways, likely loads of sediments and nutrients from upland sources, and additional practices necessary to ensure proper functioning of the RFBS. Soil type and underlying regional geology allow inferences about hydrologic pathways. Sediment and nutrient loads contained within the flows passing though the RFBS depend on the predominant land-use and soil properties adjacent to the RFBS. Whether additional practices, such as site preparation to remove channels or fencing to prevent livestock from entering the riparian area, are required must be determined by site conditions.

The "Individual Field Information" input box contains five tabbed pages to record the relevant variables for the individual field. Information concerning the current land-use, the alternative cover and management for each of the three RFBS zones, and the type of additional practices are separately recorded within the input box. The first of the tabbed pages, "Field Information", contains several text and drop boxes. Total field size and slope are recorded in the text boxes.[1] A drop box contains a list of the most common

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[1] Some information, such as slope and soil type, are recorded but not used directly in calculations. Further, the buffer design is entered manually through various input boxes. The model should be married to a formula for calculating buffer width based on site conditions. NRCS District Conservationist Bruce Nichols suggested such a formula should be developed in 1995 when commenting on the Interim Report of the Riparian Buffer Panel Interim Report (Riparian Forest Buffer Panel 1996, p 352). Ultimately, inclusion of such a formula allows an appropriate default design.

agricultural land-uses in the Virginia portion of the CBW. The selection is recorded and used in later calculations. A list and description of the included land-uses can be found in Appendix A. Example enterprise budgets are displayed in Appendix B.

The "Field Information" page also records the area of the RFBS requiring special site preparation. The length and width of areas requiring each type of site preparation should be estimated and recorded in the appropriate text box. Light sight preparation includes a single pass of heavy disking, seedbed disking, mulch, and netting. Moderate site preparation includes two passes of heavy disking and seedbed preparation. Heavy site preparation assumes four passes of heavy disking and seedbed preparation. Budgets and costs for site preparation are presented in Appendix C.

The next tabbed page allows the user to specify additional required practices for an effective RFBS. If a stream crossing is required, the DSS will record the selection between the "50-100 Foot Stream Crossing" and the "<50 Foot Stream Crossing". The choices are contained within the drop box. A fencing type, if necessary, may be chosen from the "Fencing Type" drop box. The length of fencing is recorded in a separate text box. If channel stabilization is required, the type selected from the drop box is recorded. The length of the channel stabilization is entered in a separate text box. Finally, the user may specify a type and size of supplemental water supply thorough a drop box. Budgets and costs for these items are displayed in Appendix D.

The width and length of the zones in the buffer determine establishment costs. In some locations existing trees may reduce the area requiring establishment. Width and length should be modified to reflect the size of the area. The width selected for Zone 1 should reflect the goals of the RFBS. A relatively small 15 foot width of mixed hardwoods can supply the bulk of aquatic habitat alterations, temperature moderation, and stream morphology stabilization.

Although mixed hardwoods maximize the production of environmental services within Zone 1, the unmanaged zone, the input box for the unmanaged zone allows the selection from several species/management options. The "Rotation Length" drop box allows for harvest of trees on a 15, 30, and 60 year rotation, as well as "No Harvest" in the unmanaged zone. The "Harvest Restriction (%)" drop box records the amount of harvest permitted in the forested zone. So, if only 5% of the forest will be harvested at the end of a rotation, then "5%" should be selected. The soil type should represent the predominant soil type in the unmanaged zone. Soil types may be found from the appropriate soil surveys.

The "Conversion Factor" represents the amount of wood product in limb, tapered bole, or wasted in manufacturing processes. The conversion factor will be higher for pulp species where limbs and other woody mass can be readily converted. Sawtimber will have much lower conversion factors. The conversion factor must always be less than twelve.

The "Mean Annual Increment" (MAI) represents the maximum growth rate of the given tree species for the particular soil type as $meter^3$/hectrare/year. MAI's for many species are available from the NRCS website at http://www.statlab.iastate.edu/soils/muir. The "ewoodland" table for the appropriate county should be downloaded and the "woodprod" for the species represents the MAI. The species index names can also be obtained from the general information index at the same site.

The MAI may over estimate timber yields. Calculated as the mean of the maximum growth rate for a species in a given location and soil, the MAI suggests a linear growth curve whose slope is the maximum rate of growth experienced by the average tree under similar circumstances. Growth rates do not remain constant and at the maximum throughout the lifespan of any timber species. Whenever possible, a qualified forester should provide a reasonable estimation of the linear growth rate for the given species, location, and harvest rotation.

The length and width of the managed zone, Zone 2, should be recorded on the next tabbed page. Again, the width of the combined forested zones should comply with the appropriate minimum standards described in the Physical Description section of Section A above. The "Management Scheme", "Rotation Length", and "Harvest Restriction (%)" is selected from the respective drop boxes. Again, the MAI and "Conversion Factor" reflects the information contained in the NRCS database and should correspond with the predominant soil type found within the zone.

Species, rotation, management scheme, and width should reflect the goals and limitations for the RFBS. If nutrient reduction and high frequency of returns are goals for the RFBS, then the area should be considered for the suitability of a pulpwood species. If high loads of nutrients are intersecting the shallow root zone, then the use of a pulpwood species is appropriate. On the other hand, should the hydrologic pathways only intersect the root zones of deeply rooted hardwood species, the manager must decide between a low frequency of returns and the service of nutrient reduction. Further still, if nutrient laden flows bypass even the deepest root zones, the landowner may prefer to install the minimum width Zone 1, 35 feet, thereby forgoing the increase in terrestrial wildlife diversity and other values resulting from a wider RFBS.

The final tabbed page of the "Individual Field Information" input box collects data on the grass vegetative filter strip. Length and width are recorded in the corresponding text boxes. For areas with low sediment loads, or where ephemeral channels are not likely to appear, the width of Zone 3 may be 0 feet. If Zone 3 is included in the RFBS design, the species will be selected from the drop box. Harvesting in Zone 3 is assumed to reflect the harvest of other grass crops in the region. The "Maintenance Interval" is chosen from the drop box and is assumed to be between one and five years. Maintenance includes the removal of channels and the re-establishment of the filter strip. For fields with higher sediment loads and rapid runoff, the maintenance interval will be more frequent.

Establishment Costs for the RFBS

The establishment cost for an RFBS depends directly on its design. A larger RFBS costs more to establish. Species selection, types and amounts of additional practices, and the types and amounts of site preparation all contribute to the cost of establishment.

The cost of site preparation is the product of the per unit cost for the type preparation and the number of units required for the RFBS design. Budgets for the

“Light”, “Moderate”, and “Heavy” site preparation are prepared on a per acre basis. The default budgets for the models displayed in Appendix C represent the NRCS EQIP budgets for Practice Code 342 – Critical Area Planting (Natural Resource Conservation Service - Virginia, 1997a, 7-8) . It is assumed the farm will have the necessary equipment to perform the site preparation. The budgets can be modified for each field. The report will automatically recalculate the financial effects with the modification. Total cost for each type of site preparation is simply the total area in acres multiplied by the cost per acre.

The establishment cost rises if a stream crossing is required. The model assumes only a single stream crossing will be used for a field. The budgets can be modified to include additional crossings or to allow for different construction costs. Budgets for the stream crossings in Appendix D have been derived from NRCS budgets for Practice Code 575 – Animal Trails and Walkways (Natural Resource Conservation Service - Virginia, 1997a, 4-5). The recorded selection from the input box directs the program to use the appropriate stream crossing budget. The total cost of establishing a stream crossing is the cost per unit.

“Fencing” and “Channel Stabilization” costs are calculated per linear foot. The budgets are derived from NRCS EQIP budgets for Practice Code 342 – Fencing and Practice Code 584 – Stream Channel Stabilization (Natural Resource Conservation Service – Virginia 1997b, 1-2, 21). Again, the budgets can be modified within the report, automatically updating the calculations.

Establishment costs for the forested zones are calculated on a per acre basis. The budgets are modified versions of the NRCS EQIP budgets for Practice Code 612 – Tree/Shrub Establishment (Natural Resource Conservation Service – Virginia 1997b, 23-24). The budgets used in the calculation are divided into two categories. The first is the general budget, which can be modified for each field. This budget captures additional establishment costs absent from the budgets for the selected “Management Scheme”. Each management scheme assumes a planting density, planting method, and a cost per unit of seedlings. Both categories of budgets may be modified. The default forest establishment budgets are displayed in Appendix E. The total establishment cost for the forested zones is the product of the cost per unit and the number of acres contained within each zone.

Establishment cost for the “Grass Vegetated Filter Strip” represents the per acre cost derived from NRCS EQIP budgets for Practice Code 393 – Filter Strip (Natural Resource Conservation Service – Virginia 1997b, 19-20). It is assumed the farm will have the necessary equipment for establishing the filter strip. Total cost for establishing Zone 3 is the total area in acres multiplied by the per acre cost of establishment..

RFBS Returns

Returns associated with harvests of marketable forest products within the RFBS influence the financial effects of adoption. Harvest of forest related products may occur in the both Zones 1 and Zone 2. Harvests of hay from Zone 3 will also influence the financial effects.

Forested products require time to mature. The length of time will be dependent on the species and site productivity. The DSS allow selection of both the species/management scheme and the length of rotation. Site productivity is encompassed in the mean annual increment recorded by the input box.

Returns for each zone are estimated on a yearly basis and then are reported as the net present value of the future harvest, discounted with the selected “Discount Rate”. For both forested zones, the first year returns are only costs. The calculation is:

Forestry Returns Year 1 = 0 – Total Establishment Cost

– Total Cost of Light Site Preparation (Zone 1 only)

– Total Cost of Moderate Site Preparation (Zone 1 only)

– Total Cost of Heavy Site Preparation (Zone 1 only)

– Cost of Steam Crossing (Zone 1 only)

– Total Fencing Cost (Zone 1 only)

– Total Water Trough Cost (Zone 1 only)

– Total Channel Stabilization Cost (Zone 1 only)

– Total Operations and Management for the individual zone

– Total Mowing Cost for the individual zone.

Calculations of returns for the second, third, and fourth year include only the cost of operations and maintenance and mowing costs. The calculation is:

Forestry Returns Year 2 = 0

– Total Operations and Management for the zone

– Total Mowing Cost for the zone.

Harvests occur every 15, 30, or 60 years, depending on the rotation length selected. The financial return for the year of harvest is reflected in the following formula.

Forestry Returns = Area of the Forested Zone

* Mean Annual Increment for the Species, Soil Type, and Location

* Year of Harvest

* 14.291 (converts M^3/Hectare/Year to Ft^3/Acre/Year)

* Conversion Factor (converts Ft^3 to board feet and

is typically less than 12 to account for waste)

* Harvest Restriction (% of trees harvested)

* Price/one-thousand board feet/1000

– Total Cost of Re- Establishment

* Percentage Harvested

– Total Periodic Mowing.

Default prices reflect the average prices reported by Timber Mart South for in the 3rd quarter of 1995 (Timber Mart South, 1995). For second and third rotations, it is assumed the oldest remaining tress will be harvested first. The remainder of the harvest consists of younger trees. Thus, the returns reflect the appropriate percentage contributed by the various aged trees. Periodic mowing is assumed to occur for the three years after harvest and only with in the reforested area.

The present value of the returns is calculated by:

Present value of Returns =

$$\text{Annual Net Returns} / (1+\text{DiscountRate})^{\text{Year} - 1} .$$

Returns from the Grass Vegetated Filter Strip occur on a yearly basis. The formula for calculating Zone 3 returns is:

GVFS Returns = Returns per Acre * Total area of the Zone.

The returns per acre represent the yield per acre multiplied by the price per unit minus the variable costs associated with management. For the first year, and for years where maintenance will occur, the cost of establishment is subtracted from the returns. Present value of returns is also calculated on a yearly basis.

Total RFBS returns without including forgone for any particular year is simply the total of the returns from each Zone.

Forgone Income

The net present value of the foregone income associated with the conversion of agricultural land to an RFBS is a cost of adoption. Specifically, the cost of foregone income depends on the area of land converted to RFBS and the current return per acre above the variable cost of production.

Calculation of the returns per acre is made using embedded enterprise budgets. The appropriate budget for the enterprise recorded in the input box is inserted into the financial report, and the return per acre net of variable costs is transferred to the field report. The modified budgets are from the Virginia Agricultural Extension Service (Virginia Agricultural Extension Service 1997; http://www.ext.vt.edu:4040/eis/owa/docdb.getcat?cat=ir-fbmm-bu). Default yields and prices used in the budgets reflect the state average over the years 1991-1996 (Virginia Agricultural Statistics Service 1991-1996). The budgets may be modified to reflect average variable costs, yield and prices received for the enterprise in the field. Again, the report automatically re-calculates the results.

The annual forgone income of the RFBS is:

Forgone Income = Total RFBS Area * Net Returns per Acre.

Future land-use may change but it is assumed the current land-use will continue throughout the life of the RFBS. Therefore the current land-use is the enterprise recorded in the “Field Information” input box. In calculating forgone income, it is further assumed that only the area of the buffer system will be “lost” to agricultural production. In application, field shape may influence the use of the remaining land. Removal of turn-around areas or the creation of islands and pockets of usable land can increase the opportunity cost through a loss of machine efficiency.

Total RFBS Returns at the Field and Farm Scale

If the net effect of establishment and maintenance costs, returns and forgone income in a year is positive then the landowner realizes buffer returns for that year on a field. If the net effect is negative then the landowner realizes a cost for that year. The present value of RFBS returns is the sum of the present value for each year of a 60 year life of the RFBS. The total present value of the field returns with RFBS adoption, or the sum of present values for the 60 year lifespan, can be converted to an annual equivalent value. The annual equivalent value represents the equivalent yearly return for the field. Subtracting the annual equivalent returns after RFBS adoption from the yearly returns before adoption yields the equivalent annual cost of adoption.

As noted, fixed costs are not included in the calculations for individual fields. An additional cost is the decreased utilization of fixed assets. Costs for machinery, buildings, and other equipment for the farm operation continue after the RFBS is implemented. The removal of land from production will increase the load of fixed assets carried by the remaining agricultural activities. However, the total load of fixed costs remains constant. Therefore charges for fixed costs are not performed within the calculations.

The present value of RFBS returns is calculated for the whole farm. The calculated number is the present payment a profit maximizing and risk neutral landowner would require to remain indifferent between continuing current land uses and installing a RFBS. The corresponding annual equivalent value of RFBS returns is calculated. This number is the annual payment for the life of the system necessary to make the farmer financially indifferent to adoption.

Section C: Representative Farm Results

Regional Variation and Sensitivity

The financial effects of buffer adoption on agricultural land within the regions of the Chesapeake Bay Watershed (CBW) depend on the general physical and agricultural characteristics of the region and the individual farm situation. Assumptions made about representative farm situations in different areas of the CBW in Virginia illustrate this result. Specific locations and associated physical properties are selected and combined with more general data concerning agricultural production and physical characteristics within the region to develop the representative farm conditions.

A representative farm can not capture the full range of financial effects. Therefore, a sensitivity analysis of a single scenario is used to measure the financial effects of changes in individual variables. Combining the effects on the representative scenarios and the results of the sensitivity analysis produces a wider range of the physical and agricultural characteristics, as well as insights into the effectiveness of possible policy initiatives to advance adoption of RFBS.

The Representative Farms and the Sensitivity Analysis

Three counties within each major region of the Virginia CBW represent the broad physiographic regions. Data gathered for each county are used to define a representative farm for the majority of agricultural land in the county. Current land-uses range from high yield grain production to low return beef cattle operations. Soil types selected for each field in the representative farm determine the physical characteristics important to the design of the RFBS for realizing environmental benefits, for defining the agricultural practices appropriate for the field, and for predicting the growth and return for harvested RFBS zones. Across the scenarios, RFBS designs range in width, species, and additional practices in accordance with site conditions.

Physical characteristics are derived from soil surveys. Agricultural characteristics are derived from Virginia Agricultural Statistics Service publications (Virginia Agricultural Statistics Service 1991-1996) and the National Agricultural Statistics Service 1992 Census of Agriculture (http://www.nass.usda.gov/census/). Forestry information for each county is gathered from the Natural Resource Conservation Service MUIR database (http://www.statlab.iastate.edu/soils/muir).

The financial effects of adoption may be particularly sensitive to changes in individual variables. Discount rates, individual zone widths, species selection, forestry growth rates, and harvest restrictions are isolated within the base case to analyze the sensitivity of the outcomes to changes in these descriptive variables.

Scenario 1: Inner Coastal Plain

The Inner Coastal Plain of Virginia is the starting point for analysis of RFBS adoption on agricultural land. The Fertile valleys of the wide rivers produce the state's highest returns in crop production and subsequent the high use of fertilizers and pesticides. In total, the region occupies 13% of the CBW (Alliance 1996, 35). Surface water in the region empties immediately into the lower portion of the Chesapeake Bay via the Rappahanock, Potomac, and other major river systems. Combined with the regional hydrology, the conditions call for the wide-spread application of RFBS for nutrient uptake.

Centrally located and bordered by the Rappahanock River, Essex County provides the location for the representative adoption scenario in this region. Agriculture accounts for roughly 30% of the county land-use. The primary agricultural enterprise involves a two-year rotation of corn for grain, soybeans, and wheat. The county ranks respectively second, fourth, and fifth in the state for production of these crops. Yields for corn for grain average 114 bushels per acre, soybeans yield 29.6 bushels per acre, and wheat yields 60.8 bushels per acre (Virginia Agricultural Statistics Service 1991-1996).[2, 3] The average size of farms with $10,000 or more in sales is 743 acres.[4] Notably, ninety-five percent of Essex County farms in this category use commercial fertilizers and agricultural chemicals (http://www.nass.usda.gov/census/).

The representative farm constructed for Essex County contains 8 fields encompassing 100 acres each. The primary enterprise for each field is the two year corn-soybean-wheat rotation.

The buffer design is fixed across all fields. The stream length per field calculates to 750 feet and remains constant across all fields.[5] The Zone 1 design includes planting in mixed hardwoods within a fifteen foot width. No harvests are allowed within the zone. A Zone 2 of 85 feet width contains Loblolly Pine grown for pulp production. A fifteen year rotation with 50% harvest restriction is assumed to apply. The conversion factor is 12. The buffer design and management optimizes nutrient uptake and removal from the surface and shallow sub-surface flows typical of the region, as well as providing an improved cash flow to the landowner. The low slope of Essex County agricultural lands and the total width of the forested zones leave little need for a filter strip. Therefore, no Zone 3 is prescribed.

To account for natural variation, as well as allow for analyzing the effects of differing productivity, the soil type in each field varies. Consequently, the Mean Annual Increment of growth for the Loblolly species reflects the MUIR data for the soil. The average MAI for the soil types is 8.75 m^3/hectare/year. Crop yields also vary with the soil

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[2] For all scenarios, prices are assumed to reflect the default state averages of the model.

[3] Average per acre yields for each county has been calculated for the years 1991-1996.

[4] Although Agricultural Census data includes smaller farms, the object of this study is to examine the effect on farms devoted to industrial agriculture. Therefore, Table 12 of the Census data (Farms with Sales of $10,000 or more) contained information most appropriate to the study.

[5] It is assumed the stream to land ratio is equal to the ratio for the Chesapeake Bay Watershed. Miles requiring buffer systems is reduced by 50%, representing the percentage of severely impaired streamside forest in the Chesapeake Bay Watershed (Fact Sheet, 1996):

110,000 mile of stream	:	64,000 $miles^2$
193.6 million yards	:	40.96 million acres
580.8 million feet	:	40.96 million acres
@15 feet	:	1 acre
7.5 feet	:	1 acre

type and have been calculated to reflect the same percentage change from the county averages as the MAI from the average across the soil types. Soil types, yields, and MAI's for each of the 8 fields are presented below in Table 2.

Table 2: Soil Types and Yields – Coastal Plain					
Field Number	***Soil Type***	***Corn for Grain (bu)***	***Soybeans (bu)***	***Winter Wheat (bu)***	***Mean Annual Increment***
1	Bibb sandy loam	130	33.8	69.4	11
2	Tomotley fine sandy loam	126	32.8	67.3	10
3	Dogue loam	117	30.4	62.4	9
4	Tetotum loam	115	29.7	61	9
5	Chickahominy silt loam	113	29.1	60	8
6	Suffolk sandy loam	107	27.7	56.9	8
7	Molena loamy sand	104	27	55.5	8
8	Atlee silt loam	99	25.7	52.7	7

Running the DSS model for the representative farm produces estimates of the financial effects of adoption. Estimates for both the whole farm and per acre of RFBS are calculated before and after adoption. The results of the runs appear in Table 3 and Table 4.

Table 3: Effects on Total Revenue – Inner Coastal Plain				
Field Number	***Field Size (acres)***	***Current Field Returns***	***Annual Equivalent Value of Field Returns with RFBS***	***Percentage Change***
1	100	$21,929.60	$21,688.39	-1.10%
2	100	$21,236.60	$20,990.67	-1.16%
3	100	$19,619.60	$19,389.08	-1.17%
4	100	$19,157.60	$18,933.50	-1.17%
5	100	$18,827.60	$18,609.25	-1.16%
6	100	$17,804.60	$17,589.69	-1.21%
7	100	$17,342.60	$17,135.73	-1.19%
8	100	$16,418.60	$16,213.45	-1.25%
Whole Farm Total	800	$152,336.80	$150,549.76	-1.17%

The fertile land of the Inner Coastal Plain representative farm produces excellent yearly returns. Note that as per acre soil productivity decreases (Table 2), the percentage decline in field returns increases (Table 3). However, as the productivity decreases, the change in the actual value of field returns decreases.

So, as a percentage of earnings, the fields of higher productivity lose relatively less of their value when compared with fields of lower productivity. However, in considering the bottom line change in earnings, farmers enjoying higher productivity sacrifice larger earnings in real terms.

The financial effects per acre of RFBS are presented in Table 4.

Table 4: Effects per Acre of RFBS – Coastal Plain

Field Number	*Per acre Total Establishment Cost*	*Forgone Income Per Acre of RFBS*	*Per Acre Present Value of RFBS Returns*	*Per Acre Annual Equivalent Value of RFBS Returns*
1	($80.15)	($219.30)	($2,784.45)	($140.09)
2	($80.15)	($212.37)	($2,807.15)	($141.23)
3	($80.15)	($196.20)	($2,655.75)	($133.62)
4	($80.15)	($191.58)	($2,557.98)	($128.70)
5	($80.15)	($188.28)	($2,492.39)	($125.40)
6	($80.15)	($178.05)	($2,453.11)	($123.42)
7	($80.15)	($173.43)	($2,361.28)	($118.80)
8	($80.15)	($164.19)	($2,341.67)	($117.82)
Whole Farm	($80.15)	($190.43)	($2,556.72)	($128.64)

Not surprisingly, the forgone income per acre of RFBS decreases with diminished field productivity. The trend holds for the annual equivalent returns of the RFBS and the related present value of RFBS returns. The adoption of RFBS results in a loss of income to the farm operation. Respectively, the estimated losses represent the annual payment and the up-front payment necessary to make a farmer *financially indifferent* to continuing current production and adoption of a RFBS on the same land area. Other motivations behind the decision to adopt may reduce or increase the necessary payment to encourage adoption.

Note should be taken of the establishment cost. Assumptions for the Essex County scenario include the absence of special site preparation. The assumption is consistent with the hand planting techniques and general conditions of land recently under plow. Removal of drainage structures, ephemeral channels, or bank stabilization will increase the establishment cost and ultimately the per acre returns of the RFBS. The effects of such additional practices are demonstrated in other scenarios.

Scenario 2: Piedmont - Schist/Gneiss and Thin Soils/Triassic Shales

The Piedmont - Schist/Gneiss occupies 15% of the CBW. The region stretches from the Inner Coastal Plain to the Blue Ridge Mountains and Shenandoah Valley, consisting of valleys with rolling to steep hills. Soils in the region may be quite deep. The Schist/Gneiss bedrock forces water to move laterally or rise to the shallow subsoil of the riparian area before entering streams. Areas with such characteristics have high potential for nutrient uptake by a RFBS. In other cases, water infiltrates the deep soils and bypasses the root zone of the RFBS. The flows follow even deeper pathways where underlying bedrock is porous marble. Such hydrologic pathways provide little potential for substantial removal of nutrients (Alliance 1996, 35).

The Piedmont – Thin Soils/Triassic Shales comprise 8% of the CBW. Dissecting the Schist/Gneiss region, the region stretches south until terminating near Louisa County. The general relief contains gently undulating hills. Thin soils promote the intersection of groundwater with the root zone of the RFBS. High potential for nutrient removal exists in such a case (Alliance 1996, 35). The typical agricultural practices on the thin soils, pasture and hay, do not generally produce high nutrient and sediment loads. In such cases, the environmental service production of a large RFBS will be reduced.

Centrally located in the Virginia portion of the region and bordered by the Rappahanock, the Rapidan, the Robinson, and the Hughes Rivers, Culpeper County serves as the representative farm for the scenario analysis. Water reaches the bay after flowing roughly 120 miles. Agriculture accounts for 115,295 of the 243,840 acres, or approximately 47% of the land (Coleman 1941, 3; http://www.nass.usda.gov/census/). Major agricultural enterprises within the county include hay, alfalfa hay, corn for silage, and dairy production. The county ranks respectively seventh, eleventh, fifth, end seventh in production of these commodities. Average per acre yields for the crops in the county have been calculated for the years 1991-1996. Corn for silage yields average 14.8 tons per acre, alfalfa yields 2.8 tons per acre for hay, and other hay 2.8 tons per acre (Virginia Agricultural Statistics Service 1991-1996). Average size of farms with $10,000 or more in sales is 505 acres (USDA, 1992, Table 12; http://www.nass.usda.gov/census/).

The representative farm constructed for Culpeper County contains 5 fields encompassing 100 acres each. The primary enterprise for each field is described below. (USDA, 1992, Table 12; http://www.nass.usda.gov/census/).

The stream length per field calculates to 750 feet and remains constant across all fields. However, physical agricultural characteristics within each field are allowed to vary by soil types, slope, and underlying hydrology. The agricultural enterprise and the RFBS design are assumed to be consistent with the physical characteristics of the field.

Congaree silt loam with 0-2% slope occurs within Culpeper County. Field 1 is assumed to be dominated by this soil. It is further assumed that hydrologic flows follow the patterns for Schist/Gneiss bedrock and intersect the root zone before entering the stream. Corn for silage under minimum tillage is the primary enterprise of the flat and moderately fertile field. The average corn silage yield per acre for the county will be used in the simulation. The buffer design has a Zone 1 stretching upslope fifteen feet from the stream edge. Mixed hardwoods are the predominant species with no harvest allowed. An 85 foot Zone 2 contains Yellow-Poplar managed for sawtimber. The rotation length is 30 years with a MAI of 8 and 50% harvest restriction. Sediment loads should be low for the low sloping field. Therefore, no Zone 3 is prescribed.

Field 2 soil type is dominated by Elioak loam of 15-25% slope. Pasture for a dairy herd fed on corn silage and alfalfa hay is the primary land use. A single forested Zone 1, containing Eastern Cottonwood, stretches 35 feet upslope stream the stream edge. The high erosion hazard and presence of manure indicate the possibility of high sediment trapping rates. Therefore, a 35 foot wide Zone 3 of Fescue-Ladino clover is prescribed. The area will be harvested for hay. Maintenance to remove ephemeral channels and re-establish grasses occurs every two years. The fencing requirement is a 4-foot woven wire with 1 strand of barbed wire. In the presence of highly erodible soils, site preparation may be necessary. It is assumed that an area of 100 feet by 20 feet will require light sight preparation, approximately 4% of the RFBS area. An area of 300 feet by 30 feet will require heavy sight preparation, approximately 17% of the RFSB area.

Field 3 is identical to Field 2, lying directly across the stream. Soil type, land use, and buffer design remain fixed. A fencing requirement also applies. However, no site preparation is necessary. To facilitate movement between the fields without damaging the stream environment, a 35 foot stream crossing is included as an additional practice.

Field 4 contains a State loam of 0-5% slope. Alfalfa hay is the primary land use. The buffer design includes a 35 foot Zone 1 of Red Oak. Zone 2 contains 85 feet of Virginia Pine managed for sawtimber on a 30 year rotation. No Zone 3 is prescribed since sediment loads are low for a hay field with little slope.

Manor silt loam of 7-14% slope occupies the majority of Field 5. Timothy hay is the primary enterprise. A 35 foot wide Zone 1 of Yellow-Poplar occupies the riparian area. No Zone 3 is necessary for the hay field. Bank stabilization must be undertaken at establishment. It is assumed that 200 feet of the stream must be stabilized with rip-rap and brush layers.

The results of the run for the Piedmont representative farm appear below in Table 5 and Table 6.

Table 5: Effects on Total Revenue – Piedmont – Schist/Gneiss and Thin Soils/Triassic Shales

Field Number	***Field Size (acres)***	***Current Field Returns***	***Annual Equivalent Value of Field Returns with RFBS***	***Percentage Change***
1	100	$18,431.56	$18,122.57	-1.68%
2	100	$11,388.27	$11,125.86	-2.30%
3	100	$11,388.27	$11,075.32	-2.75%
4	100	$2,307.95	$2,260.17	-2.07%
5	100	$6,527.49	$6,434.79	-1.42%
Whole Farm Total	500	$50,043.54	$49,018.71	-2.05%

Table 6: Effects per Acre of RFBS – Piedmont – Schist/Gneiss and Thin Soils/Triassic Shales				
Field Number	*Per acre Total Establishment Cost*	*Forgone Income Per Acre of RFBS*	*Per Acre Present Value of RFBS Returns*	*Per Acre Annual Equivalent Value of RFBS Returns*
1	($198.00)	($184.32)	($3,566.94)	($179.46)
2	($1,610.47)	($113.88)	($4,327.47)	($217.73)
3	($2,443.81)	($113.88)	($5,160.81)	($259.65)
4	($80.15)	($23.08)	($551.62)	($27.75)
5	($1,708.08)	($65.27)	($3,057.59)	($153.84)
Whole Farm	($990.39)	($103.91)	($3,154.80)	($159.73)

Comparing the Culpeper scenario with the scenario in Essex County, lower opportunity costs exist for all fields. Thus considering forgone income alone RFBS might be more acceptable to landowners in this region. However, if the RFBS is expected to achieve desired environmental results, significant establishment costs may be incurred by including necessary additional practices.

RFBS establishment costs are higher than Essex County, reflecting both species selection and additional practices. Planting for hardwood sawtimber includes higher sapling costs and the labor intensive use of stakes. Fields 2 and 3 include fencing, site preparation, and a stream crossing. All of these practices are commonly needed in heavily grazed pastures with erodible soils. Stream crossings will be necessary for adoption sites where dairy herds must ford the stream to reach the milking facilities. Site preparation also increases the establishment cost of Field 5.

The grass filter strips of Fields 2 and 3 are harvested for hay with the need to maintain and re-establish the filter every two years.

Scenario 3: Piedmont Valley & Ridge – Limestone/Marble

The Piedmont Valley and Ridge – Limestone/Marble occupies 12% of the CBW. The region stretches in a narrow band from central Pennsylvania to the southwest terminus of the CBW. The region consists valley streams and steep hills. Soils in the region are thin an erodible among the steeper slopes. The porous limestone and marble bedrock allows water to infiltrate to groundwater or may pass though the root zone for a short distance prior top entering the stream. Areas with such characteristics have a low potential for nutrient uptake. Due to the steep slopes and soils with moderate to high erosion hazards, the grass vegetative filter strip of Zone 3 increases in importance (Alliance, 1996).

The eastern portion of Augusta County contains the Blue Ridge Mountains and portions of the Piedmont Ridge and Valley. Water reaches the bay after flowing roughly 200 miles through the Potomac River and James River watersheds. Agriculture accounts for 287,442 of the 631,040 acres, or approximately 46% of the land (Hockman, 1977; USDA, 1992, Table 1; http://www.nass.usda.gov/census/). Major agricultural enterprises within the county include hay, alfalfa hay, and cattle for beef production. The county ranks respectively first, second and first in production of these commodities for the state. Average per acre yields for the crops in the county have been calculated for the years 1991-1996. Alfalfa hay yields 3.1 tons per acre and other hay yields 2.4 tons per acre (Virginia Agricultural Statistics Service 1991-1996). Average size of farms with $10,000 or more in sales is 309 acres (USDA, 1992, Table 12; http://www.nass.usda.gov/census/).

The representative farm constructed for Augusta County contains 3 fields encompassing 100 acres each.

A Frederick-Christian silt loam with 15-25% slope occupies Field 1. Orchard grass and Red Clover hay is the primary enterprise. The average yield per acre for the county will be used in the simulation. The buffer design includes a Zone 1 stretching upslope thirty-five feet from the stream edge. Mixed hardwoods are the predominant species. No Zone 3 is prescribed for the hay field. In the presence of highly erodible soils, extensive site preparation may be necessary. It is assumed that an area of 50 feet by 30 feet, or 5% of the RFBS area, will require moderate site preparation. It is further assumed that an area of 200 feet by 30 feet, or 23% of the RFBS area, will require heavy sight preparation.

Field 2 soil type is dominated by Bookwood silt loam of 7-10% slope. Alfalfa hay is the primary land use. A single forested Zone containing mixed hardwood stretches 35 feet upslope stream the stream edge. No Zone 3 is prescribed. An area of 300 feet by 30 feet, or 28% of the RFBS area, requires moderate sight preparation.

Rock outcrop-Frederick complex sloping is found in Field 3. A beef cow herd calving in fall and fed on a hay ration is the primary land-use. Zone 1 contains mixed hardwoods within the 35 foot width. The high erosion hazard and presence of manure indicate the possibility of high sediment trapping rates. Therefore, a 35 foot wide Zone 3 of Orchard Grass - Ladino Clover and Partridge Peas (for wildlife) planted with lime fertilizer is prescribed. The area will be harvested for hay. Maintenance to remove ephemeral channels and re-establish grasses is assumed to occur every 3 years. A fencing requirement applies, and it is assumed that a 3 strand barbed wire fence will be installed.

Table 7: Effects on Total Revenue – Piedmont Valley & Ridge – Limestone/Marble

Field Number	***Field Size (acres)***	***Current Field Returns***	***Annual Equivalent Value of Field Returns with RFBS***	***Percentage Change***
1	100	$7,396.65	$7,344.34	-0.71%
2	100	$5,643.95	$5,597.69	-0.82%
3	100	$5,893.21	$5,735.17	-2.68%
Whole Farm Total	500	$18,933.81	$18,677.20	-1.36%

Table 8: Effects per Acre of RFBS – Piedmont Valley & Ridge – Limestone/Marble				
Field Number	*Per acre Total Establishment Cost*	*Forgone Income Per Acre of RFBS*	*Per Acre Present Value of RFBS Returns*	*Per Acre Annual Equivalent Value of RFBS Returns*
1	($203.21)	($73.97)	($1,725.48)	($86.81)
2	($351.94)	($34.01)	($919.50)	($76.77)
3	($981.43)	($58.93)	($2,606.25)	($131.13)
Whole Farm	($629.51)	($62.07)	($2,115.96)	($106.46)

Forgone income for the Orchard Grass and Red Clover hay of Field 1 is low, despite higher than average yields. Low forgone income is associated with the Beef Cattle enterprise on Field 3.

Establishment costs reflect site preparation on Fields 1 and 2. The fencing requirement for Field 3 raises the establishment cost significantly. The large negative returns of the RFBS on Field 2 reflect both high establishment cost and high forgone income.

Sensitivity Analysis

To accomplish the sensitivity analysis, a scenario is selected as a base case. All variables of the base scenario remain fixed, except for the variable of interest. The base case scenario is similar to the Essex County scenario. However, yields reflect the state average for the crops. The sensitivity analysis focuses on the financial sensitivity per acre of RFBS. Fixed costs are not reflected in the sensitivity analysis calculations.

The base case scenario consists of a 100 acre field on which corn for grain, soybeans, and wheat are grown in a two year rotation. Yields for the crops reflect the state average over the years 1991-1996 (Virginia Agricultural Statistics Service 1991-1996). The RFBS design includes a 15 foot wide Zone 1 of Mixed Hardwoods. No harvest is permitted within the unmanaged zone. Zone 2 is 85 feet wide and planted in Loblolly Pine grown for pulp. Harvest occurs every 15 years and is restricted to 50% of the total number of trees. The mean annual increment is 8 M^3/hectare/year. No additional practices are required. A five percent discount rate is assumed.

Discount Rate

Landowner/farmers who do not value present consumption over future consumption will have a low discount rate. The discount rate also reflects the farmers attitude towards risk. If the farmer feels the amount of future returns are uncertain, i.e. the investment is risky, a higher discount rate will apply.

Discount rates play an important role in examining the financial effects of RFBS adoption. Both future returns from the RFBS and the future value of foregone production must be discounted by the appropriate rate. To test the sensitivity of the financial effects of the RFBS to differences in discount rates, the base case described above is repeatedly run through the DSS. Only the discount rate is altered in each run. A 5% rate has been used in all preceding analyses. The results of the discount rate sensitivity analysis appear in Table 9.

The discount rate greatly influences the financial effects of RFBS adoption. The long rotation periods for forest harvests and the projection of foregone agricultural income throughout the 60 year lifespan of the RFBS creates a reciprocal effect between the annual equivalent value and the present value of RFBS adoption. As the discount rate decreases, the present value of the cost of adoption increases. Intuitively, the present value of foregone income in future years increases. However, the annual equivalent value of the cost of adoption decreases with a decreasing discount rate. The annual cost is lower because the future costs are not highly discounted.

Two conclusions may be drawn form Table 9. First, the discount rate plays an important role in calculating the ultimate cost of adoption. Second, individuals with a high discount rate may prefer an immediate lump-sum subsidy, while individuals with a low discount rate may prefer and annual subsidy. The steady cash flow may also be appealing to individual as a hedge against volatile agricultural markets.

Table 9: Effects Per Acre of RFBS – Discount Rate Sensitivity Analysis

Discount Rate	***Per Acre Annual Equivalent Value of RFBS Returns with Forgone Income***	***Per Acre Present Value of RFBS Returns with Forgone Income***
1%	($82.74)	($3,756.93)
3%	($104.34)	($2,974.27)
4%	($113.89)	($2,679.65)
** 5% **	($122.56)	($2,436.07)
7%	($137.41)	($2,064.16)
9%	($149.35)	($1,798.52)

** ** indicates base case

Buffer Design

The size and design of the buffer might be modified depending on the site conditions without losing environmental benefits. RFBS size and design also alters the financial results. The sensitivity analysis for various RFBS designs appears in Table 10.

The decreasing negative returns for the RFBS as the widths increase is a result of changes in the ratio of Zone 2 to Zone 1. The returns produced from Zone 2 reduce the financial impact of adoption on a per acre basis. However, wider RFBS designs will cost more in absolute terms due to the additional acreage consumed..

Table 10: Effects Per Acre of RFBS – RFBS Design Sensitivity Analysis				
Buffer Design	***Per Acre Present Value of RFBS Returns with Forgone Income***	***Per Acre Annual Equivalent Value of RFBS Returns with Forgone Income***	***Establishment Cost***	***Total Buffer Area***
Zone 1 - 35 ft. width Zone 2 – 0 ft. width Zone 3 – 0 ft. width	($3,769.25)	($189.64)	($198.00)	0.6
Zone 1 - 15 ft. width Zone 2 – 30 ft. width Zone 3 – 0 ft. width	($2,732.61)	($137.03)	($105.57)	0.77
Zone 1 - 15 ft. width Zone 2 – 80 ft. width Zone 3 – 0 ft. width	($2,448.45)	($123.19)	($81.25)	1.64
** Zone 1 - 15 ft. width ** ** Zone 2 – 85 ft. width ** ** Zone 3 – 0 ft. width **	($2,436.07)	($122.56)	($80.15)	1.72

Harvest Restrictions

Harvest restrictions reflect a variety of considerations. Primarily, restrictions are designed to ensure the continued functioning of the RFBS system. Note should be taken that while some functions are protected by tighter harvest restrictions, other functions are reduced. Frequent and large scale harvests remove nutrients stored in the woody mass, and the fast growing younger trees improve nutrient uptake. However, deep root systems of the older trees have a higher likelihood of intersecting sub-surface flows. Table 11 reports the effects of changes in harvest restrictions.

Table 11: Effects Per Acre of RFBS – Harvest Restriction Sensitivity Analysis			
Harvest Restriction (Zone 2 only)	***Per Acre Establishment Cost***	***Per Acre Present Value of RFBS Returns with Forgone Income***	***Per Acre Annual Equivalent Value of RFBS Returns with Forgone Income***
10%	($80.15)	($3,420.38)	($172.09)
30%	($80.15)	($2,858.88)	($143.84)
** 50% **	($80.15)	($2,436.07)	($122.56)
100%	($80.15)	($1,958.95)	($98.56)

Table 11 illustrates the significance of harvest restrictions on the calculation of financial effects of the RFBS. Therefore the rules governing RFBS design and management should carefully consider the purpose and results from of harvest restrictions. Such restrictions might only be applied when there are clear environmental benefits.

Volunteer Labor and Donated Saplings

Many programs encourage the use of private sector funds and volunteer labor for RFBS establishment. Volunteer organizations often provide free labor to farmers interested in restoring a riparian forest. Large industrial forest organizations might make saplings available at no charge. Table 12 examines the effects of free labor and saplings on total costs. The changes in costs are not significant.

Table 12: Effects Per Acre of RFBS - Free Planting Labor and Seedlings

Assistance	***Per Acre Annual Equivalent Value of RFBS Returns with Forgone Income***	***Per Acre Present Value of RFBS Returns with Forgone Income***	***Per Acre Establishment Cost***
** No Assistance **	($122.65)	($2,436.07)	($80.15)
Free Seedlings	($121.00)	($2,405.04)	($54.75)
Free Planting Labor	($118.92)	($2,363.70)	($25.40)
Free Planting Labor and Free Seedlings	($117.36)	($2,332.68)	$0.00

Mean Annual Increment

Testing the sensitivity of cost estimates to changes in the Mean Annual Increment provides a measure of the likely affects of revising yield calculations. The need for accurate yield estimates in establishing the financial effects of adoption is clearly demonstrated. Table 13 displays the cost analysis from a range of MAI's. Per acre present value decreases by 46% as MAI moves from 10 to 4. The likely overestimation of MAI's presented in the MUIR database is discussed in Section B.

Table 13: Effects Per Acre of RFBS – Mean Annual Increment Sensitivity Analysis			
Mean Annual Increment	***Per Acre Establishment Cost***	***Per Acre Present Value of RFBS Returns with Forgone Income***	***Per Acre Annual Equivalent Value of RFBS Returns with Forgone Income***
4	($80.15)	($3,090.96)	($155.51)
5	($80.15)	($2,972.23)	($147.28)
6	($80.15)	($2,763.51)	($139.04)
7	($80.15)	($2,599.79)	($130.80)
** 8 **	($80.15)	($2,436.07)	($122.56)
9	($80.15)	($2,272.34)	($114.33)
10	($80.15)	($2,108.62)	($106.09)

Tree Species

Tree species selection occurs to fulfill a variety of considerations. Hardwoods produce high quality sawtimber and wildlife habitat. The rotation length and the discount rate of the landowner may reduce the monetary value of timber returns. Fast growing species may be more desirable in uptake and removal of nutrients and in providing a smoother cash flow.

Table 14 examines the financial differences in selecting various tree species for the base scenario. Both establishment costs and returns vary with species selection. Note should be taken that the short rotation, low value loblolly species produces higher returns than the long rotation, high value hardwood sawtimber. The result is indicative of the effects of lower establishment costs and the discount rate. Lower discount rates will improve the returns in hardwood species, although perhaps not to the levels of loblolly pine.

Table 14: Effects Per Acre of RFBS – Species and Management Sensitive Analysis			
Species and Management	***Per Acre Establishment Cost***	***Per Acre Present Value of RFBS Returns with Opportunity Cost***	***Per Acre Annual Equivalent Value of RFBS Returns with Opportunity Cost***
** Loblolly Pine on 15 year rotation managed for Pulp **	($80.15)	($2,436.07)	($122.56)
Yellow Poplar on 30 year rotation managed for Chip-n-Saw	($93.83)	($2,640.25)	($132.84)
Virginia Pine on 30 year rotation managed for Pine Sawtimber	($80.15)	($2,691.21)	($148.99)
Southern Red Oak on 60 year rotation managed for Oak Sawtimber	($198.00)	($3,699.93)	($186.15)
Sweetgum on 60 year rotation managed for Hardwood Pulp	($198.00)	($3,708.05)	($186.56)

Least Cost Analysis

The sensitivity analysis reveals the variables with the greatest impact on the cost of adoption. Considering these variables in the design of RFBS allows the least cost design to be achieved. However, cost considerations must remain secondary to environmental goals. Thus, the site characteristics assumed for each original representative scenario continue to play a role in determining buffer design.

The lessons from the sensitivity analysis are applied to the original representative scenarios as a least cost approach to RFBS adoption. Three fields from each scenario are chosen. An RFSB is designed for each field to meet the environmental requirements in a least cost fashion. The Decision Support System is utilized to obtain estimates of the per acre costs of adopting the least cost design.

Two general changes have been made to the RFBS scenarios in all of the selected fields. First, the discount rate has been lowered from 5% to 4%. Evidence suggests that landowners engaging in long-term BMP’s have longer time horizons and place greater value on future returns (Pease et al 1997; Lynne, Shonkwiler, and Rola 1988).

Second, possible additional practices, such as heavy sight preparation or bank stabilization, have been removed. Therefore, establishment costs may be reduced dramatically from the original scenario. Fencing remains on all pasture land, although the lowest cost fencing materials are used.

Scenario 1: Inner Coastal Plain

Three fields of the Essex County representative scenario were chosen for examination. Field 1 represents the highest productivity. Field 5 has moderate productivity. Field 8 represents the lowest productivity. The Corn-Wheat-Soybean two-year rotation is the agricultural enterprise in each field.

No harvest restrictions are applied to Zone 2 and a 20% harvest in Zone 1 is allowed. To maximize the potential for nutrient uptake and forestry returns, Zone 2 contains 85 ft of Loblolly Pine managed for pulp on a 15 year rotation. Zone 1 contains 15 ft of mixed hardwoods managed for sawtimber harvest on a 60-year rotation.

Mean Annual Increments are conservatively reduced to reflect shortcomings. The MAI's for Field 1 are nine and six for Loblolly and mixed hardwoods respectively. The MAI's for Field 5 are seven and five. Field 8 MAI's are six and four.

Table 15: Inner Coastal Plain – Least Cost Scenario					***Original Scenario***
Field Number	Per acre Total Establishment Cost	Forgone Income Per Acre of RFBS	Per Acre Present Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns
1	($80.15)	($219.30)	($2,829.70)	($120.27)	($140.09)
5	($80.15)	($188.28)	($2,677.40)	($113.79)	($125.40)
8	($80.15)	($164.19)	($2,400.40)	($102.20)	($117.82)

Table 15 displays the estimates for adopting the least cost design on the selected Essex County fields. Net present value RFBS returns estimates have increased when compared with Table 4. However, annual equivalent estimates have decreased. The effects of a lower discount rate provide a partial explanation. Returns from harvests of forest products decreased, a result of lowering the MAI. Overall, the least cost RFBS design shows a slight reduction in costs.

Scenario 2: Piedmont - Schist/Gneiss and Thin Soils/Triassic Shales

Field 1, Field 3, and Field 4 of the Culpeper County scenario were chosen for examination. The primary enterprise of each field is corn silage, pasture for a dairy herd, and Alfalfa hay, respectively. As in the original scenario, buffer design varies with land use and assumed site characteristics in order to meet environmental goals.

The least cost buffer design for Field 1 includes changes in species selection and management. Loblolly Pine, instead of Yellow-Poplar, with a MAI of 7 is planted in the 85 foot wide Zone 2. No harvest restrictions apply on the fifteen year rotation. Zone 1 contains 15 feet of Oak with a 20% harvest restriction. The MAI for Zone 1 is assumed to be 6. A 4% discount rate is selected and used throughout the Culpeper scenario.

Field 3 contains a 35 foot wide Zone 1 of Red Oak. An MAI of 5 is selected. The Harvest restriction is 30% at the end of the 60 year rotation. The additional 20 feet of width in Zone 1, as compared to Zone 1 of Field 1, allows a larger harvest. Therefore the 30% harvest restriction is assumed to be in compliance with the environmental goals of the A 15 foot Zone 3 of Fescue-Ladino Clover is included to spread flows and trap sediment. Maintenance is assumed to occur every two years. A fence of three-strand barbed wire is erected for livestock exclusion. The stream crossing is omitted, assuming a secondary water source is present.

The RFBS of Field 4 contains 15 feet of Red Oak managed for sawtimber with a 20% harvest restriction. The MAI is 5. The 85 foot wide Zone 2 is contains Loblolly managed for pulp with a MAI of 6. No harvest restriction applies.

Table 16: Piedmont – Schist/Gneiss and Thin Soils/Triassic Shales - Least Cost Scenario					***Original Scenario***
Field Number	Per acre Total Establishment Cost	Forgone Income Per Acre of RFBS	Per Acre Present Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns
1	($80.15)	($184.32)	($2,582.90)	($109.78)	($179.46)
3	($1,160.12)	($113.88)	($4,305.45)	($182.99)	($259.65)
4	($80.15)	($39.74)	$921.05	$39.15	($27.75)

The least cost design decreased the cost of adoption in all cases. Returns from timber increased with species and harvest restriction modifications. The low opportunity cost and increased timber yields combined to make the RFBS a profitable undertaking in Field 4.

The largest decrease is observed in Field 3. Much of the reduction is due to the removal of the stream crossing requirement. Establishment cost fell from $2,443.81 (see Table 6) to $1,160.12 above for Field 3.

Scenario 3: Piedmont Valley & Ridge – Limestone/Marble

A least cost buffer, sensitive to assuring environmental benefits site characteristics for the individual field, was designed for each of the three fields in the Augusta County Scenario. Field 1 contains Orchard grass and Red Clover hay as the primary enterprise. The buffer design includes a 35 foot Zone 1 of Oak managed for sawtimber. The MAI is assumed to be 5 and a harvest restriction of 30% applies. No Zone 3 is prescribed for the hay field.

Field 2 Alfalfa hay is the primary land use. A single forested Zone containing mixed Oak stretches 35 feet upslope stream the stream edge. The MAI is 6 and the 30%

harvest restriction applies. No Zone 3 is prescribed.

A beef cow herd calving in fall and fed on a hay ration is the primary land-use of Field 3. Zone 1 contains Oak within the 35 foot width. An MAI of 5 and 30% harvest restriction are assumed. The high erosion hazard and presence of manure indicate the need for sediment trapping and conversion of runoff to sheet flow. Therefore, a 15 foot wide Zone 3 of Orchard Grass - Ladino Clover and Partridge Peas (for wildlife) is prescribed to reduce sediment loads and prevent channelization which would allow bypass of the RFBS. Maintenance to remove ephemeral channels and re-establish grasses is assumed to occur every 3 years. The area will be harvested for hay. A fencing requirement applies, and it is assumed that a 3 strand barbed wire fence will be installed.

Table 17: Piedmont Valley & Ridge – Limestone/Marble - Least Cost Scenario					***Original Scenario***
Field Number	Per acre Total Establishment Cost	Forgone Income Per Acre of RFBS	Per Acre Present Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns
1	($198.00)	($73.97)	($1,902.29)	($80.85)	($86.81)
2	($198.00)	($34.01)	($1,470.68)	($62.51)	($76.77)
3	($1,347.60)	($58.93)	($3,012.55)	($128.04)	($131.13)

Lower annual equivalent costs are observed in all fields. Few changes were made to the original RFBS designs. Present value costs were lower in Fields 1 and 3, but rose in Field 2. The lower discount rate raised the present value cost of adoption above the original estimate.

Fine tuning RFBS design to lower costs is viable only if the environmental services of the RFSB are maintained. In some cases, additional practices will be required. If the rush to lower costs compromises RFBS functions, the lower costs will be buying few goods.

Section D: Financial and Non-financial Incentives for RFBS Adoption

Riparian Forest Buffer Systems remain a voluntary practice for agricultural landowners. Although some farmers may install and maintain a RFBS that impose net costs, many more landowners will require financial incentives before they will consider RFBS adoption. Considerations other that the simple amount of financial assistance may influence the adoption of an RFBS. In considering an RFBS adoption, landowners may compare cash flow from the RFBS with the current land use, the length of contract that requires the land to be in an RFBS in return for a cash subsidy, and the performance regulations for the RFBS within the contractual agreement.

Conservation Reserve Program

The Conservation Reserve Program (CRP) is administered by the USDA Commodity Credit Corporation (CCC), the Farm Service Agency, and the various State and county USDA offices. The current rules governing the CRP became effective on February 12, 1997.

The CRP permits the CCC to enter into contractual agreements with landowners or operators to convert land to conservation purposes.[6] The length of the contract must be between 10 and 15 years. The program specifically declares that riparian buffers are eligible for the CRP program.

Table 18: Financial Effects of CRP Enrollment

Program Payments	***Per Acre Establishment Cost***	***Per Acre Present Value of RFBS Returns with Forgone Income***	***Per Acre Annual Equivalent Value of RFBS Returns with Forgone Income***
No CRP Payments	($80.15)	($2,436.07)	($122.56)
50% Establishment Cost-Share	($40.08)	($2,957.64)	($148.81)
15 year Rental Payment @ $70/acre/year	($80.15)	($2,384.37)	($119.96)
60 year Rental Payment @ $70/acre/year	($80.15)	($2,293.88)	($115.41)
Cost-Share and 15 year Rental @ $70/acre/year	($40.08)	($2,882.21)	($145.01)
Cost-Share and 60 Year Rental @ $70/acre/year	($40.08)	($2,253.81)	($113.39)

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[6] Operators who can demonstrate control of the property for the life of the contract are eligible to receive funds.

The CRP participant must develop a conservation plan and a tree planting plan. In exchange for following the plan, the CCC will pay 50% of the cost of establishment. The CCC will also pay an annual rental rate based on the productivity of the soil. Failure to comply with the terms of the contract will result in forfeiture of future payments and an obligation to repay all previous payments plus interest. Further, no harvests are allowed within the CRP acreage. This harvest restrictions eliminate returns from the grass and forested zones. The CRP rules may provide an exception for harvesting after lapse of the contract. However, no guarantee for contract renewal exists (Federal Register 1997, 7601-7635).

The CRP cost-share provides several important cash-flow benefits to landowners. The potential participant must consider the cost of creating conservation and tree planting plans, but the initial payment allows for immediate reimbursement of a portion of establishment costs. Second, the annual rental payment provides compensation for forgone income on a yearly basis. The owner also may participate in other non-federal programs.

The rental payment also provides leverage in forcing compliance. Withholding payments does not impose the burden of fine and recovery on the program. In contrast, a one-time payment requires recovery of money already in the hands of the landowner, a much more complicated and politically expensive task.

Wetlands Reserve Program

The Natural Resources Conservation Service administers the Wetlands Reserve Program (WRP) for the CCC. To participate, the owner must agree to implement a Wetlands Reserve Plan of Operation. In exchange, a permanent or temporary easement for the use of the land under the Plan of Operation is granted to the Federal government. Easement payments are disbursed over 5 to 30 years. The amount of the total easement payment is determined by the soil types, types of crops capable of being grown, production history, location, real estate market values, appraisals and market analyses, and tax rates and assessments. The full easement payment will be granted for a permanent easement. However, thirty year easements will receive between 50% to 75% of the total easement payment.

WRP provides for sharing the costs of restoration up to 100% for permanent easements. Cost sharing is limited to 50% to 75% for 30 year easements. The landowner may receive additional cost-share from other public and private agencies (7 CFR Parts 620 and 1467, RIN 0578-AA16).

Several limitations exist for the use of the WRP as an incentive for RFBS adoption. First, many riparian areas can not be classified as wetlands. Second, the WRP does not provide for harvesting within any portion of the enrolled land. Finally, in the event of non-performance, the government retains the right to enter the property and perform remedial actions. Further, the government may withhold WRP payments and recover administrative, legal, and other enforcement related costs. Both the loss of future rights and high liability present a major obstacles for landowner acceptance.

The WRP targets wetlands as critical areas in need of restoration and protection.

Qualifying lands will likely have high organic matter and high water table, a combination with high potential for nutrient uptake and sequestration. A liberal policy for granting WRP enrollment of riparian lands has a high probability of encouraging the establishment of valuable Riparian Forest Buffer Systems.

Wildlife Habitat Incentives Program and Environmental Quality Improvement Program

The Natural Resources Conservation Service administers the Wildlife Habitat Incentives Program (WHIP) to provide assistance to landowners wishing to improve wildlife habitat on their property. Participation requires the development of a Wildlife Habitat Development Plan. The Environmental Quality Improvement Program is administered jointly by the NRCS and the Farm Services Agency. A conservation plan must be submitted to be eligible for participation. For both programs, cost-share payments are made up to 75% of the cost of implementation of the habitat development plan. The plan must be adhered to for 5 to 10 years. Failure to comply will result in the termination of cost-share payments and/or the return with interest of any previous payments (Federal Register 1997, 28257-28292).

Unlike the CRP, annual rental payments are not made for enrolled land. Further, the cost-share element may be insufficient for RFBS with high establishment costs. However, harvesting within the enrolled land is not expressly forbidden by the rules. WHIP and EQIP programs show a good potential for the establishment of smaller buffers with low establishment costs and limited forgone income.

Table 19: Financial Effects of EQIP or WHIP Enrollment

Program Payments	***Per Acre Establishment Cost***	***Per Acre Present Value of RFBS Returns with Forgone Income***	***Per Acre Annual Equivalent Value of RFBS Returns with Forgone Income***
No Program Payments	($80.15)	($2,436.07)	($122.56)
75% Cost-Share	($20.04)	($2,358.52)	($118.66)

Conservation Farm Option

The Conservation Farm Option is designed to encourage the development of farms as pilot projects. Participation requires the submission of a Conservation Farm Pilot Proposal. The proposal is a comprehensive plan to implement farm wide conservation measures. The program is competitive, and only proposals with innovative technologies and assistance delivery systems are selected.

The contract period is 10 years with a 5 year renewal option. Annual payments are equal to the expected payments from CRP, WRP, and EQIP. Participation in all other Federal conservation programs is prohibited. Although payments are theoretically equivalent to the other programs, implementation of a farm-wide program may encourage assistance from other public and private sources. Further, farmers with positions of leader ship in the community should be encouraged to apply, as the CFO is designed for the dispersal of technology through example. However, farmers must recognize the significant cost of burdensome paperwork.

State Incentives

The Federal programs do allow the landowner to also accept payments from non-federal sources. All states in the CBW have programs that can be matched with the federal programs.

The Maryland Department of Natural Resources offers a one-time payment of $300 dollars per acre for the installation of a forested buffer through the Buffer Incentive Program. Buffer width must be a minimum of 50 feet. The contract period is 10 years. Notably, current participants have enrolled only marginal farmland. The MD Buffer Incentive Program witnessed a significant decline in applicants when the payment was reduced from $500 to the present $300.

Virginia's cost-share program, the Woodland Buffer Filter Area program, also requires a 50 foot minimum forested buffer. In exchange, the participant receives a $100 per acre payment from the Department of Conservation and Recreation. Contract length is 3 years.

The Stream Bank Fencing Program in Pennsylvania offers to pay the full cost of fencing installation if the landowner establishes a minimum 12 foot width buffer. Although only applicable for livestock producers, the program provides a well-supported and lucrative incentive. While not a requirement, the exclusion of livestock from the riparian area is an important component in achieving nutrient reduction and stabilization of the riparian habitat. The program is easily the most supportive state incentive.

Table 20: Financial Effects of State Incentive Plans

Program Payments	***Per Acre Establishment Cost***	***Per Acre Present Value of RFBS Returns with Forgone Income***	***Per Acre Annual Equivalent Value of RFBS Returns with Forgone Income***
No Program Payments	($80.15)	($2,436.07)	($122.56)
$300 MD Buffer Incentive Program	($80.15)	($2,261.83)	($113.80)
$100 VA Woodland Buffer Filter Program	($80.15)	($2,377.99)	($119.64)

Enrollment in Multiple Programs

Federal program rules explicitly allow participants to receive additional assistance from state and private sources. Farmers applying for assistance at both the State and Federal levels will enjoy higher financial incentives for adoption. Again, the costs of paperwork and compliance should be considered by the individual.

Table 21: Financial Effects of Multiple Incentive Plans			
Program Payments	***Per Acre Establishment Cost***	***Per Acre Present Value of RFBS Returns with Forgone Income***	***Per Acre Annual Equivalent Value of RFBS Returns with Forgone Income***
No Program Payments	($80.15)	($2,436.07)	($122.56)
$300 MD Buffer Incentive Program & Full CRP Enrollment	($80.15)	($1,993.88)	($100.32)
$300 MD Buffer Incentive Program & WHIP/EQIP Cost-Share	($20.04)	($2,184.28)	($109.90)

Alternative Market Products

Besides the harvest of traditional forest products, many landowners may consider the harvest and sale of non-traditional products from the RFBS. Non-traditional forest products include edibles, medicinal and dietary supplements, floral and decorative products, and specialty woods for craft production.

Mushrooms, nuts, and berries comprise the majority of harvested edible products. The products are often familiar additions to home-cooked meals, particularly in years past. Although not typically found in the farmer's market, anecdotal evidence suggest the presence of an emerging market (Hamlett and Chamberlain, 1998.)

Medicinal forest products might also appear in the cabinets of agricultural homesteads in years past. Unlike edible products, small but established market exists for many medicinal products found in CBW forests. Ginseng is widely cultivated in Canada and the United States and sold in a market with an even wider range of prices. During 1997, the prices paid per pound ranged from $10 to more than $400 per pound. The highest prices were commanded by the oldest and "wildest" looking roots (Beyfuss, 1998, 151). Such fluctuation indicates an unstable market, and expected returns from cultivation should be heavily discounted. Other marketable medicinal include goldenseal, mayapple, sassafras, and white oak bark, although markets for these products are less defined than for ginseng (Hamlett and Chamberlain, 1998).

Many other alternative forest products, in including floral, fuelwood, and specialty wood products, may be present within a RFBS. It will be to the creativity and determination of the landowner to make profitable use of the harvest. Most farmers will not pursue the marketing of these products. Investments of time and labor for harvest and market research are high, and the returns are uncertain. However, these products may present a feasible method of justifying the decision to adopt for a few of the most creative and determined.

While many alternatives exist to supplement farm income, only those alternatives directly related to the establishment and maintenance of a RFBS have been considered. Thus, a farm capable of supporting a resource-based tourism or fee hunting operation already has substantial assets. The addition of a RFBS may enhance these enterprises, but an RFBS alone will have little effect.

Other Markets

Efforts to reduce global output of carbon from the burning of fossil fuels are resulting in limits to total aggregate output for individual countries. To meet the new standards, identifiable sources of carbon will be required to reduce carbon output. Forests capture atmospheric carbon. In the future, markets in credits for carbon sequestration may provide an additional method of financing RFBS adoption.

Requirements on new developments prevent the destruction of wetlands. However, developers have the option to restore wetlands in other areas. The sale of wetland mitigation credits is a limited but viable alternative financing method for the establishment of RFBS.

Least Cost Scenarios with Maximum Financial Incentives under Conservation Farm Option Concept

Applying the existing financial incentives to the least cost scenarios of Section C yields the final assessments of landowner level costs of adoption. Estimates were calculated for each of the three fields in the three least cost scenarios. Establishment cost-share is assumed to be 85% (a combination of CRP-like programs and State programs). A one-time payment of $300 is included in the calculations. A $70 per acre rental payment for all sixty years completes the financial incentive package. Unlike current CRP rules, harvests are permissible under the restrictions described for each field in the least cost scenarios.

Cost estimates for the least cost scenarios with maximum financial incentives are presented in Tables 22 – 25 below.

Table 22: Coastal Plain - Least Cost Scenario with Financial Incentives					***Least Cost Scenario***
Field Number	Per acre Total Establishment Cost	Forgone Income Per Acre of RFBS	Per Acre Present Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns
1	($12.02)	($219.30)	($814.58)	($34.62)	($120.27)
5	($12.02)	($188.28)	($662.28)	($28.15)	($113.79)
8	($12.02)	($164.19)	($385.28)	($16.38)	($102.20)

Table 23: Piedmont – Schist/Gneiss and Thin Soils/Triassic Shales - Least Cost Scenario with Financial Incentives					***Least Cost Scenario***
Field Number	Per acre Total Establishment Cost	Forgone Income Per Acre of RFBS	Per Acre Present Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns
1	($12.02)	($184.32)	($567.78)	($24.13)	($109.78)
3	($202.14)	($113.88)	($1,213.01)	($51.55)	($182.99)
4	($12.02)	($295.79)	$2,936.17	$124.79	$39.15

Table 24: Piedmont Valley & Ridge – Limestone/Marble - Least Cost Scenario with Financial Incentives					***Least Cost Scenario***
Field Number	Per acre Total Establishment Cost	Forgone Income Per Acre of RFBS	Per Acre Present Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns	Per Acre Annual Equivalent Value of RFBS Returns
1	($29.70)	($73.97)	$213.00	$9.05	($80.85)
2	($29.70)	($34.01)	$644.61	$27.40	($62.51)
3	($202.14)	($58.93)	$78.89	$3.40	($128.04)

Maximizing available financial incentives dramatically reduced the cost of adoption in all scenarios. Nearly one-half of the adoption scenarios produced positive, though small, annual returns.

Fields displaying positive returns were those with low agricultural returns. Thus the per acre value of foregone income is small. For instance, the Ridge and Valley region of Augusta County produces poor agricultural returns. All of the least cost RFBS systems designed and estimated for Augusta County yielded positive returns when the maximum financial incentives were included in the calculations.

In contrast, RFBS on the high yield corn-wheat-soybean rotation in Essex County continued to cost between $102 to $120 /acre/year. Many of these highly productive lands are operated by profit-maximizing farmers or are operated by renters. Both profit-maximizing behavior and rented land have been observed to be negatively correlated with adoption of long-term BMP's (Lynne, Shonkwiler, and Rola 1988, 16). These results underscore again the importance of considering the value of foregone agricultural production in calculating the cost of adoption.

A second dramatic result is observed in Field 3 of Table 23 and Field 3 Table 24. The high establishment cost of the fencing practice has been greatly offset by the 85% cost-share. Quite intuitively, RFBS with high establishment costs receive a larger percentage change when cost-share is applied. Yet the magnitude of the change suggests cost-share programs deserve special attention in areas where additional establishment practices are needed.

Section E: Conclusions

Overview

Riparian Forest Buffer Systems have the potential to improve the stream environment, increase habitat for and diversity of wildlife, reduce nutrient loads to the waters of the Chesapeake Bay Watershed, and trap sediments within the riparian area. The potential for nutrient and sediment control can vary from very high to no significant potential, depending on land use, current degradation, soil characteristics, slope, maintenance, and hydrologic conditions. The variables affecting RFBS potential change across regions, and even change across fields in individual farms.

RFBS should be designed with a recognition that environmental functions vary with site characteristics. Widths, management schemes, and species of Zone 1 (the unmanaged zone), Zone 2 (the managed zone), and Zone 3 (the grass vegetated filter strip) can vary with the site conditions. Additional practices, such as stream channelization, fencing, and special site preparation, may be added to ensure the proper functioning of the RFBS.

In assessing the landowner level costs of RFBS adoption, establishment and financial opportunity costs must be considered. Establishment costs vary with RFBS design, while financial opportunity costs vary with management of the RFBS and with the value of the current land-use.

The information costs associated with estimating costs for a single point within the matrix of variables are reduced by the Decision Support System. The DSS provides a simple means of estimating the costs of adoption for any specific scenario.

Representative scenarios, derived from several sources of information, illustrated the diversity of the relevant variables found within the Chesapeake Bay Watershed. The resulting estimates of adoption costs reflect the diversity of designs and land-use values. However, the relative influence of individual variables, measured through a sensitivity analysis, allows fine tuning of RFBS designs to achieve the least cost design for meeting the environmental goals established for the particular RFBS.

Direct financial incentive programs have been created to help landowners overcome a portion of the costs of adoption. Examining the financial incentives against a base case scenario revealed the promise and shortcomings of individual programs. The programs were combined and applied to the least cost scenarios. The resulting estimates showed a much smaller cost of adoption than in the original scenarios. In some cases the RFBS produced positive returns.

Results

Overall, the range of costs revealed in the assessment is not surprising, given the range of conditions simulated. However, while many factors affect the costs, the most significant cost determinants were requirements for additional practices to assure proper functioning of the RFBS and the value of forgone agricultural returns. While costs in achieving goals can not be avoided, information may help the costs be minimized.

The value of foregone income plays a large role in the costs of adoption. Considering all examined scenarios, per acre foregone income ranged from a low of $23.08 to a high of $219.30. Even cast in the most favorable light and maximum incentives, the highest returning agricultural land continued to have high costs of adoption. Large annual rental payments provide both a means of reducing the burden and a steady cash flow.

Design requirements are the second major cost determinant. Size, width and species selection each affect establishment costs. Equally important are the additional practices which ensure proper functioning of the RFBS. Fencing, additional site preparation, stream channelization, stream crossings, and additional watering tanks can combine to push establishment costs well into the thousands of dollars per acre. Where establishment costs are high, cost-share programs have a significant effect on lowering the costs of adoption to the landowner.

Agriculture and Forestry Considerations

Uncertainties abound in assessing forestry returns. Additionally, agricultural landowners may discount price forecasts for forest products more heavily than traditional forest landowners. Further, harvests are generally conducted as large scale operations. Higher harvest cost may be inherent for RFBS, although the ease of accessibility associated with farmland may have the opposite effect.

One positive sign for the market of small-scale harvests exist in the potential of the portable sawmill (Greason 1998, 165-170). Small-scale milling operations may perfectly match the needs of the landowner and create new jobs in rural areas. The fundamental elements of markets and management schemes for portable milling operations deserve consideration.

A second concern is common to all agricultural management decisions. Long-term projections of price in agricultural markets may affect the decision to adopt. The analysis clearly demonstrated the importance of forgone agricultural income in determining the financial effects of adoption. Should prices for products which may be produces in the riparian area greatly outpace inflation, a substantial incentive will exist to liquidate the forest products of the RFBS and convert the land to agricultural production. Binding contracts, penalties, and the cost of conversion may be seen as limiting the future “rights” of the farmer to farm the riparian area. Should agricultural prices rise below the rate of inflation, foregone income will decrease. In such circumstances, the cost of adoption will be reduced.

Depending on the individual field, the landowner may experience a loss in equipment efficiency due to increased time and damage when turning in fields. Flexible buffer designs allow the farmer to include turning areas, thereby reducing the efficiency loss. Farmers may also experience a loss in growth rates due to shading of crops near the riparian area. Finally, RFBS may increase damage by acting as a vector to pests, including wildlife, insects, and noxious weeds (Tjaden 1998, 199-208).

Economies of Scale Contiguous Control and Establishment of RFBS

Contiguous buffers represent an economy of scale in both the production of environmental services and establishment costs. Contiguous buffers allow the movement of wildlife along a corridor, thus connecting larger forested areas. Studies have confirmed that large woody debris travel only a short distance from the source. Contiguous buffers allow the continuation of the food chain and movement of organisms within the streams (Lowrance, et al 1995, 11).

Establishment of a RFSB requires planning. The design, the transport of supplies, even the contact of local professionals, presents a cost in time and money. By organizing farmers along a stretch of stream, the costs of establishment, maintenance, and harvest can be shared. Organized landowners may also receive favorable assessments in obtaining subsidies and in market activities associated with RFBS.

A Note about Enforcement

Enforcement of contracts, whether Federal, State, or a private market, can require significant outlay of funds. The exact amounts of enforcement costs depend on the contract and state of technology for monitoring performance. Most programs have site inspections to ensure survival of trees, removal of ephemeral channels, and compliance with harvest regulations.

Contracts directly aimed at nutrient reduction require scientific monitoring. Unfortunately, determination of nutrient reduction requires the installation of expensive equipment and periodic monitoring. Should future regulations, whether on-farm or off-farm, require individuals to meet nutrient standards, RFBS will not be able to cost effectively document nutrient reductions.

A second major consideration in enforcement costs surround maintenance. The need for removal of ephemeral channels is essential to the functioning of the nutrient and sediment trapping properties of the buffer. Periodic inspections, probably less than five year intervals, will record maintenance failures. The cost of such inspections and how they may be borne in the markets and government programs should be examined.

Focusing on Adoption Locations

Restoring riparian forests for controlling the stream environment may be encouraged throughout the watershed. Using taxpayer funds to encourage adoption in hopes of achieving water quality targets requires a careful examination of the location of proposed adoption sites. As noted above, creating contiguous buffers allows greater production of environmental services. Priority may be given to connecting areas of contiguous buffers to serve as corridors for wildlife.

Subsidies aimed at encouraging adoption for control of nutrient and sediments entering the mainstem of the Chesapeake Bay should consider the location of the adoption area. Significant cost implications have been demonstrated for where nutrient goals are established within a watershed (Schleich, White, and Stephenson 1996, 2884). Subsidies for RFSB designed to prevent nutrients from entering the mainstem of the bay may be more successful of applied to the Inner and Outer Coastal Plains. Both the physical properties of the regions and the proximity to the mainstem will increase the effectiveness of such a policy focus.

Attitudes and Non-Market Values

Attitudes of landowners play a role in the adoption decision. Few farmers are purely profit-maximizers. This study focused on the implications to profitability of RFBS adoption. Other studies have used survey techniques to elicit the value of attitudes toward conservation and owner characteristics in the adoption decision. The studies reviewed suffered from several limitations. First, most participants were drawn from individuals already enrolled in conservation programs. Thus, participants had only conjecture in assessing the reasons their neighbors chose not to participate in conservation programs.

A second limitation arises from the focus on short-term BMP's. Adopting conservation tillage or Integrated Pest Management BMP's requires little capital expenditure and easy return to previous practices. Long-term conservation BMP's, such as RFBS, require substantial investment and high-costs for returning to previous practices.

Two studies which examined attitudes in adopting long-term conservation behavior were reviewed. One study reported a high number of the enrollees in the WRP, EWRP and USFWS Private Lands Program had college and graduate degrees (Pease et al 1997, 8). The overwhelming majority of participants listed increasing wildlife habitat leaving wild lands to future generations and natural beauty as important factors in the adoption decision (Pease et al 1997, 11). A second study showed a positive correlation was shown for adopting conservation practices and agreeing with statements supporting conservation (Lynne, Shonkwiler, and Rola 1988, 16). Respondents indicated participating in outdoor activities and reading nature related literature as a youth (Pease et al 1997, 15).

Profit maximizing attitudes either produced a negative correlation with adoption (Lynne, Shonkwiler, and Rola 1988, 16) or was listed as unimportant in the adoption decision (Pease et al 1997, 11). Rented property was negatively correlated with adoption of conservation measures (Lynne, Shonkwiler, and Rola 1988, 16). Beliefs about why other landowners refused to participate leaned toward a dislike of government programs, the value of foregone income, and lack of knowledge regarding the existence of such programs (Pease et al 1997, 14).

Individuals must weight the value of attitudes and non-market factors in the adoption decision. Arriving at the ideal subsidy level based on the individuals attitudes will be impossible outside of a market. However, the studies reviewed indicate non-market factors will mitigate profit-maximizing behavior and allow for subsidies to be below break-even levels.

Use of the Decision Support System

The Decision Support System is designed to be used in researching the financial implications of RFBS adoption. Many uses for the system can be envisioned, both in research and extension.

Adoption of RFBS has occurred on a limited scale. Information on the observed effects of adoption can be collected and compared to estimates generated for the site by the DSS. Such procedures allow refinement of the model, resulting in improved accuracy.

The model may be used to assess the cost of adopting RFBS along an entire stream, county, or watershed. Data on site characteristics and agricultural enterprises at many levels is readily available. Such studies allow comparisons in making policy decisions and assessing goals.

The DSS may be used by extension personnel in educating landowners on the design of RFBS and the financial effects of adoption. Trade-offs between design and costs can be readily shown, as well as changes in estimates of returns from harvests of agricultural and RFBS products.

The model also provides an excellent tool for the collection of data. In addition to the records generated within the cost reports, additional information can be requested and handled through the simple introduction of input boxes and lines of VBA code. The model will be especially useful for this purpose if extension regularly use the DSS in proposing RFBS to landowners.

Ultimately, the DSS may be tied to physical models of environmental service production. The marriage of physical and economic models will allow the creation a price per unit of environmental service for a variety of buffer designs at a given location. Current physical models are limited in the ability to observe sub-surface flows. Future technology may allow more accurate physical modeling.

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Appendix A – Sample Report

A –1 Sample "Whole Farm Report" Page from DSS Output

WHOLE FARM REPORT

FARM INFORMATION

Size of Farm:
300 Acres

Number of Fields:
3

RFBS INFORMATION

Total Buffer Size:
5.17 Acres

Percent of Farm in RFBS:
2%

Total Establishment Cost:
$ 414.01
Per Acre of RFBS:
$ 80.15

CURRENT RETURNS

Whole Farm Annual Returns:
$ 57,175.80

RETURNS WITH BUFFER ADOPTION

Annual Equivalent Value of Whole Farm Returns:
$ 57,039.53

Value of Opportunity Cost:
$ 984.43
Per acre of RFBS:
$ 190.59

Annualized RFBS Returns
With Opportunity Cost:
$ (136.27)
Per acre of RFBS:
$ (26.38)

Present Value of RFBS Returns:
($3,206.16)
Per acre of Buffer:
$ (620.71)

A – 2 Sample "Field Report" Page from DSS Output

FIELD REPORT

FIELD INFORMATION

PHYSICAL PROPERTIES

Category	
Field Size	100 *Acres*
Average Slope	0

MANAGEMENT INFORMATION

Discount Rate	4%

AGRICULTURAL INFORMATION

Primary Enterprise

Type CORN – SOYBEANS - WHEAT 2 YEAR ROTATION

Returns per acre
without Fixed Costs $ 219.30

Whole Field Returns without RFBS Adoption

Currently Yearly Returns
without Fixed Costs $ 21,929.60

Whole Field Returns with RFBS Adoption

Annual Equivalent Value of Yearly Returns	$	21,869.99			
Opportunity Cost of RFBS Adoption	$	377.58			
Annual Equivalent Value of RFBS Returns Including Opportunity Cost	$	(59.61)	*Per acre*	$	(34.62)
Present Value of Buffer Returns	$	(1,402.51)	*Per acre*	$	(814.58)
Total Establishment Cost	$	138.00	*Per acre*	$	80.15

RIPARIAN FOREST BUFFER SYSTEM INFORMATION					
FINANCIAL INCENTIVES					
Type		***Amount per Acre***			
One-Time Incentive Payment			300		
Annual Rental Payment			70		
Percentage Cost-Share			85%		
UNMANAGED FOREST ZONE					
Category					
Forestry Information					
Soil Type					
Mean Annual Increment		6			
Tree Species		MIXED HARDWOOD SAWTIMBER			
Rotation Length		60 YRS.			
Harvest Restriction		20%			
Conversion Factor		6			
Price Per MBF		$ 134.00			
	Length	*Width*	*Total Area (ac)*	*Cost per Unit*	*Total Cost*
Establishment Cost	750	15	0.26	$ 198.00	$ 51.14
Additional Requirements					
Site Preparation	*Length*	*Width*	*Total Area (ac)*	*Cost per Acre*	*Total Cost*
Light	0	0	0.00	$ 331.50	$ -
Moderate	0	0	0.00	$ 546.50	$ -
Heavy	0	0	0.00	$ 546.50	$ -
Stream Crossing			*# of Units*	*Cost per Unit*	*Total Cost*
Type	NONE		1	$ -	$ -
Fencing			*Linear Feet*	*Cost per Foot*	*Total Cost*
Type	NONE				
Cost			0	$ -	$ -
Channel Stabilization			*Linear Feet*	*Cost per Foot*	*Total Cost*
Type	NONE				
Cost			0	$ -	$ -
Trough or Tank			*# of Units*	*Cost per Unit*	*Total Cost*
Type	NONE				
Cost			1	$ -	$ -
Annual Operation and Maintenance			1	$ -	$ -
Periodic Maintenance			*Total Area (ac)*	*Cost per Acre*	*Total Cost*
Annual Operations and Maintenance			0.26	$ -	$ -
Periodic Mowing (First four years)			0.26	$ 14.00	$ 3.62

MANAGED FOREST ZONE					
Category					
Forestry Information					
Soil Type					
Mean Annual Increment:	9				
Tree Species	PINE PULPWOOD				
Rotation Length	15 YRS.				
Harvest Restriction	100%				
Conversion Factor	12				
Price Per MBF	$ 112.00				
	Length	*Width*	*Total Area (ac)*	*Cost per Unit*	*Total Cost*
Establishment Cost	750	85	1.46	$ 59.36	$ 86.87
Periodic Maintenance			*Total Area (ac)*	*Cost per Acre*	*Total Cost*
Annual Operations and Maintenance			1.46	$ 2.00	$ 2.93
Periodic Mowing (First four years)			1.46	$ 14.00	$ 20.49

GRASS FILTER STRIP					
Category					
Grass Filter Information					
Grass Species:	SWITCHGRASS - NO-TILL, W/O LIME, FERT, HERBICIDE				
Maintenance Interval (Yrs):					
	Length	*Width*	*Total Area (ac)*	*Cost per Unit*	*Total Cost*
Establishment Cost	0	0	0.00	$ 66.03	$ -
Maintenance					
			Total Area (ac)	*Cost per Acre*	*Total Cost*
Ephemeral Channel Removal			0	$ 8.00	$ -
Total Maintenance Cost					$ -
Harvest					
			Total Area (ac)	*Returns per Acre*	*Total Returns*
Returns			0.00	$ (239.01)	$ -

RFBS TOTALS	
Total Area	1.72 *Acres*
Total Establishment Cost	$ 138.00

Appendix B – Common Agricultural Enterprises of Virginia

Enterprises of Virginia Embedded in the Model	
Barley Grown For Grain In A Full Year	Beef Cow Herd Calving In Fall Fed On Fescue Pasture
Barley And Soybeans Grown In Rotation During A Year	Beef Cow Herd Calving In Fall Fed On A Litter Ration
Corn Grown For Grain With Conventional Tillage	Beef Cow Herd Calving In Fall Fed On A Hay Ration
Corn Grown For Grain With Minimum Tillage	Beef Cow Herd Calving In Fall Fed On A Silage Ration
Corn Grown For Silage With Minimum Tillage	Beef Cow Herd Calving In Fall Fed On A Silage Litter Ration
Corn Grown For Silage With Conventional Tillage	Beef Cow Herd Calving In Spring Fed On Fescue Pasture
Alfalfa Hay With Conventional Establishment	Beef Cow Herd Fed Calving In Spring On Litter Ration Fescue Pasture
Alfalfa Grown For Hay	Beef Cow Herd Fed Calving In Spring On A Hay Ration
Alfalfa Grown For Haylage	Beef Cow Herd Fed Calving In Spring On A Silage Ration
Alfalfa Hay With No-Till Establishment	Beef Cow Herd Fed Calving In Spring On A Silage Litter Ration
Barley And Corn Grown In Rotation During A Year	Stocker Heifers Raised Spring To Fall
Regular Pasture Maintenance	Heifers Raised For Replacement
Orchard Grass And Red Clover Grown For Hay	Stocker Steers Fed On A Silage Litter Ration
Timothy Grass Grown For Hay	Stocker Steers Fed On A Hay-Litter-Corn Ration
Grain Sorghum Grown With Minimum Tillage	Stocker Steers Fed On A Hay Ration
Wheat And Corn For Silage Grown In Rotation	Stocker Steers Fed On A Silage Supplement Ration
Wheat Grown With Intensive Management	Light Stocker Steers Fed On A Hay Ration
Wheat And Soybeans Grown In Rotation	Stocker Steers Fed On A Hay-Litter-Corn Ration With Less Than 45 Days Pasture
Straw Grown For Special Purpose	Stocker Steers Fed On A Silage Litter Ration With Less Than 45 Days Pasture
Soybeans And Barley Silage Grown In Rotation	Stocker Steers Fed On A Silage Supplement Ration With Less Than 45 Days Pasture
Corn And Barley Silage Grown In Rotation	Stocker Steers Purchased In March And Sold In Fall
	Stocker Steers Purchased In March And Sold In Fall
	Dairy Herd (Size) Maintained On A Corn And Alfalfa Ration
	Dairy Herd Maintained On A Corn Ration

Appendix C – Example Enterprise Budgets

C – 1 Example Row Crop Budget

CORN GRAIN MINIMUM TILL

6.

102.2 BUSHEL YIELD   1 ACRE

ITEM	UNIT	PRICE	QUANTITY	TOTAL	YOUR EST.
RETURNS PER ACRE	BU	$ 2.78	102.2		
GROSS				$284.12	
NET W/O FIXED COSTS				$47.46	
NET				($83.51)	
PREHARVEST EXPENSES					
SEED CORN	UNIT	$77.17	0.33	$25.47	______
RYE SEED	BU	$8.51	1.50	$12.77	______
NITROGEN *	LBS	$0.31	145.00	$44.95	______
PHOSPHATE *	LBS	$0.28	40.00	$11.20	______
POTASH	LBS	$0.15	60.00	$9.00	______
FERTILIZER APPLICATION	ACRE	$5.50	1.00	$5.50	______
LIME	TON	$22.47	0.66	$14.83	______
CHEMICALS					
HERBICIDES	ACRE	$32.37	1.00	$32.37	______
INSECTICIDES	ACRE	$0.00	1.00	$0.00	______
FUNGICIDES	ACRE	$0.00	1.00	$0.00	______
CHEMICAL APPLICATION	ACRE	$6.00	1.00	$6.00	______
FUEL,OIL, LUBE	ACRE	$7.94	1.00	$7.94	______
REPAIRS	ACRE	$20.76	1.00	$20.76	______
PREHARVEST LABOR	HOUR	$6.00	1.74	$10.44	______
CASH RENT OR LAND COST	ACRE	$0.00	1.00	$0.00	______
CROP INSURANCE	____	_____	_____	______	______
SCOUTING	____	_____	_____	______	______
OTHER COSTS					
______________	____	_____	_____	______	______
______________	____	_____	_____	______	______
PRODUCTION INTEREST	A.P.R.	9.00%	201.22	$9.05	______
TOTAL PREHARVEST EXPENSES		$2.06 PER BU.		$210.27	______
HARVEST EXPENSES					
FUEL, OIL, LUBE	ACRE	$2.05	1.00	$2.05	______
REPAIRS	ACRE	$6.67	1.00	$6.67	______
HARVEST LABOR	HOUR	$6.00	0.39	$2.33	______
HAULING	BU	$0.15	102.20	$15.33	______
STORAGE	BU	$0.00	102.20	$0.00	______
DRYING	BU		102.20	$0.00	______
______________	____	_____	_____	______	______

TOTAL HARVEST EXPENSES		$0.26 PER BU.		$26.38	______
TOTAL VARIABLE COST		$2.32 PER BU.		$236.65	______
MACHINERY FIXED COSTS (BASED ON NEW EQUIPMENT COST)				$130.97	______
OTHER FIXED COSTS	____	______	______	______	______
______________	____	______	______	______	______
TOTAL COST		$3.60 PER BU.		$367.62	______

CHEMICALS:	TYPE	UNIT	PRICE	QUANT.
GRAMAXONE	H	PT	$4.54	1.50
STICKER	H	PT	$1.83	0.50
AATREX 4L	H	QT	$3.60	2.00
DUAL 8E	H	PT	$8.72	2.00

* NOTE: NITROGEN AND PHOSPHORUS REQUIREMENTS WILL VARY WITH MANURE USE AND/OR RESIDUAL NUTRIENT LEVELS IN THE SOIL.

DEVELOPED BY VIRGINIA COOPERATIVE EXTENSION FARM MGT. STAFF JAN. 1997

C – 2 Example Beef Budget

BEEF COWS CALVING IN FALL -STOCKPILED FESCUE PASTURE

1.

100 COWS 90 % CALF CROP

60 DAYS ON STOCKPILED FESCUE PASTURE

15 % REPLACEMENTS KEPT AS % OF COW HERD

15 % ANNUAL CULLING RATE 1.0 % ANNUAL COW DEATH LOSS

ITEM			UNIT	PRICE	QUANTITY	TOTAL	YOUR EST
CASH INCOME							
STEERS	45 @	6.00	CWT	$65.60	270.00	$17,712.00	______
HEIFERS	30 @	5.50	CWT	$65.60	165.00	$10,824.00	______
CULL COWS	14 @	10.00	CWT	$38.02	140.00	$5,322.80	______
CULL BULL	1 @	16.00	CWT	$38.00	16.00	$608.00	______
			TOTAL CASH INCOME			$34,466.80	______
CASH EXPENSES							
		FEED WASTE					
CORN SILAGE		5.0%	TON	$30.00	0.00	$0.00	______
BROIL LITTER		5.0%	TON	$15.00	0.00	$0.00	______
ALFALFA HAY		5.0%	TON	$120.00	0.00	$0.00	______
GRASS HAY		5.0%	TON	$40.00	105.43	$4,217.06	______
CORN GRAIN		2.0%	BU	$4.00	230.52	$922.10	______
SBOM 48%		0.0%	TON	$305.00	0.00	$0.00	______
OTHER FEED		5.0%	TON	$0.00	0.00	$0.00	______
GRINDING & MIXING			CWT	$0.00	0.00	$0.00	______
SALT & MINERAL			CWT	$22.00	68.00	$1,496.00	______
VET & MEDICINE			HEAD	$16.77	100.00	$1,677.49	______
SUPPLIES			HEAD	$2.00	100.00	$200.00	______
REPLACEMENT BULL			HEAD	$1,200.00	1.00	$1,200.00	______

STOCKPILED FESCUE	ACRE	$30.00	66.67	$2,000.00	_______
PASTURE	ACRE	$18.00	250.00	$4,500.00	_______
HAUL CULL CATTLE	HEAD	$5.20	15.00	$78.00	_______
MARKET CULL CATTLE	HEAD	-----	15.00	$163.62	_______
HAUL CALVES	HEAD	$3.75	75.00	$281.25	_______
MARKET CALVES	HEAD	-----	75.00	$833.22	_______
BLDG. & FENCE REPAIR	-----	-----	-----	$250.00	_______
UTILITIES	-----	-----	-----	$125.00	_______
OTHER,(insurance etc.)	-----	-----	-----	$0.00	_______
LABOR FICA = 7.65%	HRS.	$0.00	800	$0.00	_______
MACHINERY (NON-CROP)	$$$	$10.00	100.00	$1,000.00	_______
		TOTAL CASH EXPENSES		$18,943.74	_______
ANNUAL DEBT PAYMENTS				$0.00	_______
RETURN TO EQUITY, MANAGEMENT, & OPER. LABOR				$15,523.06	_______
RETURN PER ACRE OF PASTURE				$62.09	

C – 3 Example Dairy Budget

DAIRY COW

CORN SILAGE RATION

28.

100 COWS
16000 LBS PRODUCTION PER COW

34 % ANNUAL CULLING RATE

3.0 % ANNUAL COW DEATH LOSS

95 % HEIFERS AS A PERCENT OF COW HERD

ITEM			UNIT	PRICE	QUANTITY	TOTAL
CASH INCOME						
MILK			CWT	$14.58	16000	$233,280.00
CULL COWS	31 @	13.00	CWT	$38.02	403.00	$15,322.06
BULL CALVES			HEAD	$30.00	47.50	$1,425.00
HEIFERS			HEAD	$1,146.00	0.00	$0.00
PATRONAGE DIVIDENDS						$11,664.00
CROP SALES						$0.00
OTHER						$0.00
			TOTAL CASH INCOME			$261,691.06
CASH EXPENSES						
		FEED WASTE				
CORN SILAGE		8.0%	TON	$30.00	1602.06	$48,061.76
ALF HAY		5.0%	TON	$100.00	80.06	$8,006.25
GRASS HAY		5.0%	TON	$70.00	143.41	$10,038.72
SBOM 48%		2.0%	TON	$300.00	95.15	$28,544.45
CORN GRAIN		2.0%	BU	$4.00	2499.91	$9,999.64
CORN DIST GR		2.0%	TON	$180.00	46.67	$8,399.70
OTHER FEED		0.0%	TON	$0.00	0.00	$0.00
PASTURE			ACRE	$20.00	125.00	$2,500.00
MINERALS			HEAD	$46.12	100.00	$4,612.00
MILK REPLACER			CWT	$82.00	27.00	$2,214.00
CALF GROWER			CWT	$13.25	235.00	$3,113.75
GRINDING & MIXING			TON	$10.00	0.00	$0.00

BREEDING		HEAD	$30.00	100.00	$3,000.00
VET & MEDICINE		HEAD	$85.00	100.00	$8,500.00
SUPPLIES		HEAD	$120.00	100.00	$12,000.00
DHIA		HEAD	$19.00	100.00	$1,900.00
HAULING MILK		CWT	$0.80	16000	$12,800.00
ASSESSMENT/ADVER/ETC		CWT	$0.26	16000	$4,200.00
HAUL & MARKET CULLS					$630.22
BLDG. & FENCE REPAIR		_____	_____	_____	$6,000.00
MACHINERY (NON-CROP)		$$$	$60.00	100.00	$6,000.00
UTILITIES		_____	_____	_____	$7,000.00
LABOR FICA	7.65%	MEN	$18,000	2.50	$48,442.50
OPERATING INTEREST		_____	_____	_____	$0.00
OTHER		_____	_____	_____	$0.00
OTHER		_____	_____	_____	$0.00
OTHER		_____	_____	_____	$0.00
			TOTAL CASH EXPENSES		$235,962.99
ANNUAL DEBT PAYMENTS					$0.00
RETURN TO EQUITY, MANAGEMENT, & OPER. LABOR					$25,728.07
RETURN PER ACRE OF PASTURE					$205.82

DEVELOPED BY VIRGINIA COOPERATIVE EXTENSION FARM MGT. STAFF

Appendix D – Budgets for Site Preparation

SITE PREPARATION

			1.00	*ACRE*
1. LIGHT				
HEAVY DISKING	*HOUR*	*$45.00*	*1.00*	*$45.00*
LIME	*TONS*	*$27.00*	*2.00*	*$54.00*
DISK FOR SEEDBED	*HOUR*	*$ 7.00*	*1.00*	*$7.00*
FERTILIZER				
NITROGEN	*LBS*	*$ 0.29*	*50.00*	*$14.50*
PHOSPHOROUS	*LBS*	*$ 0.23*	*100.00*	*$23.00*
POTASSIUM	*LBS*	*$ 0.14*	*100.00*	*$14.00*
APPLICATION	*BROADCAST*	*$ 4.00*	*1.00*	*$4.00*
SMALL GRAIN MULCH	*TONS*	*$40.00*	*2.00*	*$80.00*
LABOR FOR STRAW	*HOUR*	*$ 6.00*	*4.00*	*$24.00*
PLASTIC NETTING	*SQARE FT*	*$ 0.01*	*3000.00*	*$30.00*
METAL ANCHORS	*CASE*	*$12.00*	*1.00*	*$12.00*
LABOR FOR NETTING	*HOUR*	*$ 6.00*	*4.00*	*$24.00*
EQUIPMENT MOBILIZATION	*ACRE*	*$ -*	*1.00*	*$0.00*
TOTAL				*$286.50*
2. MODERATE				
HEAVY DISKING	*HOUR*	*$65.00*	*4.00*	*$260.00*
LIME	*TONS*	*$27.00*	*2.00*	*$54.00*
DISK FOR SEEDBED	*HOUR*	*$ 7.00*	*1.00*	*$7.00*
FERTILIZER				
NITROGEN	*LBS*	*$ 0.29*	*50.00*	*$14.50*
PHOSPHOROUS	*LBS*	*$ 0.23*	*100.00*	*$23.00*
POTASSIUM	*LBS*	*$ 0.14*	*100.00*	*$14.00*
APPLICATION	*BROADCAST*	*$ 4.00*	*1.00*	*$4.00*
SMALL GRAIN MULCH	*TONS*	*$40.00*	*2.00*	*$80.00*
LABOR FOR STRAW	*HOUR*	*$ 6.00*	*4.00*	*$24.00*
PLASTIC NETTING	*SQARE FT*	*$ 0.01*	*3000.00*	*$30.00*
METAL ANCHORS	*CASE*	*$12.00*	*1.00*	*$12.00*
LABOR FOR NETTING	*HOUR*	*$ 6.00*	*4.00*	*$24.00*
EQUIPMENT MOBILIZATION	*ACRE*	*$ -*	*1.00*	*$0.00*
TOTAL				*$546.50*
3. HEAVY				
HEAVY DISKING	*HOUR*	*$65.00*	*4.00*	*$260.00*
LIME	*TONS*	*$27.00*	*2.00*	*$54.00*
DISK FOR SEEDBED	*HOUR*	*$ 7.00*	*1.00*	*$7.00*
FERTILIZER				
NITROGEN	*LBS*	*$ 0.29*	*50.00*	*$14.50*

PHOSPHOROUS	LBS	$ 0.23	100.00	$23.00
POTASSIUM	LBS	$ 0.14	100.00	$14.00
APPLICATION	BROADCAST	$ 4.00	1.00	$4.00
SMALL GRAIN MULCH	TONS	$40.00	2.00	$80.00
LABOR FOR STRAW	HOUR	$ 6.00	4.00	$24.00
PLASTIC NETTING	SQARE FT	$ 0.01	3000.00	$30.00
METAL ANCHORS	CASE	$12.00	1.00	$12.00
LABOR FOR NETTING	HOUR	$ 6.00	4.00	$24.00
EQUIPMENT MOBILIZATION	ACRE	$ -	1.00	$0.00
TOTAL				$546.50

Appendix E – Budgets for Additional Practices

E –1 Channel Stabilization

CHANNEL STABALIZATION BUDGETS

ITEM	UNIT	PRICE	QUANTITY	TOTAL
1. BIOENGINEERING BASED ON 8 FT. BANK SLOPED TO 3:1 INCLINE STABALIZED				
WITH RIPRAP AND EARTH MOVEMENT;				
BRUSH LAYERS;				
LIVE FASCINES;				
STAKES	LN. FOOT	$ 21.50	1.00	$21.50
RIPRAP	LN. FOOT	$ 9.00	1.00	$9.00
TOTAL				$30.50
2. BIOENGINEERING BASED ON 8 FT. BANK SLOPED TO 3:1 INCLINE STABALIZED				
WITH ROOTWADS AND EARTH MOVEMENT;				
BRUSH LAYERS;				
LIVE FASCINES;				
STAKES	LN. FOOT	$ 10.50	1.00	$10.50
7-10' ROOTWADS & LABOR	LN. FOOT	$ 11.00	1.00	$11.00
TOTAL				$21.50
3. 8 FT. SLOPED BANKS WITH RIPRAP ONLY				
RIPRAP	LN. FOOT	$ 91.00	1.00	$91.00
TOTAL				$91.00

E – 2 Stream Crossing Budgets

STREAM CROSSING

ITEM	UNIT		PRICE	QUANTITY	TOTAL
1. LESS THAN 50 FT WIDTH					
SHAPING AND GRADING	HOUR	$	45.00	10.00	$450.00
BACKHOE ROCK PLACEMENT	HOUR	$	45.00	2.00	$90.00
RIPRAP	TONS	$	5.75	30.00	$172.50
# 57 GRAVEL	TONS	$	6.80	10.00	$68.00
12 FT GEOTEXTILE	LN. FOOT	$	1.60	50.00	$80.00
LABOR	HOUR	$	6.00	12.00	$72.00
EQUIPMENT MOBILIZATION	UNIT	$	200.00	1.00	$200.00
TOTAL	UNIT				$1,132.50
2. 50' TO 100FT' WIDTH					
SHAPING AND GRADING	HOUR	$	45.00	15.00	$675.00
BACKHOE ROCK PLACEMENT	HOUR	$	45.00	4.00	$180.00
RIPRAP	TONS	$	5.75	50.00	$287.50
# 57 GRAVEL	TONS	$	6.80	30.00	$204.00
12 FT GEOTEXTILE	LN. FOOT	$	1.60	100.00	$160.00
LABOR	HOUR	$	6.00	12.00	$72.00
EQUIPMENT MOBILIZATION	ACRE	$	200.00	1.00	$200.00
TOTAL	UNIT				$1,778.50

E – 3 Fencing Budgets

FENCING

ITEM	UNIT		PRICE	QUANTITY	TOTAL
1. 3 STRAND BARBED WIRE					
ALL ITEMS	LN. FOOT	$	1.30	1.00	$1.30
INSTALLATION	LN. FOOT	$	0.07	1.00	$0.07
TOTAL	LN. FOOT				$1.37
2. 4 STRAND BARBED WIRE					
ALL ITEMS	LN. FOOT	$	1.40	1.00	$1.40
INSTALLATION	LN. FOOT	$	0.07	1.00	$0.07
TOTAL	LN. FOOT				$1.47
3. 5 STRAND BARBED WIRE					
ALL ITEMS	LN. FOOT	$	1.50	1.00	$1.50
INSTALLATION	LN. FOOT	$	0.08	1.00	$0.08
TOTAL	LN. FOOT				$1.58
4. 4 FT WOVEN WIRE					
ALL ITEMS	LN. FOOT	$	1.90	1.00	$1.90
INSTALLATION	LN. FOOT	$	0.10	1.00	$0.10
TOTAL	LN. FOOT				$2.00
5. 4 FT WOVEN WIRE PLUS 1 STRAND BARBED WIRE					
ALL ITEMS	LN. FOOT	$	2.10	1.00	$2.10
INSTALLATION	LN. FOOT	$	0.11	1.00	$0.11
TOTAL	LN. FOOT				$2.21
6. 4 FT WOVEN WIRE PLUS 2 STRAND BARBED WIRE					
ALL ITEMS	LN. FOOT	$	2.30	1.00	$2.30
INSTALLATION	LN. FOOT	$	0.12	1.00	$0.12
TOTAL	LN. FOOT				$2.42
7. 2 STRAND POLY WIRE					
ALL ITEMS	LN. FOOT	$	0.50	1.00	$0.50
INSTALLATION	LN. FOOT	$	0.03	1.00	$0.03
ELECTRICAL CHARGER	UNIT	$	399.00	1.00	$399.00
TOTAL	LN. FOOT				$399.03
8. 2 STRAND HT WIRE					
ALL ITEMS	LN. FOOT	$	0.85	1.00	$0.85
INSTALLATION	LN. FOOT	$	0.04	1.00	$0.04
ELECTRICAL CHARGER	UNIT	$	399.00	1.00	$399.00
TOTAL	LN. FOOT				$399.04
9. 3 STRAND HT WIRE					
ALL ITEMS	LN. FOOT	$	1.10	1.00	$1.10
INSTALLATION	LN. FOOT	$	0.06	1.00	$0.06
ELECTRICAL CHARGER	UNIT	$	399.00	1.00	$399.00
TOTAL	LN. FOOT				$399.06
10. 4 STRAND HT WIRE					
ALL ITEMS	LN. FOOT	$	1.50	1.00	$1.50
INSTALLATION	LN. FOOT	$	0.08	1.00	$0.08
ELECTRICAL CHARGER	UNIT	$	399.00	1.00	$399.00
TOTAL	LN. FOOT				$399.08

Trough or Tank Supplemental Water Supply

ITEM	UNIT	PRICE		QUANTITY	TOTAL
1. 4 OPENING FREEZE PROOF, 33 GALLON TANK					
BACKHOE EARTH MOVEMMENT	HOUR	$	45.00	1	$45.00
33 GALLON TANK	UNIT	$	520.00	1	$520.00
CONCRETE	CU. YARD	$	50.00	3	$150.00
CORRUGATED PLASTIC PIPE	LN. FOOT	$	3.50	3	$10.50
GRAVEL	TONS	$	8.70	4	$34.80
LABOR	HOUR	$	6.00	6	$36.00
TOTAL					$796.30
ANNUAL O & M	UNIT	$	41.00	1	$41.00
2. 6 OPENING FREEZE PROOF, 100 GALLON					
BACKHOE EARTH MOVEMMENT	HOUR	$	45.00	1	$45.00
100 GALLON TANK	UNIT	$	745.00	1	$745.00
CONCRETE	CU. YARD	$	50.00	3	$150.00
CORRUGATED PLASTIC PIPE	LN. FOOT	$	3.50	3	$10.50
GRAVEL	TONS	$	8.70	4	$34.80
LABOR	HOUR	$	6.00	6	$36.00
TOTAL					$1,021.30
ANNUAL O & M	UNIT	$	41.00	1	$41.00
3. PRE-CAST CONCRETE, 500 GALLON					
BACKHOE EARTH MOVEMMENT	HOUR	$	45.00	1	$45.00
100 GALLON TANK	UNIT	$	300.00	1	$300.00
CONCRETE	CU. YARD	$	50.00	0	$0.00
GALVANIZED PIPE 1.5 IN.	LN. FOOT	$	2.50	20	$50.00
GRAVEL	TONS	$	8.70	4	$34.80
LABOR	HOUR	$	6.00	4	$24.00
TOTAL					$453.80
ANNUAL O & M	UNIT	$	41.00	1	$41.00
4. CONVERTED HEAVY EQUIPMENT TIRE(8FT), 750 GALLON					
BACKHOE EARTH MOVEMMENT	HOUR	$	45.00	2	$90.00
100 GALLON TANK	UNIT	$	150.00	1	$150.00
CONCRETE	CU. YARD	$	50.00	1.5	$75.00
GALVANIZED PIPE 1.5 IN.	LN. FOOT	$	2.50	10	$25.00
GALVANIZED PIPE 2 IN.	LN. FOOT	$	3.30	10	$33.00
GRAVEL	TONS	$	8.70	4	$34.80
LABOR	HOUR	$	6.00	6	$36.00
TOTAL					$443.80
ANNUAL O & M	UNIT	$	41.00	1	$41.00

5. RESEVIOR OF PRE-CAST CONCRETE, 1,500 GALLON					
BACKHOE EARTH MOVEMMENT	*HOUR*	*$*	*45.00*	*2*	*$90.00*
100 GALLON TANK	*UNIT*	*$*	*495.00*	*1*	*$495.00*
CONCRETE	*CU. YARD*	*$*	*50.00*	*0*	*$0.00*
GALVANIZED PIPE 1.5 IN.	*LN. FOOT*	*$*	*2.50*	*20*	*$50.00*
GRAVEL	*TONS*	*$*	*8.70*	*0*	*$0.00*
LABOR	*HOUR*	*$*	*6.00*	*2*	*$12.00*
TOTAL					*$647.00*
ANNUAL O & M	*UNIT*	*$*	*41.00*	*1*	*$41.00*

6. RESEVIOR OF PRE-CAST CONCRETE, 2,600 GALLON					
BACKHOE EARTH MOVEMMENT	*HOUR*	*$*	*45.00*	*2*	*$90.00*
100 GALLON TANK	*UNIT*	*$*	*740.00*	*1*	*$740.00*
CONCRETE	*CU. YARD*	*$*	*50.00*	*0*	*$0.00*
GALVANIZED PIPE 1.5 IN.	*LN. FOOT*	*$*	*2.50*	*20*	*$50.00*
GRAVEL	*TONS*	*$*	*8.70*	*0*	*$0.00*
LABOR	*HOUR*	*$*	*6.00*	*2*	*$12.00*
TOTAL					*$892.00*
ANNUAL O & M	*UNIT*	*$*	*41.00*	*1*	*$41.00*

Appendix F – Forestry Budgets

UNMANAGED FOREST BUDGET

ITEM	UNIT		PRICE	QUANTITY	TOTAL
				1 ACRE	
HARVEST RETURNS	UNIT	$	-		
ESTABLISHMENT COSTS	ACRE				
ADDITIONAL COSTS					
NITROGEN *	LBS	$	-	0.00	$0.00
PHOSPHATE *	LBS	$	-	0.00	$0.00
POTASH	LBS	$	-	0.00	$0.00
FERTILIZER APPLICATION	ACRE	$	-	1.00	$0.00
LIME	TON	$	-	0.00	$0.00
CHEMICALS					
HERBICIDES	ACRE	$	-	0.00	$0.00
INSECTICIDES	ACRE	$	-	0.00	$0.00
FUNGICIDES	ACRE	$	-	0.00	$0.00
CHEMICAL APPLICATION	ACRE	$	-	0.00	$0.00
TOTAL ESTABLISHMENT COSTS					$0.00
ANNUAL OPERATIONS & MAINTENANCE					
_____	ACRE	$	-	1.00	$0.00
TOTAL O&M					$0.00
PERIODIC COSTS					
MOWING (1ST 4 YEARS)	ACRE	$	7.00	2.00	$14.00
___					
POST-HARVEST	ACRE	$	1.00	1.00	$1.00

SPECAIL SITE PREPARATION COSTS

ITEM	UNIT	PRICE	QUANTITY	TOTAL
SITE PREPARATION	ACRE			
LIGHT				$286.50
MODERATE				$546.50
HEAVY				$546.50
STREAM CROSSING	UNIT			$0.00
FENCING	LN. FOOT			$0.00
CHANNEL STABALIZATION	LN. FOOT			$0.00

SPECIES SPECIFIC DATA

ITEM	UNIT		PRICE	QUANTITY	TOTAL
1. PINE PULPWOOD					
ESTABLISHMENT COST					
SEEDLINGS	PER ACRE			435	
	PER 1000	$	33.00	0.44	$14.36
PLANTING LABOR	PER ACRE	$	45.00	1.00	$45.00
TOTAL	PER ACRE				$59.36
POST-HARVEST	PER ACRE	$	-	1.00	$0.00
HARVEST					
TOTAL	PER ACRE	$	40.00		
2. PINE SAWTIMBER					
ESTABLISHMENT COST					
SEEDLINGS	PER ACRE			435	
	PER 1000	$	33.00	0.44	$14.36
PLANTING LABOR	PER ACRE	$	45.00	1.00	$45.00
TOTAL	PER ACRE				$59.36
POST-HARVEST	PER ACRE	$	-	2.00	$0.00
HARVEST					
TOTAL	PER ACRE	$	273.00		
3. CHIP-N-SAW					
ESTABLISHMENT COST					
SEEDLINGS	PER ACRE			435	
	PER 1000	$	70.00	0.44	$30.45
PLANTING LABOR	PER ACRE	$	45.00	1.00	$45.00
TOTAL	PER ACRE				$75.45
POST-HARVEST	PER ACRE	$	-	3.00	$0.00
HARVEST					
TOTAL	PER ACRE	$	62.00		
4. OAK SAWTIMBER					
ESTABLISHMENT COST					
SEEDLINGS	PER ACRE			110	
	PER 100	$	80.00	1.10	$88.00
PLANTING LABOR	PER SEEDLING	$	1.00	110.00	$110.00
TOTAL	PER ACRE				$198.00
POST-HARVEST	PER ACRE	$	-	5.00	$0.00
HARVEST					
TOTAL	PER ACRE	$	126.00		

5. MIXED HARDWOOD SAWTIMBER					
ESTABLISHMENT COST					
SEEDLINGS	*PER ACRE*			*110*	
	PER 100	*$*	*80.00*	*1.10*	*$88.00*
PLANTING LABOR	*PER SEEDLING*	*$*	*1.00*	*110.00*	*$110.00*
STAKES & TUBES	*PER ACRE*	*$*	*2.80*	*110*	*$308.00*
STAKES & TUBES/LABOR	*PER ACRE*	*$*	*0.30*	*110*	*$33.00*
TOTAL	*PER ACRE*				*$341.00*
POST-HARVEST	*PER ACRE*	*$*	*-*	*6.00*	*$0.00*
HARVEST					
TOTAL	*PER ACRE*	*$*	*134.00*		

6. POWER POLES					
ESTABLISHMENT COST					
SEEDLINGS	*PER ACRE*			*110*	
	PER 100	*$*	*80.00*	*1.10*	*$88.00*
PLANTING LABOR	*PER SEEDLING*	*$*	*1.00*	*110.00*	*$110.00*
TOTAL	*PER ACRE*				*$198.00*
POST-HARVEST	*PER ACRE*	*$*	*-*	*7.00*	*$0.00*
HARVEST					
TOTAL	*PER ACRE*	*$*	*358.00*		

7. HARDWOOD PULP					
ESTABLISHMENT COST					
SEEDLINGS	*PER ACRE*			*110*	
	PER 100	*$*	*80.00*	*1.10*	*$88.00*
PLANTING LABOR	*PER SEEDLING*	*$*	*1.00*	*110.00*	*$110.00*
STAKES & TUBES	*PER ACRE*	*$*	*2.80*	*110*	*$308.00*
STAKES & TUBES/LABOR	*PER ACRE*	*$*	*0.30*	*110*	*$33.00*
TOTAL	*PER ACRE*				*$341.00*
POST-HARVEST	*PER ACRE*	*$*	*-*	*8.00*	*$0.00*
HARVEST					
TOTAL	*PER ACRE*	*$*	*17.00*		

Curriculum Vitae

Clifton Lee Smith

EDUCATION:

Master of Science in Agricultural and Applied Economics

Virginia Polytechnic Institute and State University, Blacksburg, VA
August, 1998

Program of Study

- Mathematical programming-Operations research
- Micro-economics- fundamental principles with calculus.
- Econometrics- elementary econometrics, and probability theory.
- Theoretical Statistics- probability theory and distributions.
- Resource Economics- attention to market based approaches.
- Systems Watershed Assessment Management and Policy
- Game Theory
- International Development.

Bachelor of Science in Agricultural and Applied Economics

Auburn University, Auburn, AL
May 1993

Program of Study

Physics, chemistry, biology, agronomy, international trade, mathematics, machine technology, water and land resource management.

Research assistant, Virginia Polytechnic Institute and State University, Blacksburg, VA
(6/96 – Present)

- Performed economic research of pollution control in agriculture
- Completed thesis concerning Riparian Forest Buffer Systems
- Worked extensively with agricultural and forestry enterprise budgets
- Extensive consideration of farm management and property issues
- Constructed user interface for farm management program

Forestry aide, Tennessee Department of Agriculture, Nashville, TN,
(5/96-8/96;6/90-8/90)

- Constructed and monitored insect traps
- Reported to supervisor monthly
- educated landowners on Gypsy Moth Eradication program.

Carpenter, Holthe Contracting Company, Sparks, MD, (3/94 – 3/96)

- Worked on two renovations and additions in historic Baltimore area
- Developed skills in framing, foundation, roofing, electrical, cabinetry, flooring, roofing, and window installation

Environmental Scientist, Neilsen, Inc. Pasadena, MD (3/94 – 5/94)

- Identified soils, hydrology, and vegetation for wetland/forestland delineation
- Worked with public and private engineers and officials on mitigation

Assembly Line Worker, Inter-City Products, Lewisburg, TN (12/93-3/94)

- Worked night shift assembling heating and cooling products for largest U.S. manufacturer

Peace Corps Volunteer, Agricultural Improvement, Guatemala (10/93)

- Examined agricultural teaching materials
- Studied and practiced Spanish language

Research Assistant, Department of Entomology, Auburn, AL (6/93 – 9/93; 6/92 – 9/92)

- Collected data involving health and pest infestations in crops
- Setup and assisted pesticide performance tests
- Performed bioassays of soils

Teaching assistant, Department of Agricultural and Applied Economics,
Auburn University (8/91- 6/93)

- Assisted in the teaching of microcomputer applications in agriculture
- Assisted international graduate students and Alabama farmers

Farm worker, Family farm, Lewisburg, TN (life-long involvement)

- Cow-calf and row crop operations
- Operated farm machinery

COMPUTER SKILLS:

- Microsoft Word and Excel Software
- GAMS and Lindo mathematical programming software
- Visual Basic programming language (used to construct thesis)

ACTIVITIES:

- Delegate for the Graduate Student Assembly
- Member of American Agricultural Economics Association

PERSONAL INFORMATION:

Residence: 5242 Edmondson Pike, Apt. 521, Nashville, TN 37211 (615) 331-9448
E-mail: Clifton_Lee_Smith@msn.com
Age: 27 Married: July 11, 1998
Hobbies: Biking. Hiking, Hunting, Fishing, various team sports